RESEARCH CENTER

FIELD

Activity Report 2018

Section Partnerships and Cooperations

Edition: 2019-03-07

ALGORITHMICS, PROGRAMMING, SOFTWARE AND ARCHITECTURE

ANTIQUE Project-Team

7. Partnerships and Cooperations

7.1. National Initiatives

7.1.1. AnaStaSec

Title: Static Analysis for Security Properties

Type: ANR générique 2014

Defi: Société de l'information et de la communication

Instrument: ANR grant

Duration: January 2015 - December 2018

Coordinator: Inria Paris-Rocquencourt (France)

Others partners: Airbus France (France), AMOSSYS (France), CEA LIST (France), Inria Rennes-Bretagne Atlantique (France), TrustInSoft (France)

Inria contact: Jérôme Feret

See also: http://www.di.ens.fr/ feret/anastasec/

Abstract: An emerging structure in our information processing-based society is the notion of trusted complex systems interacting via heterogeneous networks with an open, mostly untrusted world. This view characterises a wide variety of systems ranging from the information system of a company to the connected components of a private house, all of which have to be connected with the outside.

It is in particular the case for some aircraft-embedded computer systems, which communicate with the ground through untrusted communication media. Besides, the increasing demand for new capabilities, such as enhanced on-board connectivity, e.g. using mobile devices, together with the need for cost reduction, leads to more integrated and interconnected systems. For instance, modern aircrafts embed a large number of computer systems, from safety-critical cockpit avionics to passenger entertainment. Some systems meet both safety and security requirements. Despite thorough segregation of subsystems and networks, some shared communication resources raise the concern of possible intrusions.

Some techniques have been developed and still need to be investigated to ensure security and confidentiality properties of such systems. Moreover, most of them are model-based techniques operating only at architectural level and provide no guarantee on the actual implementations. However, most security incidents are due to attackers exploiting subtle implementation-level software vulnerabilities. Systems should therefore be analyzed at software level as well (i.e. source or executable code), in order to provide formal assurance that security properties indeed hold for real systems.

Because of the size of such systems, and considering that they are evolving entities, the only economically viable alternative is to perform automatic analyses. Such analyses of security and confidentiality properties have never been achieved on large-scale systems where security properties interact with other software properties, and even the mapping between high-level models of the systems and the large software base implementing them has never been done and represents a great challenge. The goal of this project is to develop the new concepts and technologies necessary to meet such a challenge.

The project ANASTASEC project will allow for the formal verification of security properties of software-intensive embedded systems, using automatic static analysis techniques at different levels of representation: models, source and binary codes. Among expected outcomes of the project will be a set of prototype tools, able to deal with realistic large systems and the elaboration of industrial security evaluation processes, based on static analysis.

7.1.2. REPAS

The project REPAS, Reliable and Privacy-Aware Software Systems via Bisimulation Metrics (coordination Catuscia Palamidessi, Inria Saclay), aims at investigating quantitative notions and tools for proving program correctness and protecting privacy, focusing on bisimulation metrics, the natural extension of bisimulation on quantitative systems. A key application is to develop mechanisms to protect the privacy of users when their location traces are collected. Partners: Inria (Comete, Focus), ENS Cachan, ENS Lyon, University of Bologna.

7.1.3. SAFTA

Title: SAFTA Static Analysis for Fault-Tolerant distributed Algorithms.

Type: ANR JCJC 2018

Duration: February 2018 - February 2022

Coordinator: Cezara Drăgoi, CR Inria

Abstract: Fault-tolerant distributed data structures are at the core distributed systems. Due to the multiple sources of non-determinism, their development is challenging. The project aims to increase the confidence we have in distributed implementations of data structures. We think that the difficulty does not only come from the algorithms but from the way we think about distributed systems. In this project we investigate partially synchronous communication-closed round based programming abstractions that reduce the number of interleavings, simplifying the reasoning about distributed systems and their proof arguments. We use partial synchrony to define reduction theorems from asynchronous semantics to partially synchronous ones, enabling the transfer of proofs from the synchronous world to the asynchronous one. Moreover, we define a domain specific language, that allows the programmer to focus on the algorithm task, it compiles into efficient asynchronous code, and it is equipped with automated verification engines.

7.1.4. TGFSYSBIO

Title: Microenvironment and cancer: regulation of TGF-β signaling

Type: ANR générique 2014

Defi: Société de l'information et de la communication

Instrument: Plan Cancer 2014-2019

Duration: December 2015 - November 2018

Coordinator: INSERM U1085-IRSET

Others partners: Inria Paris (France), Inria Rennes-Bretagne Atlantique (France),

Inria contact: Jérôme Feret

Abstract: Most cases of hepatocellular carcinoma (HCC) develop in cirrhosis resulting from chronic liver diseases and the Transforming Growth Factor β (TGF-β) is widely regarded as both the major pro-fibrogenic agent and a critical inducer of tumor progression and invasion. Targeting the deleterious effects of TGF-β without affecting its physiological role is the common goal of therapeutic strategies. However, identification of specific targets remains challenging because of the pleiotropic effects of TGF-β linked to the complex nature of its extracellular activation and signaling networks.

Our project proposes a systemic approach aiming at to identifying the potential targets that regulate the shift from anti- to pro-oncogenic effects of TGF-β. To that purpose, we will combine a rule-based model (Kappa language) to describe extracellular TGF-beta activation and large-scale state-transition based (Cadbiom formalism) model for TGF-β-dependent intracellular signaling pathways. The multi-scale integrated model will be enriched with a large-scale analysis of liver tissues using shotgun proteomics to characterize protein networks from tumor microenvironment whose remodeling is responsible for extracellular activation of TGF-β. The trajectories and upstream regulators of the final model will be analyzed with symbolic model checking techniques and abstract

interpretation combined with causality analysis. Candidates will be classified with semantic-based approaches and symbolic bi-clustering technics. All efforts must ultimately converge to experimental validations of hypotheses and we will use our hepatic cellular models (HCC cell lines and hepatic stellate cells) to screen inhibitors on the behaviors of TGF-β signal.

The expected results are the first model of extracellular and intracellular TGF-β system that might permit to analyze the behaviors of TGF-β activity during the course of liver tumor progression and to identify new biomarkers and potential therapeutic targets.

7.1.5. VeriAMOS

Title: Verification of Abstract Machines for Operating Systems

Type: ANR générique 2018

Defi: Société de l'information et de la communication

Instrument: ANR grant

Duration: January 2019 - December 2022

Coordinator: Inria Paris (France)

Others partners: LIP6 (France), IRISA (France), UGA (France)

Inria contact: Xavier Rival

Abstract: Operating System (OS) programming is notoriously difficult and error prone. Moreover, OS bugs can have a serious impact on the functioning of computer systems. Yet, the verification of OSes is still mostly an open problem, and has only been done using user-assisted approaches that require a huge amount of human intervention. The VeriAMOS proposal relies on a novel approach to automatically and fully verifying OS services, that combines Domain Specific Languages (DSLs) and automatic static analysis. In this approach, DSLs provide language abstraction and let users express complex policies in high-level simple code. This code is later compiled into low level C code, to be executed on an abstract machine. Last, the automatic static analysis verifies structural and robustness properties on the abstract machine and generated code. We will apply this approach to the automatic, full verification of input/output schedulers for modern supports like SSDs.

7.2. European Initiatives

7.2.1. FP7 & H2020 Projects

Type: IDEAS

Defi:

Instrument: ERC Proof of Concept Grant 2018

Objectif: Static Analysis for the VErification of Spreadsheets

Duration: January 2019 - June 2020

Coordinator: Inria (France)

Partner: None

Inria contact: Xavier Rival

Abstract: Spreadsheet applications (such as Microsoft Excel + VBA) are heavily used in a wide range of application domains including engineering, finance, management, statistics and health. However, they do not ensure robustness properties, thus spreadsheet errors are common and potentially costly. According to estimates, the annual cost of spreadsheet errors is around 7 billion dollars. For instance, in 2013, a series of spreadsheet errors at JPMorgan incurred 6 billion dollars trading losses. Yet, expert reports estimate about 90 % of the spreadsheets contain errors. The MemCAD ERC StG project opened the way to novel formal analysis techniques for spreadsheet applications. We propose to leverage these results into a toolbox able to safely *verify*, *optimize* and *maintain* spreadsheets, so as to reduce the likelihood of spreadsheet disasters. This toolbox will be commercialized by the startup MATRIXLEAD.

7.3. International Research Visitors

7.3.1. Visits of International Scientists

7.3.1.1. Internships

Jérôme Feret has supervised the M1 Internship of Aurélie Faure de Pebeyre (AIV Master) and the M2 Internship of Albin Salazar (AIV Master).

Xavier Rival is supervising M1 Internships of Guillaume Reboullet and of Luc Chabassier (M1 at DIENS).

Vincent Danos supervised interns Raja Ben Ali and Jaime Aujaud (L2 Epitech).

AOSTE2 Team

9. Partnerships and Cooperations

9.1. National Initiatives

9.1.1. FUI

9.1.1.1. CEOS

Participants: Slim Ben Amor, Liliana Cucu, Cristian Maxim, Mehdi Mezouak, Yves Sorel, Walid Talaboulma.

This project was started on May 2017. Partners of the project are: ADCIS, ALERION, Aéroports de Lyon, EDF, ENEDIS, RTaW, EDF, Thales Communications and Security, ESIEE engineering school and Lorraine University. The CEOS project delivers a reliable and secure system of inspections of pieces of works using professional mini-drone for Operators of Vital Importance coupled with their Geographical Information System. These inspections are carried out automatically at a lower cost than current solutions employing helicopters or off-road vehicles. Several software applications proposed by the industrial partners, are developed and integrated in the drone, within an innovative mixed-criticality approach using multi-core platforms.

9.1.1.2. WARUNA

Participants: Liliana Cucu, Adriana Gogonel, Yves Sorel, Walid Talaboulma.

This FUI funded project was started on September 2015 and it is preparing its final conclusions for the beginning of 2019. It has targeted the creation of the framework Time4Sys within the PolarSys project [12]. This open source framework allows timing analyses from models to simulation for different application domains like avionics, railways, medical, aerospace, automotive, etc. and it is available at https://www.polarsys.org/time4sys.

9.1.2. PIA

9.1.2.1. ES3CAP

Participants: Keryan Didier, Dumitru Potop Butucaru.

The objectives of the ES3CAP (Embedded Smart Safe Secure Computing Autonomous Platform) project are to:

- Build a hardware and software industry-grade solution for the development of computation-intensive critical application. The solution should cover the needs of industrial end users, and target multi/many-core hardware platforms. The solution with come with 3 to 6 usage profiles specific to various industries (automotive, aerospace, defence).
- Improve the technology readiness level of the proposed development flow from TRL4-5 (technology development) to TRL6-7, thus approaching as much as possible commercialization.
- Build an alternate, perennial ecosystem for critical real-time OSs and development tools, for computer vision, data fusion and neural networks. The tools and components must be available on a prototyping and demonstration platform that is safe and secure.
- Capitalize on the convergence between the automotive and aerospace markets on subjects such as security, safety, decision making, and big data.

9.1.2.2. DEPARTS

Participants: Liliana Cucu, Adriana Gogonel, Walid Talaboulma.

This BGLE funded project of the national support programme Investissements d'Avenir has started on October 1st, 2012 and provided its final conclusions on December 2018. Inria has provided a final prototype version of the EVT Kopernic tool taking into account homogenous variation factors for the execution times. Swapping algorithms allowing WCET decrease are currently finalized within the PhD thesis of Walid Talaboulma with a defense expected during the spring of 2019.

9.2. European Initiatives

9.2.1. Collaborations in European Programs, Except FP7 & H2020

9.2.1.1. ASSUME

Participants: Keryan Didier, Fatma Jebali, Dumitru Potop Butucaru.

Program: ITEA

Project acronym: ASSUME

Project title: Affordable Safe and Secure Mobility Evolution

Duration: September 2015 - August 2018

Coordinator: Daimler

Other partners: among 38 partners Absint, Ansys, Airbus, Kalray, Safran, Thales, ENS, KTH, FZI, etc.

Abstract: Future mobility solutions will increasingly rely on smart components that continuously monitor the environment and assume more and more responsibility for a convenient, safe and reliable operation. Currently the single most important roadblock for this market is the ability to come up with an affordable, safe multi-core development methodology that allows industry to deliver trustworthy new functions at competitive prices. ASSUME will provide a seamless engineering methodology, which addresses this roadblock on the constructive and analytic side.

9.2.2. Collaborations with Major European Organizations

University of York: Real-Time System Group (UK)

Uncertainties in real-time systems: the utilization of extreme value theory has received increased efforts from our community and more rigorous principles are needed for its full understanding. Our two research teams have gathered these principles in several publications.

ARIC Project-Team

9. Partnerships and Cooperations

9.1. National Initiatives

9.1.1. ANR DYNA3S Project

Participants: Guillaume Hanrot, Gilles Villard.

Dyna3S has been a 2013-2018 ANR project headed by Valérie Berthé (IRIF, U. Paris 7). The Web page of the project is https://www.irif.fr/~dyna3s. The aim of Dyna3S was to study algorithms that compute the greatest common divisor (gcd) from the point of view of dynamical systems. A gcd algorithm is considered as a discrete dynamical system by focusing on integer input. In Lyon we have worked on the computation of the gcd of several integers, in link with integer relation algorithms based on lattice basis reduction. A main motivation of Dyna3S was also discrete geometry, a framework where the understanding of basic primitives, discrete lines and planes, relies on algorithms of the Euclidean type.

9.1.2. ANR FastRelax Project

Participants: Nicolas Brisebarre, Guillaume Hanrot, Vincent Lefèvre, Jean-Michel Muller, Bruno Salvy, Serge Torres.

FastRelax stands for "Fast and Reliable Approximation". It is a four year ANR project (started in October 2014 and extended till September 2019). The web page of the project is http://fastrelax.gforge.inria.fr/. It is headed by B. Salvy and involves AriC as well as members of the Marelle Team (Sophia), of the Mac group (LAAS, Toulouse), of the Specfun and Toccata Teams (Saclay), as well as of the Pequan group in UVSQ and a colleague in the Plume group of LIP.

The aim of this project is to develop computer-aided proofs of numerical values, with certified and reasonably tight error bounds, without sacrificing efficiency. Applications to zero-finding, numerical quadrature or global optimization can all benefit from using our results as building blocks. We expect our work to initiate a "fast and reliable" trend in the symbolic-numeric community. This will be achieved by developing interactions between our fields, designing and implementing prototype libraries and applying our results to concrete problems originating in optimal control theory.

9.1.3. ANR MetaLibm Project

Participants: Claude-Pierre Jeannerod, Jean-Michel Muller.

MetaLibm is a four-year project (started in October 2013 and extended till March 2018) focused on the design and implementation of code generators for mathematical functions and filters. The web page of the project is http://www.metalibm.org/ANRMetaLibm/. It is headed by Florent de Dinechin (INSA Lyon and Socrate team) and, besides Socrate and AriC, also involves teams from LIRMM (Perpignan), LIP6 (Paris), CERN (Geneva), and Kalray (Grenoble). The main goals of the project are to automate the development of mathematical libraries (libm), to extend it beyond standard functions, and to make it unified with similar approaches developed in or useful for signal processing (filter design). Within AriC, we are especially interested in studying the properties of fixed-point arithmetic and floating-point arithmetic that can help develop such a framework.

9.1.4. ANR ALAMBIC Project

Participants: Benoît Libert, Fabien Laguillaumie, Ida Tucker.

ALAMBIC is a four-year project (started in October 2016) focused on the applications of cryptographic primitives with homomorphic or malleability properties. The web page of the project is https://crypto.di.ens.fr/projects:alambic:description. It is headed by Damien Vergnaud (ENS Paris and CASCADE team) and, besides AriC, also involves teams from the XLIM laboratory (Université de Limoges) and the CASCADE team (ENS Paris). The main goals of the project are: (i) Leveraging the applications of malleable cryptographic primitives in the design of advanced cryptographic protocols which require computations on encrypted data; (ii) Enabling the secure delegation of expensive computations to remote servers in the cloud by using malleable cryptographic primitives; (iii) Designing more powerful zero-knowledge proof systems based on malleable cryptography.

9.1.5. RISQ Project

Participants: Chitchanok Chuengsatiansup, Fabien Laguillaumie, Benoît Libert, Damien Stehlé.

RISQ (Regroupement de l'Industrie française pour la Sécurité Post – Quantique) is a BPI-DGE four-year project (started in January 2017) focused on the transfer of post-quantum cryptography from academia to industrial poducts. The web page of the project is http://risq.fr. It is headed by Secure-IC and, besides AriC, also involves teams from ANSSI (Agence Nationale de la Sécurité des Systèmes d'Information), Airbus, C& S (Communication et Systèmes), CEA (CEA-List), CryptoExperts, Gemalto, Orange, Thales Communications & Security, Paris Center for Quantum Computing, the EMSEC team of IRISA, and the Cascade and Polsys Inria teams. The outcome of this project will include an exhaustive encryption and transaction signature product line, as well as an adaptation of the TLS protocol. Hardware and software cryptographic solutions meeting these constraints in terms of security and embedded integration will also be included. Furthermore, documents guiding industrials on the integration of these post-quantum technologies into complex systems (defense, cloud, identity and payment markets) will be produced, as well as reports on the activities of standardization committees.

9.2. European Initiatives

9.2.1. LattAC ERC grant

Participants: Shi Bai, Laurent Grémy, Gottfried Herold, Elena Kirshanova, Fabien Laguillaumie, Huyen Nguyen, Alice Pellet–Mary, Miruna Rosca, Damien Stehlé, Alexandre Wallet, Weiqiang Wen.

Damien Stehlé was awarded an ERC Starting Grant for his project *Euclidean lattices: algorithms and cryptography* (LattAC) in 2013 (1.4Meur for 5 years from January 2014). The LattAC project aims at studying all computational aspects of lattices, from algorithms for manipulating them to applications. The main objective is to enable the rise of lattice-based cryptography.

9.2.2. PROMETHEUS Project

Participants: Laurent Grémy, Fabien Laguillaumie, Benoît Libert, Damien Stehlé.

PROMETHEUS (Privacy-Preserving Systems from Advanced Cryptographic Mechanisms Using Lattices) is a 4-year European H2020 project (call H2020-DS-2016-2017, Cybersecurity PPP Cryptography, DS-06-2017) that started in January 2018. It gathers 8 academic partners (ENS de Lyon and Université de Rennes 1; CWI, Pays-Bas; IDC Herzliya, Israel; Royal Holloway University of London, United Kingdom; Universitat Politècnica de Catalunya, Spain; Ruhr-Universität Bochum, Germany; Weizmann Institute, Israel), 4 industrial partners (Orange, Thales, TNO, Scytl). The goal of this project is to develop a toolbox of privacy-preserving cryptographic algorithms and protocols (like group signatures, anonymous credentials, or digital cash systems) that resist quantum adversaries. Solutions will be mainly considered in the context of Euclidean lattices and they will be analyzed from a theoretical point of view (i.e., from a provable security aspect) and a practical angle (which covers the security of cryptographic implementations and side-channel leakages). The project is hosted by ENS de Lyon and Benoît Libert is the administrative coordinator while Orange is the scientific leader.

9.2.3. Other international projects

9.2.3.1. IFCPAR grant: "Computing on Encrypted Data: New Paradigms in Functional Encryption"

Participants: Benoît Libert, Damien Stehlé.

3-year project accepted in July 2018. Expected beginning on January 1, 2019. Benoît Libert is co-PI with Shweta Agrawal (IIT Madras, India). Budget on the French side amounts to 100k€.

Functional encryption is a paradigm that enables users to perform data mining and analysis on encrypted data. Users are provided cryptographic keys corresponding to particular functionalities which enable them to learn the output of the computation without learning anything about the input. Despite recent advances, efficient realizations of functional encryption are only available for restricted function families, which are typically represented by small-depth circuits: indeed, solutions for general functionalities are either way too inefficient for pratical use or they rely on uncertain security foundations like the existence of circuit obfuscators (or both). This project will explore constructions based on well-studied hardness assumptions and which are closer to being usable in real-life applications. To this end, we will notably consider solutions supporting other models of computation than Boolean circuits – like Turing machines – which support variable-size inputs. In the context of particular functionalities, the project will aim for more efficient realizations that satisfy stronger security notions.

9.3. International Initiatives

9.3.1. Participation in International Programs

Vincent Lefèvre actively participated in the revision of the IEEE Standard for Floating-Point Arithmetic (IEEE 754) for 2019.

9.4. International Research Visitors

9.4.1. Visits of International Scientists

- Lloyd Nicholas Trefethen, from Oxford University (UK), is an expert in numerical analysis and notably the systematic use of Chebyshev approximation. He spent the academic year 2017-2018 with AriC.
- Warwick Tucker, from Uppsala University (Sweden), is an expert of certified computation for dynamical systems. He spent the academic year 2017-2018 with AriC.

9.4.2. Internships

Monosij Maitra, PhD student at IIT Madras (India) under the supervision of Shweta Agrawal, did a 2-month internship, in September and October 2018.

Joel Dahne did an internship with Bruno Salvy from May to July.

9.4.3. Visits to International Teams

- From November 15 to December 15, 2018, Benoît Libert visited the "Cryptography and Coding Research Group" of the Nanyang Technological University (Singapore).
- From July 1 to July 31, 2018, Damien Stehlé visited the cryptography group of Prof. Jung Hee Cheon, at Seoul National University (South Korea)

AROMATH Project-Team

7. Partnerships and Cooperations

7.1. Regional Initiatives

Our team AROMATH participates to the VADER project for VIRTUAL MODELING of RESPIRATION, UCA Jedi, axis “Modélisation, Physique et Mathématique du vivant". http://benjamin.mauroy.free.fr/VADER.

7.2. European Initiatives

7.2.1. FP7 & H2020 Projects

Program: Marie Skłodowska-Curie ITN

Project acronym: ARCADES

Project title: Algebraic Representations in Computer-Aided Design for complEx Shapes

Duration: January 2016 - December 2019

Coordinator: I.Z. Emiris (NKUA, Athens, Greece, and ATHENA Research Innovation Center)

Scientist-in-charge at Inria: L. Busé

Other partners: U. Barcelona (Spain), Inria Sophia Antipolis (France), J. Kepler University, Linz (Austria), SINTEF Institute, Oslo (Norway), U. Strathclyde, Glascow (UK), Technische U. Wien (Austria), Evolute GmBH, Vienna (Austria).

Webpage: http://arcades-network.eu/

Abstract: ARCADES aims at disrupting the traditional paradigm in Computer-Aided Design (CAD) by exploiting cutting-edge research in mathematics and algorithm design. Geometry is now a critical tool in a large number of key applications; somewhat surprisingly, however, several approaches of the CAD industry are outdated, and 3D geometry processing is becoming increasingly the weak link. This is alarming in sectors where CAD faces new challenges arising from fast point acquisition, big data, and mobile computing, but also in robotics, simulation, animation, fabrication and manufacturing, where CAD strives to address crucial societal and market needs. The challenge taken up by ARCADES is to invert the trend of CAD industry lagging behind mathematical breakthroughs and to build the next generation of CAD software based on strong foundations from algebraic geometry, differential geometry, scientific computing, and algorithm design. Our game-changing methods lead to real-time modelers for architectural geometry and visualisation, to isogeometric and design-through-analysis software for shape optimisation, and marine design & hydrodynamics, and to tools for motion design, robot kinematics, path planning, and control of machining tools.

7.3. International Initiatives

7.3.1. Inria International Partners

NSFC collaboration project with Gang Xu, Hangzhou Dianzi University, China, “Research on theory and method of time-varying parameterization for dynamic isogeometric analysis”, 2018-2021.

7.4. International Research Visitors

7.4.1. Visits of International Scientists

Aron Simis, University of Recife, Brazil, visited L. Busé for a week (October 8-12) to work on birationality of rational map by means of syzygy-based techniques.

Ibrahim Adamou, Univ. Dan Dicko Dankoulodo de Maradi, Niger, visited B. Mourrain (26 Nov.- 21 Dec.) to work on 3-dimensional VoronoïDiagrams of half-lines and medial axes of curve arcs.

7.4.1.1. Internships

Yairon Cid Ruiz, a PhD srudent at Barcelona in the Arcades network, visited L. Busé for 6 months (October 2017- March 2018) to work on birationality criteria for multi-graded rational maps with a view towards free form deformation problems.

Clément Laroche, a PhD student in Greece in the Arcades network, visited L. Busé and F. Yildirim for one month (October) for a collaboration on implicization matrices of rational curve in arbitrary dimension by means of quadratic relations.

Kim Perriguey, did a six months internship with L. Busé (December 2017-May 2018). She developed paramteric models for the human walk for the extraction of locomotive parameters. This work was done in collaboration with Pierre Alliez (EPI Titane) and the start-up Ekinnox (Sophia Antipolis).

7.4.2. Visits to International Teams

7.4.2.1. Research Stays Abroad

F. Yildirim was on secondment at MISSLER Topsolid (France), for 3 months (Mai-July).

From October 25th to November 25th, E. Hubert visited the Institute for Computational and Experimental Research in Mathematics (Providence USA) during the program *Nonlinear Algebra*.

CAIRN Project-Team

9. Partnerships and Cooperations

9.1. National Initiatives

9.1.1. Labex CominLabs - 3DCORE (2014-2018)

Participants: Olivier Sentieys, Daniel Chillet, Cédric Killian, Jiating Luo, Van Dung Pham.

3DCORE (3D Many-Core Architectures based on Optical Network on Chip) is a project investigating new solutions based on silicon photonics to enhance by 2 to 3 magnitude orders energy efficiency and data rate of on-chip interconnect in the context of a many-core architecture. Moreover, 3DCore will take advantage of 3D technologies to design a specific optical layer suitable for a flexible and energy efficient high-speed optical network on chip (ONoC). 3DCORE involves CAIRN, FOTON (Rennes, Lannion) and Institut des Nanotechnologies de Lyon. For more details see https://3d-opt-many-cores.cominlabs.u-bretagneloire.fr.

9.1.2. Labex CominLabs - RELIASIC (2014-2018)

Participant: Emmanuel Casseau.

RELIASIC (Reliable Asic) will address the issue of fault-tolerant computation with a bottom-up approach, starting from an existing application as a use case (a GPS receiver) and adding some redundant mechanisms to allow the GPS receiver to be tolerant to transient errors due to low voltage supply. RELIASIC involves CAIRN, Lab-STICC (Lorient) and IETR (Rennes, Nantes). In this project, CAIRN is in charge of the analysis and design of arithmetic operators for fault tolerance. We focus on the hardware implementations of conventional arithmetic operators such as adders, multipliers. We also propose a lightweight design and assessment framework for arithmetic operators with reduced-precision redundancy. For more details see https://reliasic.cominlabs.u-bretagneloire.fr

9.1.3. Labex CominLabs & Lebesgue - H-A-H (2014-2018)

Participants: Arnaud Tisserand, Gabriel Gallin, Audrey Lucas.

H-A-H for *Hardware and Arithmetic for Hyperelliptic Curves Cryptography* is a project on advanced arithmetic representation and algorithms for hyper-elliptic curve cryptography. It will provide novel implementations of HECC based cryptographic algorithms on custom hardware platforms. H-A-H involves CAIRN (Lannion) and IRMAR (Rennes). For more details see http://h-a-h.inria.fr/.

9.1.4. Labex CominLabs - BBC (2016-2020)

Participants: Olivier Sentieys, Cédric Killian, Joel Ortiz Sosa.

The aim of the BBC (on-chip wireless Broadcast-Based parallel Computing) project is to evaluate the use of wireless links between cores inside chips and to define new paradigms. Using wireless communications enables broadcast capabilities for Wireless Networks on Chip (WiNoC) and new management techniques for memory hierarchy and parallelism. The key objectives concern improvement of power consumption, estimation of achievable data rates, flexibility and reconfigurability, size reduction and memory hierarchy management. In this project, CAIRN will address new low-power MAC (media access control) technique based on CDMA access as well as broadcast-based fast cooperation protocol designed for resource sharing (bandwidth, distributed memory, cache coherency) and parallel programming. For more details see https://bbc.cominlabs.u-bretagneloire.fr

9.1.5. Labex CominLabs - SHERPAM (2014-2018)

Participant: Patrice Quinton.

Heart failure and peripheral artery disease patients require early detection of health problems in order to prevent major risk of morbidity and mortality. Evidence shows that people recover from illness or cope with a chronic condition better if they are in a familiar environment (i.e., at home) and if they are physically active (i.e., practice sports). The goal of the Sherpam project is to design, implement, and validate experimentally a monitoring system allowing biophysical data of mobile subjects to be gathered and exploited in a continuous flow. Transmission technologies available to mobile users have been improved a lot during the last two decades, and such technologies offer interesting prospects for monitoring the health of people anytime and anywhere. The originality of the Sherpam project is to rely simultaneously and in an agile way on several kinds of wireless networks in order to ensure the transmission of biometric data, while coping with network disruptions. Sherpam also develops new signal processing algorithms for activity quantification and recognition which represent now a major social and public health issue (monitoring of elderly patient, personalized quantification activity, etc.). Sherpam involves research teams from several scientific domains and from several laboratories of Brittany (IRISA/CASA, LTSI, M2S, CIC-IT 1414-CHU Rennes and LAUREPS). For more details see https://sherpam.cominlabs.u-bretagneloire.fr

9.1.6. DGA RAPID - FLODAM (2017–2021)

Participants: Olivier Sentieys, Angeliki Kritikakou.

FLODAM is an industrial research project for methodologies and tools dedicated to the hardening of embedded multi-core processor architectures. The goal is to: 1) evaluate the impact of the natural or artificial environments on the resistance of the system components to faults based on models that reflect the reality of the system environment, 2) the exploration of architecture solutions to make the multi-core architectures fault tolerant to transient or permanent faults, and 3) test and evaluate the proposed fault tolerant architecture solutions and compare the results under different scenarios provided by the fault models. For more details see https://flodam.fr

9.2. European Initiatives

9.2.1. H2020 ARGO

Participants: Steven Derrien, Olivier Sentieys, Mickael Dardaillon, Ali Hassan El Moussawi.

Program: H2020-ICT-04-2015

Project acronym: ARGO

Project title: WCET-Aware Parallelization of Model-Based Applications for Heterogeneous Parallel Systems

Duration: Feb. 2016 - Feb. 2019

Coordinator: KIT

Other partners: KIT (Germany), UR1/Inria/CAIRN, Recore Systems (Netherlands), TEI-WG (Greece), Scilab Ent. (France), Absint (Ger.), DLR (Ger.), Fraunhofer (Ger.)

Increasing performance and reducing cost, while maintaining safety levels and programmability are the key demands for embedded and cyber-physical systems, e.g. aerospace, automation, and automotive. For many applications, the necessary performance with low energy consumption can only be provided by customized computing platforms based on heterogeneous many-core architectures. However, their parallel programming with time-critical embedded applications suffers from a complex toolchain and programming process. ARGO will address this challenge with a holistic approach for programming heterogeneous multi- and many-core architectures using automatic parallelization of model-based real-time applications. ARGO will enhance WCET-aware automatic parallelization by a cross-layer programming approach combining automatic tool-based and user-guided parallelization to reduce the need for expertise in programming parallel heterogeneous architectures. The ARGO approach will be assessed and demonstrated by prototyping comprehensive time-critical applications from both aerospace and industrial automation domains on customized heterogeneous many-core platforms.

9.2.2. ANR International ARTEFaCT

Participants: Olivier Sentieys, Van Phu Ha, Tomofumi Yuki.

Program: ANR International France-Switzerland
Project acronym: ARTEFaCT
Project title: AppRoximaTivE Flexible Circuits and Computing for IoT
Duration: Feb. 2016 - Dec. 2019
Coordinator: CEA
Other partners: CEA-LETI, CAIRN, EPFL

The ARTEFaCT project aims to build on the preliminary results on inexact and exact near-threshold and sub-threshold circuit design to achieve major energy consumption reductions by enabling adaptive accuracy control of applications. ARTEFaCT proposes to address, in a consistent fashion, the entire design stack, from physical hardware design, up to software application analysis, compiler optimizations, and dynamic energy management. We do believe that combining sub-near-threshold with inexact circuits on the hardware side and, in addition, extending this with intelligent and adaptive power management on the software side will produce outstanding results in terms of energy reduction, i.e., at least one order of magnitude, in IoT applications. The project will contribute along three research directions: (1) approximate, ultra low-power circuit design, (2) modeling and analysis of variable levels of computation precision in applications, and (3) accuracy-energy trade- offs in software.

9.3. International Initiatives

9.3.1. Inria International Labs

EPFL-Inria

Associate Team involved in the International Lab:

9.3.1.1. IoTA

Title: Ultra-Low Power Computing Platform for IoT leveraging Controlled Approximation
International Partner (Institution - Laboratory - Researcher):
Ecole Polytechnique Fédérale de Lausanne (Switzerland) - Christian Enz
Start year: 2017
See also: https://team.inria.fr/cairn/IOTA

Energy issues are central to the evolution of the Internet of Things (IoT), and more generally to the ICT industry. Current low-power design techniques cannot support the estimated growth in number of IoT objects and at the same time keep the energy consumption within sustainable bounds, both on the IoT node side and on cloud/edge-cloud side. This project aims to build on the preliminary results on inexact and exact sub/near-threshold circuit design to achieve major energy consumption reductions by enabling adaptive accuracy control of applications. IoTA proposes to address, in a consistent fashion, the entire design stack, from hardware design, up to software application analysis, compiler optimizations, and dynamic energy management. The main scientific challenge is twofold: (1) to add adaptive accuracy to hardware blocks built in near/sub threshold technology and (2) to provide the tools and methods to program and make efficient use of these hardware blocks for applications in the IoT domain. This entails developing approximate computing units, on one side, and methods and tools, on the other side, to rigorously explore trade-offs between accuracy and energy consumption in IoT systems. The expertise of the members of the two teams is complementary and covers all required technical knowledge necessary to reach our objectives, i.e., ultra low power hardware design (EPFL), approximate operators and functions (Inria, EPFL), formal analysis of precision in algorithms (Inria), and static and dynamic energy management (Inria, EPFL). Finally, the proof of concept will consist of results on (1) an adaptive, inexact or exact, ultra-low power microprocessor in 28 nm process and (2) a real prototype implemented in an FPGA platform combining processors and hardware accelerators. Several software use-cases relevant for the IoT domain will be considered, e.g., embedded vision, IoT sensors data fusion, to practically demonstrate the benefits of our approach.

9.3.2. Inria International Partners

9.3.2.1. LRS

Title: Loop unRolling Stones: compiling in the polyhedral model

International Partner (Institution - Laboratory - Researcher):

Colorado State University (United States) - Department of Computer Science - Prof. Sanjay Rajopadhye

9.3.2.2. HARAMCOP

Title: Hardware accelerators modeling using constraint-based programming

International Partner (Institution - Laboratory - Researcher):

Lund University (Sweden) - Department of Computer Science - Prof. Krzysztof Kuchcinski

9.3.2.3. SPINACH

Title: Secure and low-Power sensor Networks Circuits for Healthcare embedded applications

International Partner (Institution - Laboratory - Researcher):

University College Cork (Ireland) - Department of Electrical and Electronic Engineering - Prof. Liam Marnane and Prof. Emanuel Popovici

Arithmetic operators for cryptography, side channel attacks for security evaluation, energy-harvesting sensor networks, and sensor networks for health monitoring.

9.3.2.4. DARE

Title: Design space exploration Approaches for Reliable Embedded systems

International Partner (Institution - Laboratory - Researcher):

IMEC (Belgium) - Francky Catthoor

Methodologies to design low cost and efficient techniques for safety-critical embedded systems, Design Space Exploration (DSE), run-time dynamic control mechanisms.

9.3.2.5. Informal International Partners

LSSI laboratory, Québec University in Trois-Rivières (Canada), Design of architectures for digital filters and mobile communications.

Department of Electrical and Computer Engineering, University of Patras (Greece), Wireless Sensor Networks, Worst-Case Execution Time, Priority Scheduling.

Karlsruhe Institute of Technology - KIT (Germany), Loop parallelization and compilation techniques for embedded multicores.

Ruhr - University of Bochum - RUB (Germany), Reconfigurable architectures.

University of Science and Technology of Hanoi (Vietnam), Participation of several CAIRN's members in the Master ICT / Embedded Systems.

9.4. International Research Visitors

9.4.1. Visits of International Scientists

Martin Kumm, University of Kassel, Germany, July 2018.

Son Tran Giang, Lecturer at ICTLab, Vietnam, December 2018.

9.4.2. Visits to International Teams

E. Casseau spent 3 weeks as a visiting researcher in the Parallel and Reconfigurable Lab. of the Electrical and Computer Engineering department, the University of Auckland, New Zealand, in December 2018.

P. Dobias (Phd student) spent 5 months in the Parallel and Reconfigurable Lab. of the Electrical and Computer Engineering department, the University of Auckland, New Zealand, from November 2018 until March 2019.

CAMUS Team

9. Partnerships and Cooperations

9.1. Regional Initiatives

9.1.1. Idex Prim'Eau

Participant: Jens Gustedt [contact].

In the framework of the Prim'Eau project of the University of Strasbourg, we study surface runoff for hydrological periods of several days. We use an efficient domain decomposition method that we apply to a real world example of Mutterbach (Moselle) with geological and flood data from the years 1920, 1940 and 2017. As the time and memory usage for these computations is important, we aim to parallelize them.

9.1.2. ADT ASNAP

Participants: Philippe Clauss, Jens Gustedt, Maxime Mogé.

Philippe Clauss, Jens Gustedt and Maxime Mogé have been involved until August 2018 in the ADT Inria project ASNAP (Accélération des Simulations Numériques pour l'Assistance Peropératoire), in collaboration with the Inria team MIMESIS. The goal was to find opportunities in the SOFA simulation platform for applying automatic parallelization techniques developed by Camus. We have investigated two approaches. One approach uses memory behavior memoïzation to generate a parallel code made of independent threads at runtime.

9.1.3. ADT ALTO (ApoLlo TakeOff)

Participants: Philippe Clauss, Muthena Abdul Wahab.

The Apollo compilation platform [4] that is being developed in Camus, dedicated to speculative and dynamic optimization and parallelization of loop nests, is the achievement of many original advances in compilation algorithms, in extensions of the polyhedral model, in speculative parallelization and in dynamic optimization of programs. It is a library of implemented knowledge and a fertile ground for other advances and extensions : for instance, an extension of the polyhedral model for handling non-linear loops would not have been possible without Apollo. However, this software platform must continuously be maintained, improved and extended.

The ALTO project, which is a 2.5 years project started in August 2018, is devoted to strengthen Apollo's software implementation in several ways, thanks to the expert engineer who has been recruited for these goals, Matthew Wahab. The main goals are the following:

- making the programming code respecting the standard rules of open-source software;
- making Apollo more robust regarding cases where some inputs may yield extreme behaviors
- implementing required improvements and extensions, as inter-procedural analysis or memory behavior memoïzation.

9.2. National Initiatives

9.2.1. ANR AJACS

Participant: Arthur Charguéraud.

The AJACS research project is funded by the programme "Société de l'information et de la communication" of the ANR, from October 2014, until March 2019. http://ajacs.inria.fr/

The goal of the AJACS project is to provide strong security and privacy guarantees on the client side for web application scripts implemented in JavaScript, the most widely used language for the Web. The proposal is to prove correct analyses for JavaScript programs, in particular information flow analyses that guarantee no secret information is leaked to malicious parties. The definition of sub-languages of JavaScript, with certified compilation techniques targeting them, will allow deriving more precise analyses. Another aspect of the proposal is the design and certification of security and privacy enforcement mechanisms for web applications, including the APIs used to program real-world applications. Arthur Charguéraud focuses on the description of a formal semantics for JavaScript, and the development of tools for interactively executing programs step-by-step according to the formal semantics.

Partners: team Celtique (Inria Rennes - Bretagne Atlantique), team Prosecco (Inria Paris), team Indes (Inria Sophia Antipolis - Méditerranée), and Imperial College (London).

9.2.2. ANR Vocal

Participant: Arthur Charguéraud.

The Vocal research project is funded by the programme "Société de l'information et de la communication" of the ANR, for a period of 48 months, starting on October 1st, 2015. https://vocal.lri.fr/

The goal of the Vocal project is to develop the first formally verified library of efficient general-purpose data structures and algorithms. It targets the OCaml programming language, which allows for fairly efficient code and offers a simple programming model that eases reasoning about programs. The library will be readily available to implementers of safety-critical OCaml programs, such as Coq, Astrée, or Frama-C. It will provide the essential building blocks needed to significantly decrease the cost of developing safe software. The project intends to combine the strengths of three verification tools, namely Coq, Why3, and CFML. It will use Coq to obtain a common mathematical foundation for program specifications, as well as to verify purely functional components. It will use Why3 to verify a broad range of imperative programs with a high degree of proof automation. Finally, it will use CFML for formal reasoning about effectful higher-order functions and data structures making use of pointers and sharing.

Partners: team Gallium (Inria Paris), team DCS (Verimag), TrustInSoft, and OCamlPro.

9.3. European Initiatives

9.3.1. FP7 & H2020 Projects

9.3.1.1. ERC Deepsea

Participant: Arthur Charguéraud.

The Deepsea project is funded by ERC from June 2013 to May 2018. It aims at developing abstractions, algorithms and languages for parallelism and dynamic parallelism with applications to problems on large data sets. Umut A. Acar (affiliated to Carnegie Mellon University and Inria Paris) is the principal investigator of this ERC-funded project. The other main researchers involved are Mike Rainey (Inria, Gallium team), who is full-time on the project, and Arthur Charguéraud (Inria, Camus team), who works part time on this project. Project website: http://deepsea.inria.fr/.

9.3.2. Collaborations with Major European Organizations

Cristian Ramon-Cortes and Rosa M. Badia: Barcelona Supercomputing Center (Spain)
A Python module for automatic parallelization and distributed execution of affine loop nests

Raquel Lazcano and Eduardo Juárez Martínez: Universidad Politecnica de Madrid (Spain)
Integration of Apollo in the Cerbero dataflow framework for adaptive code generation.

9.4. International Initiatives

9.4.1. Inria International Partners

9.4.1.1. Informal International Partners

The CAMUS team maintains regular contacts with the following entities:

- Reservoir Labs, New York, NY, USA
- University of Batna, Algeria
- Ohio State University, Colombus, USA
- Louisiana State University, Baton Rouge, USA
- Colorado State University, Fort Collins, USA
- Indian Institute of Science (IIIS) Bangalore, India
- Barcelona Supercomputing Center, Barcelona, Spain

9.5. International Research Visitors

9.5.1. Visits of International Scientists

Rachid Seghir (Maître de conférences A, University of Batna, Algeria) visited our team (June 16-23, 2018), to participate to the mid-thesis evaluation of Harenome Ranaivoarivony-Razanajato, and work with Vincent Loechner on our ongoing collaboration co-advising Toufik Baroudi.

9.5.2. Internships

Toufik Baroudi is a PhD student under the supervision of Rachid Seghir at University of Batna (Algeria). He is co-advised by Vincent Loechner, and visiting our team as an intern for one year since November 2018, founded by the Algerian *Programme National Exceptionnel (PNE)*. His PhD defense is planned at the end of 2019.

CARAMBA Project-Team

9. Partnerships and Cooperations

9.1. Regional Initiatives

9.1.1. CPER CyberEntreprises

Program: CPER (Contrat de Plan État Région)

Project title: Cyber-Entreprises

Duration: 01/07/2015 - 31/12/2020

Coordinator: Emmanuel Thomé and Marc Jungers (CRAN)

Other partners: Inria, LORIA, CRAN, IECL, Centrale Supelec, LCFC.

Abstract: cf web site (in French only).

A high-performance computer cluster was funded by the CPER Cyber-entreprises project (Région Grand-Est, French Ministry of Research and Higher Education, Inria, CNRS). This cluster is also mentioned in 6.4 .

9.2. National Initiatives

9.2.1. FUI Industrial Partnership on Lightweight Cryptography

Program: FUI (Fonds Unique Interministériel)

Project acronym: PACLIDO

Project title: Protocoles et Algorithmes Cryptographiques Légers pour l'Internet Des Objets

Duration: 12/2017 - 12/2020

Coordinator: Airbus Cybersecurity.

Other partners: organisme, labo (pays) Airbus Cybersecurity, LORIA-CNRS, Rtone, Trusted Objects, CEA, Sophia Engineering, Université de Limoges, Saint-Quentin-en-Yvelines.

This contract is dedicated to the definition of new lightweight cryptographic primitives for the IoT. See web site for a full presentation.

CASCADE Project-Team

7. Partnerships and Cooperations

7.1. National Initiatives with Industry

7.1.1. CryptoComp

Program: FUI

Duration: October 2014 – November 2018

Coordinator: CryptoExperts

Partners: CEA, CNRS, Kalray, Inria, Dictao, Université de Limoges, VIACESS, Bertin technologies, GEMALTO

Local coordinator: David Pointcheval

We aim at studying delegation of computations to the cloud, in a secure way.

7.1.2. ANBLIC

Title: Analysis in Blind Clouds

Program: FUI

Duration: January 2018 – December 2020

Coordinator: Wallix

Partners: UPEC, CEA, Ingenico, Atos, SOGETI, CoeSSI

Local coordinator: David Pointcheval

The main goal is to industrialize for the first time several privacy enhancing technologies that are on the edge of theory and practice.

Fully Homomorphic Encryption let cloud providers compute arbitrary functions on their client's encrypted data, ensuring at the same time full privacy and functionality. Functional Encryption is a refinement of classical encryption, which allows data owners to delegate fine-grained access to their data. Thus it is possible to enable the computation of aggregated statistics over your personal data, while cryptographically ensuring its confidentiality.

However both these technologies still suffer from prohibitive inefficiencies for business applications. ANBLIC's academic partners will create new cryptographic schemes and performance models, tailored for industrial use cases, and create the first real-life scenario of encrypted queries on encrypted data and on open data.

7.1.3. RISQ

Program: GDN

Duration: February 2017 – September 2020

Coordinator: Secure-IC

Partners: ANSSI, AIRBUS, C-S, CEA LIST, CryptoExperts, Inria/ENS/CASCADE, GEMALTO, Inria POLSYS, Inria AriC, IRISA, Orange Labs, THALES, UVSQ, PCQC

Local coordinator: Michel Abdalla

The main goal of RISQ is to help the French Industry and Academia become a significant international player in the transition to post-quantum cryptography.

7.2. National Collaborations with Academics

7.2.1. EnBiD

Title: Encryption for Big Data

Program: ANR JCJC

Duration: October 2014 – September 2019

PI: Hoeteck Wee

Partners: Université Paris 2, Université Limoges

The main objective of this project is to study techniques for efficient and expressive functional encryption schemes. Functional encryption is a novel paradigm for public-key encryption that enables both fine-grained access control and selective computation on encrypted data, as is necessary to protect big, complex data in the cloud.

7.2.2. EfTrEC

Title: Efficient Transferable E-Cash

Program: ANR JCJC

Duration: October 2016 – September 2020

PI: Georg Fuchsbauer

Partners: Université Paris 2

This project deals with e-cash systems which let users transfer electronic coins between them offline. The main objectives of this project are:

- establish a clean formal model for the primitive;
- construct schemes which are practically efficient;
- develop schemes that are resistant to attacks on quantum computers.

7.2.3. ALAMBIC

Title: AppLicAtions of MalleaBIlity in Cryptography

Program: ANR PRC

Duration: October 2016 – September 2020

PI: Damien Vergnaud

Partners: ENS Lyon, Université Limoges

The main objectives of the proposal are the following:

- Define theoretical models for "malleable" cryptographic primitives that capture strong practical attacks (in particular, in the settings of secure computation outsourcing, server-aided cryptography, cloud computing and cryptographic proof systems);
- Analyze the security and efficiency of primitives and constructions that rely on malleability;
- Conceive novel cryptographic primitives and constructions (for secure computation outsourcing, server-aided cryptography, multi-party computation, homomorphic encryption and their applications);
- Implement these new constructions in order to validate their efficiency and effective security.

7.3. European Initiatives

7.3.1. CryptoAction

Title: Cryptography for Secure Digital Interaction

Program: H2020 ICT COST

Duration: April 2014 – April 2018

Local coordinator: Michel Abdalla

The aim of this COST CryptoAction is to stimulate interaction between the different national efforts in order to develop new cryptographic solutions and to evaluate the security of deployed algorithms with applications to the secure digital interactions between citizens, companies and governments.

7.3.2. CryptoCloud

Title: Cryptography for the Cloud

Program: FP7 ERC Advanced Grant

Duration: June 2014 – May 2020

PI: David Pointcheval

The goal of the CryptoCloud project is to develop new interactive tools to provide privacy in the Cloud.

7.3.3. SAFEcrypto

Title: Secure Architectures of Future Emerging Cryptography

Program: H2020

Duration: January 2015 – January 2019

Coordinator: The Queen's University of Belfast

Partners: Inria/ENS (France), Emc Information Systems International (Ireland), Hw Communications (United Kingdom), The Queen's University of Belfast (United Kingdom), Ruhr-Universitaet Bochum (Germany), Thales Uk (United Kingdom), Universita della Svizzera italiana (Switzerland), IBM Research Zurich (Switzerland)

Local coordinator: Michel Abdalla

SAFEcrypto will provide a new generation of practical, robust and physically secure post quantum cryptographic solutions that ensure long-term security for future ICT systems, services and applications. Novel public-key cryptographic schemes (digital signatures, authentication, public-key encryption, identity-based encryption) will be developed using lattice problems as the source of computational hardness. The project will involve algorithmic and design optimisations, and implementations of the lattice-based cryptographic schemes addressing the cost, energy consumption, performance and physical robustness needs of resource-constrained applications, such as mobile, battery-operated devices, and of real-time applications such as network security, satellite communications and cloud. Currently a significant threat to cryptographic applications is that the devices on which they are implemented leak information, which can be used to mount attacks to recover secret information. In SAFEcrypto the first analysis and development of physical-attack resistant methodologies for lattice-based cryptographic implementations will be undertaken. Effective models for the management, storage and distribution of the keys utilised in the proposed schemes (key sizes may be in the order of kilobytes or megabytes) will also be provided. This project will deliver proof-of-concept demonstrators of the novel lattice-based public-key cryptographic schemes for three practical real-word case studies with real-time performance and low power consumption requirements. In comparison to current state-of-the-art implementations of conventional public-key cryptosystems (RSA and Elliptic Curve Cryptography (ECC)), SAFEcrypto's objective is to achieve a range of lattice-based architectures that provide comparable area costs, a 10-fold speed-up in throughput for real-time application scenarios, and a 5-fold reduction in energy consumption for low-power and embedded and mobile applications.

7.3.4. ECRYPT-NET

Title: Advanced Cryptographic Technologies for the Internet of Things and the Cloud

Program: H2020 ITN

Duration: March 2015 – February 2019

Coordinator: KU Leuven (Belgium)

Partners: KU Leuven (Belgium), Inria/ENS (France), Ruhr-Universität Bochum (Germany), Royal Holloway, University of London (UK), University of Bristol (UK), CryptoExperts (France), NXP Semiconductors (Belgium), Technische Universiteit Eindhoven (the Netherlands)

Local coordinator: Michel Abdalla

ECRYPT-NET is a research network of six universities and two companies, as well as 7 associated companies, that intends to develop advanced cryptographic techniques for the Internet of Things and the Cloud and to create efficient and secure implementations of those techniques on a broad range of platforms.

7.3.5. aSCEND

Title: Secure Computation on Encrypted Data

Program: H2020 ERC Starting Grant

Duration: June 2015 – May 2020

PI: Hoeteck Wee

The goals of the aSCEND project are (i) to design pairing- and lattice-based functional encryption that are more efficient and ultimately viable in practice; and (ii) to obtain a richer understanding of expressive functional encryption schemes and to push the boundaries from encrypting data to encrypting software.

7.3.6. FENTEC

Title: Functional Encryption Technologies

Program: H2020

Duration: January 2018 – December 2020

Coordinator: ATOS Spain SA

Scientific coordinator: Michel Abdalla

Partners: Inria/ENS (France), Flensburg University (Germany), KU Leuven (Belgium), University of Helsinki (Finland), Nagra (Switzerland), XLAB (Switzerland), University of Edinburgh (United Kingdom), WALLIX (France)

Local coordinator: Michel Abdalla

Functional encryption (FE) has recently been introduced as a new paradigm of encryption systems to overcome all-or-nothing limitations of classical encryption. In an FE system the decryptor deciphers a function over the message plaintext: such functional decryptability makes it feasible to process encrypted data (e.g. on the Internet) and obtain a partial view of the message plaintext. This extra flexibility over classical encryption is a powerful enabler for many emerging security technologies (i.e. controlled access, searching and computing on encrypted data, program obfuscation...). FENTEC's mission is to make the functional encryption paradigm ready for wide-range applications, integrating it in ICT technologies as naturally as classical encryption. The primary objective is the efficient and application-oriented development of functional encryption systems. FENTEC's team of cryptographers, software and hardware experts and information technology industry partners will document functional encryption needs of specific applications and subsequently design, develop, implement and demonstrate applied use of functional cryptography. Ultimately, a functional encryption library for both SW and HW-oriented application will be documented and made public so that it may be used by European ICT entities. With it, the FENTEC team will build emerging security technologies that increase the trustworthiness of the European ICT services and products. Concretely, the FENTEC team will showcase the expressiveness and versatility of the functional encryption paradigm in 3 use cases:

- Privacy-preserving digital currency, enforcing flexible auditing models
- Anonymous data analytics enabling computation of statistics over encrypted data, protecting European Fundamental Rights of Data Protection and Privacy
- Key and content distribution with improved performance & efficiency as foundational technology for establishing secure communication among a vast number of IOT devices.

7.4. International Initiatives with Industry

7.4.1. CryptBloC

Title: Cryptography for the Blockchain

Partners: MSR Redmond (USA), MSR Cambridge (UK), Inria

Duration: October 2017 – October 2021

PI: Georg Fuchsbauer

The goal of this Microsoft-Inria joint project on privacy and decentralization is to use cryptography to improve privacy on the blockchain and decentralized systems more generally. We will investigate means of privacy-preserving authentication, such as electronic currencies, and other applications of blockchain and distributed transparency mechanisms.

7.5. International Research Visitors

- Yuval Ishai (Technion)
- Dan Boneh (Stanford)
- Katsuyuki Takashima (Mitsubishi and Kyushu University)
- Tal Malkin (Columbia)
- Adam O'Neill (Georgetown University)
- Julian Loss (Ruhr Universität Bochum)

CASH Team

8. Partnerships and Cooperations

8.1. National Initiatives

8.1.1. ANR

- Matthieu Moy submitted an ANR project as scientific coordinator entitled "Distributed Efficient Architecture for the Rapid (Co)simulation of Multiphysics Objects" (48 months, partners Verimag, TIMA and LIP6).
- Laure Gonnord's "Jeune Chercheur" ANR, CODAS, has started in January 2018 (42 months).

8.1.2. Scientific Advising

- Christophe Alias is scientific advisor (concours scientifique, 20%) for the XTREMLOGIC start-up.

8.2. International Initiatives

8.2.1. Informal International Partners

- Christophe Alias has regular collaborations with Sanjay Rajopadhye from Colorado State University, USA (3 publications, one publication submitted 7.1).
- Ludovic Henrio has regular collaborations with university of Linköping (one publication last year, 2 submissions); University of Oslo, University of Uppsala, and TU Darmstadt on active objects (2 publications being written); Chalmers university and Univ of Twente (one publication submitted).
- Laure Gonnord has regular collaborations with Fernando Pereira from UFMG, Brasil (5 publications in total, last in 2017). In 2018 she has began a collaboration with Tobias Grösser, from ETH Zurich.

CELTIQUE Project-Team

6. Partnerships and Cooperations

6.1. National Initiatives

6.1.1. The ANR AnaStaSec project

Participants: Frédéric Besson, Sandrine Blazy, Thomas Jensen, Alexandre Dang, Julien Lepiller.

Static program analysis, Security, Secure compilation

The AnaStaSec project (2015–2018) aims at ensuring security properties of embedded critical systems using static analysis and security enhancing compiler techniques. The case studies are airborne embedded software with ground communication capabilities. The Celtique project focuses on software fault isolation which is a compiler technology to ensure by construction a strong segregation of tasks.

This is a joint project with the Inria teams ANTIQUE and PROSECCO, CEA-LIST, TrustInSoft, AMOSSYS and Airbus Group.

6.1.2. The ANR MALTHY project

Participant: David Cachera.

The MALTHY project, funded by ANR in the program INS 2013, aims at advancing the state-of-the-art in real-time and hybrid model checking by applying advanced methods and tools from linear algebra and algebraic geometry. MALTHY is coordinated by VERIMAG, involving CEA-LIST, Inria Rennes (Tamis and Celtique), Inria Saclay (MAXPLUS) and VISEO/Object Direct.

6.1.3. The ANR AJACS project

Participants: Gurvan Cabon, Thomas Jensen, Alan Schmitt.

The goal of the AJACS project is to provide strong security and privacy guarantees on the client side for web application scripts. To this end, we propose to define a mechanized semantics of the full JavaScript language, the most widely used language for the Web. We then propose to develop and prove correct analyses for JavaScript programs, in particular information flow analyses that guarantee no secret information is leaked to malicious parties. The definition of sub-languages of JavaScript, with certified compilation techniques targeting them, will allow us to derive more precise analyses. Finally, we propose to design and certify security and privacy enforcement mechanisms for web applications, including the APIs used to program real-world applications.

The project partners include the following Inria teams: Celtique, Indes, Prosecco, and Toccata; it also involves researchers from Imperial College as external collaborators. The project runs from December 2014 to March 2019.

6.1.4. The ANR DISCOVER project

Participants: Sandrine Blazy, David Cachera, Delphine Demange, Thomas Jensen, David Pichardie, Yon Fernandez de Retana, Yannick Zakowski.

The DISCOVER project project (2014–09/2019) aims at leveraging recent foundational work on formal verification and proof assistants to design, implement and verify compilation techniques used for high-level concurrent and managed programming languages. The ultimate goal of DISCOVER is to devise new formalisms and proof techniques able to scale to the mechanized correctness proof of a compiler involving a rich class of optimizations, leading to efficient and scalable applications, written in higher-level languages than those currently handled by cutting-edge verified compilers.

In the light of recent work in optimizations techniques used in production compilers of high-level languages, control-flow-graph based intermediate representations seems too rigid. Indeed, the analyses and optimizations in these compilers work on more abstract representations, where programs are represented with data and control dependencies. The most representative representation is the sea-of-nodes form, used in the Java Hotspot Server Compiler, and which is the rationale behind the highly relaxed definition of the Java memory model. DISCOVER proposes to tackle the problem of verified compilation for shared-memory concurrency with a resolute language-based approach, and to investigate the formalization of adequate program intermediate representations and associated correctness proof techniques.

The project runs from October 2014 to September 2019.

6.1.5. The ANR CISC project

Participants: Frédéric Besson, Thomas Jensen, Alan Schmitt.

The goal of the CISC project is to investigate multitier languages and compilers to build secure IoT applications with private communication. In particular, we aim at extending multitier platforms by a new orchestration language that we call Hiphop.js to synchronize internal and external activities of IoT applications as a whole. Our goal is to define language, semantics, attacker models, and policies for the IoT and investigate automatic implementation of privacy and security policies by multitier compilation of IoT applications. To guarantee such applications are correct, and in particular that the required security and privacy properties are achieved, we propose to certify them using the Coq proof assistant. We plan to implement the CISC results as extensions of the multitier language Hop.js (developed at Inria), based on the JavaScript language to maximize its impact. Using the new platform, we will carry out experimental studies on IoT security.

The project partners include the following Inria teams: Celtique, Collège de France, Indes, and Privatics. The project runs from April 2018 to March 2022.

6.2. European Initiatives

6.2.1. FP7 & H2020 Projects

6.2.1.1. The ERC VESTA project

Participants: David Pichardie, Sandrine Blazy, Nicolas Barré, Stefania Dumbrava, Jean-Christophe Léchenet, Rémi Hutin.

The VESTA project aims at proposing guidance and tool-support to the designers of static analysis, in order to build advanced but reliable static analysis tools. We focus on analyzing low-level softwares written in C, leveraging on the CompCert verified compiler. Verasco is a verified static analyser that analyses C programs and follows many of the advanced abstract interpretation technique developped for Astrée. The outcome of the VESTA project will be a platform that help designing other verified advanced abstract interpreters like Verasco, without starting from a white page. We will apply this technique to develop security analyses for C programs. The platform will be open-source and will help the adoption of abstract interpretation techniques.

This a consolidator ERC awarded to David Pichardie for 5 year. The project started in september 2018.

6.2.2. Collaborations in European Programs, Except FP7 & H2020

Program:CA COST Action CA15123

Project acronym: EUTYPES

Project title: European research network on types for programming and verification

Duration: 03/2016 to 03/2020

Coordinator: Herman Geuvers (Radboud University Nijmegen, The Netherlands)

Other partners: Austria, Belgium, Czech Republic, Denmark, Estonia, Finland, France, Macedonia, Germany, Hungary, Israel, Italy, Lithuania, Netherlands, Norway, Poland, Portugal, Romania, Serbia, Slovenia, Spain, Sweden, United Kingdom

Abstract: Types are pervasive in programming and information technology. A type defines a formal interface between software components, allowing the automatic verification of their connections, and greatly enhancing the robustness and reliability of computations and communications. In rich dependent type theories, the full functional specification of a program can be expressed as a type. Type systems have rapidly evolved over the past years, becoming more sophisticated, capturing new aspects of the behaviour of programs and the dynamics of their execution.

This COST Action will give a strong impetus to research on type theory and its many applications in computer science, by promoting (1) the synergy between theoretical computer scientists, logicians and mathematicians to develop new foundations for type theory, for example as based on the recent development of "homotopy type theory", (2) the joint development of type theoretic tools as proof assistants and integrated programming environments, (3) the study of dependent types for programming and its deployment in software development, (4) the study of dependent types for verification and its deployment in software analysis and verification. The action will also tie together these different areas and promote cross-fertilisation.

Sandrine Blazy is Substitute Member of the Managment Committee for France.

6.3. International Initiatives

6.3.1. Inria International Partners

6.3.1.1. Declared Inria International Partners

WEBCERT

Title: Verified Trustworthy web Applications

International Partner (Institution - Laboratory - Researcher):

Imperial College London - Department of Computing - Philippa Gardner

Duration: 2015 - 2019

Start year: 2015

See also: JSCert web page

The WebCert partnership focuses on applying formal methods to the JavaScript language: mechanized specification, development of an executable formal specification, design of a program logic, development of verification tools, and study of secure sub-languages.

CIDRE Project-Team

8. Partnerships and Cooperations

8.1. Regional Initiatives

- **Region Bretagne ARED Grant :** the PhD of Mourad Leslous on malicious codes in Android applications is supported by a grant from the Région Bretagne.
- **Labex COMINLABS contract (2014-2018): "Kharon-Security" - http://kharon.gforge.inria.fr**

  Google Play offers more than 800'000 applications (apps), and this number increases every day. Google play users have performed more than 25 billion app downloads. These applications vary from games to music, video, books, tools, etc. Unfortunately, each of these application is an attack vector on Android. The number of malicious applications (pieces of malware) discovered during the first six months of 2013 exceeds the number of pieces of malware discovered during the 2010 to 2012 period, more than 700 thousand malicious and risky applications were found in the wild. In this context, we propose the Kharon-Security project to stem the progression of Android pieces of malware. We propose to combine static and dynamic monitoring to compute a behavioral signature of Android malware. Behavioral signatures are helpful to understand how malware infect the devices and how they spread information in the Android operating system. Static analysis is essential to understand which particular event or callback triggers malware payload.

  In the project we have already developed GroddDroid a tool dedicated to automatic identification and execution of suspicious code. We have also built a dataset of Android malware. In this dataset, all malware are entirely manually reverse and documented. We have also developed an analysis platform. This platform is been deployed at the High Research Laboratory.
- **Labex COMINLABS contract (2015-2018): "HardBlare-Security" - https://hardblare.cominlabs.u-bretagneloire.fr/**

  The general context of the HardBlare project is to address Dynamic Information Flow Tracking (DIFT) that generally consists in attaching marks to denote the type of information that is saved or generated within the system. These marks are then propagated when the system evolves and information flow control is performed in order to guarantee a safe execution and storage within the system. Existing solutions imply a large overhead induced by the monitoring process. Some attempts rely on a hardware-software approach where DIFT operations are delegated to a coprocessor. Nevertheless, such approaches are based on modified processors. Beyond the fact hardware-assisted DIFT is hardly adopted, existing works do not take care of coprocessor security and multicore/multiprocessor embedded systems.

  We plan to implement DIFT mechanisms on boards including a non-modified ARM processor and a FPGA such as those based on the Xilinx Zynq family. The HardBlare project is a multidisciplinary project between CentraleSupélec IETR SCEE research team, CentraleSupélec Inria CIDRE research team and UBS Lab-STICC laboratory. Mounir Nasr Allah is doing his PhD in the context of this project. The main objective of this PhD is to study how hybrid analysis could improve hardware assisted DIFT using static analysis performed at compile-time. Another objective is to manage labels for persistent memory (i.e., files) using a modified OS kernel.
- **Labex COMINLABS contract (2016-2019): "BigClin" - https://bigclin.cominlabs.u-bretagneloire.fr/fr**

  Health Big Data (HBD) is more than just a very large amount of data or a large number of data sources. The data collected or produced during the clinical care process can be exploited at different levels and across different domains, especially concerning questions related to clinical and

translational research. To leverage these big, heterogeneous, sensitive and multi-domain clinical data, new infrastructures are arising in most of the academic hospitals, which are intended to integrate, reuse and share data for research.

Yet, a well-known challenge for secondary use of HBD is that much of detailed patient information is embedded in narrative text, mostly stored as unstructured data. The lack of efficient Natural Language Processing (NLP) resources dedicated to clinical narratives, especially for French, leads to the development of ad-hoc NLP tools with limited targeted purposes. Moreover, the scalability and real-time issues are rarely taken into account for these possibly costly NLP tools, which make them inappropriate in real-world scenarios. Some other today's challenges when reusing Health data are still not resolved: data quality assessment for research purposes, scalability issues when integrating heterogeneous HBD or patient data privacy and data protection. These barriers are completely interwoven with unstructured data reuse and thus constitute an overall issue which must be addressed globally.

In this project, we plan to develop distributed methods to ensure both the scalability and the online processing of these NLP/IR and data mining techniques; In a second step, we will evaluate the added value of these methods in several real clinical data and on real use-cases, including epidemilology and pharmaco-vigilance, clinical practice assessment and health care quality research, clinical trials.

8.2. National Initiatives

8.2.1. ANR

- **ANR Project: PAMELA (2016-2020) - https://project.inria.fr/pamela/**

  PAMELA is a collaborative ANR project involving Rennes 1 university (ASAP and CIDRE teams in Rennes), Inria Lille (MAGNET team), LIP6 (MLIA team) and two start-ups, Mediego and Snips. It aims at developing machine learning theories and algorithms in order to learn local and personalized models from data distributed over networked infrastructures. The project seeks to provide first answers to modern information systems built by interconnecting many personal devices holding private user data in the search of personalized suggestions and recommendations. More precisely, we will focus on learning in a collaborative way with the help of neighbors in a network. We aim to lay the first blocks of a scientific foundation for these new types of systems, in effect moving from graphs of data to graphs of data and learned models. CIDRE's contribution in this project involves the design of adversary models and privacy metrics suitable to the privacy-related issues of this distributed learning paradigm.

8.3. International Research Visitors

8.3.1. Visits of International Scientists

Carlos Maziero, Professor at the Federal University of Parana (Curitiba, Brazil) has visited our team from January 2018 till December 2018. During his stay, he has worked on models of normal behaviours in distributed applications.

8.3.1.1. Research Stays Abroad

Mourad Leslous did an international mobility of three months in the team of Lorenzo Cavallaro in the Information Security Group (ISG) at Royal Holloway, University of London. This mobility was part of the program of EIT Digital Doctoral School, a European institute that promotes entrepreneurship and innovation among PhD students. During this mobility, he worked on control flow and data flow dependencies in order to detect the malicious code inside Android applications.

COMETE Project-Team

7. Partnerships and Cooperations

7.1. Regional Initiatives

7.1.1. OPTIMEC

Project title: Optimal Mechanisms for Privacy Protection

Funded by: DigiCosme

Duration: September 2016 - July 2018

Coordinator: Catuscia Palamidessi, Inria Saclay, EPI Comète

Other PI's: Serge Haddad, ENS Cachan.

Abstract: In this project we investigate classes of utility and privacy measures, and we devise methods to obtain optimal mechanisms with respect to the trade-off between utility and privacy. In order to represent the probabilistic knowledge of the adversary and of the user, and the fact that mechanisms themselves can be randomized, we consider a probabilistic setting. We focus, in particular, on measures that are expressible as linear functions of the probabilities.

7.1.2. SUPREME

Project title: Statistical-Utility Preserving Methods for Privacy Protection

Funded by: Département STIC

Duration: 2018 - 2019

Coordinator: Catuscia Palamidessi, Inria Saclay, EPI Comète

Other PI's: Serge Haddad, ENS Cachan.

Abstract: In this project we study the theoretical foundations, methods and tools to protect the privacy of the individuals under certain constraints. In particular we focus on mechanisms that: (1) are robust with respect to combination of information from different sources, (2) can be applied directly by the user, thus avoiding the need of a trusted party, and (3) provide an optimal trade-off between privacy and utility.

7.2. National Initiatives

7.2.1. REPAS

Program: ANR Blanc

Project title: Reliable and Privacy-Aware Software Systems via Bisimulation Metrics

Duration: October 2016 - September 2021

Coordinator: Catuscia Palamidessi, Inria Saclay, EPI Comète

Other PI's and partner institutions: Ugo del Lago, Inria Sophia Antipolis (EPI Focus) and University of Bologna (Italy). Vincent Danos, ENS Paris. Filippo Bonchi, ENS Lyon.

Abstract: In this project we investigate quantitative notions and tools for proving program correctness and protecting privacy. In particular, we focus on bisimulation metrics, which are the natural extension of bisimulation on quantitative systems. As a key application, we will develop a mechanism to protect the privacy of users when their location traces are collected.

7.2.2. MAGIC

Program: PEPS I3A

Project title: Machine Games for Information Protection

Duration: February 2018 - December 2018

Coordinator: Konstantinos Chatzikokolakis, CNRS (EPI Comète) and Ecole Polytechnique

Other PI's and partner institutions: Giovanni Cherubin, EPFL, Switzerland. Serge Haddad, ENS Cachan.

Abstract: In this project, we study a Machine Learning approach to develop methods for the Protection of Private Information. The idea is based on the Generative Adversarial Network (GAN) paradigm: the defender and the attacker are modeled as two adversaries in a game, where the payoff is the attacker's acquisition of the user's private data by exploiting the system vulnerabilities, side information, and probabilistic inference.

7.3. International Initiatives

7.3.1. Inria Associate Teams

7.3.1.1. LOGIS

Title: Logical and Formal Methods for Information Security

Inria principal investigator: Konstantinos Chatzikokolakis

International Partners:

Mitsuhiro Okada, Keio University (Japan)

Yusuke Kawamoto, AIST (Japan)

Tachio Terauchi, JAIST (Japan)

Masami Hagiya, University of Tokyo (Japan)

Start year: January 2016 - December 2018

URL: http://www.lix.polytechnique.fr/~kostas/projects/logis/

Abstract: The project aims at integrating the logical / formal approaches to verify security protocols with (A) complexity theory and (B) information theory. The first direction aims at establishing the foundations of logical verification for security in the computational sense, with the ultimate goal of automatically finding attacks that probabilistic polynomial-time adversaries can carry out on protocols. The second direction aims at developing frameworks and techniques for evaluating and reducing information leakage caused by adaptive attackers.

7.3.2. Participation in International Programs

7.3.2.1. CLASSIC

Program: Colciencias - Conv. 712.

Project acronym: CLASSIC.

Project title: Concurrency, Logic and Algebra for Social and Spatial Interactive Computation.

Duration: Oct 2016 - Oct 2019.

URL: http://goo.gl/Gv6Lij

Coordinator: Camilo Rueda, Universidad Javeriana de Cali, Colombia.

Other PI's and partner institutions: Carlos Olarte, Universidade Federal do Rio Grande do Norte, Brazil and Frank Valencia, CNRS-LIX and Inria Saclay.

Abstract: This project will advance the state of the art of domains such as mathematical logic, order theory and concurrency for reasoning about spatial and epistemic behaviour in multi-agent systems..

7.3.2.2. EPIC

Program: STIC-Amsud.

Project acronym: EPIC.

Project title: EPistemic Interactive Concurrency/

Duration: Oct 2016 - Oct 2018.

URL: https://sites.google.com/site/sticamsudepic/

Coordinator: Frank Valencia, CNRS-LIX and Inria Saclay.

Other PI's and partner institutions: Carlos Olarte, Universidade Federal do Rio Grande do Norte, Brazil and Camilo Rueda, Universidad Javeriana de Cali, Colombia.

Abstract: The aim of the project is to coherently combine and advance the state of the art of domains such as concurrency theory, information theory and rewriting systems for reasoning about social networks.

7.3.2.3. FACTS

Program: ECOS NORD.

Project acronym: FACTS.

Project title: Foundational Approach to Cognition in Today?s Society.

Duration: Jan 1 2019 - Dec 31, 2021.

URL: https://goo.gl/zVhg32

Coordinator: Frank Valencia, Ecole Polytechnique.

Other PI's and partner institutions: Jean-Gabriel Ganascia LIP6, Sorbonne University and Camilo Rueda, Universidad Javeriana de Cali, Colombia.

Abstract: This projects aims at studying the phenomenon of "Group Polarization"; the tendency for a group to learn or acquire beliefs or to make decisions that are more extreme than the initial inclinations of its members.

7.3.3. Inria International Partners

7.3.3.1. PriDat

Project title: Privacy-Friendly Data Analytics

Funded by: Siebel Energy Institute

Duration: September 2018 - August 2019

Coordinator: Catuscia Palamidessi, Inria Saclay, EPI Comète

Other PI's: Giovanni Cherubin, EPFL, Switzerland. Moreno Falaschi, University of Siena, Italy. Mario Ferreira, Federal University of Minas Gerais, Brazil.

Abstract: The objective of this project is to develop methodologies for protecting the privacy of individuals while letting their data be collected and used for analytical purposes.

7.3.3.2. Informal International Partners

Geoffrey Smith, Florida International University, USA

Carroll Morgan, NICTA , Australia

Annabelle McIver, Maquarie University, Australia

Mario Ferreira Alvim Junior, Assistant Professor, Federal University of Minas Gerais, Brazil

Camilo Rueda, Professor, Universidad Javeriana de Cali, Colombia

Carlos Olarte, Universidade Federal do Rio Grande do Norte, Brazil

Camilo Rocha, Associate Professor, Universidad Javeriana de Cali, Colombia

7.4. International Research Visitors

7.4.1. Visits of International Scientists

Mario Ferreira Alvim Junior, Assistant Professor, Federal University of Minas Gerais, Brazil. Dec 2018

Borja de Balle Pigem. Sr. Machine Learning Scientist. Amazon, UK. Dec 2018

Takao Murakami, Assistant Professor, National Institute of Advanced Industrial Science and Technology (AIST), Japan. Dec 2018

Yusuke Kawamoto, Assistant Professor, National Institute of Advanced Industrial Science and Technology (AIST), Japan. March 2018 and Nov-Dec 2018

Carlos Olarte, Assistant Professor, Universidade Federal do Rio Grande do Norte, Brazil. Oct-Dec 2018

Daniele Gorla, Professor, University of Rome “La Sapienza”. Aug - Sep 2018.

Giovanna Broccia, PhD student, University of Pisa, Italy, June 2018

Camilo Rueda, Professor, Universidad Javeriana de Cali, Colombia. May 2018 and Nov 2018

Prakash Panangaden, University of McGill, Montreal, Canada. Feb 2018

7.4.2. Internships

Haoteng Yin. Academy for Advanced Interdisceplinary Studies, Peking University. From June 2018 until Sept 2018.

Kacem Kefki. University of Paris Saclay. From June 2018 until July 2018.

Arthur Américo. Universidade Federal de Minas Gerais. From April 2018 until June 2018.

Noémie Fong. ENS Paris. From April 2018 until Sept 2019.

Pedro Bahamondes. Ecole Polytechnique. From Sept 2017 until March 2018.

Joaquin Felici. Univ. of Cordoba. From Sept 2017 until Jan 2018.

Jason Lopez, Universidad Javeriana de Cali, Colombia. From May until Agost 2018.

CONVECS Project-Team

8. Partnerships and Cooperations

8.1. Regional Initiatives

8.1.1. ARC6 Programme

Participants: Lina Marsso, Radu Mateescu [correspondent], Wendelin Serwe.

ARC6 is an academic research community funded by the Auvergne Rhône-Alpes region, whose objective is to foster the scientific collaborations between different academic institutions of the region working in the domain of information and communication technologies. ARC6 organizes various scientific animations (conferences, working groups, summer schools, etc.) and issues a yearly call for PhD and post-doctorate research project proposals.

Lina Marsso is supported by an ARC6 grant (from October 2016 to October 2019) on formal methods for testing networks of programmable logic controllers, under the supervision of Radu Mateescu and Wendelin Serwe (CONVECS), Ioannis Parissis and Christophe Deleuze (LCIS, Valence).

8.2. National Initiatives

8.2.1. PIA (Programme d'Investissements d'Avenir)

8.2.1.1. CAPHCA

Participants: Frédéric Lang, Radu Mateescu [correspondent], Wendelin Serwe.

CAPHCA (*Critical Applications on Predictable High-Performance Computing Architectures*) is a project funded by the PIA. The project, led by IRT Saint-Exupéry (Toulouse), involves a dozen of industrial partners (among which Airbus, CS Systèmes d'Information, Synopsis, and Thalès Avionics), the University Paul Sabatier (Toulouse), and Inria Grenoble – Rhône-Alpes (CONVECS and SPADES project-teams). CAPHCA addresses the dual problem of achieving performance and determinism when using new, high performance, multicore System-on-Chip (SoC) platforms for the deployment of real-time, safety-critical applications. The methodology adopted by CAPHCA consists in building a pragmatic combination of methods, tools, design constraints and patterns deployable at a short-term horizon in the industrial domains targeted in the project.

CAPHCA started in December 2017 for four years. The main contributions of CONVECS to CAPHCA are the detection of concurrency errors in parallel applications by means of formal methods and verification techniques.

8.2.2. Competitivity Clusters

8.2.2.1. SECURIOT-2

Participants: Lian Apostol, Hubert Garavel [correspondent], Radu Mateescu, Wendelin Serwe.

SECURIOT-2 is a project funded by the FUI (*Fonds Unique Interministériel*) within the *Pôle de Compétitivité* Minalogic. The project, led by Tiempo Secure (Grenoble), involves the SMEs (*Small and Medium Enterprises*) Alpwise, Archos, Sensing Labs, and Trusted Objects, the Institut Fourier and the VERIMAG laboratories of Université Grenoble Alpes, and CONVECS. SECURIOT-2 aims at developing a secure micro-controller unit (SMCU) that will bring to the IoT a high level of security, based on the techniques used for smart cards or electronic passports. The SMCU will also include an original power management scheme adequate with the low power consumption constraints of the IoT.

SECURIOT-2 started in September 2017 for three years. The main contributions of CONVECS to SECURIOT-2 are the formal modeling and verification of the asynchronous hardware implementing the secure elements developed by the project partners.

8.2.3. Other National Collaborations

We had sustained scientific relations with the following researchers:

- Xavier Etchevers (Orange Labs, Meylan),
- Fabrice Kordon and Lom Messan Hillah (LIP6, Paris),
- Eric Jenn and Viet Anh Nguyen (IRT Saint-Exupéry, Toulouse),
- Ioannis Parissis and Oum-El-Kheir Aktouf (LCIS, Valence),
- Pascal Poizat (LIP6, Paris).

8.3. European Initiatives

8.3.1. Collaborations in European Programs, Except FP7 & H2020

Program: PHC Amadeus

Project acronym: RIDINGS

Project title: Rigourous Development of GALS Systems

Duration: January 2017 – December 2018

Coordinator: Inria Grenoble – Rhône-Alpes / CONVECS

Other partners: TU Graz, Institute of Software Technology (Austria)

Abstract: GALS systems, composed of synchronous components (driven by local clocks) that communicate through a network, are increasingly spreading with the development of the IoT. GALS systems are intrinsically complex due to the interplay of synchronous and asynchronous aspects, which make their development and debugging difficult. Therefore, it is necessary to adopt rigorous design methodologies, based on formal methods assisted by efficient validation tools. The RIDINGS project aims at enhancing the design flow of a GALS system by integrating the automatic generation of conformance tests from the formal model and the temporal properties used for verifying the system. This yields a double benefit for the designer: (i) it makes possible to check that a physical implementation conforms to the verified model; (ii) the development cost of the model and properties is distributed on the verification and testing phases of the design process, therefore increasing the return on investment.

8.3.2. Collaborations with Major European Organizations

The CONVECS project-team is member of the FMICS (*Formal Methods for Industrial Critical Systems*) working group of ERCIM [0]. H. Garavel and R. Mateescu are members of the FMICS board, H. Garavel being in charge of dissemination actions.

8.4. International Initiatives

H. Garavel is a member of IFIP (*International Federation for Information Processing*) Technical Committee 1 (*Foundations of Computer Science*) Working Group 1.8 on Concurrency Theory chaired successively by Luca Aceto and Jos Baeten.

8.4.1. Inria International Partners

8.4.1.1. Informal International Partners

Saarland University (Germany): we collaborate on a regular basis with the DEPEND (*Dependable Systems and Software*) research group headed by Holger Hermanns, who received an ERC Advanced Grant (“POWVER”) in 2016.

[0] http://fmics.inria.fr

8.4.2. Other International Collaborations

In 2018, we had scientific relations with several universities and institutes abroad, including:

- University of Málaga, Spain (Francisco Durán),
- University of Cali, Colombia (Camilo Rocha),
- University of Zaragoza, Spain (José Ignacio Requeno),
- ISTI/CNR, Pisa, Italy (Franco Mazzanti),
- RWTH Aachen, Germany (Joost-Pieter Katoen),
- Saarland University, Germany (Holger Hermanns),
- Eindhoven University of Technology, The Netherlands (Anton Wijs and Sander de Putter).

8.5. International Research Visitors

8.5.1. Visits of International Scientists

- H. Garavel is an invited professor at Saarland University (Germany) as a holder of the Gay-Lussac Humboldt Prize.
- Josip Bozic, Birgit Hofer, Hermann Felbinger, and Franz Wotawa (TU Graz, Austria) visited us from March 5 to March 9, 2018 in the framework of the RIDINGS PHC project (see § 8.3.1).
- G. Salaün visited the University of Málaga (Spain) from May 30 to June 13 and from December 16 to December 22, 2018.
- L. Marsso and R. Mateescu visited TU Graz (Austria) from August 20 to August 24, 2018 in the framework of the PHC RIDINGS project.

The annual CONVECS seminar was held in Dullin (France) on July 10–12, 2018. The following invited scientists attended the seminar:

- Eric Jenn (IRT Saint-Exupéry / Thales Avionics) gave on July 10, 2018 a talk entitled "*The CAPHCA Project, or How to Be Fast and Reasonable*".
- Viet Anh Nguyen (IRT Saint-Exupéry) gave on July 12, 2018 a talk entitled "*Cache-conscious Offline Real-time Scheduling for Multi-core Platforms: Algorithms and Implementation*".
- Yliès Falcone (CORSE project-team) gave on July 11, 2018 a talk entitled "*Some Recent Work on the Runtime Monitoring of Systems*".

CORSE Project-Team

9. Partnerships and Cooperations

9.1. Regional Initiatives

9.1.1. HEAVEN Persyval Project

- Title: HEterogenous Architectures: Versatile Exploitation and programiNg
- HEAVEN leaders: François Broquedis, Olivier Muller [TIMA lab]
- CORSE participants: François Broquedis, Frédéric Desprez, Georgios Christodoulis, Manuel Selva
- Computer architectures are getting more and more complex, exposing massive parallelism, hierarchically-organized memories and heterogeneous processing units. Such architectures are extremely difficult to program as they most of the time make application programmers choose between portability and performance.

  While standard programming environments like OpenMP are currently evolving to support the execution of applications on different kinds of processing units, such approaches suffer from two main issues. First, to exploit heterogeneous processing units from the application level, programmers need to explicitly deal with hardware-specific low-level mechanisms, such as the memory transfers between the host memory and private memories of a co-processor for example. Second, as the evolution of programming environments towards heterogeneous programming mainly focuses on CPU/GPU platforms, some hardware accelerators are still difficult to exploit from a general-purpose parallel application.

  FPGA is one of them. Unlike CPUs and GPUs, this hardware accelerator can be configured to fit the application needs. It contains arrays of programmable logic blocks that can be wired together to build a circuit specialized for the targeted application. For example, FPGAs can be configured to accelerate portions of code that are known to perform badly on CPUs or GPUs. The energy efficiency of FPGAs is also one of the main assets of this kind of accelerators compared to GPUs, which encourages the scientific community to consider FPGAs as one of the building blocks of large scale low-power heterogeneous multicore platforms.

  However, only a fraction of the community considers programming FPGAs for now, as configurations must be designed using low-level description languages such as VHDL that application programmers are not experienced with.

  The main objective of this project is to improve the accessibility of heterogeneous architectures containing FPGA accelerators to parallel application programmers. The proposed project focuses on three main aspects:

  – Portability: we don't want application programmers to redesign their applications completely to benefit from FPGA devices. This means extending standard parallel programming environments like OpenMP to support FPGA. Improving application portability also means leveraging most of the hardware-specific low-level mechanisms at the run-time system level;

  – Performance: we want our solution to be flexible enough to get the most out of any heterogeneous platforms containing FPGA devices depending on specific performance needs, like computation throughput or energy consumption for example;

  – Experiments: Experimenting with FPGA accelerators on real-life scientific applications is also a key element of our project proposal. In particular, the solutions developed in this project will allow comparisons between architectures on real-life applications from different domains like signal processing and computational finance.

Efficient programming and exploitation of heterogeneous architectures implies the development of methods and tools for system design, embedded or not. The HEAVEN project proposal fits in the PCS research action of the PERSYVAL-lab. The PhD of Georgios Christodoulis and the PostDoc of Manuel Selva are funded by this project.

9.2. National Initiatives

9.2.1. PIA ELCI

- Title: Software environment for computation-intensive applications
- Coordinator: Corinne Marchand (BULL SAS)
- CORSE participants: François Broquedis, Philippe Virouleau
- INRIA Partners: Avalon, Cardamon, Myriads; Realopt, Roma, Storm, Tadaam
- Other Partners: Algo'Tech, CEA, Cenaero, CERFACS, CORIA, Kitware, Onera, SAFRAN
- Duration: from Sept. 2014 to March 2018
- Abstract: The ELCI project main goal is to develop a highly-scalable new software stack to tackle high-end supercomputers, from numerical solvers to programming environments and run-time systems. In particular, the CORSE team is studying the scalability of OpenMP run-time systems on large scale shared memory machines through the PhD of Philippe Virouleau, co-advised by researchers from the CORSE and AVALON Inria teams. This work intends to propose new approaches based on a compiler/run-time cooperation to improve the execution of scientific task-based programs on NUMA platforms. The PhD of Philippe Virouleau is funded by this project.

9.2.2. IPL ZEP

- Title: Zero-Power computing systems
- Coordinator: Kevin Marquet (INRIA Socrate)
- CORSE participants: Fabrice Rastello
- Other INRIA Partners: Cairn, Pacap
- Duration: from Apr. 2017 to Sept. 2019
- Abstract: The ZEP project addresses the issue of designing tiny computing objects with no battery by combining non-volatile memory (NVRAM), energy harvesting, micro-architecture innovations, compiler optimizations, and static analysis. The main application target is Internet of Things (IoT) where small communicating objects will be composed of this computing part associated to a low-power wake-up radio system. The ZEP project gathers four Inria teams that have a scientific background in architecture, compilation, operating system and low power together with the CEA Lialp and Lisan laboratories of CEA LETI & LIST. The major outcomes of the project will be a prototype harvesting board including NVRAM and the design of a new microprocessor associated with its optimizing compiler and operating system.

9.3. European Initiatives

9.3.1. FP7 & H2020 Projects

9.3.1.1. EoCoE

Title: Energy oriented Centre of Excellence for computer applications

Programm: H2020

Duration: October 2015 - October 2018

Coordinator: CEA

Partners:

Barcelona Supercomputing Center - Centro Nacional de Supercomputacion (Spain)

Commissariat A L Energie Atomique et Aux Energies Alternatives (France)

Centre Europeen de Recherche et de Formation Avancee en Calcul Scientifique (France)

Consiglio Nazionale Delle Ricerche (Italy)

The Cyprus Institute (Cyprus)

Agenzia Nazionale Per le Nuove Tecnologie, l'energia E Lo Sviluppo Economico Sostenibile (Italy)

Fraunhofer Gesellschaft Zur Forderung Der Angewandten Forschung Ev (Germany)

Instytut Chemii Bioorganicznej Polskiej Akademii Nauk (Poland)

Forschungszentrum Julich (Germany)

Max Planck Gesellschaft Zur Foerderung Der Wissenschaften E.V. (Germany)

University of Bath (United Kingdom)

Universite Libre de Bruxelles (Belgium)

Universita Degli Studi di Trento (Italy)

INRIA contact: Michel Kern

CORSE contact: Jean Francois Méhaut

CORSE participants: Jean Francois Méhaut, Frédéric Desprez and Francieli Zanon Boito

The aim of the present proposal is to establish an Energy Oriented Centre of Excellence for computing applications, (EoCoE). EoCoE (pronounce "Echo") will use the prodigious potential offered by the ever-growing computing infrastructure to foster and accelerate the European transition to a reliable and low carbon energy supply. To achieve this goal, we believe that the present revolution in hardware technology calls for a similar paradigm change in the way application codes are designed. EoCoE will assist the energy transition via targeted support to four renewable energy pillars: Meteo, Materials, Water and Fusion, each with a heavy reliance on numerical modeling. These four pillars will be anchored within a strong transverse multidisciplinary basis providing high-end expertise in applied mathematics and HPC. EoCoE is structured around a central Franco-German hub coordinating a pan-European network, gathering a total of 8 countries and 23 teams. Its partners are strongly engaged in both the HPC and energy fields; a prerequisite for the long-term sustainability of EoCoE and also ensuring that it is deeply integrated in the overall European strategy for HPC. The primary goal of EoCoE is to create a new, long lasting and sustainable community around computational energy science. At the same time, EoCoE is committed to deliver high-impact results within the first three years. It will resolve current bottlenecks in application codes, leading to new modeling capabilities and scientific advances among the four user communities; it will develop cutting-edge mathematical and numerical methods, and tools to foster the usage of Exascale computing. Dedicated services for laboratories and industries will be established to leverage this expertise and to foster an ecosystem around HPC for energy. EoCoE will give birth to new collaborations and working methods and will encourage widely spread best practices.

Francieli Zanon Boito started in November 2017 as post-doc for the EoCoe project. She is working with Frédéric Desprez, Thierry Deutsch (CEA INAC) and Jean Francois Méhaut. Francieli is investigating the data storage issues for the scientific workflows on the nano-scale characterization center (PFNC@Minatec http://inac.cea.fr/en/Phocea/Vie_des_labos/Ast/ast_technique.php?id_ast=217).

9.3.1.2. PRACE-5IP

Title: PRACE-5IP (PRACE Fifht Implementation Phase)

Program H2020

Duration: 01/01/2013 - 30/04/2019

Inria partners: Hiepacs team (Inria Bordeaux Sud-Ouest), Storm team (Inria Bordeaux Sud-Ouest), Nachos team (Inria Sophia Antipolis Méditerranée), CORSE team (Inria Grenoble Rhône Alpes)
INRIA contact: Stéphane Lanteri (Nachos, Sophia Antipolis)

CORSE contact: Jean Francois Méhaut

CORSE participants: François Broquedis, Jean Francois Méhaut

The objectives of PRACE-5IP are to build on and seamlessly continue the successes of PRACE and start new innovative and collaborative activities proposed by the consortium. These include:

- assisting the transition to PRACE2 including analysis of TransNational Access;
- strengthening the internationally recognized PRACE brand;
- continuing and extend advanced training which so far provided more than 18800 person-training days;
- preparing strategies and best practices towards Exascale computing;
- coordinating and enhancing the operation of the multi-tier HPC systems and services;
- supporting users to exploit massively parallel systems and novel architectures.

The INRIA contribution is in the prolongation of involvement (jointly with CINES) in PRACE 4IP – WP7. The participation of Inria's researchers has been enlarged to include project-teams that were all involved in the C2S@Exa Inria Project Lab. The Inria teams will contribute to the WP7 and the following sub-tasks:

- Task 7.1: Applications Enabling Services for PRACE systems
- Task 7.4 Provision of Numerical Libraries for Heterogeneous/Hybrid Architectures

The activities are organized along two complementary lines

- Generic (or transverse) technologies for simulation software
- Specific (or vertical) technologies i.e. simulation software

The CORSE activities for PRACE-5IP will start with the hiring of one year postdoc in 2018. We will work on the DIOGENEs (DisOntinous GalErkin Nanoscale Solvers) software suite developed in the Nachos team. The post-doc will investigate the new vectorization features of processors.

9.3.2. Collaborations in European Programs, Except FP7 & H2020

Program: COST

Project acronym: ArVI

Project title: Run-Time Verification beyond Monitoring

Duration: December 2014 - Dec 2018

Coordinator: Martin Leucker, University of Lubeck

Abstract: Run-Time verification (RV) is a computing analysis paradigm based on observing a system at run-time to check its expected behavior. RV has emerged in recent years as a practical application of formal verification, and a less ad-hoc approach to conventional testing by building monitors from formal specifications.

There is a great potential applicability of RV beyond software reliability, if one allows monitors to interact back with the observed system, and generalizes to new domains beyond computers programs (like hardware, devices, cloud computing and even human centric systems). Given the European leadership in computer based industries, novel applications of RV to these areas can have an enormous impact in terms of the new class of designs enabled and their reliability and cost effectiveness.

This Action aims to build expertise by putting together active researchers in different aspects of run-time verification, and meeting with experts from potential application disciplines. The main goal is to overcome the fragmentation of RV research by (1) the design of common input formats for tool cooperation and comparison; (2) the evaluation of different tools, building a growing sets benchmarks and running tool competitions; and (3) by designing a road-map and grand challenges extracted from application domains.

9.4. International Initiatives

9.4.1. Inria Associate Teams Not Involved in an Inria International Labs

9.4.1.1. IOComplexity

Title: Automatic characterization of data movement complexity

International Partner (Institution - Laboratory - Researcher):

Ohio State University (United States) - Computer Science and Artificial Intelligence Laboratory - P. Sadayappan

Start year: 2018

See also: https://team.inria.fr/corse/iocomplexity/

The goal of this project is to extend techniques for automatic characterisation of data movement of an application to the design of performance estimation.

The EA as three main objectives: 1. broader applicability of IO complexity analysis; 2. Hardware characterisation; 3. Performance model.

9.5. International Research Visitors

9.5.1. Visits of International Scientists

- Mohamad Jaber visited the Inria Corse team in January 2018.

9.5.2. Visits to International Teams

9.5.2.1. Sabbatical programme

- Fabrice Rastello was on sabbatical at Colorado State University (USA) from July 2017 till July 2018.
- Yliès Falcone visited American University of Beirut (Lebanon) in May 2018 through an Erasmus exchange programme.

9.5.2.2. Research Stays Abroad

- Fabian Gruber visited the Colorado State University to work with Louis-Noël Pouchet from 18.03.2018 to 17.04.2018.
- Fabian Gruber visited the Ohio State University to work with P. Sadayappan , Changwan Hong, and Aravind Sukumaran-Rajam from 18.11.2018 to 01.12.2018.

DATASHAPE Project-Team

9. Partnerships and Cooperations

9.1. National Initiatives

9.1.1. ANR

9.1.1.1. ANR ASPAG

Participant: Marc Glisse.

- Acronym : ASPAG.

- Type : ANR blanc.

- Title : Analysis and Probabilistic Simulations of Geometric Algorithms.

- Coordinator : Olivier Devillers (équipe Inria Gamble).

- Duration : 4 years from January 2018 to December 2021.

- Others Partners: Inria Gamble, LPSM, LABRI, Université de Rouen, IECL, Université du Littoral Côte d'Opale, Telecom ParisTech, Université Paris X (Modal'X), LAMA, Université de Poitiers, Université de Bourgogne.

- Abstract:

The analysis and processing of geometric data has become routine in a variety of human activities ranging from computer-aided design in manufacturing to the tracking of animal trajectories in ecology or geographic information systems in GPS navigation devices. Geometric algorithms and probabilistic geometric models are crucial to the treatment of all this geometric data, yet the current available knowledge is in various ways much too limited: many models are far from matching real data, and the analyses are not always relevant in practical contexts. One of the reasons for this state of affairs is that the breadth of expertise required is spread among different scientific communities (computational geometry, analysis of algorithms and stochastic geometry) that historically had very little interaction. The Aspag project brings together experts of these communities to address the problem of geometric data. We will more specifically work on the following three interdependent directions.

(1) Dependent point sets: One of the main issues of most models is the core assumption that the data points are independent and follow the same underlying distribution. Although this may be relevant in some contexts, the independence assumption is too strong for many applications.

(2) Simulation of geometric structures: The phenomena studied in (1) involve intricate random geometric structures subject to new models or constraints. A natural first step would be to build up our understanding and identify plausible conjectures through simulation. Perhaps surprisingly, the tools for an effective simulation of such complex geometric systems still need to be developed.

(3) Understanding geometric algorithms: the analysis of algorithm is an essential step in assessing the strengths and weaknesses of algorithmic principles, and is crucial to guide the choices made when designing a complex data processing pipeline. Any analysis must strike a balance between realism and tractability; the current analyses of many geometric algorithms are notoriously unrealistic. Aside from the purely scientific objectives, one of the main goals of Aspag is to bring the communities closer in the long term. As a consequence, the funding of the project is crucial to ensure that the members of the consortium will be able to interact on a very regular basis, a necessary condition for significant progress on the above challenges.

- See also: https://members.loria.fr/Olivier.Devillers/aspag/

9.2. European Initiatives

9.2.1. FP7 & H2020 Projects

9.2.1.1. GUDHI

Title: Algorithmic Foundations of Geometry Understanding in Higher Dimensions

Programm: FP7

Type: ERC

Duration: February 2014 - January 2019

Coordinator: Inria

Inria contact: Jean-Daniel Boissonnat.

The central goal of this proposal is to settle the algorithmic foundations of geometry understanding in dimensions higher than 3. We coin the term geometry understanding to encompass a collection of tasks including the computer representation and the approximation of geometric structures, and the inference of geometric or topological properties of sampled shapes. The need to understand geometric structures is ubiquitous in science and has become an essential part of scientific computing and data analysis. Geometry understanding is by no means limited to three dimensions. Many applications in physics, biology, and engineering require a keen understanding of the geometry of a variety of higher dimensional spaces to capture concise information from the underlying often highly nonlinear structure of data. Our approach is complementary to manifold learning techniques and aims at developing an effective theory for geometric and topological data analysis. To reach these objectives, the guiding principle will be to foster a symbiotic relationship between theory and practice, and to address fundamental research issues along three parallel advancing fronts. We will simultaneously develop mathematical approaches providing theoretical guarantees, effective algorithms that are amenable to theoretical analysis and rigorous experimental validation, and perennial software development. We will undertake the development of a high-quality open source software platform to implement the most important geometric data structures and algorithms at the heart of geometry understanding in higher dimensions. The platform will be a unique vehicle towards researchers from other fields and will serve as a basis for groundbreaking advances in scientific computing and data analysis.

9.3. International Research Visitors

9.3.1. Visits of International Scientists

- Wolfgang Polonik, UC Davis, California. Sept. and Oct. 2018. Statistical aspects of persistent homology.
- Arijit Ghosh, Indian Statistical Institute, Kolkata, India (December 2018)
- Ramsay Dyer, Berkeley Publishing (December 2018)

9.3.1.1. Internships

- Shreya Arya, BITS Pilani University, India, August-July 2018.

DATASPHERE Team

9. Partnerships and Cooperations

9.1. Regional Initiatives

The team is hosted by IXXI, the Complex System Institute, at ENS Lyon, and strongly involved in the interdisciplinary cooperation promoted by IXXI. Stéphane Grumbach is vice-director of IXXI. Kavé Salamatian is in the Executive committee of the Data Institute of Grenoble Alps Institute, and of the Cyber@Alps Institute of cybersecurity.

9.2. National Initiatives

- Chaire Castex, Ecole Militaire, Paris.
- AMNECYS (Alpine Multidisciplinary NEtwork on CYber-security Studies), University of Grenoble-Alpes.
- GEODE Research team on Geopolitics.

9.3. International Initiatives

9.3.1. Inria International Partners

9.3.1.1. Informal International Partners

- RIHN, Research Institute on Humanity and Nature, Kyoto.
- Information School, UC Berkeley.
- ICT, Institute of Computing Technologies, Chinese Academy of Sciences, Beijing.
- CSIRO, Sydney.
- Center for CyberSecurity, University Macquarie, Sydney.
- Center for Internet Human Rights (CIHR), Berlin.

9.4. International Research Visitors

9.4.1. Visits to International Teams

9.4.1.1. Research Stays Abroad

Stéphane Grumbach has been visiting scientist at the Research Institute on Humanity and Nature, RIHN, in Kyoto.

DEDUCTEAM Project-Team

8. Partnerships and Cooperations

8.1. National Initiatives

The ANR PROGRAMme is an ANR for junior researcher Liesbeth Demol (CNRS, UMR 8163 STL, University Lille 3) to which G. Dowek participates. The subject is: “What is a program? Historical and Philosophical perspectives”. This project aims at developing the first coherent analysis and pluralistic understanding of “program” and its implications to theory and practice.

8.2. International Initiatives

Brazil: STIC Amsud.

Argentina: Ecos

China: Inria-NSFC

8.3. Informal International Partners

Our main international partners are Alejandro Diáz-Caro (Buenos Aires), Bruno Lopes (Niteroi), Ying Jiang (Beijing), Florian Rabe (Bremen), Brigitte Pientka (McGill), César Muñoz (NASA), and Stéphane Graham-Lengrand (SRI).

8.4. International Research Visitors

Alejandro Díaz-Caro (Buenos Aires) has visited Deducteam for two weeks.

Ying Jiang (Beijing) has visited Deducteam for three weeks.

Aristomenis-Dionysios Papadopoulos (Imperial College, London) has visited Deducteam. He worked with Frédéric Blanqui on the development of a rewrite tactic in DEDUKTI [27].

8.4.1. Visits to International Teams

Gilles Dowek has spent two weeks at the University of Buenos Aires.

Gilles Dowek has spent two weeks at the Institute of Aerospace (USA).

GAIA Team

9. Partnerships and Cooperations

9.1. National Initiatives

9.1.1. ANR

- *ANR project MSDOS* (Multidimensional System: Digression on Stability, coordinator: Nima Yeganefar (Poitiers University), 2014-2018) aimed at studying stability and stabilization problems for multidimensional systems by means of both analytic and algebraic methods. For more information, see https://www.lias-lab.fr/msdos/doku.php.
- *ANR TurboTouch* (High-performance touch interactions, coordinator: G. Casiez (MJOLNIR team, Inria), 2014–2019) develops methods and tools on transfer functions to allow high performance tactile interactions (e.g. high precision and low latency) adapted to the user and to the task. This research project is developed in collaboration with the Loki team, Inria Lille – Nord Europe (project leader). For more information, seehttp://mjolnir.lille.inria.fr/turbotouch/.
- *ANR WaQMoS* (Coastal waters Quality surveillance using bivalve Mollusk-based Sensors, coordinator: D. Efimov (Non-A Post, Inria), 2015–2020) develops a biosensor, based on measurements and interpretation of bi- valves mollusks behavior, for remote online detection of coastal water pollution and cli- mate change consequences. This research project is developed in collaboration with the Valse team, Inria Lille – Nord Europe (project leader). For more information, see https://team.inria.fr/non-a/anr-waqmos/.

9.2. European Initiatives

9.2.1. Collaborations with Major European Organizations

Mohamed Barakat: University of Siegen (Germany)
Effective module theory, effective homological algebra, algebraic analysis, computer algebra, implementation.
Georg Regensburger: Institute for Algebra, Johannes Kepler University Linz (Austria)
Rings of integro-differential-delay operators, computer algebra, implementation.
Daniel Robertz: University of Plymouth (United Kingdom)
Effective algebraic analysis, mathematical systems theory, computer algebra, implementation.

9.3. International Initiatives

9.3.1. Inria Associate Teams Not Involved in an Inria International Labs

WeCare, Inria Northern European Associate Team with the team of A. Medvedev from Uppsala University on effective algorithms for estimation and control in wearable devices for health and care, 2018–2020.

We participate in *HoTSMoCE*, an Inria Associated team with Non-A Post and the team of L. Fridman (UNAM, Mexico), on the development of algebraic and homogeneous tools for sliding mode control and estimation.

9.4. International Research Visitors

9.4.1. Visits of International Scientists

- Thomas Cluzeau, XLIM, University of Limoges, May 2018.
- Marc Moreno Maza, University of Western Ontario, London, Ontario, Canada, September 2018.
- Alexander Medvedev, University of Uppsala (03–05/10/2018).
- Fredrik Olsson, University of Uppsala (26–30/11/2018).
- Elisa Hubert (Safran Tech) visited us twice (23–24/07/2018, 12–13/09/2018) to work on the problem of gear fault diagnostic based on algebraic and symbolic approaches.

GALLINETTE Project-Team

7. Partnerships and Cooperations

7.1. Regional Initiatives

Vercoma (Atlanstic 2020/Attractivity grant)

Goal: Verified comupter mathematics.

Coordinator: A. Mahboubi.

Duration: 08/2018 - 08/2021.

7.2. National Initiatives

7.2.1. ANR

FastRelax (ANR-14-CE25-0018).

Goal: Develop computer-aided proofs of numerical values, with certified and reasonably tight error bounds, without sacrificing efficiency.

Coordinator: Bruno Salvy (Inria, ENS Lyon).

Participant: A. Mahboubi.

Duration: 2014-2019.

Website: http://fastrelax.gforge.inria.fr/.

Note: This project started when A. Mahboubi was still in the Specfun project at the Saclay Île-de-France CRI. The budget is still managed there, within the Toccata project, but remains available to A. Mahboubi.

7.3. European Initiatives

7.3.1. H2020 Projects

7.3.1.1. CoqHoTT

Title: Coq for Homotopy Type Theory

Programm: H2020

Type: ERC

Duration: June 2015 - May 2020

Coordinator: Inria

Inria contact: Nicolas TABAREAU

Every year, software bugs cost hundreds of millions of euros to companies and administrations. Hence, software quality is a prevalent notion and interactive theorem provers based on type theory have shown their efficiency to prove correctness of important pieces of software like the C compiler of the CompCert project. One main interest of such theorem provers is the ability to extract directly the code from the proof. Unfortunately, their democratization suffers from a major drawback, the mismatch between equality in mathematics and in type theory. Thus, significant Coq developments have only been done by virtuosos playing with advanced concepts of computer science and mathematics. Recently, an extension of type theory with homotopical concepts such as univalence is gaining traction because it allows for the first time to marry together expected principles of equality. But the univalence principle has been treated so far as a new axiom which breaks one fundamental property of mechanized proofs: the ability to compute with programs that make use

of this axiom. The main goal of the CoqHoTT project is to provide a new generation of proof assistants with a computational version of univalence and use them as a base to implement effective logical model transformation so that the power of the internal logic of the proof assistant needed to prove the correctness of a program can be decided and changed at compile time—according to a trade-off between efficiency and logical expressivity. Our approach is based on a radically new compilation phase technique into a core type theory to modularize the difficulty of finding a decidable type checking algorithm for homotopy type theory. The impact of the CoqHoTT project will be very strong. Even if Coq is already a success, this project will promote it as a major proof assistant, for both computer scientists and mathematicians. CoqHoTT will become an essential tool for program certification and formalization of mathematics.

7.3.2. Collaborations in European Programs, Except FP7 & H2020

Program: COST

Project acronym: EUTYPES

Project title: The European research network on types for programming and verification

Duration: 21/03/2016 - 20/03/2020.

Coordinator: Herman Geuvers (Radboud Univerity, Nijmegen, The Netherlands)

Abstract: Types are pervasive in programming and information technology. A type defines a formal interface between software components, allowing the automatic verification of their connections, and greatly enhancing the robustness and reliability of computations and communications. In rich dependent type theories, the full functional specification of a program can be expressed as a type. Type systems have rapidly evolved over the past years, becoming more sophisticated, capturing new aspects of the behaviour of programs and the dynamics of their execution.

This COST Action will give a strong impetus to research on type theory and its many applications in computer science, by promoting (1) the synergy between theoretical computer scientists, logicians and mathematicians to develop new foundations for type theory, for example as based on the recent development of "homotopy type theory", (2) the joint development of type theoretic tools as proof assistants and integrated programming environments, (3) the study of dependent types for programming and its deployment in software development, (4) the study of dependent types for verification and its deployment in software analysis and verification. The action will also tie together these different areas and promote cross-fertilisation.

Europe has a strong type theory community, ranging from foundational research to applications in programming languages, verification and theorem proving, which is in urgent need of better networking. A COST Action that crosses the borders will support the collaboration between groups and complementary expertise, and mobilise a critical mass of existing type theory research.

7.4. International Initiatives

7.4.1. Inria International Labs

Inria Chile

Associate Team involved in the International Lab:

7.4.1.1. GECO

Title: Gradual verification and robust proof Engineering for COq

International Partner (Institution - Laboratory - Researcher):

Universidad de Chile (Chile) - DCC, Pleaid team - Éric Tanter

Start year: 2018

See also: http://geco.gforge.inria.fr

The development of tools to construct software systems that respect a given specification is a major challenge of current and future research in computer science. Interactive theorem provers based on type theory, such as Coq, have shown their effectiveness to prove correctness of important pieces of software like the C compiler of the CompCert project. Certified programming with dependent types is attracting a lot of attention recently, and Coq is the de facto standard for such endeavors, with an increasing amount of users, pedagogical material, and large-scale projects. Nevertheless, significant work remains to be done to make Coq more usable from a software engineering point of view.

This collaboration project gathers the expertise of researchers from Chile (Inria Chile, Universidad de Chile, Universidad Católica de Valparaíso) and France (Inria Nantes, Inria Paris), in different areas that are crucial to develop the vision of certified software engineering. The focus of this project is both theoretical and practical, covering novel foundations and methods, design of concrete languages and tools, and validation through specific case studies.

The end result will be a number of enhancements to the Coq proof assistant (frameworks, tactic language) together with guidelines and demonstrations of their applicability in realistic scenarios.

7.5. International Research Visitors

7.5.1. Visits of International Scientists

- Ambrus Kaposi has visited Gallinette from April 15 to July 15 as part of the ERC 'Visiting Fellowship Programmes' whose aims it to promote the widening of participation of researchers with a high potential in the ERC calls. The Scientific Council of the ERC believes that increasing the international exposure of researchers can help them to develop their full research potential. For this reason the ERC has invited relevant national and regional authorities in Europe to fund potential ERC candidates from the country or the region to visit teams of existing ERC Principal Investigators. The purpose is to offer these potential candidates an opportunity to broaden and strengthen their research profile and vision in an internationally competitive research environment before applying for an ERC grant.
- Simon Huber (University of Göteborg) has visited Simon Boulier and Nicolas Tabareau from Feb 26 to March 2 as a Short-Term Scientific Mission (STSM) funded by the EUTYPES COST Action.
- Jesper Cockx (Chalmers University) has visited Gaetan Gilbert and Nicolas Tabareau from Feb 19 to Feb 23 as a Short-Term Scientific Mission (STSM) funded by the EUTYPES COST Action.

7.5.1.1. Internships

- A. Defourné has visited the team from April to August for an internship on the subject "A Mini-ML with resource management", supervised by G. Munch-Maccagnoni and R. Douence.
- L. Pujet has visited the team from April to August for an internship on the subject "Interpreting Cubical Type Theory using forcing", supervised by N. Tabareau.

7.5.2. Visits to International Teams

7.5.2.1. Research Stays Abroad

- A. Mahboubi has been appointed as Endowed Professor at the Vrije Universiteit Amsterdam on a chair entitled "Automated verification of mathematical proof".
- G. Munch-Maccagnoni has visited the University of Cambridge from July 9th to July 19th to work with M. Fiore on the topic of categorical semantics of effects and resources in programming languages.
- G. Munch-Maccagnoni has visited Jane Street on July 19th to work with L. White on the topic of resource management in the OCaml programming language.

GALLIUM Project-Team

9. Partnerships and Cooperations

9.1. National Initiatives

9.1.1. ANR projects

9.1.1.1. Vocal

Participants: Armaël Guéneau, Xavier Leroy, François Pottier.

The "Vocal" project (2015–2020) aims at developing the first mechanically verified library of efficient general-purpose data structures and algorithms. It is funded by *Agence Nationale de la Recherche* under its "appel à projets générique 2015".

A first release of the library has been published in December 2018. It contains a small number of verified data structures, including resizable vectors, hash tables, priority queues, and Union-Find.

9.1.2. FUI Projects

9.1.2.1. Secur-OCaml

Participants: Damien Doligez, Fabrice Le Fessant.

The "Secur-OCaml" project (2015–2018) has been coordinated by the OCamlPro company, with a consortium focusing on the use of OCaml in security-critical contexts, while OCaml is currently mostly used in safety-critical contexts. Gallium has been involved in this project to integrate security features in the OCaml language, to build a new independent interpreter for the language, and to update the recommendations for developers issued by the former LaFoSec project of ANSSI. The end-of-project meeting took place in September 2018.

9.2. European Initiatives

9.2.1. FP7 & H2020 Projects

9.2.1.1. Deepsea

Participants: Umut Acar, Vitaly Aksenov, Arthur Charguéraud, Adrien Guatto, Michael Rainey.

The Deepsea project (2013–2018) is coordinated by Umut Acar and funded by FP7 as an ERC Starting Grant. Its objective is to develop abstractions, algorithms and languages for parallelism and dynamic parallelism, with applications to problems on large data sets.

9.2.2. ITEA3 Projects

9.2.2.1. Assume

Participants: Gergö Barany, Xavier Leroy, Luc Maranget.

ASSUME (2015–2018) is an ITEA3 project involving France, Germany, Netherlands, Turkey and Sweden. The French participants are coordinated by Jean Souyris (Airbus) and include Airbus, Kalray, Sagem, ENS Paris, and Inria Paris. The goal of the project is to investigate the usability of multicore and manycore processors for critical embedded systems. Our involvement in this project focuses on the formalisation and verification of memory models and of automatic code generators from reactive languages, as well as on extensions to the CompCert C compiler.

9.3. International Initiatives

9.3.1. Informal International Partners

- Princeton University: interactions between the CompCert verified C compiler and the Verified Software Toolchain developed at Princeton.
- The University of Cambridge and ARM Ltd, Cambridge and Imperial College London: formal modeling and testing of weak memory models.

GAMBLE Project-Team

9. Partnerships and Cooperations

9.1. Regional Initiatives

We organized, with colleagues of the mathematics department (Institut Elie Cartan Nancy) a regular working group about geometry and probability.

9.2. National Initiatives

9.2.1. ANR SingCAST

Project title: Singular Curves and Surfaces Topology
Duration: March 2014 – August 2018
Coordinators: Guillaume Moroz 60%, and Marc Pouget 40%
Abstract: The objective of the young-researcher ANR grant SingCAST was to intertwine further symbolic/numeric approaches to compute efficiently solution sets of polynomial systems with topological and geometrical guarantees in singular cases. We focused on two applications: the visualization of algebraic curves and surfaces and the mechanical design of robots. We developed dedicated symbolic-numerical methods that take advantage of the structure of the associated polynomial systems that cannot be handled by purely symbolic or numerical methods.

The project had a total budget of 100k€. Project website: https://project.inria.fr/singcast/.

9.2.2. ANR SoS

Project title: Structures on Surfaces
Duration: 4 years
Starting Date: April 1st, 2018
Coordinator: Monique Teillaud
Participants:

- Gamble project-team, Inria.
- LIGM (Laboratoire d'Informatique Gaspard Monge), Université Paris-Est Marne-la-Vallée. Local Coordinator: Éric Colin de Verdière.
- RMATH (Mathematics Research Unit), University of Luxembourg. National Coordinator: Hugo Parlier

SoS is co-funded by ANR (ANR-17-CE40-0033) and FNR (INTER/ANR/16/11554412/SoS) as a PRCI (Projet de Recherche Collaborative Internationale).

The central theme of this project is the study of geometric and combinatorial structures related to surfaces and their moduli. Even though they work on common themes, there is a real gap between communities working in geometric topology and computational geometry and SoS aims to create a long lasting bridge between them. Beyond a common interest, techniques from both ends are relevant and the potential gain in perspective from long-term collaborations is truly thrilling.

In particular, SoS aims to extend the scope of computational geometry, a field at the interface between mathematics and computer science that develops algorithms for geometric problems, to a variety of unexplored contexts. During the last two decades, research in computational geometry has gained wide impact through CGAL, the Computational Geometry Algorithms Library. In parallel, the needs for non-Euclidean geometries are arising, e.g., in geometric modeling, neuromathematics, or physics. Our goal is to develop computational geometry for some of these non-Euclidean spaces and make these developments readily available for users in academy and industry.

To reach this aim, SoS will follow an interdisciplinary approach, gathering researchers whose expertise cover a large range of mathematics, algorithms and software. A mathematical study of the objects considered will be performed, together with the design of algorithms when applicable. Algorithms will be analyzed both in theory and in practice after prototype implementations, which will be improved whenever it makes sense to target longer-term integration into CGAL.

Our main objects of study will be Delaunay triangulations and circle patterns on surfaces, polyhedral geometry, and systems of disjoint curves and graphs on surfaces.

Project website: https://members.loria.fr/Monique.Teillaud/collab/SoS/.

9.2.3. ANR Aspag

Project title: Analyse et Simulation Probabilistes d'Algorithmes Géométriques
Duration: 4 years
Starting date: January 1st, 2018
Coordinator: Olivier Devillers
Participants:

- Gamble project-team, Inria.
- Labri (Laboratoire Bordelais de Recherche en Informatique), Université de Bordeaux. Local Coordinator: Philippe Duchon.
- Laboratoire de Mathématiques Raphaël Salem, Université de Rouen. Local Coordinator: Pierre Calka.
- LAMA (Laboratoire d'Analyse et de Mathématiques Appliquées), Université Paris-Est Marne-la-Vallée. Local Coordinator: Matthieu Fradelizi

Abstract: ASPAG projet is funded by ANR undered number ANR-17-CE40-0017 .

The analysis and processing of geometric data has become routine in a variety of human activities ranging from computer-aided design in manufacturing to the tracking of animal trajectories in ecology or geographic information systems in GPS navigation devices. Geometric algorithms and probabilistic geometric models are crucial to the treatment of all this geometric data, yet the current available knowledge is in various ways much too limited: many models are far from matching real data, and the analyses are not always relevant in practical contexts. One of the reasons for this state of affairs is that the breadth of expertise required is spread among different scientific communities (computational geometry, analysis of algorithms and stochastic geometry) that historically had very little interaction. The Aspag project brings together experts of these communities to address the problem of geometric data. We will more specifically work on the following three interdependent directions.

(1) Dependent point sets: One of the main issues of most models is the core assumption that the data points are independent and follow the same underlying distribution. Although this may be relevant in some contexts, the independence assumption is too strong for many applications.

(2) Simulation of geometric structures: The phenomena studied in (1) involve intricate random geometric structures subject to new models or constraints. A natural first step would be to build up our understanding and identify plausible conjectures through simulation. Perhaps surprisingly, the tools for an effective simulation of such complex geometric systems still need to be developed.

(3) Understanding geometric algorithms: the analysis of algorithm is an essential step in assessing the strengths and weaknesses of algorithmic principles, and is crucial to guide the choices made when designing a complex data processing pipeline. Any analysis must strike a balance between realism and tractability; the current analyses of many geometric algorithms are notoriously unrealistic. Aside from the purely scientific objectives, one of the main goals of Aspag is to bring the communities closer in the long term. As a consequence, the funding of the project is crucial to ensure that the members of the consortium will be able to interact on a very regular basis, a necessary condition for significant progress on the above challenges.

Project website: https://members.loria.fr/Olivier.Devillers/aspag/.

9.2.4. PHC Embeds II

Embeds is a bilateral, two-year project funded by the PHC Barrande program. It is joint between various french locations (Paris Est, Grenoble and, since september 2018, Nancy) and Charles University (Prague). The PI are Xavier Goaoc and Martin Tancer. It started in 2015 for two years, and was renewed in 2017 for two more years (5kE/year on the french side to support travels).

Starting Date: January 1st, 2017.
Duration: 2 years.

9.2.5. Institut Universitaire de France

Xavier Goaoc was appointed *junior member* of the Institut Universitaire de France, a grant supporting a reduction in teaching duties and funding.

Starting Date: October 1st, 2014.
Duration: 5 years.

9.3. International Initiatives

9.3.1. Inria Associate Teams Not Involved in an Inria International Labs

9.3.1.1. TRIP

Title: Triangulation and Random Incremental Paths

International Partner: Carleton University (Canada) - Prosenjit Bose

Start year: 2018

See also: https://members.loria.fr/Olivier.Devillers/trip/

The two teams are specialists of Delaunay triangulation with a focus on computation algorithms on the French side and routing on the Canadian side. We plan to attack several problems where the two teams are complementary: - Stretch factor of the Delaunay triangulation in 3D. - Probabilistic analysis of Theta-graphs and Yao-graphs. - Smoothed analysis of a walk in Delaunay triangulation. - Walking in/on surfaces. - Routing in non-Euclidean spaces.

9.3.1.2. Astonishing

Title: ASsociate Team On Non-ISH euclIdeaN Geometry

International Partner: University of Groningen (Netherlands) - Institute of Systems Science - Gert Vegter

Start year: 2017

See also: https://members.loria.fr/Monique.Teillaud/collab/Astonishing/

Some research directions in computational geometry have hardly been explored. The spaces in which most algorithms have been designed are the Euclidean spaces $\mathbb{R}^d$. To extend further the scope of applicability of computational geometry, other spaces must be considered, as shown by the concrete needs expressed by our contacts in various fields as well as in the literature. Delaunay triangulations in non-Euclidean spaces are required, e.g., in geometric modeling, neuromathematics, or physics. Topological problems for curves and graphs on surfaces arise in various applications in computer graphics and road map design. Providing robust implementations of these results is a key towards their reusability in more applied fields. We aim at studying various structures and algorithms in other spaces than $\mathbb{R}^d$, from a computational geometry viewpoint. Proposing algorithms operating in such spaces requires a prior deep study of the mathematical properties of the objects considered, which raises new fundamental and difficult questions that we want to tackle.

9.4. International Research Visitors

9.4.1. Visits of International Scientists

Gert Vegter spent three weeks in GAMBLE in the framework of the Astonishing associate team.

Jean-Lou De Carufel and Prosenjit Bose spent one week in GAMBLE in the framework of the TRIP associate team.

Martin Tancer, Vojta Kalusza and Pavel Paták, from Charles University (Prague), spent one week each in GAMBLE. They were supported by the PHC program EMBEDS II.

9.4.2. Visits to International Teams

Olivier Devillers spent two weeks at the Computational Geometry Lab of Carleton University http://cglab.ca/about.html in the framework of the TRIP associate team.

Charles Duménil spent one month at the Computational Geometry Lab of Carleton University http://cglab.ca/about.html in the framework of the TRIP associate team.

Monique Teillaud and Iordan Iordanov spent one month at Johann Bernouilli Institute for Mathematics and Computer Science of the University of Groningen in the framework of the Astonishing associate team.

GRACE Project-Team

8. Partnerships and Cooperations

8.1. Regional Initiatives

Participants: Daniel Augot, Matthieu Rambaud.

A "research initiative" "BART" (Blockchain advanced research and technologies) has been launched with three partners: Inria, Institut Mines-Télécom, and System-X. This is funded by *Institut de recherche* System-X, located in Paris-Saclay area, whose objective is to connect industry and academia. A new PhD has been started, with L. Benmouffok, hired in October 2018, whose topic is the use of secure multiparty computation in blockchains.

8.2. National Initiatives

8.2.1. ANR

Participants: Daniel Augot, Alain Couvreur, Matthieu Rambaud.

MANTA (accepted July 2015, starting March 2016): "Curves, surfaces, codes and cryptography". This project deals with applications of coding theory error correcting codes to in cryptography, multi-party computation, and complexity theory, using advanced topics in algebraic geometry and number theory. The kickoff was a one week-retreat in Dordogne (20 participants), and we had another four day meeting in Saclay in November 17. See http://anr-manta.inria.fr/.

8.3. European Initiatives

8.3.1. SPARTA

- Program: H2020
- Project acronym: SPARTA
- Project title: SPARTA
- Duration: three years
- Coordinator: CEA
- Other partners: IMT, Inria, ANSSI
- Abstract: Propose, test, validate and exploit the possible organizational, technological and operational setup of a cybersecurity competence network; Produce a roadmap that include targets to be achieved by the end of the project, as well as priorities to be addressed in the future by the Cybersecurity Competence Network; Serve to align research, education and certification; Build on and align existing roadmap efforts.
  Participant: Benjamin Smith.

8.3.2. PQCRYPTO

Title: Post-quantum cryptography for long-term security

Programm: H2020

Duration: March 2015 - March 2018

Coordinator: TECHNISCHE UNIVERSITEIT EINDHOVEN

Partners:

Academia Sinica (Taiwan)

Bundesdruckerei (Germany)

Danmarks Tekniske Universitet (Denmark)

Katholieke Universiteit Leuven (Belgium)

Nxp Semiconductors Belgium Nv (Belgium)

Ruhr-Universitaet Bochum (Germany)

Stichting Katholieke Universiteit (Netherlands)

Coding Theory and Cryptology group, Technische Universiteit Eindhoven (Netherlands)

Technische Universitaet Darmstadt (Germany)

University of Haifa (Israel)

Inria contact: Nicolas Sendrier

Online security depends on a very few underlying cryptographic algorithms. Essentially all applications today are based on RSA or on the discrete-logarithm problem in finite fields or on elliptic curves. Cryptographers optimize parameter choices and implementation details for these systems and build protocols on top of these systems; cryptanalysts fine-tune attacks and establish exact security levels for these systems.

These systems are all broken as soon as large quantum computers are built. Long-term confidential documents such as patient health-care records and state secrets have to guarantee security for many years, but information encrypted today using RSA or elliptic curves and stored until quantum computers are available will then be as easy to decipher.

PQCRYPTO will allow users to switch to post-quantum cryptography: PQCRYPTO will design a portfolio of high-security post-quantum public-key systems, and will improve the speed of these systems, with reference implementations.

Our team is engaged in WP3.3 “advanced applications for the cloud”. We envision to focus essentially on secure multiparty computation, essentially the information theoretically secure constructions, who are naturally secure against a quantum computer invoked on classical queries. We will study whether these protocols still resist quantum queries. This work sub package started March 2015, ended in March 2018.

Participants: Daniel Augot, Matthieu Rambaud.

HYCOMES Project-Team

8. Partnerships and Cooperations

8.1. Regional Initiatives

Participant: Benoît Caillaud.

Benoît Caillaud is contributing to the SUNSET projects of the CominLabs excellence laboratory [0]. This project focuses on the computation of surgical procedural knowledge models from recordings of individual procedures, and their execution [27]. The objective is to develop an enabling technology for procedural knowledge based computer assistance of surgery. In this project, we demonstrate its potential added value in nurse and surgeon training [36], [35]. In 2018, Benoît Caillaud and Aurélien Lamercerie (SemLIS team of IRISA) have maintained and enhanced the Demodocos prototype software. This software is synthesizing surgical process models (expressed in the ♯Seven language developed in the Hybrid team, Inria Rennes) from instances of surgical procedures. These models can be executed in a virtual reality environment developed by the Hybrid team.

8.2. National Initiatives

8.2.1. Inria Project Lab (IPL): ModeliScale, Languages and Compilation for Cyber-Physical System Design

The project gathers researchers from three Inria teams, and from three other research labs in Grenoble and Paris area.

Name	*Team*	*Inria Center or Laboratory*
Vincent Acary Bernard Brogliato Alexandre Rocca	Tripop	Inria Grenoble Rhône Alpes
Albert Benveniste Benoît Caillaud Khalil Ghorbal Christelle Kozaily Mathias Malandain Benoît Vernay	Hycomes	Inria Rennes Bretagne Atlantique
Marc Pouzet Tim Bourke Imsail Lakhim-Bennani	Parkas	ENS & Inria Paris
Goran Frehse	SSH	ENSTA Paris-Tech.
Antoine Girard		L2S-CNRS, Saclay
Eric Goubault Sylvie Putot	Cosynus	LIX, École Polytechnique, Saclay

The main objective of ModeliScale is to advance modeling technologies (languages, compile-time analyses, simulation techniques) for CPS combining physical interactions, communication layers and software components. We believe that mastering CPS comprising thousands to millions of components requires radical changes of paradigms. For instance, modeling techniques must be revised, especially when physics is involved. Modeling languages must be enhanced to cope with larger models. This can only be done by combining new compilation techniques (to master the structural complexity of models) with new mathematical tools (new numerical methods, in particular).

[0] https://s3pm.cominlabs.u-bretagneloire.fr/fr

MiodeliScale gathers a broad scope of experts in programming language design and compilation (reactive synchronous programming), numerical solvers (nonsmooth dynamical systems) and hybrid systems modeling and analysis (guaranteed simulation, verification). The research program is carried out in close cooperation with the Modelica community as well as industrial partners, namely, Dassault Systèmes as a Modelica/FMI tool vendor, and EDF and Engie as end users.

In 2018, three general meetings have been organized, with presentations of the partners on new results related to hybrid systems modeling and verification. A two days workshop open to a larger community of researchers and engineers has been organized, with a focus on model-based system diagnosis [0]. The programme of the workshop comprized invited talks by Erik Frisk and Mattias Krysander on the use of DAE Structural Analysis methods to generated automatically embedded diagnosers from a system model.

Two PhDs funded by the ModeliScale IPL have started in October 2018:

- Christelle Kozaily has started a PhD, under the supervision of Vincent Acary (TRIPOP team at Inria Grenoble), Benoît Caillaud, Khalil Ghorbal on the structural and numerical analysis of non-smooth DAE systems. She is located in the Hycomes team at Inria Rennes.
- Ismail Lahkim-Bennani has started a PhD under the supervision of Goran Frehse (ENSTA Paris-Tech.) and Marc Pouzet (PARKAS team, Inria/ENS Paris). His PhD topic is on random testing of hybrid systems, using techniques inspired by QuickCheck [33].

8.2.2. FUI ModeliScale: Scalable Modeling and Simulation of Large Cyber-Physical Systems

Participants: Albert Benveniste, Benoît Caillaud, Khalil Ghorbal, Mathias Malandain.

FUI ModeliScale is a French national collaborative project coordinated by Dassault Systèmes. The partners of this project are: EDF and Engie as main industrial users; DPS, Eurobios and PhiMeca are SME providing mathematical modeling expertise; CEA INES (Chambéry) and Inria are the academic partners. The project started January 2018, for a maximal duration of 42 months. Three Inria teams are contributing to the project : Hycomes, Parkas (Inria Paris / ENS) and Tripop (Inria Grenoble / LJK).

The focus of the project is on the scalable analysis, compilation and simulation of large Modelica models. One of the main contributions expected from Inria are:

- A novel structural analysis algorithms for multimode DAE systems, capable of handling large systems of guarded equations, that do not depend on the enumeration of a possibly exponential number of modes.
- The partitioning and high-performance distributed co-simulation of large Modelica models, based on the results of the structural analysis.

In 2018, two reports have been delivered: the first one is a state of the art on structural analysis methods for DAE systems [0], while the second details a structural analysis algorithm for multimode DAE systems [0]. It is an improvement of the algorithm presented in [16].

8.3. International Initiatives

8.3.1. Informal International Partners

The Hycomes team has a continued collaboration with Martin Otter (DLR, Munich, Germany) and Hilding Elmqvist (Mogram AB, Lund, Sweden), on the structural analysis and compilation of the Modelica language [17]. The team is also establishing a collaboration with John Pryce from the University of Cardiff (UK), on the structural analysis of DAE systems.

[0] https://team.inria.fr/modeliscale/workshop-on-diagnostics-25-26-january-2018/
[0] Modeliscale project, deliverable M2.1.1 1, Structural Analysis of Differential-Algebraic Equations (DAE), State-of-the-Art.
[0] Modeliscale project, deliverable M2.1.2 1, Algorithms for the structural Analysis of Multi-Mode DAE Systems.

8.4. International Research Visitors

8.4.1. Visits of International Scientists

Prof. Jean-Baptiste Jeannin, from the University of Michigan (Ann Arbor, Mi, USA) has visited the Hycomes team at the beginning of Summer 2018. He has collaborated with Kahlil Ghorbal and Benoît Caillaud on the topics cyber-physical systems modeling and contract-based reasoning.

KAIROS Team

9. Partnerships and Cooperations

9.1. Regional Initiatives

9.1.1. Université Côte d'Azur Academy 1

In the context of the UCA Jedi IDEX, associated with the UCA ComUE, we have applied to a number of funding initiatives. The project Smart IoT for Mobility has been funded for three years by the Academy RISE. This project is lead by the LEAT and Kairos is building a formal language for the design of smart contracts in the context of a mobility project with Renault Software Labs. The smart contracts are persisted in a secured distributed ledgers (through blockchain technology). The SyMag company, a subsidiary of BNP Paribas, is providing the technology to access block chain with a ledger-agnostic API. A PhD (at LEAT) and a Post-doc (within Kairos) positions are funded by this project. A complementary funding has been asked to the ANR with the generic call 2019.

9.2. National Initiatives

9.2.1. Investissements d'Avenir: PIA Clarity

Participants: Julien Deantoni, Robert de Simone, Amin Oueslati, Frédéric Mallet, Marie-Agnès Peraldi-Frati.

This project was funded by the LEOC Call (*Logiciel Embarqué et Objets Connectés*) of the national support programme *Investissements d'Avenir*. It ended in January 2018. Partners were: Thales (several divisions), Airbus, Areva, Altran, All4Tec, Artal, the Eclipse Fondation, Scilab Enterprises, CESAMES, U. Rennes, and Inria. The purpose of the project is to develop and promote an open-source version of the ARCADIA Melody system design environment from Thales, renamed CAPPELLA for that purpose. In this project we investigated extensions of Capella to enable simulation and analysis of mode automata in the context of model based system engineering.

9.2.2. CNRS GDRs

We are registered members of three GDR funded by CNRS : SoC^2, on topics of Hardware-software codesign and Non-Functional Property modeling for co-simulation; LTP, on verification and language design for reactive CPS systems; GPL,con Programming and Software Engineering (LaHMA group), LTP, Langages, Types et Preuves.

9.3. International Initiatives

9.3.1. Inria International Labs

The SACCADES LIAMA project came to a conclusion with the ending of the related Associated Team with ECNU Shanghai. We are actively working on a renewal of this colaboration, integrating the new generation of Professors there.

9.3.2. Inria International Partners

9.3.2.1. Declared Inria International Partners

- Luigi Liquori has a steady collaboration with researchers from University of Udine, and Turin, Italy.
- We collaborate with the University of Verona on topics of CPS co-simulation. This partly funds a support engineer on their side.
- M.A Peraldi-Frati participates in an international cooperation between University Côte d'Azur, University of Danang (Vietnam) and AUF. This collaboration crystallized through the DNIIT excellence initiative between Univ of Danang and UCA. M.A Peraldi-Frati is involved in the SLEGO project (Specific domain Language for Experience Global Orchestration)[22].

9.3.2.2. TuMuLT

Title: Trustworthy Modeling using Logical Time

International Partner (Institution - Laboratory - Researcher):

ECNU (China) - Software Engineering Institute - Min Zhang

Duration: 2018 - 2022

Start year: 2018

See also: https://team.inria.fr/tumult/

We have four main research directions:

- Modeling the Uncertain Environments of Cyber-Physical Systems (CPS): Logical Time was one of the main scientific foundations of the AOSTE Team. From the background in theory of concurrency, we are used to consider mainly discrete control systems that can guarantee a functional determinism independently of any implementation-specific timing variation. Addressing CPS means widening those assumptions to consider the external environment as part of the design. The environment obeys the law of physics that usually depend on physical time consideration with models that are approximation of the reality and that necessarily introduce a wide uncertainty on the behavior. This task explores the definition of sound extensions to logical time to capture both the physical continuous behavior and make an abstract characterization as a statistical approximation [25].
- SMT For Logical Time: While synchronous systems usually focus on finite state-based control systems, our abstraction of logical time relies on both Boolean algebra (for synchronous operations) and integer arithmetic, Solving a system of logical-time constraints is NP-complete but we strive to find efficient algorithms to solve sub-classes of well defined systems. In that context, SMT is a promising solution to combine and solve systems that combine several theories. We had first results on this aspect [8] but we still need to increase the subset of constraints that can be addressed efficiently as well as the performances of the solving tools.
- Spatio-Temporal Specification for Trustworthy Intelligent Transportation Systems: Focusing on Intelligent Transportation Systems as a subset of Cyber-Physical Systems, we encounter specific problems. In addition to the temporal factor omni-present in real-time and embedded systems, a physical location plays also a central role. Functions of the system (like a train) must be done both at the right time AND at the right location. This task focuses on extensions of our framework for a spatio-temporal logics based on logical time. This means a description of the location of infrastructures as well as the ability to build constraints that depend both on time (logic or physical) and locations (logical or physical).
- Open pNets: Methods for analyzing and guaranteeing the properties of critical and complex systems, including their data and time depend aspects, have strongly evolved with the emergence of efficient satisfiability checking engines (SAT and SMT). We are working on novel methods combining classical verification paradigms (state-space construction and minimization, model-checking) with SMT approaches to create symbolic and compositional verification methods and tool platforms. We have interesting preliminary results [26], and collaborate actively on both fundamental results and prototype development.

9.3.3. Participation in Other International Programs

- PHC Xu Quangqi funded by ANR for International collaborations with China in 2008.
  - PI: Frédéric Mallet (France) and Zhang Min (China)
  - Title: SMT FOR LOGICAL TIME
  - Description: The main goal of the project was to build an efficient encoding of logical time in SMT solvers. This goal has been achieved (see New Result in Section 7.1).

9.4. International Research Visitors

- Xue-Yang ZHU, assistant research professor at Institute of Software, Chinese Academy of Science, Beijing.
- Zhang Min, Assistant Professor, ECNU Shanghai, 2 weeks in August 2018,
- Changbo Wang, Professor, Dean of Computer Science Department, ECNU Shanghai, 2 weeks in August 2018.

9.4.1. Internships

Zechen HOU benefited from an Inria International Internship Grant.

9.4.2. Visits to International Teams

9.4.2.1. Explorer programme

Julien Deantoni has spent one week visiting the Modelling, Simulation and Design Lab (MSDL) in Antwerp, funded by the MPM4CPS European cost action.

9.4.2.2. Research Stays Abroad

Eric Madelaine has spent 1 month visiting the Software engineering and computer Science department at ECNU Shanghai (2 weeks in May, 2 week in October).

LFANT Project-Team

7. Partnerships and Cooperations

7.1. National Initiatives

7.1.1. ANR Alambic – AppLicAtions of MalleaBIlity in Cryptography

Participant: Guilhem Castagnos.

https://crypto.di.ens.fr/projects:alambic:main

The ALAMBIC project is a research project formed by members of the Inria Project-Team CASCADE of ENS Paris, members of the AriC Inria project-team of ENS Lyon, and members of the CRYPTIS of the university of Limoges. G. Castagnos is an external member of the team of Lyon for this project.

Non-malleability is a security notion for public key cryptographic encryption schemes that ensures that it is infeasible for an adversary to modify ciphertexts into other ciphertexts of messages which are related to the decryption of the first ones. On the other hand, it has been realized that, in specific settings, malleability in cryptographic protocols can actually be a very useful feature. For example, the notion of homomorphic encryption allows specific types of computations to be carried out on ciphertexts and generate an encrypted result which, when decrypted, matches the result of operations performed on the plaintexts. The homomorphic property can be used to create secure voting systems, collision-resistant hash functions, private information retrieval schemes, and for fully homomorphic encryption enables widespread use of cloud computing by ensuring the confidentiality of processed data.

The aim of the ALAMBIC project to investigate further theoretical and practical applications of malleability in cryptography. More precisely, this project focuses on three different aspects: secure computation outsourcing and server-aided cryptography, homomorphic encryption and applications and << paradoxical >> applications of malleability.

7.1.2. ANR CLap–CLap – The p-adic Langlands correspondence: a constructive and algorithmical approach

Participant: Xavier Caruso.

The p-adic Langlands correspondence has become nowadays one of the deepest and the most stimulating research programs in number theory. It was initiated in France in the early 2000's by Breuil and aims at understanding the relationships between the p-adic representations of p-adic absolute Galois groups on the one hand and the p-adic representations of p-adic reductive groups on the other hand. Beyond the case of $\mathrm{GL}_2(\mathbb{Q}_p)$ which is now well established, the p-adic Langlands correspondence remains quite obscure and mysterious new phenomena enter the scene; for instance, on the $\mathrm{GL}_n(F)$-side one encounters a vast zoology of representations which seems extremely difficult to organize.

The CLap–CLap ANR project aims at accelerating the expansion of the p-adic Langlands program beyond the well-established case of $\mathrm{GL}_2(\mathbb{Q}_p)$. Its main originality consists in its very constructive approach mostly based on algorithmics and calculations with computers at all stages of the research process. We shall pursue three different objectives closely related to our general aim:

1. draw a conjectural picture of the (still hypothetical) p-adic Langlands correspondence in the case of GL_n,
2. compute many deformation spaces of Galois representations and make the bridge with deformation spaces of representations of reductive groups,
3. design new algorithms for computations with Hilbert and Siegel modular forms and their associated Galois representations.

This project will also be the opportunity to contribute to the development of the mathematical software SAGEMATH and to the expansion of computational methodologies.

7.2. European Initiatives

7.2.1. H2020 Projects

Title: OpenDreamKit

Program: H2020

Duration: January 2016 - December 2020

Coordinator: Nicolas Thiéry

Inria contact: Karim Belabas

Description http://cordis.europa.eu/project/rcn/198334_en.html, http://opendreamkit.org

OpenDreamKit is a Horizon 2020 European Research Infrastructure project (#676541) that will run for four years, starting from September 2015. It provides substantial funding to the open source computational mathematics ecosystem, and in particular popular tools such as LinBox, MPIR, SageMath, GAP, Pari/GP, LMFDB, Singular, MathHub, and the IPython/Jupyter interactive computing environment.

7.3. International Initiatives

7.3.1. Inria International Labs

International Laboratory for Research in Computer Science and Applied Mathematics
Associate Team involved in the International Lab:

7.3.1.1. FAST

Title: (Harder Better) FAster STronger cryptography

International Partner

Université des Sciences et Techniques de Masuku (Gabon) - Tony Ezome and the PRMAIS project

Start year: 2017

See also: https://www.inria.fr/en/associate-team/fast

The project aims to develop better algorithms for elliptic curve cryptography with prospect of the two challenges ahead: - securing the internet of things - preparing towards quantum computers.

Elliptic curves are currently the fastest public-key cryptosystem (with a key size that can fit on embeded devices) while still through a different mode of operation beeing (possibly) able to resist quantum based computers.

Activities for this year involved:

- Tony Ezome organised a Cimpa school on Courbes algébriques pour une arithmétique efficace des corps finis from 17/11/2018 - 30/11/2018 in Ziguinchor (Sénégal), Institution Université Assane Seck de Ziguinchor.
- Abdoul Asiz Ciss and Damien Robert represented the team at the Journées du Lirima. One of the suggestion was to find industrial collaborations in Africa, especially in Senegal. Ongoing work is done by the team to find such a collaboration, especially on the new challenges of post-quantum cryptography.
- Abdoulaye Maiga visited in Bordeaux to work with Damien Robert from 22/10/2018 to 18/01/2019. Tony Ezome and Mohamadou Sall visited from 08/12/2018 to 22/12/2018.

Activities for this year involved the funding of Luca De Feo to speak at the EMA “Mathématiques pour la Cryptographie Post-quantique et Mathématiques pour le Traitement du Signal”, organised by Djiby Sow and Abdoul Asiz Ciss organised an EMA at the École Polytechnique de Thiès (Sénégal) from May 10 to May 23, about “Cryptographie à base d’isogénies”; the visit of Abdoulaye Maiga to the LFANT team where he worked with Damien Robert to find absolute invariants of good reduction modulo 2 for abelian surfaces; and the organisation by Damien Robert of a workshop in Bordeaux with most of the team members from September 04 to September 08. The slides or proceedings are available at https://lfant.math.u-bordeaux.fr/index.php?category=seminar&page=2017.

7.3.2. Inria International Partners

7.3.2.1. Informal International Partners

The team is used to collaborate with Leiden University through the ALGANT program for PhD joint supervision.

Eduardo Friedman (U. of Chile), long term collaborator of K. Belabas and H. Cohen is a regular visitor in Bordeaux (about 1 month every year).

7.4. International Research Visitors

7.4.1. Visits of International Scientists

- Nicolas Mascot (American University of Beirut, Lebanon) visited the team for a week (8-12/01/2018).
- Alex Bartel (University of Glasgow, UK) visited the team for two weeks (27/03/2018 to 07/04/2018).
- Takashi Fukuda (Nihon University, Japan) visited the team for two months (20/01/2018 to 25/03/2018)
- Tony Ezome (Université des Sciences et Techniques de Masuku) and Mohamadou Sall (Dakar) visited the team for two weeks in December. Abdoul Aziz (Dakar) visited the team for one week in September.
- Abdoulaye Maiga visited the team for three months, from October to January 2019.

Researchers visiting the team to give a talk to the team seminar include Elie Eid (Université de Rennes), Jean-François Biasse (University of South Florida), Francesco Battistoni (University of Milan), Alex Bartel (Glasgow University), Tristan Vaccon (Université de Limoges), and Takashi Fukuda (Nihon University).

7.4.2. Visits to International Teams

A. Page visited Alex Bartel (University of Glasgow, UK) for two weeks (16-27/07/2018) and Michael Lipnowski (McGill University, Montreal, Canada) for two weeks (10-23/11/2018).

A. Page and Alex Bartel did a research stay in Oberwolfach (Allemagne) with the Research In Pairs programme for three weeks (14/10/2018-3/11/2018).

MARELLE Project-Team

8. Partnerships and Cooperations

8.1. National Initiatives

8.1.1. ANR

We are currently members of four projects funded by the French national agency for research funding.

- TECAP "Analyse de protocoles, Unir les outils existants", starting on October 1st, 20117, for 60 months, with a grant of 89 kEuros. Other partners are Inria teams PESTO (Inria Nancy grand-est), Ecole Polytechnique, ENS Cachan, IRISA Rennes, and CNRS. The corresponding researcher for this contract is Benjamin Grégoire.
- SafeTLS "La sécurisation de l'Internet du futur avec TLS 1.3" started on October 1st, 2016, for 60 months, with a grant of 147kEuros. Other partners are Université de Rennes 1, and secrétariat Général de la Défense et de la Sécurité Nationale. The corresponding researcher for this contract is Benjamin Grégoire.
- BRUTUS "Chiffrements authentifiés et résistants aux attaques par canaux auxiliaires", started on October 1st, 2014, for 60 months, with a grant of 41 kEuros for Marelle. Other partners are Université de Rennes 1, CNRS, secrétariat Général de la défense et de la sécurité nationale, and Université des Sciences et Technologies de Lille 1. The corresponding researcher for this contract is Benjamin Grégoire.
- FastRelax, "Fast and Reliable Approximations", started on October 1st, 2014, for 60 months, with a grant of 75 kEuros for Marelle. Other partners are Inria Grenoble (ARIC project-team), LAAS-CNRS (Toulouse), Inria Saclay (Toccata and Specfun project-teams), and LIP6-CNRS (Paris). The corresponding researcher for this contract is Laurence Rideau.

8.1.2. FUI

The acronym *FUI* stands for "fonds unique interministériel" and is aimed at research and development projects in pre-industrial phase. The Marelle team is part of one such project.

- VERISICC (formal verification for masking techniques for security against side-channel attacks), This contracts concerns 5 partners: CRYPTOEXPERTS a company from the Paris region (île de France), ANSSI (Agence Nationale de Sécurité des Systèmes d'Information), Oberthur Technologies, University of Luxembourg, and Marelle. A sixth company (Ninjalabs) acts as a sub-contractant. The financial grant for Marelle is 391 kEuros, including 111kEuros that are reserved for the sub-contractant. This project started in October 2018 for a duration of 4 years. The corresponding researcher for this contract is Benjamin Grégoire.

8.2. International Research Visitors

8.2.1. Visits of International Scientists

8.2.1.1. Internships

Joshua Gansher from Cornell and Sunjay Cauligi from the University of California at San Diego visited for three months, as part of their PhD training.

Vincent Laporte from IMDEA Madrid visited for 9 months.

Benoît Viguier from Radboud University, Nijmegen visited for 1 month.

8.2.2. Visits to International Teams

Yves Bertot visited AIST in February in Tsukuba, Japan, ITU Copenhagen in April in Copenhagen, Denmark, and the DeepSpec Summer School in July at Princeton University.

MEXICO Project-Team

9. Partnerships and Cooperations

9.1. Regional Initiatives

- Serge Haddad and Yann Duplouy have been participating in the *Simulation pour la sécurité du véhicule autonome*(SVA) project at SystemX, in cooperation with Renault, on the application of formal methods to the development of embedded systems for autonomous vehicles.
- Matthias Függer co-leads the Digicosme working group HicDiesMeus on "Highly Constrained Discrete Agents for Modeling Natural Systems" (parsys.lri.fr/HicDiesMeus).
- Matthias Függer participates in the Farman project Dicimus in collaboration with Thomas Nowak (LRI). The project is on modeling of bacterial interactions using techniques from distributed computing theory and VLSI design.

9.2. National Initiatives

- Thomas Chatain, Stefan Haar, Serge Haddad and Stefan Schwoon are participating in the ANR Project ALGORECELL.
- Matthias Függer participates in the ANR project FREDDA on verification and synthesis of distributed algorithms.
- Laurent Fribourg participates in Digicosme Emergence Project “CODECSY” in collaboration with Antoine Girard (CentraleSupelec).

9.3. European Initiatives

Serge Haddad is a member of the European project ERC EQualIS “Enhancing the Quality of Interacting Systems” headed by Patricia Bouyer.

9.4. International Initiatives

9.4.1. Inria Associate Teams Not Involved in an Inria International Labs

9.4.1.1. LifeForm

Title: Life Sciences need formal Methods !

International Partner (Institution - Laboratory - Researcher):

Newcastle University (United Kingdom) - School of Computing Science - Victor Khomenko

Start year: 2016

See also: http://projects.lsv.ens-cachan.fr/LifeForm/

This project extends an existing cooperation between the MEXICO team and Newcastle University on partial-order based formal methods for concurrent systems. We enlarge the partnership to bioinformatics and synthetic biology. The proposal addresses addresses challenges concerning formal specification, verification, monitoring and control of synthetic biological systems, with use cases conducted in the Center for Synthetic Biology and the Bioeconomy (CSBB) in Newcastle. A main challenge is to create a solid modelling framework based on Petri-net type models that allow for causality analysis and rapid state space exploration for verification, monitoring and control purposes; a potential extension to be investigated concerns the study of attractors and cell reprogramming in Systems Biology.

9.4.2. Inria International Partners

9.4.2.1. Informal International Partners

Josep Carmona (UPC Barcelona) visited us in April and July 2018. He collaborated with Thomas Chatain on process mining.

9.5. International Research Visitors

9.5.1. Visits to International Teams

9.5.1.1. Research Stays Abroad

- Juraj Kolcˇák has started, in August 2018, a 6-month research visit in the MMM group / NII Tokyo (Japan), funded by the ERATO project, to work with the PI, Prof. Ichiro Hasuo. Stefan Haar has visited that group from Oct 29 to Friday Nov 2, preceded by a visit to Prof. Tatsuya Akutsu's group at Kyoto University (Uji campus) on Oct 26.

MOCQUA Team

8. Partnerships and Cooperations

8.1. National Initiatives

8.1.1. ANR

- Project acronym: ANR PRCE SoftQPro (ANR-17-CE25-0009)
  Project title: Solutions logicielles pour l'optimisation des programmes et ressources quantiques.
  Duration: Dec. 2017 - Nov. 2021
  Coordinator: Simon Perdrix
  Other partners: Atos-Bull, LRI, CEA-Saclay.
  Participants: Simon Perdrix, Emmanuel Jeandel, Emmanuel Hainry, and Romain Péchoux
  Abstract: Quantum computers can theoretically solve problems out of reach of classical computers. We aim at easing the crucial back and forth interactions between the theoretical approach to quantum computing and the technological efforts made to implement the quantum computer. Our software-based quantum program and resource optimisation (SoftQPRO) project consists in developing high level techniques based on static analysis, certification, transformations of quantum graphical languages, and optimisation techniques to obtain a compilation suite for quantum programming languages. We will target various computational model back-ends (e.g. QRAM, measurement-based quantum computations) as well as classical simulation. Classical simulation is central in the development of the quantum computer, on both ends: as a way to test quantum programs but also as a way to test quantum computer prototypes. For this reason we aim at designing sophisticated simulation techniques on classical high-performance computers (HPC).
- Project acronym: ANR PRCI VanQuTe (ANR-17-CE24-0035)
  Project title: Validation of near-future quantum technologies.
  Duration: Dec. 2017 - Nov. 2021
  Coordinator: Simon Perdrix
  Other partners: Atos-Bull, LRI, CEA-Saclay.
  Participants: Simon Perdrix, Emmanuel Jeandel, Emmanuel Hainry, and Romain Péchoux
  Abstract: Quantum computers can theoretically solve problems out of reach of classical computers. We aim at easing the crucial back and forth interactions between the theoretical approach to quantum computing and the technological efforts made to implement the quantum computer. Our software-based quantum program and resource optimisation (SoftQPRO) project consists in developing high level techniques based on static analysis, certification, transformations of quantum graphical languages, and optimisation techniques to obtain a compilation suite for quantum programming languages. We will target various computational model back-ends (e.g. QRAM, measurement-based quantum computations) as well as classical simulation. Classical simulation is central in the development of the quantum computer, on both ends: as a way to test quantum programs but also as a way to test quantum computer prototypes. For this reason we aim at designing sophisticated simulation techniques on classical high-performance computers (HPC).

8.1.2. Autres initiatives

- Quantex. Project acronym: PIA-GDN/Quantex. (initially an ITEA3 project finally funded by the *Grands défis du Numérique / Programme d'investissements d'avenir*).
  Project title: Simulation/Emulation of Quantum Computation.
  Duration: Feb. 2018 - Jan 2021.
  Coordinator: Huy-Nam Nguyen (Atos Bull).
  Other partners: Atos-Bull, LRI, CEA Grenoble.
  Participants: Simon Perdrix (WP leader), Emmanuel Jeandel
  Abstract: The lack of quantum computers leads to the development of a variety of software-based simulators to assist in the research and development of quantum algorithms. This proposal focuses on the development of a combined software-based and hardware-accelerated toolbox for quantum computation. A quantum computing stack including specification language, libraries and optimisation/execution tools will be built upon a well-defined mathematical framework mixing classical and quantum computation. Such an environment will be dedicated to support the expression of quantum algorithms for the purpose of investigation and verification.

8.2. European Initiatives

8.2.1. FP7 & H2020 Projects

Mathieu Hoyrup participates in the Marie-Curie RISE project Computing with Infinite Data coordinated by Dieter Spreen (Univ. Siegen) that has started in April 2017.

8.3. International Initiatives

8.3.1. Inria International Labs

8.3.1.1. IIL projects

Simon Perdrix is the WP leader in the ANR PRCI project VanQuTe (with LIP6, and the Singapore University of Technology and Design, the National University of Singapore, and the Nanyang Technological University). Emmanuel Jeandel is also a member of this project.

8.4. International Research Visitors

8.4.1. Visits of International Scientists

- Victor Selivanov (Kazan University) was an Inria invited researcher in September 2018. We have worked on the computable aspects of Descriptive Set Theory.
- Cristóbal Rojas (Universidad Andres Bello, Santiago) visited us during one month in September 2018. We have worked on the computable aspects of invariant measures in dynamical systems.
- Alexander Frank (Universidad Andres Bello, Santiago) visited us during three weeks in September-October 2018. We have worked on the computable aspects of invariant measures in dynamical systems.
- Bruce Kapron (University of Victoria, Canada) visited us in October 2018. We have worked on applications of tier based type systems to characterize the class of second order functionals computable in polynomial time.
- Damiano Mazza (CNRS, Université de Paris 13) visited us in March 2018. We have worked on the adaptation of linear logic to a functional programming languages with infinite streams to characterize the class of first order functions over the real computable in polynomial time.

OURAGAN Team

9. Partnerships and Cooperations

9.1. European Initiatives

9.1.1. FP7 & H2020 Projects

Program:H2020-EU.1.1. - EXCELLENT SCIENCE - European Research Council (ERC)

Project acronym: Almacrypt

Project title: Algorithmic and Mathematical Cryptology

Duration: 01/2016 - 12/2010

Coordinator: Antoine Joux

Abstract: Cryptology is a foundation of information security in the digital world. Today's internet is protected by a form of cryptography based on complexity theoretic hardness assumptions. Ideally, they should be strong to ensure security and versatile to offer a wide range of functionalities and allow efficient implementations. However, these assumptions are largely untested and internet security could be built on sand. The main ambition of Almacrypt is to remedy this issue by challenging the assumptions through an advanced algorithmic analysis. In particular, this proposal questions the two pillars of public-key encryption: factoring and discrete logarithms. Recently, the PI contributed to show that in some cases, the discrete logarithm problem is considerably weaker than previously assumed. A main objective is to ponder the security of other cases of the discrete logarithm problem, including elliptic curves, and of factoring. We will study the generalization of the recent techniques and search for new algorithmic options with comparable or better efficiency. We will also study hardness assumptions based on codes and subset-sum, two candidates for post-quantum cryptography. We will consider the applicability of recent algorithmic and mathematical techniques to the resolution of the corresponding putative hard problems, refine the analysis of the algorithms and design new algorithm tools. Cryptology is not limited to the above assumptions: other hard problems have been proposed to aim at post-quantum security and/or to offer extra functionalities. Should the security of these other assumptions become critical, they would be added to Almacrypt's scope. They could also serve to demonstrate other applications of our algorithmic progress. In addition to its scientific goal, Almacrypt also aims at seeding a strengthened research community dedicated to algorithmic and mathematical cryptology.

9.2. International Initiatives

9.2.1. Inria International Labs

9.2.1.1. Informal International Partners

- CQT Singapour (UMI CNRS Majulab)
- UFPA - Para -Brésil (José Miguel Veloso)
- Institut Joseph Fourier - Université Grenoble Alpes (Martin Deraux, V. Vitse et Pierre Will)
- Max-Planck-Institut für Informatik - Saarbrücken - Germany (Michael Sagraloff)
- Holon Institute of Technology, Israel (Jeremy Kaminsky)

9.3. International Research Visitors

9.3.1. Visits of International Scientists

- Jeremy Kaminsky (Holon Institute of Technology, Israel). 3-months visitor in Ouragan and École Polytechnique (MAX) and École des Mines. Chateaubriand Fellow. Subjects: Control Theory, Algebraic Geometry and Computer Vision.

PACAP Project-Team

9. Partnerships and Cooperations

9.1. Regional Initiatives

The Brittany Region is partially funding a PhD fellowship for Niloofar Charmchi on the topic "Hardware prefetching and related issues".

9.2. National Initiatives

9.2.1. Capacités: Projet "Investissement d'Avenir" (1/11/14 – 31/01/2018)

Participants: Damien Hardy, Viet Anh Nguyen, Isabelle Puaut.

The project objective is to develop a hardware and software platform based on manycore architectures, and to demonstrate the relevance of these manycore architectures (and more specifically the Kalray manycore) for several industrial applications. The Kalray MPPA manycore architecture is currently the only one able to meet the needs of embedded systems simultaneously requiring high performance, lower power consumption, and the ability to meet the requirements of critical systems (low latency I/O, deterministic processing times, and dependability).

The project partners are Kalray (lead), Airbus, Open-Wide, Safran Sagem, IS2T, Real Time at Work, Dassault Aviation, Eurocopter, MBDA, ProbaYes, IRIT, Onera, Verimag, Inria, IRISA, Tima and Armines.

9.2.2. Zero Power Computing Systems (ZEP): Inria Project Lab (2017–2020)

Participants: Erven Rohou, Bahram Yarahmadi.

This proposal addresses the issue of designing tiny wireless, batteryless, computing objects, harvesting energy in the environment. The energy level harvested being very low, very frequent energy shortages are expected. In order for the new system to maintain a consistent state, it will be based on a new architecture embedding non-volatile RAM (NVRAM). In order to benefit from the hardware innovations related to energy harvesting and NVRAM, software mechanisms will be designed. On the one hand, a compilation pass will compute a worst-case energy consumption. On the other hand, dedicated runtime mechanisms will allow:

1. to manage efficiently and correctly the NVRAM-based hardware architecture;
2. to use energy intelligently, by computing the worst-case energy consumption.

The ZEP project gathers four Inria teams that have a scientific background in architecture, compilation, operating systems together with the CEA Lialp and Lisan laboratories of CEA LETI & LIST [42]. The main application target is Internet of Things (IoT).

9.2.3. ANR Continuum (2015–2019)

Participants: Rabab Bouziane, Erven Rohou.

The CONTINUUM project aims to address the energy-efficiency challenge in future computing systems by investigating a design continuum for compute nodes, which seamlessly goes from software to technology levels via hardware architecture. Power saving opportunities exist at each of these levels, but the real measurable gains will come from the synergistic focus on all these levels as considered in this project. Then, a cross-disciplinary collaboration is promoted between computer science and microelectronics, to achieve two main breakthroughs: i) combination of state-of-the-art heterogeneous adaptive embedded multicore architectures with emerging communication and memory technologies and, ii) power-aware dynamic compilation techniques that suitably match such a platform.

Continuum started on Oct 1st 2015. Partners are LIRMM and Cortus SAS.

9.2.4. Hybrid SIMD architectures (2018–2019)

Participants: Sylvain Collange, Alexandre Kouyoumdjian, Erven Rohou.

The project objective is to define new parallel computer architectures that offer high parallel performance on high-regularity workloads while keeping the flexibility to run more irregular parallel workloads. inspired by both GPU and SIMD or vector architectures.

This project is funded by the French Ministry of Armed Forces (*Ministère des Armées*).

9.2.5. DGA/PEC ARMOUR (2018–2021)

Participants: Kévin Le Bon, Erven Rohou.

ARMOUR (dynAmic binaRy optiMizatiOn cyber-secURity) aims at improving the security of computing systems at the software level. Our contribution will be twofold: (1) identify vulnerabilities in existing software, and (2) develop adaptive countermeasure mechanisms against attacks. We will rely on dynamic binary rewriting (DBR) which consists in observing a program and modifying its binary representation in memory while it runs. DBR does not require the source code of the programs it manipulates, making it convenient for commercial and legacy applications. We will study the feasibility of an adaptive security agent that monitors target applications and deploys (or removes) countermeasures based on dynamic conditions. Lightweight monitoring is appropriate when the threat condition is low, heavy countermeasures will be dynamically woven into the code when an attack is detected. Vulnerability analysis will be based on advanced fuzzing. DBR makes it possible to monitor and modify deeply embedded variables, inaccessible to traditional monitoring systems, and also to detect unexpected/suspicious values taken by variables and act before the application crashes.

ARMOUR is funded by DGA (*Direction Générale de l'Armement*) and PEC (*Pôle d'Excellence Cyber*).

9.3. European Initiatives

9.3.1. FP7 & H2020 Projects

9.3.1.1. ANTAREX

Participants: Loïc Besnard, Imane Lasri, Erven Rohou.

Title: Auto-Tuning and Adaptivity appRoach for Energy efficient exascale HPC Systems

Program: H2020

Duration: September 2015 – November 2018

Coordinator: Politecnico di Milano, Italy (POLIMI)

Partners:

- Consorzio Interuniversitario Cineca (Italy)
- Dompé Farmaceutici Spa (Italy)
- Eidgenoessische Technische Hochschule Zürich (Switzerland)
- Vysoka Skola Banska - Technicka Univerzita Ostrava (Czech Republic)
- Politecnico di Milano (Italy)
- Sygic As (Slovakia)
- Universidade do Porto (Portugal)

Inria contact: Erven Rohou

Energy-efficient heterogeneous supercomputing architectures need to be coupled with a radically new software stack capable of exploiting the benefits offered by the heterogeneity at all the different levels (supercomputer, job, node) to meet the scalability and energy efficiency required by Exascale supercomputers. ANTAREX will solve these challenging problems by proposing a disruptive holistic approach spanning all the decision layers composing the supercomputer software stack and exploiting effectively the full system capabilities (including heterogeneity and energy management). The main goal of the ANTAREX project is to provide a breakthrough approach to express application self-adaptivity at design-time and to runtime manage and autotune applications for green and heterogenous High Performance Computing (HPC) systems up to the Exascale level.

9.3.1.2. ARGO

Participants: Imen Fassi, Damien Hardy, Isabelle Puaut.

Title: Argo: WCET-Aware Parallelization of Model-Based Applications for Heterogeneous Parallel Systems

Program: H2020

Type: RIA

Duration: Jan 2016 – Mar 2019

Coordinator: Karlsruhe Institut für Technologie (Germany)

Université de Rennes 1 contact: Steven Derrien

Partners:

Karlsruher Institut für Technologie (Germany)

SCILAB enterprises SAS (France)

Université de Rennes 1 (France)

Technologiko Ekpaideftiko Idryma (TEI) Dytikis Elladas (Greece)

Absint GmbH (Germany)

Deutsches Zentrum für Luft- und Raumfahrt EV (Germany)

Fraunhofer (Germany)

Increasing performance and reducing costs, while maintaining safety levels and programmability are the key demands for embedded and cyber-physical systems in European domains, e.g. aerospace, automation, and automotive. For many applications, the necessary performance with low energy consumption can only be provided by customized computing platforms based on heterogeneous many-core architectures. However, their parallel programming with time-critical embedded applications suffers from a complex toolchain and programming process. Argo (WCET-Aware PaRallelization of Model-Based Applications for HeteroGeneOus Parallel Systems) will address this challenge with a holistic approach for programming heterogeneous multi- and many-core architectures using automatic parallelization of model-based real-time applications. Argo will enhance WCET-aware automatic parallelization by a crosslayer programming approach combining automatic tool-based and user-guided parallelization to reduce the need for expertise in programming parallel heterogeneous architectures. The Argo approach will be assessed and demonstrated by prototyping comprehensive time-critical applications from both aerospace and industrial automation domains on customized heterogeneous many-core platforms.

Argo also involves Steven Derrien and Angeliki Kritikakou from the CAIRN team.

9.3.1.3. HiPEAC4 NoE

Participants: Pierre Michaud, Erven Rohou, André Seznec.

P. Michaud, A. Seznec and E. Rohou are members of the European Network of Excellence HiPEAC4.

HiPEAC4 addresses the design and implementation of high-performance commodity computing devices in the 10+ year horizon, covering both the processor design, the optimizing compiler infrastructure, and the evaluation of upcoming applications made possible by the increased computing power of future devices.

9.3.1.4. Eurolab-4-HPC

Participant: Erven Rohou.

Title: EuroLab-4-HPC: Foundations of a European Research Center of Excellence in High Performance Computing Systems

Program: H2020

Duration: September 2018 – September 2020

Coordinator: Chalmers Tekniska Hoegskola AB (Sweden)

Partners:

Barcelona Supercomputing Center - Centro Nacional de Supercomputacion (Spain)

Chalmers Tekniska Hoegskola (Sweden)

Foundation for Research and Technology Hellas (Greece)

Universität Stuttgart (Germany)

The University of Manchester (United Kingdom)

Inria (France)

Universität Augsburg (Germany)

ETH Zürich (Switzerland)

École Polytechnique Federale de Lausanne (Switzerland)

Technion - Israel Institute of Technology (Israel)

The University of Edinburgh (United Kingdom)

Rheinisch-Westfaelische Technische Hochschule Aachen (Germany)

Universiteit Gent (Belgium)

Inria contact: Albert Cohen (Inria Paris)

Europe has built momentum in becoming a leader in large parts of the HPC ecosystem. It has brought together technical and business stakeholders from application developers via system software to exascale systems. Despite such gains, excellence in high performance computing systems is often fragmented and opportunities for synergy missed. To compete internationally, Europe must bring together the best research groups to tackle the long-term challenges for HPC. These typically cut across layers, e.g., performance, energy efficiency and dependability, so excellence in research must target all the layers in the system stack. The EuroLab-4-HPC project's bold overall goal is to build connected and sustainable leadership in high-performance computing systems by bringing together the different and leading performance oriented communities in Europe, working across all layers of the system stack and, at the same time, fueling new industries in HPC.

9.4. International Initiatives

9.4.1. ANR CHIST-ERA SECODE 2016–2018

Participants: Damien Hardy, Nicolas Kiss, Erven Rohou.

Title: SECODE – Secure Codes to Thwart Cyber-Physical Attacks

CHIST-ERA - RTCPS

Duration: January 2016 – December 2018

Coordinator: Télécom Paris Tech (France)

Partners:

Télécom Paris Tech (France)

Inria (France)

Université Paris 8 (France)

Sabancı Üniversitesi (Turkey)

Université Catholique de Louvain (Belgium)

Inria contact: Erven Rohou

In this project, we specify and design error correction codes suitable for an efficient protection of sensitive information in the context of Internet of Things (IoT) and connected objects. Such codes mitigate passive attacks, like memory disclosure, and active attacks, like stack smashing. The innovation of this project is to leverage these codes for protecting against both cyber and physical attacks. The main advantage is a full coverage of attacks of the connected embedded systems, which is considered as a smart connected device and also a physical device. The outcome of the project is first a method to generate and execute cyber-resilient software, and second to protect data and its manipulation from physical threats like side-channel attacks.

9.5. International Research Visitors

9.5.1. Visits of International Scientists

9.5.1.1. Internships

Caio de Lima and Marcos Siraichi, both from Universidade Federal de Minas Gerais (Brazil), visited PACAP for internships:

- Caio de Lima: Jan 9 – Apr 5;
- Marcos Siraichi: Dec 15 2017 – Mar 3 and Jul 16 – Oct 13.

9.5.2. Visits to International Teams

André Seznec visited Intel Microprocessor Research Labs at Bangalore (India) from 24th to 28th of September.

PARKAS Project-Team

8. Partnerships and Cooperations

8.1. National Initiatives

The Inria Project Lab (IPL) *Modeliscale* treats the modelling and analysis of Cyber-Physical Systems at large scale. The PARKAS team contributes their expertise in programming language design for reactive and hybrid systems to this multi-team effort.

8.1.1. ANR

ANR/CHIST-ERA DIVIDEND project, 2013-2018.

8.1.2. FUI: Fonds unique interministériel

Modeliscale contract (AAP-24). Using Modelica at scale to model and simulate very large Cyber-Physical Systems. Principal industrial partner: Dassault-Systèmes. Inria contacts are Benoit Caillaud (HYCOMES, Rennes) and Marc Pouzet (PARKAS, Paris).

8.1.3. Others

Marc Pouzet is scientific advisor for the Esterel-Technologies/ANSYS company.

8.2. European Initiatives

8.2.1. H2020 Projects

Program: H2020 “Smart Anything Everywhere (SAE)” initiative

Project acronym: TETRAMAX

Project title: Technology Transfer via Multinational Application Experiments

Duration: September 2017 – August 2021

Coordinator: Rainer Leupers

Other partners: Rheinisch-Westfaelische Technische Hochschule Aachen, RWTH (Germany); AMG Technology Ood, AMGT (Bulgaria); Ruhr-Universitaet Bochum, RUB (Germany); Budapesti Muszaki Es Gazdasagtudomanyi Egyetem, BME (Hungary); Universitat Politecnica De Catalunya, UPC (Spain); Control Data Systems Srl, CDS (Romania); Chalmers Tekniska Hoegskola Ab, CHALMERS, (Sweden); Technische Universiteit Delft, TuDelft (Netherlands); The University Of Edinburgh, UEDIN, (United Kingdom); Fundingbox Accelerator Sp z o.o., FBOX, (Poland); Universiteit Gent, UGENT (Belgium); Vysoka Skola Banska -Technicka Univerzita Ostrava, IT4I, (Czech Republic); Institut Jozef Stefan, JSI, Slovenia, Techmo Spolka z o.o., TECHMO (Poland); Universita Di Pisa, PISA (Italy); Tallinna Tehnikaulikool, TTU (Estonia); Tty-Saatio,TUT (Finland); Think Silicon Ereyna Kai Technologia Anonymi, Etairia, THINKS (Greece); Technische Universitaet Muenchen, TUM (Germany); Sveuciliste U Zagrebu Fakultet Elektrotehnike I Racunarstva, UZAGREB, (Croatia); Zentrum Fur Innovation Und Technik In Nordrhein-Westfalen GmbH, ZENIT (Germany).

Abstract: The overall ambition of TETRAMAX is building and leveraging a European Competence Center Network in customized low-energy computing, providing easy access for SMEs and mid-caps to novel CLEC technologies via local contact points. This is a bidirectional interaction: SMEs can demand CLEC technologies and solutions via the network, and vice versa academic research institutions can actively and effectively offer their new technologies to European industries. Furthermore, TETRAMAX wants to support 50+ industry clients and 3rd parties with innovative technologies, using different kinds of Technology Transfer Experiments (TTX) to accelerate innovation within European industries and to create a competitive advantage in the global economy.

8.2.2. Collaborations in European Programs, Except FP7 & H2020

Program: ITEA3
Project acronym: 14014 ASSUME
Project title: Affordable Safe & Secure Mobility Evolution
Duration: September 2015 – December 2018
Coordinator: Dumitru Potop Butucaru
Other partners: *France:* Airbus, École Normale Supérieure (ENS), Esterel Technologies, Kalray SA, Safran Aircraft Engines SAS SNECMA, Safran Electronics & Defense Sagem, Sorbonne Université, Thales; *Germany:* AbsInt Angewandte Informatik GmbH, Assystem Germany GmbH, BTC Embedded Systems AG, Daimler AG, FZI Forschungszentrum Informatik, Karlsruhe Institute of Technology (KIT), Kiel University, Model Engineering Solutions GmbH, OFFIS, Robert Bosch GmbH, Technical University of Munich; *Netherlands:* Eindhoven University of Technology, NXP Semiconductors Netherlands BV, Recore Systems BV, TNO, University of Twente, VDL Enabling Transport Solutions, Verum Software Tools BV; *Sweden:* Arcticus Systems AB, FindOut Technologies AB, KTH (Royal Institute of Technology), Mälardalen University, Scania; *Turkey:* Arçelik, Ericsson Ar-Ge, Ford Otosan, Havelsan, KoçSistem, UNIT Information Technologies R&D Ltd.
Abstract: Future mobility solutions will increasingly rely on smart components that continuously monitor the environment and assume more and more responsibility for a convenient, safe and reliable operation. Currently the single most important roadblock for this market is the ability to come up with an affordable, safe multi-core development methodology that allows industry to deliver trustworthy new functions at competitive prices. ASSUME will provide a seamless engineering methodology, which addresses this roadblock on the constructive and analytic side.

8.3. International Initiatives

8.3.1. Inria Associate Teams Not Involved in an Inria International Labs

8.3.1.1. POLYFLOW

Title: Polyhedral Compilation for Data-Flow Programming Languages
International Partner (Institution - Laboratory - Researcher):

IISc Bangalore (India) - Department of Computer Science and Automation (CSA) - Uday Kumar Reddy Bondhugula

Start year: 2016
See also: http://polyflow.gforge.inria.fr
The objective of the associate team is to foster collaborations on fundamental and applied research. It also supports training sessions, exchange of undergraduate and master students, and highlighting opportunities in the partners' research, education and economic environments.

Polyhedral techniques for program transformation are now used in several proprietary and open source compilers. However, most of the research on polyhedral compilation has focused on imperative languages, where computation is specified in terms of computational statements within nested loops and control structures. Graphical data-flow languages, where there is no notion of statements or a schedule specifying their relative execution order, have so far not been studied using a powerful transformation or optimization approach. These languages are extremely popular in the system analysis, modeling and design of embedded reactive control applications. They also underline the construction of domain-specific languages and compiler intermediate representations. The execution semantics of data-flow languages impose a different set of challenges for compilation and optimization. We are studying techniques enabling the extraction of a polyhedral representation from data-flow programs, to transform them with the goal of generating memory-efficient and high-performance code for modern architectures.

The research conducted in PolyFlow covers both fundamental and applied aspects. The partners also emphasize the development of solid research tools. The associate team will facilitate their dissemination as free software and their exploitation through industrial collaborations.

8.3.2. Participation in Other International Programs

- VerticA (Francesco Zappa Nardelli), 2017-2020, joint project with Northeastern University, USA, financed by the ONR (Office of Naval Research), $1.5M (subcontract for $150k).

8.3.2.1. Indo-French Center of Applied Mathematics

POLYFLOW

Title: Polyhedral Compilation for Data-Flow Programming Languages

International Partner (Institution - Laboratory - Researcher):

IISc Bangalore (India) - Uday Kumar Reddy Bondhugula

Duration: 2016 - 2018

Start year: 2016

The objective of the associate team is to foster collaborations on fundamental and applied research. It also supports training sessions, exchange of undergraduate and master students, and highlighting opportunities in the partners' research, education and economic environments. Polyhedral techniques for program transformation are now used in several proprietary and open source compilers. However, most of the research on polyhedral compilation has focused on imperative languages, where computation is specified in terms of computational statements within nested loops and control structures. Graphical data-flow languages, where there is no notion of statements or a schedule specifying their relative execution order, have so far not been studied using a powerful transformation or optimization approach. These languages are extremely popular in the system analysis, modeling and design of embedded reactive control applications. They also underline the construction of domain-specific languages and compiler intermediate representations. The execution semantics of data-flow languages impose a different set of challenges for compilation and optimization. We are studying techniques enabling the extraction of a polyhedral representation from data-flow programs, to transform them with the goal of generating memory-efficient and high-performance code for modern architectures. The research conducted in PolyFlow covers both fundamental and applied aspects. The partners also emphasize the development of solid research tools. The associate team will facilitate their dissemination as free software and their exploitation through industrial collaborations.

PARSIFAL Project-Team

8. Partnerships and Cooperations

8.1. National Initiatives

8.1.1. ANR

COCA HOLA: Cost Models for Complexity Analyses of Higher-Order Languages, coordinated by B. Accattoli, 2016–2019.

FISP: The Fine Structure of Formal Proof Systems and their Computational Interpretations, coordinated by Lutz Straßburger in collaboration with Université Paris 7, Universität Innsbruck and TU Wien, 2016–2019.

8.1.2. Competitivity Clusters

UPScale: Universality of Proofs in SaCLay, a Working Group of LabEx DigiCosme, organized by Chantal Keller (LRI) with regular participation from Parsifal members and a post-doc co-supervision.

8.2. International Research Visitors

8.2.1. Internships

Simon Colin did an M1 internship supervised by G. Scherer, conducting a static analysis to check the safety, in OCaml, of unboxing annotations on type declarations.

Alban Reynaud did an L3 internship supervised by G. Scherer, conducting a static analysis to check the safety, in OCaml, of recursive value declarations.

8.2.2. Visits to International Teams

8.2.2.1. Research Stays Abroad

S. Graham-Lengrand was an International Fellow at SRI International, for 25 months over a period of three years between 2015 and 2018.

PESTO Project-Team

9. Partnerships and Cooperations

9.1. National Initiatives

9.1.1. CNRS

CNRS PEPS INS2I 2016-2018 project ASSI *Analyse de Sécurité de Systèmes Industriels*, duration: 2 years, leader: Pascal Lafourcade (Univ Clermont-Ferrand), participant Pesto: Jannik Dreier, other participants: Marie-Laure Potet, Maxime Puys (Univ Grenoble-Alpes).

The goal of the project is to develop an approach to verify protocols used in industrial control (SCADA) systems using tools such as *TAMARIN* or ProVerif. These protocols have specific security requirements such as flow integrity, going beyond the classical authentication and secrecy properties. The project also aims at analyzing different intruder models matching the particularities of industrial systems, and to develop specific modeling and verification techniques.

9.1.2. ANR

- ANR SEQUOIA *Security properties, process equivalences and automated verification*, duration: 4 years, since October 2014, leader: Steve Kremer, other partners: ENS Cachan, Univ Luxembourg. Most protocol analysis tools are restricted to analyzing reachability properties while many security properties need to be expressed in terms of some process equivalences. The increasing use of observational equivalence as a modeling tool shows the need for new tools and techniques that are able to analyze such equivalence properties. The aims of this project are *(i)* to investigate which process equivalences — among the plethora of existing ones — are appropriate for a given security property, system assumptions and attacker capabilities; *(ii)* to advance the state of the art of automated verification for process equivalences, allowing for instance support for more cryptographic primitives, relevant for case studies; *(iii)* to study protocols that use low-entropy secrets expressed using process equivalences; *(iv)* to apply these results to case studies from electronic voting.
- ANR TECAP *Protocol Analysis — Combining Existing Tools*, duration: 4 years, starting in 2018, leader: Vincent Cheval, other partners: ENS Cachan, Inria Paris, Inria Sophia Antipolis, IRISA, LIX. Despite the large number of automated verification tools, several cryptographic protocols (e.g. stateful protocols) still represent a real challenge for these tools and reveal their limitations. To cope with these limits, each tool focuses on different classes of protocols depending on the primitives, the security properties, etc. Moreover, the tools cannot interact with each other as they evolve in their own model with specific assumptions. The aim of this project is to get the best of all these tools, that is, to improve the theory and implementations of each individual tool towards the strengths of the others and to build bridges that allow the cooperations of the methods/tools. We will focus in this project on CryptoVerif, EasyCrypt, Scary, ProVerif, *TAMARIN*, *Akiss* and APTE. In order to validate the results obtained in this project, we will apply our results to several case studies such as the Authentication and Key Agreement protocol from the telecommunication networks, the Scytl and Helios voting protocols, and the low entropy 3D-Secure authentication protocol. These protocols have been chosen to cover many challenges that the current tools are facing.

9.1.3. Fondation MAIF

Project *Protection de l'information personnelle sur les réseaux sociaux*, from October 2014 to March 2018. The goal of the project is to lay the foundation for a risk verification environment on privacy in social networks. Given social relations, this environment will rely on the study of metrics to characterize the security level for a user. Next, by combining symbolic and statistical techniques, our objective is to synthesize a model of risk behavior as a rule base. Finally, a verifier based on model-checking will be developed to assess the security level of user. The partners are Pesto (leader), Orpailleur and Fondation MAIF.

9.2. European Initiatives

9.2.1. FP7 & H2020 Projects

- SPOOC (2015–2020) [0]— ERC Consolidator Grant on Automated Security Proofs of Cryptographic Protocols: Privacy, Untrusted Platforms and Applications to E-voting Protocols.

  The goals of the Spooc project are to develop solid foundations and practical tools to analyze and formally prove security properties that ensure the privacy of users as well as techniques for executing protocols on untrusted platforms. We will

  – develop foundations and practical tools for specifying and formally verifying new security properties, in particular privacy properties;

  – develop techniques for the design and automated analysis of protocols that have to be executed on untrusted platforms;

  – apply these methods in particular to novel e-voting protocols, which aim at guaranteeing strong security guarantees without the need to trust the voter client software.

  Steve Kremer is the leader of the project.

9.3. International Initiatives

9.3.1. Inria International Partners

9.3.1.1. Informal International Partners

- Collaboration with David Basin, Ralf Sasse and Lara Schmid (ETH Zurich), Cas Cremers (Univ Oxford), and Sasa Radomirovic (Univ Dundee) on the improvement of the *TAMARIN* prover
- Collaboration with Constantin Catalin Dragan (Univ of Surrey), Francois Dupressoir (Univ of Surrey), and Bogdan Warinschi (Univ Bristol) on proving security of voting protocols with EasyCrypt.
- Collaboration with Matteo Maffei (Univ Wien) on type systems for e-voting systems
- Collaboration with Bogdan Warinschi (Univ Bristol) on defining game-based privacy for e-voting protocols
- Collaboration with Robert Künnemann (CISPA, Germany) on the development of the SAPIC tool.
- Collaboration with Paliath Narendran's group (SUNY Albany) on automated deduction
- Collaboration with Hanifa Boucheneb's group (Polytechnique Montreal) on model-checking of collaborative systems
- Collaboration with John Mullins's group (Polytechnique Montreal) on information hiding

9.4. International Research Visitors

9.4.1. Visits of International Scientists

- Bogdan Warinschi (Univ Bristol), November 2018

[0] https://members.loria.fr/SKremer/files/spooc/index.html

PI.R2 Project-Team

7. Partnerships and Cooperations

7.1. National Initiatives

Pierre-Louis Curien, Yves Guiraud, Hugo Herbelin, and Alexis Saurin are members of the GDR Informatique Mathématique, in the LHC (Logique, Homotopie, Catégories) and Scalp (Structures formelles pour le calcul et les preuves) working groups. Alexis Saurin is coordinator of the Scalp working group.

Pierre-Louis Curien, Yves Guiraud (local coordinator) and Matthieu Sozeau are members of the GDR Topologie Algébrique, federating French researchers working on classical topics of algebraic topology and homological algebra, such as homotopy theory, group homology, K-theory, deformation theory, and on more recent interactions of topology with other themes, such as higher categories and theoretical computer science.

Yves Guiraud is member of the GDR Tresses, federating French researchers working on algebraic, algorithmic and topological aspects of braid groups, low-dimensional topology, and connected subjects.

Yann Régis-Gianas collaborates with Mitsubishi Rennes on the topic of differential semantics. This collaboration led to the CIFRE grant for the PhD of Thibaut Girka.

Yann Régis-Gianas collaborates with ANSSI on the topic of certified ful programming in Coq.

Yann Régis-Gianas is a member of the ANR COLIS dedicated to the verification of Linux Distribution installation scripts. This project is joint with members of VALS (Univ Paris Sud) and LIFL (Univ Lille).

Yann Régis-Gianas and Alexis Saurin (coordinator) are members of the four-year RAPIDO ANR project, started in January 2015. RAPIDO aims at investigating the use of proof-theoretical methods to reason and program on infinite data objects. The goal of the project is to develop logical systems capturing infinite proofs (proof systems with least and greatest fixpoints as well as infinitary proof systems), to design and to study programming languages for manipulating infinite data such as streams both from a syntactical and semantical point of view. Moreover, the ambition of the project is to apply the fundamental results obtained from the proof-theoretical investigations (i) to the development of software tools dedicated to the reasoning about programs computing on infinite data, *e.g.* stream programs (more generally coinductive programs), and (ii) to the study of properties of automata on infinite words and trees from a proof-theoretical perspective with an eye towards model-checking problems. Other permanent members of the project are Christine Tasson from IRIF (PPS team), David Baelde from LSV, ENS-Cachan, and Pierre Clairambault, Damien Pous and Colin Riba from LIP, ENS-Lyon.

Matthieu Sozeau is a member of the CoqHoTT project led by Nicolas Tabareau (Gallinette team, Inria Nantes & École des Mines de Nantes), funded by an ERC Starting Grant. The post-doctoral grant of Eric Finster is funded by the CoqHoTT ERC and Amin Timany's 2-month visit was funded on the ERC as well.

7.2. European Initiatives

7.2.1. Collaborations in European Programs, Except FP7 & H2020

Hugo Herbelin is a deputy representative of France in the COST action EUTYPES. The full name of the project (whose scientific leader is Herman Geuvers, from the University of Nijmegen) is "European research network on types for programming and verification".

Presentation of EUTYPES: Types are pervasive in programming and information technology. A type defines a formal interface between software components, allowing the automatic verification of their connections, and greatly enhancing the robustness and reliability of computations and communications. In rich dependent type theories, the full functional specification of a program can be expressed as a type. Type systems have rapidly evolved over the past years, becoming more sophisticated, capturing new aspects of the behaviour of programs and the dynamics of their execution. This COST Action will give a strong impetus to research on type theory and its many applications in computer science, by promoting (1) the synergy between theoretical computer scientists, logicians and mathematicians to develop new foundations for type theory, for example as based on the recent development of "homotopy type theory", (2) the joint development of type theoretic tools as proof assistants and integrated programming environments, (3) the study of dependent types for programming and its deployment in software development, (4) the study of dependent types for verification and its deployment in software analysis and verification. The action will also tie together these different areas and promote cross-fertilisation.

7.3. International Initiatives

7.3.1. IIL projects

Matthieu Sozeau is part of an international collaboration network CSEC "Certified Software Engineering in Coq" funded by Inria Chile, Conicyt and the CoqHoTT ERC, which officially started in early 2018. The participants include Eric Tanter (primary investigator) and Nicolas Tabareau.

7.3.2. Inria Associate Teams Not Involved in an Inria International Labs

7.3.2.1. Associate team

Pierre-Louis Curien and Claudia Faggian are members of the CRECOGI associate team, coordinated on one side by Ugo dal Lago (research-team FoCUS , Inria Sophia and Bologna), and on the other side by Ichiro Hasuo (NII, Tokyo). The full name of the project is Concurrent, Resourceful and full Computation, by Geometry of Interaction.

Presentation of CRECOGI: Game semantics and geometry of interaction (GoI) are two closely related frameworks whose strengh is to have the characters of both a denotational and an operational semantics. They offer a high-level, mathematical (denotational) interpretation, but are interactive in nature. The formalisation in terms of movements of tokens through which programs communicate with each other can actually be seen as a low-level program. The current limit of GoI is that the vast majority of the literature and of the software tools designed around it have a pure, sequential functional language as their source language. This project aims at investigating the application of GoI to concurrent, resourceful, and effectful computation, thus paving the way to the deployment of GoI-based correct-by-construction compilers in real-world software developments in fields like (massively parallel) high-performance computing, embedded and cyberphysical systems, and big data. The presence of both the Japanese GoI community (whose skills are centered around effects and coalgebras) and the French GoI community (more focused on linear logic and complexity analysis) bring essential, complementary, ingredients.

7.3.2.2. Joint Inria-CAS project

Pierre-Louis Curien is principal investigator on the French side for a joint project Inria - Chinese Academy of Sciences. The project's title is "Verification, Interaction, and Proofs". The principal investigator on the Chinese side is Ying Jiang, from the Institute of Software (ISCAS) in Beijing. The participants of the project on the French side are Pierre-Louis Curien and Jean-Jacques Lévy, as well as other members of IRIF (Thomas Ehrhard, Jean Krivine, Giovanni Bernardi, Ahmed Bouajjani, Mihaela Sighireanu, Constantin Enea, Gustavo Petri), and Gilles Dowek (Deducteam team of Inria Saclay). On the Chinese side, the participants are Ying Jiang, as well as other members of the ISCAS (Angsheng Li, Xinxin Liu, Yi Lü, Peng Wu, Yan Rongjie, Zhilin Wu, and Wenhui Zhang), and Yuxi Fu (from Shanghai Jiaotong University). The project funds the postdoc of Kailiang Ji at University Paris 7, that started in December 2017 and will end in Marche 2019.

Presentation of VIP: The line between "verification" and "proofs" is comparable to the one separating satisfiability and provability: in a formal system, a formula can be trusted either if it is satisfied in the intended model (for all of its instances), or if it can be proved formally by using the axioms and inference rules of some logical system. These two directions of work are called model-checking and proof-checking, respectively. One of the aims of the present project is to bring specialists of the two domains together and to tackle problems where model-checking and proof-checking can be combined (the "V" and the "P" of the acronym). Applications in the realm of distributed computation, or concurrency theory (the "I" of the acronym) are particularly targeted.

7.3.3. Inria International Partners

7.3.3.1. Informal International Partners

The project-team has collaborations with University of Aarhus (Denmark), KU Leuven, University of Oregon, University of Tokyo, University of Sovi Sad and the Institute of Mathematics of the Serbian Academy of Sciences, University of Nottingham, Institute of Advanced Study, MIT, University of Cambridge, Universidad Nacional de Córdoba, and Universidad de Chile.

7.4. International Research Visitors

7.4.1. Visits of International Scientists

Mauro Jaskelioff (National University of Rosario and CONICET, Argentina) visited the team for a week in May 2018.

Vadim Zaliva (PhD student at CMU) visited the team for one month in July 2018 and collaborated with Matthieu Sozeau on the use of Template-Coq to verify translations from shallow to deep embeddings.

7.4.2. Internships

Yann Régis-Gianas supervised the internship of Loïc Peyrot (Master 1, Paris Diderot) about the development of a tool to define exercises for the learn-ocaml platform in a single ML file.

Yann Régis-Gianas supervised the internship of Carine Morel (Master 1, Paris Diderot) about the development of a user-friendly teaching-oriented documentation for the learn-ocaml platform.

Yann Régis-Gianas supervised the internship of Olivier Martinot (Licence 3, Paris Diderot) about the implementation of a set of efficient incrementalised combinators for list processing in cache-transfer style.

Alexis Saurin co-supervised the internship of Ikram Cherigi (Master 2 LMFI, Paris Diderot) about classical realisability and forcing in set theory.

Alexis Saurin supervised the internship of Xavier Onfroy (Master 2 LMFI, Paris Diderot) on formalisation of circular proofs in fixed-point logics and the decidability of validity.

Alexis Saurin supervised the internship of Kostia Chardonnet (Master 1 MPRI, Paris Diderot) about call-by-need calculus, degrees of lazyness and probabilistic lambda calculus.

7.4.3. Research Stays Abroad

Pierre-Louis Curien visited East China Normal University for a month from mid-October to mid-November 2018 (collaborations with Yuxin Deng and Min Zhang) as invited professor.

Pierre-Louis Curien visited the Institute of Mathematics of the Serbian Academy of Sciences in Belgrade in September 2018 for a week (collaboration with Zoran Petrić and other coauthors).

Hugo Herbelin participated to the Types, Sets and Constructions Trimester Program at the Hausdorff Research Institute of Mathematics in Bonn, May-August 2018.

POLSYS Project-Team

8. Partnerships and Cooperations

8.1. Regional Initiatives

- **French Ministry of Armies**

  POLSYS has a collaboration with the French Ministry of Armies.

- **Grant GAMMA** (funded by PGMO).

  GLOBAL ALGEBRAIC SHOOTING METHOD IN OPTIMAL CONTROL AND APPLICATIONS

  Optimal control consists in steering a system from an initial configuration to a final one, while minimizing some given cost criterion. One of the current main challenges is to develop innovative methods for computing global solutions. This is crucial for applications where validating the global control laws is a crucial but a highly time consuming and expensive phase. GAMMA focuses on the wide range of optimal control problems having an algebraic structure, involving for instance polynomial or semi-algebraic dynamics and costs, or switches between polynomial models. In this case, GAMMA aims at designing methods relying on algebraic computations to the mainstream shooting method in order to yield optimal solutions that purely numerical techniques cannot provide.

8.2. National Initiatives

8.2.1. ANR

- **ANR Jeunes Chercheurs GALOP (Games through the lens of ALgebra and OPptimization)**

  `Duration:` 2018–2022

  GALOP [0] is a Young Researchers (JCJC) project with the purpose of extending the limits of the state-of-the-art algebraic tools in computer science, especially in stochastic games. It brings original and innovative algebraic tools, based on symbolic-numeric computing, that exploit the geometry and the structure and complement the state-of-the-art. We support our theoretical tools with a highly efficient open-source software for solving polynomials. Using our algebraic tools we study the geometry of the central curve of (semi-definite) optimization problems. The algebraic tools and our results from the geometry of optimization pave the way to introduce algorithms and precise bounds for stochastic games.

  `Participants:` E. Tsigaridas [contact], F. Johansson, H. Gimbert, J.-C. Faugère, M. Safey El Din.

8.2.2. Programme d'investissements d'avenir (PIA)

- **PIA grant RISQ: Regroupement of the Security Industry for Quantum-Safe security (2017-2020).** The goal of the RISQ project is to prepare the security industry to the upcoming shift of classical cryptography to quantum-safe cryptography. (J.-C. Faugère [contact], and L. Perret).

  The RISQ [0] project is certainly the biggest industrial project ever organized in quantum-safe cryptography. RISQ is one of few projects accepted in the call Grands DΓ©fis du NumΓ©rique which is managed by BPI France, and will be funded thanks to the so-called Plan d'Investissements d'Avenir.

  The RISQ project is a natural continuation of POLSYS commitment to the industrial transfert of quantum-safe cryptography. RISQ is a large scale version of the HFEBoost project; which demonstrated the potential of quantum-safe cryptography.

[0] https://project.inria.fr/galop/
[0] http://risq.fr/

POLSYS actively participated to shape the RISQ project. POLSYS is now a member of the strategic board of RISQ, and is leading the task of designing and analyzing quantum-safe algorithms. In particular, a first milestone of this task was to prepare submissions to NIST's quantum-safe standardisation process.

- **ANR SESAME (Singularités Et Stabilité des AsservisseMEnts référencés capteurs)**

  Duration: 2018–2022

  Participants: J.-C. Faugère, M. Safey El Din.

8.3. European Initiatives

8.3.1. FP7 & H2020 Projects

- **Innovative Training Network POEMA (Polynomial Optimization, Efficiency through Moments and Algebra)**

  Duration: 2019-2022.

  POEMA is a Marie Skłodowska-Curie Innovative Training Network (2019-2022).

  Its goal is to train scientists at the interplay of algebra, geometry and computer science for polynomial optimization problems and to foster scientific and technological advances, stimulating interdisciplinary and intersectoriality knowledge exchange between algebraists, geometers, computer scientists and industrial actors facing real-life optimization problems.

  Participants: J. Berthomieu, J.-C. Faugère, M. Safey El Din [contact], E. Tsigaridas.

8.3.2. Collaborations in European Programs, Except FP7 & H2020

Program: COST

Project acronym: CryptoAction

Project title: Cryptography for Secure Digital Interaction

Duration: Apr. 2014 - Apr. 2018

Coordinator: Claudio ORLANDI

Abstract: As increasing amounts of sensitive data are exchanged and processed every day on the Internet, the need for security is paramount. Cryptography is the fundamental tool for securing digital interactions, and allows much more than secure communication: recent breakthroughs in cryptography enable the protection - at least from a theoretical point of view - of any interactive data processing task. This includes electronic voting, outsourcing of storage and computation, e-payments, electronic auctions, etc. However, as cryptography advances and becomes more complex, single research groups become specialized and lose contact with "the big picture". Fragmentation in this field can be dangerous, as a chain is only as strong as its weakest link. To ensure that the ideas produced in Europe's many excellent research groups will have a practical impact, coordination among national efforts and different skills is needed. The aim of this COST Action is to stimulate interaction between the different national efforts in order to develop new cryptographic solutions and to evaluate the security of deployed algorithms with applications to the secure digital interactions between citizens, companies and governments. The Action will foster a network of European research centers thus promoting movement of ideas and people between partners.

Program: COST

Project acronym: CRYPTACUS

Project title: Cryptanalysis of ubiquitous computing systems

Duration: Dec. 2014 - Dec. 2018

Coordinator: Gildas AVOINE

Abstract: Recent technological advances in hardware and software have irrevocably affected the classical picture of computing systems. Today, these no longer consist only of connected servers, but involve a wide range of pervasive and embedded devices, leading to the concept of “ubiquitous computing systems”. The objective of the Action is to improve and adapt the existent cryptanalysis methodologies and tools to the ubiquitous computing framework. Cryptanalysis, which is the assessment of theoretical and practical cryptographic mechanisms designed to ensure security and privacy, will be implemented along four axes: cryptographic models, cryptanalysis of building blocks, hardware and software security engineering, and security assessment of real-world systems. Researchers have only recently started to focus on the security of ubiquitous computing systems. Despite the critical flaws found, the required highly-specialized skills and the isolation of the involved disciplines are a true barrier for identifying additional issues. The Action will establish a network of complementary skills, so that expertise in cryptography, information security, privacy, and embedded systems can be put to work together. The outcome will directly help industry stakeholders and regulatory bodies to increase security and privacy in ubiquitous computing systems, in order to eventually make citizens better protected in their everyday life.

8.4. International Research Visitors

8.4.1. Visits of International Scientists

8.4.1.1. Internships

Reine Abi Rached

Date: Apr. 2018 - Aug. 2018

Institution: Université de Versailles –St-Quentin-en-Yvelines

Supervisor: Jean-Charles Faugère, Jérémy Berthomieu

Hadrien Brochet

Date: Jun. 2018 - Aug. 2018

Institution: ENS Lyon

Supervisor: Elias Tsigaridas

Phuoc Le

Date: Apr. 2018 - Aug. 2018

Institution: Université de Versailles –St-Quentin-en-Yvelines

Supervisor: Jean-Charles Faugère, Mohab Safey El Din

8.4.2. Visits to International Teams

8.4.2.1. Research Stays Abroad

Elias Tsigaridas was a visiting research scientist at the ICERM institute (Brown University) during the special semester on "Nonlinear Algebra" (Sep – Nov 2018).

PRIVATICS Project-Team

7. Partnerships and Cooperations

7.1. Regional Initiatives

7.1.1. AMNECYS

- Title: AMNECYS
- Duration: 2015 - .
- Coordinator: CESICE, UPMF.
- Others partners: Inria/Privatics and LIG/Moais, Gipsa-lab, LJK, Institut Fourier, TIMA, Vérimag, LISTIC (Pole MSTIC) .
- Abstract: Privatics participates to the creation of an Alpine Multidisciplinary NEtwork on CYbersecurity Studies (AMNECYS). The academic teams and laboratories participating in this project have already developed great expertise on encryption technologies, vulnerabilities analysis, software engineering, protection of privacy and personal data, international & European aspects of cybersecurity. The first project proposal (ALPEPIC ALPs-Embedded security: Protecting Iot & Critical infrastructure) focuses on the protection of the Internet of Things (IoT) and Critical Infrastructure (CI).

7.1.2. Data Institute

- Title: Data Institute UGA
- Duration: 2017 - .
- Coordinator: TIMC-IMAG.
- Others partners: AGEIS, BIG, CESICE, GIN, GIPSA-lab, IAB, IGE, IPAG, LAPP, LARHRA, LIDILEM, LIG, LISTIC, LITT&ArTS, LJK, LUHCIE, LECA, OSUG, PACTE, TIMC-IMAG
- Abstract: Privatics is leading the WP5 (Data Governance, Data Protection and Privacy). This action (WP5) aims to analyze, in a multi-disciplinary perspective, why and how specific forms of data governance emerge as well as the consequences on the interaction between the state, the market and society. The focus will be on the challenges raised by the collection and use of data for privacy, on the data subjects' rights and on the obligations of data controllers and processors. A Privacy Impact/Risk assessments methodology and software will be proposed. A case study will focus on medical and health data and make recommendations on how they should be collected and processed.

7.1.3. CyberAlps

- Title: CyberAlps
- Duration: 2018 - .
- Coordinator: IF.
- Others partners: CEA LETI, CERAG, CESICE, CREg, G2E lab, GIPSA-lab, GSCOP, IF, LCIS, LIG, LISTIC, LJK, PACTE, TIMC-IMAG, VERIMAG.
- Abstract: The Grenoble Alpes Cybersecurity Institute aims at undertaking ground-breaking interdisciplinary research in order to address cybersecurity and privacy challenges. Our main technical focus is on low-cost secure elements, critical infrastructures, vulnerability analysis and validation of large systems, including practical resilience across the industry and the society. Our approach to cybersecurity is holistic, encompassing technical, legal, law-enforcement, economic, social, diplomatic, military and intelligence-related aspects with strong partnerships with the private sector and robust national and international cooperation with leading institutions in France and abroad.

7.1.4. Antidot

- Title: Antidot
- Type: Fédération Informatique de Lyon (inter laboratories project)
- Duration: September 2018 - 2020.
- Coordinator: Inria.
- Others partners: LIRIS.
- Abstract: The ANTIDOT project is interested in the privacy issues raised by the increasingly ubiquitous collection of mobility data and their exploitation by third-party applications. The objective of this project is to propose solutions and tools to increase the user awareness about the risks of violation of their privacy in the context of the mobile Internet. In order to achieve this objective, ANTIDOT will jointly address the study of information gathering mechanisms, the study of mobility data vulnerabilities and the protection of this personal data.

7.2. National Initiatives

7.2.1. FUI

Title: ADAGE (Anonymous Mobile Traffic Data Generation).

Type: FUI.

Duration: July 2016 - September 2018.

Coordinator: Orange.

Others partners: Inria, CNRS LAAS.

Abstract: The project ADAGE aims at developping solutions for the anonymization of mobility traces produced by mobile operators.

7.2.2. ANR

7.2.2.1. CISC

Title: Certification of IoT Secure Compilation.

Type: ANR.

Duration: April 2018 - March 2022.

Coordinator: Inria INDES project-team (France)

Others partners: Inria CELTIC project-team (France), College de France (France) (France).

See also: http://cisc.gforge.inria.fr.

Abstract: The objective of the ANR CISC project is to investigate multitier languages and compilers to build secure IoT applications with private communication. A first goal is to extend multitier platforms by a new orchestration language that we call Hiphop.js to synchronize internal and external activities of IoT applications as a whole. CISC will define the language, semantics, attacker models, and policies for the IoT and investigate automatic implementation of privacy and security policies by multitier compilation of IoT applications. To guarantee such applications are correct, and in particular that the required security and privacy properties are achieved, the project will certify them using the Coq proof assistant.

7.2.2.2. SIDES 3.0

Title: Application of privacy by design to biometric access control.

Type: ANR.

Duration: August 2017 - August 2020.

Coordinator: Uness (France).

Others partners: Inria, UGA, ENS, Theia, Viseo.

Abstract: Since 2013, faculties of medicine have used a shared national platform that enables them to carry out all of their validating exams on tablets with automatic correction. This web platform entitled SIDES allowed the preparation of the medical students to the Computerized National Classing Events (ECN) which were successfully launched in June 2016 (8000 candidates simultaneously throughout France). SIDES 3.0 proposes to upgrade the existing platform. Privatics goals in this project is to ensure that privacy is respected and correctly assessed .

7.2.2.3. DAPCODS/IOTics

Title: DAPCODS/IOTics.

Type: ANR 2016.

Duration: May 2017 - Dec. 2020.

Coordinator: Inria PRIVATICS.

Others partners: Inria DIANA, EURECOM, Univ. Paris Sud, CNIL.

Abstract:

Thanks to the exponential growth of Internet, citizens have become more and more exposed to personal information leakage in their digital lives. This trend began with web tracking when surfing the Internet with our computers. The advent of smartphones, our personal assistants always connected and equipped with many sensors, further reinforced this tendency. And today the craze for "quantified self" wearable devices, for smart home appliances or for other connected devices enable the collection of potentially highly sensitive personal information in domains that were so far out of reach. However, little is known about the actual practices in terms of security, confidentiality, or data exchanges. The enduser is therefore prisoner of a highly asymmetric system. This has important consequences in terms of regulation, sovereignty, and leads to the hegemony of the GAFAs (Google, Amazon, Facebook and Apple). Security, transparency and user control are three key properties that should be followed by all the stakeholders of the smartphone and connected devices ecosystem. Recent scandals show that the reality is sometimes at the opposite.

The DAPCODS project gathers four renowned research teams, experts in security, privacy and digital economy. They are seconded by CNIL, the French data protection agency. The project aims at contributing along several axes:

- by analyzing the inner working of a significant set of connected devices in terms of personal information leaks. This will be made possible by analyzing their data flows (and associated smartphone application if applicable) from outside (smartphone and/or Wifi network) or inside, through ondevice static and dynamic analyses. New analysis methods and tools will be needed, some of them leveraging on previous works when applicable;
- by studying the device manufacturers' privacy policies along several criteria (e.g., accessibility, precision, focus, privacy risks). In a second step, their claims will be compared to the actual device behavior, as observed during the test campaigns. This will enable an accurate and unique ranking of connected devices;
- by understanding the underlying ecosystem, from the economical viewpoint. Data collected will make it possible to define the blurred boundaries of personal information market, a key aspect to set up an efficient regulation;
- and finally, by proposing a public website that will rank those connected devices and will inform citizens. We will then test the impact of this information on the potential change of behavior of stakeholders.

By giving transparent information of hidden behaviors, by highlighting good and bad practices, this project will contribute to reduce the information asymmetry of the system, to give back some control to the endusers, and hopefully to encourage certain stakeholders to change practices.

7.2.3. Inria Innovation Laboratory

Title: LEELCO (Low End-to-End Latency COmmunications).

Duration: 3 years (2015 - 2018).

Coordinator: Inria PRIVATICS.

Others partners: Expway.

Abstract:

This Inria Innovation Lab aims at strengthening Expway (http://www.expway.com/) commercial offer with technologies suited to real-time data transmissions, typically audio/video flows. In this context, the end-to-end latency must be reduced to a minimum in order to enable a high quality interaction between users, while keeping the ability to recover from packet losses that are unavoidable with wireless communications in harsh environments. In this collaboration we focus on new types of Forward Erasure Correction (FEC) codes based on a sliding encoding windows, and on the associated communication protocols, in particular an extension to FECFRAME (RFC6363) to such FEC codes. The outcomes of this work are proposed to both IETF and 3GPP standardisation organisations, in particular in the context of 3GPP mission critical communication services activity. The idea of this 3GPP activity is to leverage on the 3GPP Evolved Multimedia Broadcast Multicast Services (eMBMS) and on the existing Long Term Evolution (LTE) infrastructure for critical communications and such services as group voice transmissions, live high-definition video streams and large data transmissions. In this context, the advanced FEC codes studied in LEELCO offer a significant improvement both from the reduced latency and increased loss recovery viewpoints compared to the Raptor codes included in the existing standard (https://hal.inria.fr/hal-01571609v1/en/).

7.2.4. Inria CNIL project

Privatics is in charged of the Cnil-Inria collaboration. This collaboration was at the origin of the Mobilitics project and it is now at the source of many discussions and collaborations on data anoymisation, risk analysis, consent or IoT Privacy. Privatics and Cnil are both actively involved on the IoTics project, that is the follow-up of the Mobilitics projects. The goal of the Mobilitics project was to study information leakage in mobile phones. The goal of IoTics is to extend this work to IoT and connected devices.

Privatics is also in charged of the organization of the Cnil-Inria prize that is awarded every year to an outstanding publication in the field of data privacy.

7.3. European Initiatives

7.3.1. Collaborations in European Programs, Except FP7 & H2020

7.3.1.1. COPES

Title: COnsumer-centric Privacy in smart Energy gridS

Programm: CHISTERA

Duration: December 2015 - december 2018

Coordinator: KTH Royal Institute of Technology

Inria contact: Cédric Lauradoux

Smart meters have the capability to measure and record consumption data at a high time resolution and communicate such data to the energy provider. This provides the opportunity to better monitor and control the power grid and to enable demand response at the residential level. This not only improves the reliability of grid operations but also constitutes a key enabler to integrate variable renewable generation, such as wind or solar. However, the communication of high resolution consumption data also poses privacy risks as such data allows the utility, or a third party, to derive detailed information about consumer behavior. Hence, the main research objective of COPES is to develop new technologies to protect consumer privacy, while not sacrificing the ”smartness”, i.e.,

advanced control and monitoring functionalities. The core idea is to overlay the original consumption pattern with additional physical consumption or generation, thereby hiding the consumer privacy sensitive consumption. The means to achieve this include the usage of storage, small scale distributed generation and/or elastic energy consumptions. Hence, COPES proposes and develops a radically new approach to alter the physical energy flow, instead of purely relying on encryption of meter readings, which provides protection against third party intruders but does not prevent the use of this data by the energy provider.

7.3.1.2. UPRISE-IoT

Title: User-centric PRIvacy & Security in IoT

Programm: CHISTERA

Duration: December 2016 - december 2019

Coordinator: SUPSI (Suisse)

Inria contact: Claude Castelluccia

The call states that "Traditional protection techniques are insufficient to guarantee users' security and privacy within the future unlimited interconnection": UPRISE-IoT will firstly identify the threats and model the behaviours in IoT world, and further will build new privacy mechanisms centred around the user. Further, as identified by the call "all aspects of security and privacy of the user data must be under the control of their original owner by means of as simple and efficient technical solutions as possible", UPRISE-IoT will rise the awareness of data privacy to the users. Finally, it will deeply develop transparency mechanisms to "guarantee both technically and regulatory the neutrality of the future internet." as requested by the call. The U-HIDE solution developed inn UPRISE-IoT will "empower them to understand and make their own decisions regarding their data, which is essential in gaining informed consent and in ensuring the take-up of IoT technologies", using a methodology that includes "co-design with users to address the key, fundamental, but inter-related and interdisciplinary aspects of privacy, security and trust."

7.4. International Initiatives

7.4.1. DATA

Title: Data and Algorithmic Transparency and Accountability

International Partner (Institution - Laboratory - Researcher):

Université du Québec à Montréal (UQAM) (Canada) - Département d'informatique - Sébastien Gambs

Start year: 2018

See also: http://planete.inrialpes.fr/data-associated-team/

The accelerated growth of the Internet has outpaced our abilities as individuals to maintain control of our personal data. The recent advent of personalized services has lead to the massive collection of personal data and the construction of detailed profiles about users. However, users have no information about the data which constitute its profile and how they are exploited by the different entities (Internet companies, telecom operators, ...). This lack of transparency gives rise to ethical issues such as discrimination or unfair processing.

In this associate team, we propose to strengthen the complementary nature and the current collaborations between the Inria Privatics group and UQAM to advance research and understanding on data and the algorithmic transparency and accountability.

7.5. International Research Visitors

7.5.1. Visits of International Scientists

- Sébastien Gambs visited the team in Lyon in April 2018 for a week to initiate the DATA collaboration. We also organized a workshop in data and algorithmic transparency during this week.
- Gergely Acs, assistant professor at Budapest University (Hungary), visited our team for 2 months, from mi-May to mid-July. He worked together with Claude Castelluccia on machine learning (in)security. In particular, he studied how adversarial examples can be used to evade monitoring, and consequently improve privacy.

PROSECCO Project-Team

8. Partnerships and Cooperations

8.1. National Initiatives

8.1.1. ANR

8.1.1.1. AnaStaSec

Title: Static Analysis for Security Properties (ANR générique 2014.)

Other partners: Inria Paris/EPI Antique, Inria Rennes/EPI Celtique, Airbus Operations SAS, AMOSSYS, CEA-LIST, TrustInSoft

Duration: January 2015 - September 2019.

Coordinator: Jérôme Féret, EPI Antique, Inria Paris (France)

Participant: Bruno Blanchet

Abstract: The project aims at using automated static analysis techniques for verifying security and confidentiality properties of critical avionics software.

8.1.1.2. AJACS

Title: AJACS: Analyses of JavaScript Applications: Certification and Security

Other partners: Inria-Rennes/Celtique, Inria-Saclay/Toccata, Inria-Sophia Antipolis/INDES, Imperial College London

Duration: October 2014 - March 2019.

Coordinator: Alan Schmitt, Inria (France)

Participants: Karthikeyan Bhargavan, Bruno Blanchet, Nadim Kobeissi

Abstract: The goal of the AJACS project is to provide strong security and privacy guarantees for web application scripts. To this end, we propose to define a mechanized semantics of the full JavaScript language, the most widely used language for the Web, to develop and prove correct analyses for JavaScript programs, and to design and certify security and privacy enforcement mechanisms.

8.1.1.3. SafeTLS

Title: SafeTLS: La sécurisation de l'Internet du futur avec TLS 1.

Other partners: Université Rennes 1, IRMAR, Inria Sophia Antipolis, SGDSN/ANSSI

Duration: October 2016 - September 2020

Coordinator: Pierre-Alain Fouque, Université de Rennes 1 (France)

Participants: Karthikeyan Bhargavan

Abstract: Our project, SafeTLS, addresses the security of both TLS 1.3 and of TLS 1.2 as they are (expected to be) used, in three important ways: (1) A better understanding: We will provide a better understanding of how TLS 1.2 and 1.3 are used in real-world applications; (2) Empowering clients: By developing a tool that will show clients the quality of their TLS connection and inform them of potential security and privacy risks; (3) Analyzing implementations: We will analyze the soundness of current TLS 1.2 implementations and use automated verification to provide a backbone of a secure TLS 1.3 implementation.

8.1.1.4. TECAP

Title: TECAP: Protocol Analysis - Combining Existing Tools (ANR générique 2017.)

Other partners: Inria Nancy/EPI PESTO, Inria Sophia Antipolis/EPI MARELLE, IRISA, LIX, LSV - ENS Cachan.

Duration: January 2018 - December 20

Coordinator: Vincent Cheval, EPI PESTO, Inria Nancy (France)

Participants: Bruno Blanchet, Benjamin Lipp

Abstract: A large variety of automated verification tools have been developed to prove or find attacks on security protocols. These tools differ in their scope, degree of automation, and attacker models. The aim of this project is to get the best of all these tools, meaning, on the one hand, to improve the theory and implementations of each individual tool towards the strengths of the others and, on the other hand, build bridges that allow the cooperations of the methods/tools. We will focus in this project on the tools CryptoVerif, EasyCrypt, Scary, ProVerif, Tamarin, AKiSs and APTE.

8.2. European Initiatives

8.2.1. FP7 & H2020 Projects

8.2.1.1. ERC Consolidator Grant: CIRCUS

Title: CIRCUS: An end-to-end verification architecture for building Certified Implementations of Robust, Cryptographically Secure web applications

Duration: April 2016 - March 2021

Coordinator: Karthikeyan Bhargavan, Inria

The security of modern web applications depends on a variety of critical components including cryptographic libraries, Transport Layer Security (TLS), browser security mechanisms, and single sign-on protocols. Although these components are widely used, their security guarantees remain poorly understood, leading to subtle bugs and frequent attacks. Rather than fixing one attack at a time, we advocate the use of formal security verification to identify and eliminate entire classes of vulnerabilities in one go.

CIRCUS proposes to take on this challenge, by verifying the end-to-end security of web applications running in mainstream software. The key idea is to identify the core security components of web browsers and servers and replace them by rigorously verified components that offer the same functionality but with robust security guarantees.

8.2.1.2. ERC Starting Grant: SECOMP

Title: SECOMP: Efficient Formally Secure Compilers to a Tagged Architecture

Duration: Jan 2017 - December 2021

Coordinator: Catalin Hritcu, Inria

Abstract: The SECOMP project is aimed at leveraging emerging hardware capabilities for fine-grained protection to build the first, efficient secure compilation chains for realistic low-level programming languages (the C language, and Low* a safe subset of C embedded in F* for verification). These compilation chains will provide a secure semantics for all programs and will ensure that high-level abstractions cannot be violated even when interacting with untrusted low-level code. To achieve this level of security without sacrificing efficiency, our secure compilation chains target a tagged architecture, which associates a metadata tag to each word and efficiently propagates and checks tags according to software-defined rules. We will use property-based testing and formal verification to provide high confidence that our compilers are indeed secure.

8.2.1.3. NEXTLEAP

Title: NEXTLEAP: NEXT generation Legal Encryption And Privacy

Programm: H2020

Duration: January 2016 - December 2018

Coordinator: Harry Halpin, Inria

Other partners: IMDEA, University College London, CNRS, IRI, and Merlinux

Abstract: NEXTLEAP aims to create, validate, and deploy protocols that can serve as pillars for a secure, trust-worthy, and privacy-respecting Internet. For this purpose NEXTLEAP will develop an interdisciplinary study of decentralisation that provides the basis on which these protocols cann be designed, working with sociologists to understand user needs. The modular specification of decentralized protocols, implemented as verified open-source software modules, will be done for both privacy-preserving secure federated identity as well as decentralized secure messaging services that hide metadata (e.g., who, when, how often, etc.).

8.3. International Initiatives

8.3.1. Inria International Partners

8.3.1.1. Informal International Partners

We have a range of long- and short-term collaborations with various universities and research labs. We summarize them by project:

- TLS analysis: Microsoft Research (Cambridge), Mozilla, University of Rennes
- F*: Microsoft Research (Redmond, Cambridge, Bangalore), MSR-Inria, CMU, MIT, University of Ljubljana, Nomadic Labs, Zen Protocol, Princeton University
- SECOMP: MPI-SWS, CISPA, Stanford University, CMU, University of Pennsylvania, Portland State University, University of Virginia, University of Iai
- Micro-Policies: University of Pennsylvania, Portland State University, MIT, Draper Labs, Dover Microsystems

8.3.2. Participation in Other International Programs

8.3.2.1. SSITH/HOPE

Title: Advanced New Hardware Optimized for Policy Enforcement, A New HOPE

Program: DARPA SSITH

Duration: December 2017 - February 2021

Coordinator: Charles Stark Draper Laboratory

Other Participants: Inria Paris, University of Pennsylvania, MIT, Portland State University, Dover Microsystems, DornerWorks

Participants from Inria Prosecco: Catalin Hritcu, Roberto Blanco, Jérémy Thibault

Abstract: A New HOPE builds on results from the Inherently Secure Processor (ISP) project that has been internally funded at Draper. Recent architectural improvements decouple the tagged architecture from the processor pipeline to improve performance and flexibility for new processors. HOPE securely maintains metadata for each word in application memory and checks every instruction against a set of installed security policies. The HOPE security architecture exposes tunable parameters that support Performance, Power, Area, Software compatibility and Security (PPASS) search space exploration. Flexible software-defined security policies cover all 7 SSITH CWE vulnerability classes, and policies can be tuned to meet PPASS requirements; for example, one can trade granularity of security checks against performance using different policy configurations. HOPE will design and formalize a new high-level domain-specific language (DSL) for defining security policies, based on previous research and on extensive experience with previous policy languages. HOPE will formally verify that installed security policies satisfy system-wide security requirements. A secure boot process enables policies to be securely updated on deployed HOPE systems. Security policies can adapt based on previously detected attacks. Over the multi-year, multi-million dollar Draper ISP project, the tagged security architecture approach has evolved from early prototypes based on results from the DARPA CRASH program towards easier integration with external designs, and is better able to scale from micro to server class implementations. A New HOPE team is led by Draper and includes faculty from University of Pennsylvania (Penn), Portland State University (PSU), Inria, and

MIT, as well as industry collaborators from DornerWorks and Dover Microsystems. In addition to Draper's in-house expertise in hardware design, cyber-security (defensive and offensive, hardware and software) and formal methods, the HOPE team includes experts from all domains relevant to SSITH, including (a) computer architecture: DeHon (Penn), Shrobe (MIT); (b) formal methods including programming languages and security: Pierce (Penn), Tolmach (PSU), Hritcu (Inria); and (c) operating system integration (DornerWorks). Dover Microsystems is a spin-out from Draper that will commercialize concepts from the Draper ISP project.

8.3.2.2. Everest Expedition

Program: Microsoft Expedition and MSR-Inria Collaborative Research Project

Expedition Participants: Microsoft Research (Cambridge, Redmond, Bangalore), Inria, MSR-Inria, CMU, University of Edinburgh

Duration of current MSR-Inria Project: October 2017 – October 2020

Participants from Inria Prosecco: Karthikeyan Bhargavan, Catalin Hritcu, Danel Ahman, Benjamin Beurdouche, Victor Dumitrescu, Nadim Kobeissi, Théo Laurent, Guido Martínez, Denis Merigoux, Marina Polubelova, Jean-Karim Zinzindohoué

Participants from other Inria teams: David Pichardie (Celtique), Jean-Pierre Talpin (TEA)

Abstract: The HTTPS ecosystem (HTTPS and TLS protocols, X.509 public key infrastructure, crypto algorithms) is the foundation on which Internet security is built. Unfortunately, this ecosystem is brittle, with headline-grabbing attacks such as FREAK and LogJam and emergency patches many times a year.

Project Everest addresses this problem by constructing a high-performance, standards-compliant, formally verified implementation of components in HTTPS ecosystem, including TLS, the main protocol at the heart of HTTPS, as well as the main underlying cryptographic algorithms such as AES, SHA2 or X25519.

At the TLS level, for instance, we are developing new implementations of existing and forthcoming protocol standards and formally proving, by reduction to cryptographic assumptions on their core algorithms, that our implementations provide a secure-channel abstraction between the communicating endpoints. Implementations of the core algorithms themselves are also verified, producing performant portable C code or highly optimized assembly language.

We aim for our verified components to be drop-in replacements suitable for use in mainstream web browsers, servers, and other popular tools and are actively working with the community at large to improve the ecosystem.

https://project-everest.github.io

8.4. International Research Visitors

8.4.1. Visits of International Scientists

- Amal Ahmed (Northeastern University, USA) joined Inria as a Visiting Professor from September 2017 to July 2018; she gave a seminar on "Compositional Compiler Verification for a Multi-Language World".
- Aaron Weiss (Northeastern University, USA) joined Inria as a Visiting Scientist from September 2017 to July 2018; he gave a seminar on "Rust Distilled: An Expressive Tower of Languages"
- Justin Hsu (University of Wisconsin–Madison, USA) visited Prosecco on 26 January 2018 and gave a talk entitled "From Couplings to Probabilistic Relational Program Logics"
- Deepak Garg (MPI-SWS, Germany) visited Prosecco on 21 February and 6 December 2018
- Marco Patrignani (CISPA, Germany) visited Prosecco on 21 February 2018
- Arthur Azevedo de Amorim (CMU) visited Prosecco on 10–13 April 2018 and gave a seminar on "The Meaning of Memory Safety"

- Prasad Naldurg (IBM Research, India) joined Prosecco as a Visiting Researcher from May 2018; he gave a Prosecco seminar on "Encrypted Analytics: Computing directly on encrypted databases"
- Vincent Gramoli (NICTA/Data61-CSIRO and University of Sydney, Australia) visited Prosecco on 27 June 2018 and gave a seminar on "The Red Belly Blockchain: Speed, Security, Scalability"
- Éric Tanter (University of Chile) joined Prosecco as Visiting Professor from July 2018 to February 2019; he gave a Prosecco seminar on "Gradual Parametricity, Revisited" and many other talks
- Andrew Tolmach (Portland State University, USA) visited Prosecco on 2–4 July 2018
- Ilya Sergey (University College London, UK) visited Prosecco on 5 September 2018 and gave a seminar on "Deductive Synthesis of Programs that Alter Data Structures"
- Jonathan Aldrich (CMU, USA) visited Prosecco on 22–26 November 2018 and gave a seminar on "Object Capabilities, Effects, and Abstraction"
- tefan Ciobâcă (University of Iai, Romania) visited Prosecco on 3–7 December 2018
- Amin Timany (KU Leuven, Belgium) visited Prosecco on 3–7 December 2018
- Cédric Fournet (Microsoft Research, UK) has visited Prosecco on various occasions
- Jonathan Protzenko (Microsoft Research, USA) has visited Prosecco on various occasions

8.4.1.1. Internships

- Benjamin Lipp (Karlsruhe Institute of Technology, Germany): from Dec 2017 to May 2018 – advised by Bruno Blanchet and Karthik Bhargavan
- Carmine Abate (University of Trento, Italy): from Dec 2017 to May 2018 – advised by Catalin Hritcu
- Jérémy Thibault (ENS Rennes, France): from Feb to Jul 2018 – advised by Catalin Hritcu
- Florian Groult (University of Orleans, France): from Apr to Oct 2018 – advised by Catalin Hritcu
- Guido Martinez (CIFASIS-CONICET Rosario, Argentina): from Sep to December 2018 – advised by Catalin Hritcu
- Elizabeth Labrada Deniz (University of Chile): from Oct 2018 to January 2019 – advised by Éric Tanter and Catalin Hritcu
- Iness Ben Guirat (INSAT): from August 2018 to January 2019 – advised by Harry Halpin

8.4.2. Visits to International Teams

- Catalin Hritcu, Danel Ahman, and Victor Dumitrescu visited Microsoft Research (Redmond, USA) on 5–25 March 2018
- Catalin Hritcu, Carmine Abate, and Jérémy Thibault visited the MPI-SWS (Saarbrücken, Germany) on 27–28 March 2018
- Catalin Hritcu visited Draper Labs (Cambridge, MA, USA) on 30 May 2018
- Karthikeyan Bhargavan, Catalin Hritcu, Danel Ahman, Benjamin Beurdouche, Victor Dumitrescu, Guido Martínez, Denis Merigoux, and Marina Polubelova visited Microsoft Research (Cambridge, UK) for Everest "All-Hands" meeting
- Harry Halpin visited the NEXTLEAP team meeting (Lausanne, Switzerland) on 15–17th of January.
- Harry Halpin visited the NEXTLEAP team meeting (Freibourg, Germany) on 21–22nd of November.
- Harry Halpin visited the final PANORAMIX team meeting (Athens, Greece) on 24–25th of September.

SECRET Project-Team

8. Partnerships and Cooperations

8.1. National Initiatives

8.1.1. ANR

- **ANR BRUTUS** ($10/14 \rightarrow 09/18$)
  Authenticated Ciphers and Resistance against Side-Channel Attacks
  ANR program: Défi Société de l'information et de la communication
  Partners: ANSSI, Inria (project-team SECRET and project-team MARELLE), Orange, University of Lille, University of Rennes, University Versailles-Saint Quentin
  160 kEuros
  The Brutus project aims at investigating the security of authenticated encryption systems. We plan to evaluate carefully the security of the most promising candidates to the CAESAR competition, by trying to attack the underlying primitives or to build security proofs of modes of operation. We target the traditional black-box setting, but also more "hostile" environments, including the hardware platforms where some side-channel information is available.
- **ANR DEREC** ($10/16 \rightarrow 09/21$)
  Relativistic cryptography
  ANR Program: jeunes chercheurs
  244 kEuros
  The goal of project DEREC is to demonstrate the feasibility of guaranteeing the security of some cryptographic protocols using the relativistic paradigm, which states that information propagation is limited by the speed of light. We plan to study some two party primitives such as bit commitment and their security against classical and quantum adversaries in this model. We then plan to the integration of those primitives into larger cryptosystems. Finally, we plan on performing a demonstration of those systems in real life conditions.
- **ANR CBCRYPT** ($10/17 \rightarrow 09/21$)
  Code-based cryptography
  ANR Program: AAP Générique 2017
  Partners: Inria SECRET (coordinator), XLIM, Univ. Rouen, Univ. Bordeaux.
  197 kEuros
  The goal of CBCRYPT is to propose code-based candidates to the NIST call aiming at standardizing public-key primitives which resist to quantum attacks. These proposals are based either on code-based schemes relying on the usual Hamming metric or on the rank metric. The project does not deal solely with the NIST call. We also develop some other code-based solutions: these are either primitives that are not mature enough to be proposed in the first NIST call or whose functionalities are not covered by the NIST call, such as identity-based encryption, broadcast encryption, attribute based encryption or functional encryption. A third goal of this project is of a more fundamental nature: namely to lay firm foundations for code-based cryptography by developing thorough and rigorous security proofs together with a set of algorithmic tools for assessing the security of code-based cryptography.

- **ANR quBIC** ($10/17 \rightarrow 09/21$)
  Quantum Banknotes and Information-Theoretic Credit Cards
  ANR Program: AAP Générique 2017
  Partners: Univ. Paris-Diderot (coordinator), Inria SECRET, UPMC (LIP6), CNRS (Laboratoire Kastler Brossel)
  87 kEuros
  For a quantum-safe future, classical security systems as well as quantum protocols that guarantee security against all adversaries must be deployed. Here, we will study and implement one of the most promising quantum applications, namely unforgeable quantum money. A money scheme enables a secure transaction between a client, a vendor and a bank via the use of a credit card or via the use of banknotes, with maximal security guarantees. Our objectives are to perform a theoretical analysis of quantum money schemes, in realistic conditions and for encodings in both discrete and continuous variables, and to demonstrate experimentally these protocols using state-of-the-art quantum memories and integrated detection devices.

8.2. European Initiatives

8.2.1. FP7 & H2020 Projects

8.2.1.1. PQCRYPTO

Title: Post-quantum cryptography for long-term security

Programm: H2020

Duration: March 2015 - March 2018

Coordinator: TECHNISCHE UNIVERSITEIT EINDHOVEN

Partners:

Academia Sinica (Taiwan)

Bundesdruckerei (Germany)

Danmarks Tekniske Universitet (Denmark)

Katholieke Universiteit Leuven (Belgium)

Nxp Semiconductors Belgium Nv (Belgium)

Ruhr-Universitaet Bochum (Germany)

Stichting Katholieke Universiteit (Netherlands)

Technische Universiteit Eindhoven (Netherlands)

Technische Universitaet Darmstadt (Germany)

University of Haifa (Israel)

Inria contact: Nicolas Sendrier

Online banking, e-commerce, telemedicine, mobile communication, and cloud computing depend fundamentally on the security of the underlying cryptographic algorithms. Public-key algorithms are particularly crucial since they provide digital signatures and establish secure communication without requiring in-person meetings. Essentially all applications today are based on RSA or on the discrete-logarithm problem in finite fields or on elliptic curves. Cryptographers optimize parameter choices and implementation details for these systems and build protocols on top of these systems; cryptanalysts fine-tune attacks and establish exact security levels for these systems. Alternative systems are far less visible in research and unheard of in practice. It might seem that having three systems offers enough variation, but these systems are all broken as soon as large quantum computers are built. The EU and governments around the world are investing heavily in building quantum computers; society needs to be prepared for the consequences, including cryptanalytic

attacks accelerated by these computers. Long-term confidential documents such as patient health-care records and state secrets have to guarantee security for many years, but information encrypted today using RSA or elliptic curves and stored until quantum computers are available will then be as easy to decipher as Enigma-encrypted messages are today. PQCRYPTO will allow users to switch to post-quantum cryptography: cryptographic systems that are not merely secure for today but that will also remain secure long-term against attacks by quantum computers. PQCRYPTO will design a portfolio of high-security post-quantum public-key systems, and will improve the speed of these systems, adapting to the different performance challenges of mobile devices, the cloud, and the Internet of Things. PQCRYPTO will provide efficient implementations of high-security post-quantum cryptography for a broad spectrum of real-world applications.

8.2.1.2. QCALL

Title: Quantum Communications for ALL

Programm: H2020-MSCA-ITN-2015

Duration: December 2016 - November 2020

Coordinator: University of Leeds (UK)

Other partners: see http://www.qcall-itn.eu/

Inria contact: Anthony Leverrier

QCALL is a European Innovative Training Network that endeavors to take the next necessary steps to bring the developing quantum technologies closer to the doorsteps of end users. QCALL will empower a nucleus of 15 doctoral researchers in this area to provide secure communications in the European continent and, in the long run, to its connections worldwide.

8.2.1.3. ERC QUASYModo

Title: QUASYModo *Symmetric Cryptography in the Post-Quantum World*

Program: ERC starting grant

Duration: September 2017 - August 2022

PI: María Naya Plasencia

As years go by, the existence of quantum computers becomes more tangible and the scientific community is already anticipating the enormous consequences of the induced breakthrough in computational power. Cryptology is one of the affected disciplines. Indeed, the current state-of-the-art asymmetric cryptography would become insecure, and we are actively searching for alternatives. Symmetric cryptography, essential for enabling secure communications, seems much less affected at first sight: its biggest known threat is Grover's algorithm, which allows exhaustive key searches in the square root of the normal complexity. Thus, so far, it is believed that doubling key lengths suffices to maintain an equivalent security in the post- quantum world. The security of symmetric cryptography is completely based on cryptanalysis: we only gain confidence in the security of a symmetric primitive through extensive and continuous scrutiny. It is therefore not possible to determine whether a symmetric primitive might be secure or not in a post-quantum world without first understanding how a quantum adversary could attack it. Correctly evaluating the security of symmetric primitives in the post-quantum world cannot be done without a corresponding cryptanalysis toolbox, which neither exists nor has ever been studied. This is the big gap I have identified and that I plan to fill with this project. Next, doubling the key length is not a trivial task and needs to be carefully studied. My ultimate aim is to propose efficient solutions secure in the post-quantum world with the help of our previously obtained quantum symmetric cryptanalysis toolbox. This will help prevent the chaos that big quantum computers would generate: being ready in advance will definitely save a great amount of time and money, while protecting our current and future communications. The main challenge of QUASYModo is to redesign symmetric cryptography for the post-quantum world.

8.2.2. Collaborations in European Programs, Except FP7 & H2020

8.2.2.1. QCDA

Program: QuantERA ERA-NET Cofund in Quantum Technologies

Project acronym: QCDA

Project title: Quantum Code Design and Architecture

Duration: February 2018 - January 2021

Coordinator: Earl Campbell, University of Sheffield, UK

Other partners: University of Sheffield (UK), TU Delft (Netherlands), TU Munich (Germany), University College London (UK)

Inria contact: Anthony Leverrier

General purpose quantum computers must follow a fault-tolerant design to prevent ubiquitous decoherence processes from corrupting computations. All approaches to fault-tolerance demand extra physical hardware to perform a quantum computation. Kitaev's surface, or toric, code is a popular idea that has captured the hearts and minds of many hardware developers, and has given many people hope that fault-tolerant quantum computation is a realistic prospect. Major industrial hardware developers include Google, IBM, and Intel. They are all currently working toward a fault-tolerant architecture based on the surface code. Unfortunately, however, detailed resource analysis points towards substantial hardware requirements using this approach, possibly millions of qubits for commercial applications. Therefore, improvements to fault-tolerant designs are a pressing near-future issue. This is particularly crucial since sufficient time is required for hardware developers to react and adjust course accordingly.

This consortium will initiate a European co-ordinated approach to designing a new generation of codes and protocols for fault-tolerant quantum computation. The ultimate goal is the development of high-performance architectures for quantum computers that offer significant reductions in hardware requirements; hence accelerating the transition of quantum computing from academia to industry. Key directions developed to achieve these improvements include: the economies of scale offered by large blocks of logical qubits in high-rate codes; and the exploitation of continuous-variable degrees of freedom.

The project further aims to build a European community addressing these architectural issues, so that a productive feedback cycle between theory and experiment can continue beyond the lifetime of the project itself. Practical protocols and recipes resulting from this project are anticipated to become part of the standard arsenal for building scalable quantum information processors.

8.3. International Initiatives

8.3.1. Inria Associate Teams Not Involved in an Inria International Labs

8.3.1.1. CHOCOLAT

Title: Chosen-prefix Collision Attack on SHA-1 with ASICs Cluster

International Partner (Institution - Laboratory - Researcher):

NTU (Singapore) - SYLLAB - Peyrin Thomas

Start year: 2017

See also: https://team.inria.fr/chocolat/

The hash function SHA-1 is one of the most widely used hash functions in the industry, but it has been shown to not be collision-resistant by a team of Chinese researchers led by Prof. Wang in 2005. However, nobody has publicly produced a real pair of colliding messages so far, because the estimated attack complexity is around 2^{63} SHA-1 computations (this represents about 70000 years of computation on a normal PC).

While a collision of SHA-1 would clearly demonstrate the weakness of the algorithm, a much more powerful attack would be to find a collision such that the prefix of the colliding messages

is chosen by some challenger beforehand. In particular, this would allow creating a rogue certificate authority certificate that would be accepted by browsers. Such an attack has already been deployed for certificates using the MD5 hash function, but MD5 is much weaker than SHA-1 and it has already been removed from most security applications. SHA-1 is still widely used and performing such an attack for certificates using SHA-1 would have a very big impact.

The objective of the project is to design a chosen-prefix collision attack against the SHA-1 hash function, and to implement the attack in practice. We estimate this will require 2^{70} computations, and we will use an ASIC cluster to perform such a computation.

8.3.2. Inria International Partners

8.3.2.1. Declared Inria International Partners

Title: Discrete Mathematics, Codes and Cryptography

International Partner (Institution - Laboratory - Researcher):

Indian Statistical Institute (India) - Cryptology Research Group - Bimal Roy

Duration: 2014 - 2018

Start year: 2014

Today's cryptology offers important challenges. Some are well-known: Can we understand existing cryptanalysis techniques well enough to devise criterion for the design of efficient and secure symmetric cryptographic primitives? Can we propose cryptographic protocols which offer provable security features under some reasonable algorithmic assumptions? Some are newer: How could we overcome the possible apparition of a quantum computer with its devastating consequences on public key cryptography as it is used today? Those challenges must be addressed, and some of the answers will involve tools borrowed to discrete mathematics, combinatorics, algebraic coding theory, algorithmic. The guideline of this proposal is to explore further and enrich the already well established connections between those scientific domains and their applications to cryptography and its challenges.

8.3.2.2. Informal International Partners

- Nanyang Technological University (Singapore): cryptanalysis of symmetric primitives.
- Ruhr-Universität Bochum (Germany): design and cryptanalysis of symmetric primitives.
- University of Sherbrooke (Canada): quantum codes.

8.4. International Research Visitors

8.4.1. Visits of International Scientists

- Thomas Peyrin, NTU Singapore, January 2018 and July 2018.
- Sristy Agrawal, Indian Institute of Science Education and Research, Kolkata, India, January 2018.
- Anastasiya Gorodilova, Sobolev Institute of Mathematics, Novosibirsk, Russia, September 2018.
- Lorenzo Grassi, IAIK, Graz University of Technology, Austria, September 2018.

8.4.1.1. Internships

- Daniel Coggia, MPRI, March-Aug. 2018
- Anaïs Querol Cruz, MPRI, March-Aug. 2018
- Florian Wartelle, UVSQ, March-Sept. 2018

8.4.2. Visits to International Teams

8.4.2.1. Research Stays Abroad

- NTU, Singapore, joint work within the CHOCOLAT Associate Team: S. Duval (April 8-19), G. Leurent (October 29 - November 10).
- University of Sherbrooke, Sherbrooke, Canada, June 11-15, 2018 (J.P. Tillich)
- Department of Computer Science and Engineering, The Hong Kong University of Science and Technology, Clear Water Bay, Kowloon, Hong Kong, September 30-October 9, 2018 (P. Charpin).

SPADES Project-Team

8. Partnerships and Cooperations

8.1. Regional Initiatives

8.1.1. CASERM (PERSYVAL-Lab project)

Participants: Pascal Fradet, Alain Girault, Gregor Goessler, Xiaojie Guo, Maxime Lesourd, Xavier Nicollin, Stephan Plassart, Sophie Quinton, Jean-Bernard Stefani, Martin Vassor.

Despite recent advances, there exists currently no integrated formal methods and tools for the design and analysis of reconfigurable multi-view embedded systems. This is the goal of the CASERM project.

The CASERM project represents a significant effort towards a COQ-based design method for reconfigurable multi-view embedded systems, in order to formalize the structure and behavior of systems and to prove their main properties. The use of a proof assistant to support such a framework is motivated by the fact that the targeted systems are both extremely complex and critical. The challenges addressed are threefold:

1. to model software architectures for embedded systems taking into account their dynamicity and multiple constraints (functional as well as non functional);
2. to propose novel scheduling techniques for dynamically reconfiguring embedded systems; and
3. to advance the state of the art in automated proving for such systems.

The objectives of CASERM that address these challenges are organized in three tasks. They consist respectively in designing an architecture description framework based on a process calculus, in proposing online optimization methods for dynamic reconfiguration systems (this is the topic of Stephan Plassart's PhD), and in developing a formal framework for real-time analysis in the COQ proof assistant (this is the topic of Xiaojie Guo's and Maxime Lesourd's PhD). A fourth task focuses on common case studies for the evaluation of the obtained results.

The CASERM consortium gathers researchers from the LIG and VERIMAG laboratories who are reknowned specialists in these fields. The project started in November 2016 and will last three years.

8.2. National Initiatives

8.2.1. ANR

8.2.1.1. RT-Proofs

Participants: Pascal Fradet, Xiaojie Guo, Maxime Lesourd, Sophie Quinton.

RT-Proofs is an ANR/DFG project between Inria, MPI-SWS, Onera, TU Braunschweig and Verimag, running from 2018 until 2020.

The overall objective of the RT-Proofs project is to lay the foundations for computer-assisted formal verification of timing analysis results. More precisely, the goal is to provide:

1. a strong formal basis for schedulability, blocking, and response-time analysis supported by the Coq proof assistant, that is as generic, robust, and modular as possible;
2. correctness proofs for new and well-established generalized response-time analysis results, and a better, precise understanding of the role played by key assumptions and formal connections between competing analysis techniques;
3. an approach for the generation of proof certificates so that analysis results – in contrast to analysis tools – can be certified.

8.2.1.2. DCore

Participants: Gregor Goessler, Jean-Bernard Stefani.

DCORE is an ANR project between Inria project teams ANTIQUE, FOCUS and SPADES, and the IRIF lab, running from 2019 to 2023.

The overall objective of the project is to develop a semantically well-founded, novel form of concurrent debugging, which we call *causal debugging*, that aims to alleviate the deficiencies of current debugging techniques for large concurrent software systems. The causal debugging technology developed by DCORE will comprise and integrate two main novel engines:

1. *a reversible execution engine* that allows programmers to backtrack and replay a concurrent or distributed program execution, in a way that is both precise and efficient (only the exact threads involved by a return to a target anterior or posterior program state are impacted);
2. a *causal analysis engine* that allows programmers to analyze concurrent executions, by asking questions of the form "what caused the violation of this program property?", and that allows for the precise and efficient investigation of past and potential program executions.

8.2.2. Institute of Technology (IRT)

8.2.2.1. CAPHCA

Participants: Alain Girault, Nicolas Hili.

CAPHCA is a project within the Antoine de Saint Exupéry IRT. The general objective of the project is to provide methods and tools to achieve performance and determinism on modern, high-performance, multi-core and FPGA-enabled SOCs. Our specific contribution lies withing work pakacges dedicated to the design of novel PRET architectures and programming languages (see Section 6.2.1).

8.3. European Initiatives

8.3.1. Collaborations in European Programs, Except FP7 & H2020

Program: Celtic-Plus
Project acronym: SENDATE
Project title: Secure Networking for a Data center cloud in Europe
Duration: April 2016 - March 2019
Coordinator: Nokia France
Other partners: Nokia, Orange, IMT, Inria
Abstract: The SENDATE project aims to develop a clean-slate architecture for converged telecommunications networks and distributed data centers supporting 5G cellular networks and the needs from the Industrial Internet and the Internet of Things. It aims to provide scientific and technical solutions for intra and inter data centrers security, control, management and orchestration, placement and management of virtual network functions, as well as high-speed transport networks for data centers access and interconnection.

8.3.2. Collaborations with Major European Organizations

We have a strong collaboration with the Technische Universität Braunschweig in Germany. In particular, Sophie Quinton is involved in the CCC project (http://ccc-project.org/) to provide methods and mechanisms for the verification of software updates after deployment in safety-critical systems, and in the TypicalCPA project which aims at computing deadline miss models for distributed systems.

We also have a recent collaboration with the MPI-SWS in Kaiserslautern (Germany) on formal proofs for real-time systems. This collaboration will be concretized by an ANR-PRCI project called RT-PROOFS starting in 2018, which involves MPI-SWS, TU Braunschweig, Inria, and Onera.

8.4. International Research Visitors

8.4.1. Visits of International Scientists

- Ismail Assayad (from U. Casablanca, Morocco) visited the team for one month in September 2018, to work on a two layer adaptive scheduling method.

SPECFUN Project-Team

8. Partnerships and Cooperations

8.1. International Research Visitors

8.1.1. Internships

- Jiadong Han did a Master internship from March to August. Under the supervision of Pierre Lairez, he studied the computation of adaptive grid to improve the computation of the homology of semialgebraic sets.

SUMO Project-Team

9. Partnerships and Cooperations

9.1. Regional Initiatives

9.1.1. Rennes Métropole: Allocation d'Installation Scientifique (AIS)

- Individual grant, led by Nicolas Markey

The objective of this project is to explore two research directions in the continuity of recent works: a truly quantitative theory of formal verification on the one hand, and the development of strategy-synthesis algorithms for modular systems on the other hand.

9.2. National Initiatives

9.2.1. ANR TickTac: Efficient Techniques for Verification and Synthesis of Real-Time Systems (2019-2023)

- Led by Ocan Sankur (SUMO);
- Participants: Thierry Jéron, Nicolas Markey, Ocan Sankur
- Partners: LSV (Cachan), ISIR (Paris), LaBRI (Bordeaux), LRDE (Paris), LIF (Marseille)

The aim of TickTac is to develop novel algorithms for the verification and synthesis of real-time systems using the timed automata formalism. One of the project's objectives is to develop an open-source and configurable model checker which will allow the community to compare algorithms. The algorithms and the tool will be used on a motion planning case study for robotics.

9.2.2. ANR STOCH-MC: Model-Checking of Stochastic Systems using approximated algorithms (2014-2018)

- web site at http://perso.crans.org/~genest/stoch.html.
- Led by Blaise Genest (SUMO);
- Participants: Nathalie Bertrand, Blaise Genest, Éric Fabre, Matthieu Pichené;
- Partners: Inria Project Team CONTRAINTES (Rocquencourt), LaBRI (Bordeaux), and IRIF (Paris).

The aim of STOCH-MC is to perform model-checking of large stochastic systems, using controlled approximations. Two formalisms will be considered: Dynamic Bayesian Networks, which represent compactly large Markov Chains; and Markov Decision Processes, allowing non deterministic choices on top of probabilities.

9.2.3. ANR HeadWork: Human-Centric Data-oriented WORKflows (2016-2020)

- web site at http://headwork.gforge.inria.fr/
- Led by David Gross-Amblard (Université Rennes 1);
- Participants : Loïc Hélouët, Éric Badouel;
- Partners: Inria Project-Teams Valda (Paris), DRUID (Rennes) SUMO (Rennes), LINKs (Lille), MNHN, Foule Factory.

The objective of this project is to develop techniques to facilite development, deployment, and monitoring of crowd-based participative applications. This requires handling complex workflows with multiple participants, incertainty in data collections, incentives, skills of contributors, ... To overcome these challenges, Headwork will define rich workflows with multiple participants, data and knowledge models to capture various kind of crowd applications with complex data acquisition tasks and human specificities. We will also address methods for deploying, verifying, optimizing, but also monitoring and adapting crowd-based workflow executions at run time.

9.2.4. IPL HAC-SPECIS: High-performance Application and Computers, Studying PErformance and Correctness In Simulation (2016-2020)

- web site at http://hacspecis.gforge.inria.fr/
- Led by Arnaud Legrand (Inria Rhône-Alpes)
- Participants: Thierry Jéron, The Anh Pham.
- Partners: Inria project-teams Avalon (Lyon), POLARIS (Grenoble), HiePACS, STORM (Bordeaux), MExICo (Saclay), MYRIADS, SUMO (Rennes), VeriDis (Nancy).

The Inria Project Lab HAC-SPECIS (High-performance Application and Computers, Studying PErformance and Correctness In Simulation, 2016-2020: http://hacspecis.gforge.inria.fr/) is a transversal project internal to Inria. The goal of the HAC SPECIS project is to answer the methodological needs raised by the recent evolution of HPC architectures by allowing application and runtime developers to study such systems both from the correctness and performance point of view. Inside this project, we collaborate with Martin Quinson (Myriads team) on the dynamic formal verification of high performance runtimes and applications. The PhD of The Anh Pham is granted by this project.

This year we have been mainly intrested in the extension of the SimGrid programming model of MPI with synchronization primitives, the formalisation in ATL, of this model, and its adaptation to dynamic partial-order-reduction methods (DPOR) that allow to reduce the explored state space. A prototype implementation of an existing method that combines DPOR with true-concurrency models has been experimented on toy examples.

9.2.5. National informal collaborations

The team collaborates with the following researchers:

- François Laroussinie (IRIF, UP7-Diderot) on logics for multi-agent systems;
- Béatrice Bérard (LIP6) on problems of opacity and diagnosis, and on problems related to logics and partial orders for security;
- Serge Haddad (Inria team MExICo, LSV, ENS Paris-Saclay) on opacity and diagnosis;
- Patricia Bouyer (LSV, ENS Paris-Saclay) on the analysis of probabilistic timed systems and quantitative aspects of verification;
- Stefan Haar and Thomas Chatain (Inria team MExICo, LSV, ENS Paris-Saclay) on topics related to concurrency and time, and to modeling and verification of metro networks, multimodal systems and passenger flows;
- Éric Rutten and Gwenaël Delaval (Inria team Ctrl-A, LIG, Université Grenoble-Alpes) on the control of reconfigurable systems as well as making the link between Reax and Heptagon/BZR (http://bzr.inria.fr/);
- Didier Lime, Olivier H. Roux (LS2N Nantes) on topics related to stochastic and timed nets;
- Loïg Jezequel (LS2N Nantes) on topics related to stochastic and timed nets, and on distributed optimal planning;

9.3. International Initiatives

9.3.1. Inria Associate Teams Not Involved in an Inria International Labs

9.3.1.1. EQUAVE

Title: Efficient Quantitative Verification

International Partner (Institution - Laboratory - Researcher):

Indian Institute of Technology Bombay (India) - Dpt of Computer Science and Engineering - S. Akshay

Start year: 2018

See also: http://www.irisa.fr/sumo/EQUAVE

Formal verification has been addressed for a long time. A lot of effort has been devoted to boolean verification, i.e., formal analyis of systems that check whether a given property is true or false.

In many settings, a boolean verdict is not sufficient. The notions of interest are for instance the amount of confidential information leaked by a system, the proportion of some protein after a duration in some experiment in a biological system, whether a distributed protocol satisfies some property only for a bounded number of participants... This calls for quantitative verification, in which algorithms compute a value such as the probability for a property to hold, the mean cost of runs satisfying it, the time needed to achieve a complex workflow...

A second limitation of formal verification is the efficiency of algorithms. Even for simple questions, verification is rapidly PSPACE-complete. However, some classes of models allow polynomial time verification. The key techniques to master complexity are to use concurrency, approximation, etc

The objective of this project is to study efficient techniques for quantitative verification, and develop efficient algorithms for models such as stochastic games, timed and concurrent systems,

9.3.1.2. QuantProb

Title: Quantitative analysis of non-standard properties in probabilistic models

International Partner (Institution - Laboratory - Researcher):

Technical University of Dresde (Germany), Faculty of Computer Science, Christel Baier

Start year: 2016

See also: http://www.irisa.fr/sumo/QuantProb/

Quantitative information flow and fault diagnosis share two important characteristics: quantities (in the description of the system as well as in the properties of interest), and users partial knowledge. Yet, in spite of their similar nature, different formalisms have been proposed. Beyond these two motivating examples, defining a unified framework can be addressed by formal methods. Formal methods have proved to be effective to verify, diagnose, optimize and control qualitative properties of dynamic systems. However, they fall short of modelling and mastering quantitative features such as costs, energy, time, probabilities, and robustness, in a partial observation setting. This project proposal aims at developing theoretical foundations of formal methods for the quantitative analysis of partially observable systems.

9.3.2. Inria International Partners

9.3.2.1. Informal International Partners

The team collaborates with the following researchers:

- Jean-François Raskin, Gilles Geeraerts (Université Libre de Bruxelles, Belgium) on multiplayer game theory and synthesis;
- Thomas Brihaye (U Mons, Belgium) on the verification of stochastic timed systems;
- Mickael Randour (U Mons, Belgium) on quantitative games for synthesis;
- Kim G. Larsen (U Aalborg, Denmark) on quantitative timed games, and on topics related to urban train systems modeling;
- Josef Widder, Marijana Laźic (TU Wien, Austria), Igor Konnov (Inria Nancy, LORIA) on the automated verification of randomized distributed algorithms.
- John Mullins (Polytechnique Montréal, Canada), on topics related to security and opacity;
- S. Akshay (IIT Bombay, India) on topics related to timed concurrent models;
- Andrea D'ariano (University Roma Tre, Italy), on topics related to train regulation.
- Alessandro Giua and Michele Pinna (Univ. Cagliari, Italy), on diagnosis and unfolding techniques for concurrent systems.

9.4. International Research Visitors

9.4.1. Visits of International Scientists

- In June 2018, S. Akshay visited the SUMO team for one week.
- Laurie Ricker (Mount Allison University, Canada) visited the team during 3 months in 2018.
- Josef Widder visited the team as an invitee of ISTIC (Université Rennes 1) : 2 weeks in September 2018.
- Romulo Meira-Goes (PhD student of S. Lafortune, University of Michigan, USA) visited our team during four months in 2018 (Synthesis of Supervisors Robust Against Sensor Deceptions Attacks).

9.4.1.1. Internships

- Flavia Palmieri, May-June 2018, Loïc Hélouët.
- M2 internship of Ritam Raha, October-December 2018, Nicolas Markey and Loïc Hélouët.
- Internship of undergraduate student Adwait Amit Godbole, Blaise Genest.

9.4.2. Visits to International Teams

In October 2018, Loïc Hélouët visited IIT Bombay and IIT Delhi for 10 days, to work within the associated team EQUAVE.

TAMIS Project-Team

9. Partnerships and Cooperations

9.1. National Initiatives

9.1.1. ANR

- ANR MALTHY, Méthodes ALgébriques pour la vérification de modèles Temporisés et HYbrides, Thao Dang, 4 years, Inria and VISEO and CEA and VERIMAG
- ANR COGITO, Runtime Code Generation to Secure Devices, 3 years, Inria and CEA and ENSMSE and XLIM.
- ANR AHMA, Automated Hardware Malware Analysis, 3,5 years (42month),
- ANR JCJC CNRS.

9.1.2. DGA

- PhD grant for Nisrine Jafri (2016–2019),
- PhD grant for Aurélien Palisse (2016–2019),
- PhD grant for Alexandre Gonzalves (2016–2019),
- PhD grant for Olivier Decourbe (2017–2020),
- PhD grant for Alexandre Zdhanov (2017–2020)
- PhD grant for Christophe Genevey Metat (2019-2022)

9.1.3. Autres

- INS2I JCJC grant for Annelie Heuser

9.2. European Initiatives

9.2.1. FP7 & H2020 Projects

9.2.1.1. ACANTO (028)

Title: ACANTO: A CyberphusicAl social NeTwOrk using robot friends

Program: H2020

Duration: February 2015 - July 2018

Coordinator: Universita di Trento

Partners:

Atos Spain (Spain), Envitel Tecnologia Y Control S.A. (Spain), Foundation for Research and Technology Hellas (Greece), Servicio Madrileno Delud (Spain), Siemens Aktiengesellschaft Oesterreich (Austria), Telecom Italia S.P.A (Italy), Universita' Degli Studi di Siena (Italy), Universita Degli Studi di Trento (Italy), University of Northumbria At Newcastle. (United Kingdom)

Inria contact: Axel Legay

'Despite its recognised benefits, most older adults do not engage in a regular physical activity. The ACANTO project proposes a friendly robot walker (the FriWalk) that will abate a some of the most important barriers to this healthy behaviour. The FriWalk revisits the notion of robotic walking assistants and evolves it towards an activity vehicle. The execution of a programme of physical training is embedded within familiar and compelling every-day activities. The FriWalk operates as a personal trainer triggering the user actions and monitoring their impact on the physical and mental well-being. It offers cognitive and emotional support for navigation pinpointing risk situations in the environment and understanding the social context. It supports coordinated motion with other FriWalks for group activities. The FriWalk combines low cost and advanced features, thanks to its reliance on a cloud of services that increase its computing power and interconnect it to other assisted living devices. Very innovative is its ability to collect observations on the user preferred behaviours, which are consolidated in a user profile and used for recommendation of future activities. In this way, the FriWalk operates as a gateway toward a CyberPhysical Social Network (CPSN), which is an important contribution of the project. The CPSN is at the basis of a recommendation system in which users' profiles are created, combined into 'circles' and matched with the opportunity offered by the environment to generate recommendations for activities to be executed with the FriWalk support. The permanent connection between users and CPSN is secured by the FriPad, a tablet with a specifically designed user interface. The CPSN creates a community of users, relatives and therapists, who can enter prescriptions on the user and receive information on her/his state. Users are involved in a large number in all the phases of the system development and an extensive validation is carried out at the end.'

9.2.1.2. ENABLE-S3 (352)

Title: ENABLE-S3: European Initiative to Enable Validation for Highly Automated Safe and Secure Systems

Program: H2020

Duration: 05/2016 - 04/2019

Coordinator: Avl List Gmbh (Austria)

Partners:

Aalborg Universitet (Denmark); Airbus Defence And Space Gmbh (Germany); Ait Austrian Institute Of Technology Gmbh (Austria); Avl Deutschland Gmbh (Germany); Avl Software And Functions Gmbh (Germany); Btc Embedded Systems Ag (Germany); Cavotec Germany Gmbh (Germany); Creanex Oy(Finland); Ceske Vysoke Uceni Technicke V Praze (Czech Republic); Deutsches Zentrum Fuer Luft - Und Raumfahrt Ev (Germany); Denso Automotive Deutschland Gmbh (Germany); Dr. Steffan Datentechnik Gmbh (Austria); Danmarks Tekniske Universitet (Denmark); Evidence Srl (Italy); Stiftung Fzi Forschungszentrum Informatik Am Karlsruher Institut Fur Technologie (Germany); Gmv Aerospace And Defence Sa (Spain); Gmvis Skysoft Sa (Portugal); Politechnika Gdanska (Poland); Hella Aglaia Mobile Vision Gmbh (Germany); Ibm Ireland Limited (Ireland); Interuniversitair Micro-Electronica Centrum (Belgium); Iminds (Belgium); Institut National De Recherche Eninformatique Et Automatique (France); Instituto Superior De Engenharia Do Porto (Portugal); Instituto Tecnologico De Informatica (Spain); Ixion Industry And Aerospace Sl (Spain); Universitat Linz (Austria); Linz Center Of Mechatronics Gmbh (Austria); Magillem Design Services Sas (France); Magneti Marelli S.P.A. (Italy); Microeletronica Maser Slspain); Mdal (France); Model Engineering Solutions Gmbhgermany); Magna Steyr Engineering Ag & Co Kg (Austria); Nabto Aps (Denmark); Navtor As (Norway); Nm Robotic Gmbh (Austria); Nxp Semiconductors Germany Gmbh(Germany); Offis E.V.(Germany); Philips Medical Systems Nederland Bvnetherlands); Rohde & Schwarz Gmbh&Co Kommanditgesellschaft(Germany); Reden B.V. (Netherlands); Renault Sas (France); Rugged Tooling Oyfinland); Serva Transport Systems Gmbh(Germany); Siemens Industry Software Nvbelgium); University Of

Southampton (Uk); Safetrans E.V. (Germany); Thales Alenia Space Espana, Saspain); Fundacion Tecnalia Research & Innovationspain); Thales Austria Gmbh (Austria); The Motor Insurance Repair Researchcentre (Uk); Toyota Motor Europe (Belgium); Nederlandse Organisatie Voor Toegepast Natuurwetenschappelijk Onderzoek Tno (Netherlands); Ttcontrol Gmbh (Austria); Tttech Computertechnik Ag (Austria); Technische Universiteit Eindhoven (Netherlands); Technische Universitat Darmstadt (Germany); Technische Universitaet Graz (Austria); Twt Gmbh Science & Innovation (Germany); University College Dublin, National University Of Ireland, Dublin (Ireland); Universidad De Las Palmas De Gran Canaria (Spain); Universita Degli Studi Di Modena E Reggio Emilia (Italy); Universidad Politecnica De Madrid (Spain); Valeo Autoklimatizace K.S. (Czech Republic); Valeo Comfort And Driving Assistance (France); Valeo Schalter Und Sensoren Gmbh (Germany); Kompetenzzentrum - Das Virtuelle Fahrzeug, Forschungsgesellschaft Mbh (Austria); Vires Simulationstechnologie Gmbh (Germany); Teknologian Tutkimuskeskus Vtt Oy (Finland); Tieto Finland Support Services Oy (Finland); Zilinska Univerzita V Ziline (Slovakia);

Inria contact: Olivier Zendra

The objective of ENABLE-S3 (http://www.enable-s3.eu) is to establish cost-efficient cross-domain virtual and semi-virtual V&V platforms and methods for ACPS. Advanced functional, safety and security test methods will be developed in order to significantly reduce the verification and validation time but preserve the validity of the tests for the requested high operation range. ENABLE-S3 aspires to substitute today's physical validation and verification efforts by virtual testing and verification, coverage-oriented test selection methods and standardization. ENABLE-S3 is use-case driven; these use cases represent relevant environments and scenarios. Each of the models, methods and tools integrated into the validation platform will be applied to at least one use case (under the guidance of the V&V methodology), where they will be validated (TRL 5) and their usability demonstrated (TRL6). Representative use cases and according applications provide the base for the requirements of methods and tools, as well as for the evaluation of automated systems and respective safety. This project is industry driven and has the objective of designing new technologies for autonomous transportation, including to secure them. TAMIS tests its results on the case studies of the project.

Within ENABLE-S3, the contribution of the TAMIS team consists in in proposing a generic method to evaluate complex automotive-oriented systems for automation (perception, decision-making, etc.). The method is based on Statistical Model Checking (SMC), using specifically defined Key Performance Indicators (KPIs), as temporal properties depending on a set of identified metrics. By feeding the values of these metrics during a large number of simulations, and the properties representing the KPIs to our statistical model checker, we evaluate the probability to meet the KPIs. We applied this method to two different subsystems of an autonomous vehicles: a perception system (CMCDOT framework) and a decision-making system. We show that the methodology is suited to efficiently evaluate some critical properties of automotive systems, but also their limitations.

Olivier Zendra, Jean Quilbeuf, Jean-Louis Lanet and Axel Legay and were involved in this project. The project supports one postdoc in TAMIS starting in 2017.

9.2.1.3. TeamPlay (653)

Title: TeamPlay: Time, Energy and security Analysis for Multi/Many-core heterogeneous PLAtforms

Program: H2020

Duration: 01/2018 - 12/2020

Coordinator: Inria

Partners:

Absint Angewandte Informatik Gmbh (Germany), Institut National De Recherche en

Informatique et Automatique (France), Secure-Ic Sas (France), Sky-Watch A/S (Danemark), Syddansk Universitet (Danemark), Systhmata Ypologistikis Orashs Irida Labs Ae (Greece), Technische Universität Hamburg-Harburg (Germany), Thales Alenia Space Espana (Spain), Universiteit Van Amsterdam (Netherlands), University Of Bristol (UK), University Of St Andrews (UK)

Inria contact: Olivier Zendra

The TeamPlay (Time, Energy and security Analysis for Multi/Many-core heterogeneous PLAtforms) project federates 6 academic and 5 industrial partners and aims to develop new, formally-motivated, techniques that will allow execution time, energy usage, security, and other important non-functional properties of parallel software to be treated effectively, and as first- class citizens. We will build this into a toolbox for developing highly parallel software for low-energy systems, as required by the internet of things, cyber-physical systems etc. The TeamPlay approach will allow programs to reflect directly on their own time, energy consumption, security, etc., as well as enabling the developer to reason about both the functional and the non-functional properties of their software at the source code level. Our success will ensure significant progress on a pressing problem of major industrial importance: how to effectively manage energy consumption for parallel systems while maintaining the right balance with other important software metrics, including time, security etc. The project brings together leading industrial and academic experts in parallelism, energy modeling/ transparency, worst-case execution time analysis, non-functional property analysis, compilation, security, and task coordination. Results will be evaluated using industrial use cases taken from the computer vision, satellites, flying drones, medical and cyber security domains. Within TeamPlay, Inria and TAMIS coordinate the whole project, while being also in charge of aspects related more specifically to security.

The permanent members of TAMIS who are involved are Olivier Zendra and Annelie Heuser.

9.2.1.4. SUCCESS

Title: SUCCESS: SecUre aCCESSibility for the internet of things

Program: CHIST-ERA 2015

Duration: 10/2016 - 10/2019

Coordinator: Middlesex University (UK)

Partners:

Middlesex University, School of Science and Technology (UK); Inria, TAMIS (France); Université Grenoble Alpes, Verimag (France); University of TWENTE, (Netherlands)

Inria contact: Ioana Cristescu

The objectives of the SUCCESS project is to use formal methods and verification tools with a proven track record to provide more transparency of security risks for people in given IoT scenarios. Our core scientific innovation will consist on the extension of well-known industry-strength methods. Our technological innovation will provide adequate tools to address risk assessment and adaptivity within IoT in healthcare environments and an open source repository to foster future reuse, extension and progress in this area. Our project will validate the scientific and technological innovation through pilots, one of which will be in collaboration with a hospital and will allow all stakeholders (e.g. physicians, hospital technicians, patients and relatives) to enjoy a safer system capable to appropriately handle highly sensitive information on vulnerable people while making security and privacy risks understandable and secure solutions accessible.

Within SUCCESS, the contribution of the TAMIS team consists in a framework for analyzing the security of a given IOT system, and notably whether it resists to attack. Our approach is to build a high-level model of the system, including its vulnerabilities, as well as an attacker. We represent the set of possible attacks using an attack tree. Finally, we evaluate the probability that an attack succeeds using Statistical Model Checking.

In the TAMIS team, Delphine Beaulaton, Najah Ben Said, Ioana Cristescu, Axel Legay and Jean Quilbeuf are involved in this project.

TEA Project-Team

9. Partnerships and Cooperations

9.1. International Initiatives

9.1.1. Inria International Labs

Sino-European Laboratory in Computer Science, Automation and Applied Mathematics
Associate Team involved in the International Lab:

9.1.1.1. CONVEX

Title: Compositional Verification of Cyber-Physical Systems

International Partner (Institution - Laboratory - Researcher):

CAS (China) - State Key Laboratory of Computer Science - Naijun Zhan

Start year: 2018

See also: http://www.irisa.fr/prive/talpin/convex

Formal modeling and verification methods have successfully improved software safety and security in vast application domains in transportation, production and energy. However, formal methods are labor-intensive and require highly trained software developers. Challenges facing formal methods stem from rapid evolution of hardware platforms, the increasing amount and cost of software infrastructures, and from the interaction between software, hardware and physics in networked cyber-physical systems.

Automation and expressivity of formal verification tools must be improved not only to scale functional verification to very large software stacks, but also verify non-functional properties from models of hardware (time, energy) and physics (domain). Abstraction, compositionality and refinement are essential properties to provide the necessary scalability to tackle the complexity of system design with methods able to scale heterogeneous, concurrent, networked, timed, discrete and continuous models of cyber-physical systems.

Project CONVEX wants to define a CPS architecture design methodology that takes advantage of existing time and concurrency modeling standards (MARTE, AADL, Ptolemy, Matlab), yet focuses on interfacing heterogeneous and exogenous models using simple, mathematically-defined structures, to achieve the single goal of correctly integrating CPS components.

Inria@SiliconValley
Associate Team involved in the International Lab:

9.1.1.2. Composite

Title: Compositional System Integration

International Partners (Institution - Laboratory - Researcher):

University of California, San Diego (United States) - Microelectronic Embedded Systems Laboratory - Rajesh Gupta

Start year: 2017

See also: http://www.irisa.fr/prive/talpin/composite

Most applications that run somewhere on the internet are not optimized to do so. They execute on general purpose operating systems or on containers (virtual machines) that are built with the most conservative assumptions about their environment. While an application is specific, a large part of the system it runs on is unused, which is both a cost (to store and execute) and a security risk (many entry points).

A unikernel, on the contrary, is a system program object that only contains the necessary the operating system services it needs for execution. A unikernel is build from the composition of a program, developed using high-level programming language, with modules of a library operating system (libOS), to execute directly on an hypervisor. A unikernel can boot in milliseconds to serve a request and shut down, demanding minimal energy and resources, offering stealthiest exposure time and surface to attacks, making them the ideal platforms to deploy on sensor networks, networks of embedded devices, smart grids and clouds.

The goal of COMPOSITE is to develop the mathematical foundations for sound and efficient composition in system programming: analysis, verification and optimization technique for modular and compositional hardware-system-software integration of unikernels. We intend to further this development with the prospect of an end-to-end co-design methodology to synthesize lean and stealth networked embedded devices.

9.2. International Research Visitors

9.2.1. Visits of International Scientists

Deian Stefan, Shravan Narayan (CSD) visited TEA in September for a week. Jonathan Protzenko (MSR Redmond) joined the meeting for a couple of days and gave a seminar at http://68nqrt.irisa.fr. Rajesh Gupta visited TEA for a month in August-September.

Lingtai Wang, ISCAS, visited TEA for a week in November.

9.2.2. Visits to International Teams

Jean-Joseph Marty visited UC San Diego in June for two weeks.

Jean-Pierre Talpin visited ISCAS, BUAA and Nankai in April, June and October, for a total period of two months, thanks to funding provided by the Chinese partners in the context of associate-project Convex.

Simon Lunel visited ISCAS for a week in December.

TOCCATA Project-Team

9. Partnerships and Cooperations

9.1. Regional Initiatives

9.1.1. ELEFFAN

Participant: Sylvie Boldo [contact].

ELEFFAN is a Digicosme project funding the PhD of F. Faissole. S. Boldo is the principal investigator. It began in 2016 for three years. https://project.inria.fr/eleffan/

The ELEFFAN project aims at formally proving rounding error bounds of numerical schemes.

Partners: ENSTA Paristech (A. Chapoutot)

9.1.2. MILC

Participant: Sylvie Boldo [contact].

MILC is a DIM-RFSI project. It is a one-year project (2018–2019) that aims at formalizing measure theory and Lebesgue integral in the Coq proof assistant. https://lipn.univ-paris13.fr/MILC/

Partners: Université Paris 13 (M. Mayero, PI), Inria Paris, Inria Saclay

9.2. National Initiatives

9.2.1. ANR CoLiS

Participants: Claude Marché [contact], Andrei Paskevich.

The CoLiS research project is funded by the programme "Société de l'information et de la communication" of the ANR, for a period of 60 months, starting on October 1st, 2015. http://colis.irif.univ-paris-diderot.fr/

The project aims at developing formal analysis and verification techniques and tools for scripts. These scripts are written in the POSIX or bash shell language. Our objective is to produce, at the end of the project, formal methods and tools allowing to analyze, test, and validate scripts. For this, the project will develop techniques and tools based on deductive verification and tree transducers stemming from the domain of XML documents.

Partners: Université Paris-Diderot, IRIF laboratory (formerly PPS & LIAFA), coordinator; Inria Lille, team LINKS

9.2.2. ANR Vocal

Participants: Jean-Christophe Filliâtre [contact], Andrei Paskevich.

The Vocal research project is funded by the programme "Société de l'information et de la communication" of the ANR, for a period of 60 months, starting on October 1st, 2015. https://vocal.lri.fr/

The goal of the Vocal project is to develop the first formally verified library of efficient general-purpose data structures and algorithms. It targets the OCaml programming language, which allows for fairly efficient code and offers a simple programming model that eases reasoning about programs. The library will be readily available to implementers of safety-critical OCaml programs, such as Coq, Astrée, or Frama-C. It will provide the essential building blocks needed to significantly decrease the cost of developing safe software. The project intends to combine the strengths of three verification tools, namely Coq, Why3, and CFML. It will use Coq to obtain a common mathematical foundation for program specifications, as well as to verify purely functional components. It will use Why3 to verify a broad range of imperative programs with a high degree of proof automation. Finally, it will use CFML for formal reasoning about effectful higher-order functions and data structures making use of pointers and sharing.

Partners: team Gallium (Inria Paris-Rocquencourt), team DCS (Verimag), TrustInSoft, and OCamlPro.

9.2.3. ANR FastRelax

Participants: Sylvie Boldo [contact], Guillaume Melquiond.

This is a research project funded by the programme “Ingénierie Numérique & Sécurité” of the ANR. It is funded for a period of 48 months and it has started on October 1st, 2014. http://fastrelax.gforge.inria.fr/

Our aim is to develop computer-aided proofs of numerical values, with certified and reasonably tight error bounds, without sacrificing efficiency. Applications to zero-finding, numerical quadrature or global optimization can all benefit from using our results as building blocks. We expect our work to initiate a "fast and reliable" trend in the symbolic-numeric community. This will be achieved by developing interactions between our fields, designing and implementing prototype libraries and applying our results to concrete problems originating in optimal control theory.

Partners: team ARIC (Inria Grenoble Rhône-Alpes), team MARELLE (Inria Sophia Antipolis - Méditerranée), team SPECFUN (Inria Saclay - Île-de-France), Université Paris 6, and LAAS (Toulouse).

9.2.4. ANR Soprano

Participants: Sylvain Conchon [contact], Guillaume Melquiond.

The Soprano research project is funded by the programme “Sciences et technologies logicielles” of the ANR, for a period of 42 months, starting on October 1st, 2014. http://soprano-project.fr/

The SOPRANO project aims at preparing the next generation of verification-oriented solvers by gathering experts from academia and industry. We will design a new framework for the cooperation of solvers, focused on model generation and borrowing principles from SMT (current standard) and CP (well-known in optimization). Our main scientific and technical objectives are the following. The first objective is to design a new collaboration framework for solvers, centered around synthesis rather than satisfiability and allowing cooperation beyond that of Nelson-Oppen while still providing minimal interfaces with theoretical guarantees. The second objective is to design new decision procedures for industry-relevant and hard-to-solve theories. The third objective is to implement these results in a new open-source platform. The fourth objective is to ensure industrial-adequacy of the techniques and tools developed through periodical evaluations from the industrial partners.

Partners: team DIVERSE (Inria Rennes - Bretagne Atlantique), Adacore, CEA List, Université Paris-Sud, and OCamlPro.

9.2.5. FUI LCHIP

Participant: Sylvain Conchon [contact].

LCHIP (Low Cost High Integrity Platform) is aimed at easing the development of safety critical applications (up to SIL4) by providing: (i) a complete IDE able to automatically generate and prove bounded complexity software (ii) a low cost, safe execution platform. The full support of DSLs and third party code generators will enable a seamless deployment into existing development cycles. LCHIP gathers scientific results obtained during the last 20 years in formal methods, proof, refinement, code generation, etc. as well as a unique return of experience on safety critical systems design. http://www.clearsy.com/en/2016/10/4260/

Partners: 2 technology providers (ClearSy, OcamlPro), in charge of building the architecture of the platform; 3 labs (IFSTTAR, LIP6, LRI), to improve LCHIP IDE features; 2 large companies (SNCF, RATP), representing public ordering parties, to check compliance with standard and industrial railway use-case.

The project lead by ClearSy has started in April 2016 and lasts 3 years. It is funded by BpiFrance as well as French regions.

9.2.6. ANR PARDI

Participant: Sylvain Conchon [contact].

Verification of PARameterized DIstributed systems. A parameterized system specification is a specification for a whole class of systems, parameterized by the number of entities and the properties of the interaction, such as the communication model (synchronous/asynchronous, order of delivery of message, application ordering) or the fault model (crash failure, message loss). To assist and automate verification without parameter instantiation, PARDI uses two complementary approaches. First, a fully automatic model checker modulo theories is considered. Then, to go beyond the intrinsic limits of parameterized model checking, the project advocates a collaborative approach between proof assistant and model checker. http://pardi.enseeiht.fr/

The proof lead by Toulouse INP/IRIT started in 2016 and lasts for 4 years. Partners: Université Pierre et Marie Curie (LIP6), Université Paris-Sud (LRI), Inria Nancy (team VERIDIS)

9.3. European Initiatives

9.3.1. FP7 & H2020 Projects

9.3.1.1. EMC2

Participant: Sylvie Boldo [contact].

A new ERC Synergy Grant 2018 project, called Extreme-scale Mathematically-based Computational Chemistry (EMC2) has just been accepted. The PIs are É. Cancès, L. Grigori, Y. Maday and J.-P. Piquemal. S. Boldo is part of the work package 3: validation and certification of molecular simulation results. https://www.sorbonne-universite.fr/newsroom/actualites/erc-synergy-grant-2018

9.3.2. Collaborations in European Programs, Except FP7 & H2020

Program: COST (European Cooperation in Science and Technology).

Project acronym: EUTypes https://eutypes.cs.ru.nl/

Project title: The European research network on types for programming and verification

Duration: 2015-2019

Coordinator: Herman Geuvers, Radboud University Nijmegen, The Netherlands

Other partners: 36 members countries, see http://www.cost.eu/COST_Actions/ca/CA15123?parties

Abstract: Types are pervasive in programming and information technology. A type defines a formal interface between software components, allowing the automatic verification of their connections, and greatly enhancing the robustness and reliability of computations and communications. In rich dependent type theories, the full functional specification of a program can be expressed as a type. Type systems have rapidly evolved over the past years, becoming more sophisticated, capturing new aspects of the behaviour of programs and the dynamics of their execution.

This COST Action will give a strong impetus to research on type theory and its many applications in computer science, by promoting (1) the synergy between theoretical computer scientists, logicians and mathematicians to develop new foundations for type theory, for example as based on the recent development of "homotopy type theory", (2) the joint development of type theoretic tools as proof assistants and integrated programming environments, (3) the study of dependent types for programming and its deployment in software development, (4) the study of dependent types for verification and its deployment in software analysis and verification. The action will also tie together these different areas and promote cross-fertilisation.

VERIDIS Project-Team

8. Partnerships and Cooperations

8.1. National Initiatives

8.1.1. ANR International Project SYMBIONT

Project acronym: SYMBIONT.

Project title: Symbolic Methods for Biological Networks.

Duration: July 2018 – June 2021.

Coordinators: Thomas Sturm and Andreas Weber (Univ. of Bonn, Germany).

Other partners: Univ. of Lille 1, Univ. of Montpellier, Inria Saclay Île de France (Lifeware), RWTH Aachen (Department of Mathematics and Joint Research Center for Computational Biomedecine), Univ. of Kassel.

Participants: Thomas Sturm.

Abstract: SYMBIONT is an international interdisciplinary project, funded by ANR in France and by DFG in Germany under the PRCI program. It includes researchers from mathematics, computer science, systems biology, and systems medicine. Computational models in systems biology are built from molecular interaction networks and rate laws, involving parameters, resulting in large systems of differential equations. The statistical estimation of model parameters is computationally expensive and many parameters are not identifiable from experimental data. The project aims at developing novel symbolic methods, aiming at the formal deduction of principal qualitative properties of models, for complementing the currently prevailing numerical approaches. Concrete techniques include tropical geometry, real algebraic geometry, theories of singular perturbations, invariant manifolds, and symmetries of differential systems. The methods are implemented in software and validated against models from computational biology databases.

More information: https://www.symbiont-project.org/.

8.1.2. ANR Project IMPEX

Project acronym: IMPEX.

Project title: Implicit and explicit semantics integration in proof based developments of discrete systems.

Duration: December 2013 – December 2018.

Coordinator: Dominique Méry.

Other partners: ENSEEIHT/IRIT Toulouse, Supélec, Telecom Sud Paris, Systerel. Pierre Castéran from LaBRI Bordeaux also contributed to the project.

Participants: Souad Kherroubi, Dominique Méry.

Abstract: Modeling languages provide techniques and tool support for the design, synthesis, and analysis of formal models that arise during system development. The semantics of these languages is well understood by their users and is therefore implicit in the models. The languages do not provide concepts for explicitly representing characteristics (domain knowledge) resulting from an analysis of the underlying application domain [69]. We suggest that ontologies are good candidates for defining domain theories and for uniquely identifying concepts encapsulating domain knowledge. The objective [50] is to offer rigorous mechanisms for handling domain knowledge in design models. The main results of the project are summarized in [18] and show the importance of three operations over models namely annotation, dependency and refactoring [38].

8.1.3. ANR Project Formedicis

Project acronym: Formedicis.

Project title: Formal methods for the development and the engineering of critical interactive systems.

Duration: January 2017 – December 2020.

Coordinator: Bruno d'Augsbourg (Onera).

Other partners: ENSEEIHT/IRIT Toulouse, ENAC, Université de Lorraine (Veridis).

Participants: Dominique Méry.

Abstract: For the last 30 years, the aerospace domain has successfully devised rigorous methods and tools for the development of safe functionally-correct software. During this process, interactive software has received a relatively lower amount of attention. However, Human-System Interactions (HSI) are important for critical systems and especially in aeronautics: for example, the investigation into the crash of the Rio-Paris flight AF 447 in 2009 pointed out a design issue in the Flight Director interface as one of the original causes of the crash. Formedicis aims at designing a formal hub language, in which designers can express their requirements concerning the interactive behavior that must be embedded inside applications, and at developing a framework for validating, verifying, and implementing critical interactive applications expressed in that language.

More information: http://www.agence-nationale-recherche.fr/Project-ANR-16-CE25-0007.

8.1.4. ANR Project DISCONT

Project acronym: DISCONT.

Project title: Correct integration of discrete and continuous models.

Duration: March 2018 – February 2022.

Coordinator: Paul Gibson (Telecom Sud Paris).

Other partners: ENSEEIHT/IRIT Toulouse, LACL, ClearSy, Université de Lorraine (Veridis).

Participants: Dominique Méry.

Abstract: Cyber-Physical Systems (CPSs) connect the real world to software systems through a network of sensors and actuators that interact in complex ways, depending on context and involving different spatial and temporal scales. Typically, a discrete software controller interacts with its physical environment in a closed-loop schema where input from sensors is processed and output is generated and communicated to actuators. We are concerned with the verification of the correctness of such discrete controllers, which requires correct integration of discrete and continuous models. Correctness should arise from a design process based on sound abstractions (including discretizations) and models of the relevant physical laws. DISCONT aims at bridging the gap between the discrete and continuous worlds of formal methods and control theory. We will lift the level of abstraction above that found in current bridging techniques and provide associated methodologies and tools. Our concrete objectives are to develop a formal hybrid model, elaborate refinement steps for control requirements, propose a rational design method and support tools, and validate them based on use cases from a range of application domains.

More information: https://fusionforge.int-evry.fr/www/discont/.

8.1.5. ANR Project PARDI

Project acronym: PARDI.

Project title: Verification of parameterized distributed systems.

Duration: January 2017 – December 2020.

Coordinator: Philippe Quéinnec (ENSEEIHT/IRIT Toulouse).

Other partners: Université Paris Sud/LRI, Université Nanterre/LIP6, Inria Nancy Grand Est (Veridis).

Participants: Marie Duflot-Kremer, Igor Konnov, Stephan Merz.

Abstract: Distributed systems and algorithms are parameterized by the number of participating processes, the communication model, the fault model, and more generally the properties of interaction among the processes. The project aims at providing methodological and tool support for verifying parameterized systems, using combinations of model checking and theorem proving. VeriDis contributes its expertise on TLA$^+$ and its verification tools, and the integration with the Cubicle model checker is a specific goal of the project.

More information: http://pardi.enseeiht.fr/.

8.1.6. Inria IPL HAC SPECIS

Project acronym: HAC SPECIS.

Project title: High-performance application and computers: studying performance and correctness in simulation.

Duration: June 2016 – June 2020.

Coordinator: Arnaud Legrand (CNRS & Inria Grenoble Rhône Alpes, Polaris).

Other partners: Inria Grenoble Rhône Alpes (Avalon), Inria Rennes Bretagne Atlantique (Myriads), Inria Bordeaux Sud Ouest (Hiepacs, Storm), Inria Saclay Île de France (Mexico), Inria Nancy Grand Est (Veridis).

Participants: Marie Duflot-Kremer, Stephan Merz.

Abstract: The goal of HAC SPECIS is to answer methodological needs of HPC application and runtime developers and to allow the study of real HPC systems with respect to both correctness and performance. To this end, this Inria Project Lab assembles experts from the HPC, formal verification, and performance evaluation communities. VeriDis contributes its expertise in formal verification techniques. In particular, our goal is to extend the functionalities of exhaustive and statistical model checking within the SimGrid platform. Yann Duplouy joined the project in December 2018 as a post-doctoral researcher with the objective of designing and implementing a statistical model checker for SimGrid.

More information: http://hacspecis.gforge.inria.fr.

8.2. European Initiatives

8.2.1. FP7 & H2020 Projects

8.2.1.1. ERC Matryoshka

Program: ERC.

Project acronym: Matryoshka.

Duration: April 2017 – March 2022.

Coordinator: Jasmin Blanchette (VU Amsterdam).

Participants: Daniel El Oraoui, Mathias Fleury, Pascal Fontaine, Hans-Jörg Schurr, Sophie Tourret, Uwe Waldmann.

Abstract: Proof assistants are increasingly used to verify hardware and software and to formalize mathematics. However, despite some success stories, they remain very laborious to use. The situation has improved with the integration of first-order automatic theorem provers – superposition provers and SMT (satisfiability modulo theories) solvers – but only so much can be done when viewing automatic provers as black boxes. We propose to deliver much higher levels of automation to users of proof assistants by fusing and extending two lines of research: automatic and interactive theorem proving. Our approach will be to enrich superposition and SMT with higher-order (HO) reasoning in

a careful manner, in order to preserve their desirable properties. With higher-order superposition and higher-order SMT in place, we will develop highly automatic provers building on modern superposition provers and SMT solvers, following a novel stratified architecture, and integrate them in proof assistants. Users stand to experience substantial productivity gains: From 2010 to 2016, the success rate of automatic provers on interactive proof obligations from a representative benchmark suite called Judgment Day has risen from 47% to 77%; with this project, we aim at 90%–95% proof automation.

More information: http://matryoshka.gforge.inria.fr/.

8.2.1.2. FET-Open CSA SC^2

Program: FET Open CSA.

Project acronym: SC^2.

Project title: Symbolic Computation and Satisfiability Checking.

Duration: July 2016 – August 2018.

Coordinator: James Davenport (U. of Bath, UK).

Other partners: see http://www.sc-square.org/CSA/welcome.html.

Participants: Pascal Fontaine, Thomas Sturm.

Abstract: The use of advanced methods for solving practical and industrially relevant problems by computers has a long history. Whereas Symbolic Computation is concerned with the algorithmic determination of exact solutions to complex mathematical problems, more recent developments in the area of Satisfiability Checking tackle similar problems but with different algorithmic and technological solutions. Before the project, the two communities were largely disjoint and unaware of the achievements of each other, despite strong reasons for them to discuss and collaborate. Researchers from the two communities rarely interacted, and also their tools lacked common, mutual interfaces for unifiying their strengths. The SC^2 project initiated a wide range of activities to bring the two communities together, identify common challenges, offer global events and bilateral visits, propose standards, and so on. Now that the project is finished, we believe that these activities will continue to foster cross-fertilization of both fields and bring mutual improvements to the techniques and the software tools developed by both communities.

8.2.2. Collaborations in European Programs, Except FP7 & H2020

Program: Erasmus+.

Project acronym: PIAF.

Project title: Pensée Informatique et Algorithmique au Fondamental / Computational Thinking in and Algorithmic in Primary Education.

Coordinator: Université de Liège.

Other partners: Université du Luxembourg, Saarland University, ESPE Nancy.

Participant: Marie Duflot-Kremer.

Abstract: The goal of the PIAF project is threefold: creating a repository of skills related to computational and algorithmic thinking, designing activities aiming at the acquisition of these skills, and evaluating the impact of these activities on primary school children and their computational thinking capacities.

8.3. International Initiatives

8.3.1. Inria International Partners

Project acronym: KANASA.

Title: Kanazawa-Nancy Partnership for Satistifiability and Arithmetics.

International Partner: Japan Advanced Institute for Science and Technology (JAIST, Dept. Intelligent Robotics, Mizuhito Ogawa).
Start year: 2016.
During the last decade, there has been tremendous progress on symbolic verification techniques, spurred in particular by the development of SMT (satisfiability modulo theories) techniques and tools. Our first direction of research will be to investigate the theoretical background and the practical techniques to integrate Interval Constraint Propagation within a generic SMT framework, including other decision procedures and quantifier handling techniques. On the purely arithmetic side, we also want to study how to unite the reasoning power of all arithmetic techniques developed in the team, including simplex-based SMT-like reasoners, Virtual Substitution, and Cylindrical Algebraic Decomposition. In particular, this includes developing theory combination frameworks for linear and non-linear arithmetic. There is a strong incentive for these kind of combinations since even non-linear SMT problems contain a large proportion of linear constraints. The partnership is supported by a Memorandum of Understanding between JAIST and LORIA.

In 2016/17, Vu Xuan Tung, then a PhD student from JAIST, spent one year in the VeriDis team, and Pascal Fontaine was a reviewer of his PhD thesis, defended in 2018. There were mutual visits in 2018, and the joint research evolves towards applying SMT techniques for detecting malware in obfuscated code.

8.4. International Research Visitors

8.4.1. Visits of International Scientists

Cezary Kaliszyk.

Date: 17 May 2018 – 17 June 2018.
Institution: University of Innsbruck, Austria.
Host: Pascal Fontaine.

Cezary Kaliszyk is an assistant professor at the University of Innsbruck. He is an expert in and a precursor of the use of machine learning in an automated reasoning context. He is the principal investigator for the ERC Starting Grant SMART (Strong Modular Proof Assistance Reasoning Across Theories). His research interests cover machine learning for theorem proving, formalization of mathematics, logical and proof translations, automated reasoning and proof data management. During his stay in Nancy, we initiated a new direction of research for quantifier instantiation, that is, using machine learning as a means of filtering the numerous instances generated by heuristic instantiation procedures in SMT.

8.4.2. Internships

Alexis Grall

Date: 1 March 2018 – 31 August 2018
Institution: Université de Lorraine
Host: Dominique Méry

In his master thesis, Alexis Grall studied the localization of Event-B models and their tranformation into the DistAlgo programming language. The Event-B models are obtained for designing distributed algorithms such as the leader election or the sliding window protocol. The transformation is proved to be sound and to preserve the properties of the Event-B models.

Axel Palaude

Date: 1 May 2018 – 31 July 2018
Institution: ENS Rennes
Host: Igor Konnov, Stephan Merz

Axel Palaude extended the short counter-example property that underlies decidability results for the verification of threshold automata (cf. section 7.2) to the case of threshold automata with real-time constraints.

ACUMES Project-Team

8. Partnerships and Cooperations

8.1. European Initiatives

8.1.1. FK32

Title: Multi-agent Fokker-Planck Nash games

Programm: Bayerisch-Französische Hochschulzentrum / Centre de Coopération Univ. Franco-Bavarois (BFHZ-CCUFB)

Duration: January - December 2018

PIs: A. Borzi (Univ. Wuerzburg) and A. Habbal

The purpose of this project is the formulation and application of a new mathematical framework for modeling avoidance and/or meeting in multi-agents' motion in the framework of differential games with stochastic processes and related Fokker-Planck equations.

8.1.2. FP7 & H2020 Projects

8.1.2.1. TramOpt

Title: A Traffic Management Optimization platform for enhanced road network efficiency

Programm: H2020

Duration: Mai 2017 - Octobre 2018

Coordinator: Inria

Inria contact: Paola Goatin

Building on the advances of the ERC TRAM3 project, the TRAMOPT PoC project aims are twofold:

- developing a robust prototype to allow real-life testing and deployment of a novel traffic control Decision Support System (DSS) based on a software platform for road traffic management including variable speed limits, ramp-metering and re-routing policies. This DSS is intended for public and private traffic managers to increase freeway network performances (e.g. congestion and pollution reduction);
- assessing the exploitation perspectives through a dedicated market study evaluating the added value of TRAMOPT over existing solutions and identifying the best business approach to foster uptake and commercialization of our technology.

8.2. International Initiatives

8.2.1. NAMReD

Program: Program Hubert Curien PHC Utique (Tunisia)

Project acronym: NAMReD

Project title: Novel Algorithms and Models for Data Reconstruction

Duration: January 2018 - December 2020

Coordinator: A. Habbal and M. Kallel (Univ. Tunis al Manar)

Abstract: The project goal is the design of new and efficient algorithms tailored for data reconstruction involving ill-posed problems. We rely on an original use of game theory and p-Kirchhoff methods. We apply these approaches for missing data recovery and image restoration.

8.2.2. Inria International Labs

Inria Chile

Associate Team involved in the International Lab:

8.2.2.1. NOLOCO

Title: Efficient numerical schemes for non-local transport phenomena

International Partner (Institution - Laboratory - Researcher):

Universidad del Bio-Bio (Chile) - Department of Mathematics - Luis Miguel Villada Osorio

Start year: 2018

See also: https://team.inria.fr/acumes/assoc-team/noloco/

This project tackles theoretical and numerical issues arising in the mathematical study of conservation laws with non-local flux functions. These equations include in a variety of applications, ranging from traffic flows to industrial processes and biology, and are intended to model macroscopically the action of non-local interactions occurring at the microscopic level.

The team, bi-located in France and Chile, has complementary skills covering the analysis, numerical approximation and optimization of non-linear hyperbolic systems of conservation laws, and their application to the modeling of vehicular and pedestrian traffic flows, sedimentation and other industrial problems.

Based on the members' expertise and on the preliminary results obtained by the team, the project will focus on the following aspects: - The development of efficient, high-order finite volume numerical schemes for the computation of approximate solutions of non-local equations. - The sensitivity analysis of the solutions on model parameters or initial conditions

The impact of the project is therefore twofold: while addressing major mathematical advances in the theory and numerical approximation of highly non-standard problems, it puts the basis for innovative tools to handle modern applications in engineering sciences.

8.2.3. Inria International Partners

8.2.3.1. ORESTE

Title: Optimal REroute Strategies for Traffic managEment

International Partner (Institution - Laboratory - Researcher):

University of California Berkeley (United States) - Electrical Engineering and Computer Science (EECS) (EECS) - Alexandre M. Bayen

Duration: 2018 - 2022

Start year: 2018

See also: https://team.inria.fr/acumes/assoc-team/oreste

The rapidly changing transportation ecosystem opens new challenges in traffic modeling and optimization approaches. We will focus in particular on the two following aspects:

Route choice apps impact. The vast use of personal route choice systems through phone applications or other devices is modifying the traditional flow of networks, requiring new models for accounting of the guidance impact. Indeed, routing apps have changed traffic patterns in the US and Europe, leading to new congestion patterns where previously no traffic was observed. Over the last decade, GPS enabled smart phones and connected personal navigation devices have disrupted the mobility landscape. Initially, the availability of traffic information led to better guidance of a small portion of motorists in the system. But as the majority of the driving public started to use apps, the systematic broadcasting of "selfish" best routes led to the worsening of traffic in numerous places, ultimately leading to the first lawsuit against one specific company in particular (Waze) accused to be the cause of these problems. This is just the beginning of an evolution, which, if not controlled and regulated, will progressively asphyxiate urban landscapes (already nearly hundreds of occurrences of this phenomenon are noticed by the popular media, which indicates the presence of probably

thousands of such issues in the US alone). Traffic managers are typically not equipped to fix these problems, and typically do not fund this research, as in order to be able to regulate and fix the problem, fundamental science needs to be advanced, modeling and game theory in particular, so remediation can happen (for which the traffic managers are equipped). In this project, we will mainly focus on the development and study of new macroscopic dynamical models to describe the aforementioned phenomena, and we will explore control strategies to mitigate their impact.

Autonomous vehicles. Besides, the foreseen deployment of connected and autonomous vehicles (CAVs) opens new perspectives both in traffic modeling and control. Indeed, CAVs are expected to modify the classical macroscopic traffic dynamics due to their peculiar motion laws, which are more uniform than human drivers' and follow different rules. Besides, due to their extended information on neighboring traffic conditions, the resulting dynamics would have a non-local character, justifying the use of rapidly developing non-local models. In any case, the different behavior of autonomous vehicles requires the design of new multi-class models capable of accounting for different vehicle classes characteristics and mutual interactions. Moreover, CAVs could be used as endogenous variable speed limiters, thus providing new action points to control traffic flow. Preliminary results show that the presence of few controlled vehicles can positively affect traffic conditions. In this setting, the interaction of AVs with the surrounding traffic can be described by strongly coupled PDE-ODE systems, which have been largely studied by the ACUMES team. Yet, the study of CAVs impact in realistic situations requires further research, in particular towards model validation, for which the Berkeley team will provide the necessary data.

8.2.3.2. Informal International Partners

University of Brescia, Information Engineering (R.M. Colombo: http://rinaldo.unibs.it/)

University of Mannheim, Scientific Computing Research Group (SCICOM) (S. Göttlich: http://lpwima.math.uni-mannheim.de/de/team/prof-dr-simone-goettlich/)

University of Rutgers - Camden, Department of Mathematical Science (B. Piccoli: https://piccoli.camden.rutgers.edu/)

University of Texas Arlington (S. Roy, https://mentis.uta.edu/explore/profile/souvik-roy)

Technical University of Kaiserslautern - Department of mathematics (B. Simeon https://www.mathematik.uni-kl.de/en/das/people/head/simeon/)

8.3. International Research Visitors

8.3.1. Visits of International Scientists

- M.D. Rosini (January 2018, Lublin University): co-direction of N. Dymski's PhD thesis.
- R.M. Colombo (July 2018, Brescia University): well-posedness of Initial Boundary Value Problems.
- L.M. Villada (September 2018, University of Bio-Bio): finite volume schemes for non-local systems of conservation laws.

8.3.2. Visits to International Teams

8.3.2.1. Research Stays Abroad

- N. Laurent-Brouty visited UC Berkeley (A. Bayen) for 1 month in April-May 2018.
- E. Rossi visited Mannheim University (S. Göttlich) for 1.5 months in September-October 2018.

BONUS Team

9. Partnerships and Cooperations

9.1. Regional Initiatives

- *CPER Data (2015-2019)*: in this project, that promotes research and software development related to advanced data science, the BONUS team is the scientific leader (N. Melab) of one of the three research lines of the project "Optimization and High-Performance Computing". In this context, a two-year (2018-2019) engineer (J-Y. Ji) is supported to develop a software demonstrator on decomposition-based big optimization. In addition, the team is co-leader of the workpackage/lever "Research infrastructures" related to the Grid'5000 nation-wide experimental testbed. This allowed to extend the testbed at Lille with a GPU-powered cluster highly important for the BONUS project. In addition, two engineers have been hired for the system & network administration of the testbed, user support and development.
- *CPER ELSAT (2015-2019)*: in this project, focused on ecomobility, security and adaptability in transport, the BONUS team is involved in the transversal research line: planning and scheduling of maintenance logistics in transportation. The team got support for a one-year (2017-2018) post-doc position (M. Rahimi).

9.2. National Initiatives

9.2.1. ANR

- *Bilateral ANR/RGC France/Hong Kong PRCI* (2016-2021), "Big Multi-objective Optimization" in collaboration with City University of Hong Kong

9.3. European Initiatives

9.3.1. FP7 & H2020 Projects

Program: H2020

Project acronym: SYNERGY

Project title: Synergy for Smart Multi-Objective Optimisation

Duration: 02 2016 - 01 2019

Coordinator: Jožef Stefan Institute (JSI), Ljubljana, Slovenia

Other partners: University of Lille (France), Cologne University of Applied Sciences (Germany)

Abstract: Many real-world application areas, such as advanced manufacturing, involve optimization of several, often time-consuming and conflicting objectives. For example, they require the maximization of the product quality while minimizing the production cost, and rely on demanding numerical simulations in order to assess the objectives. These, so-called multi-objective optimization problems can be solved more efficiently if parallelization is used to execute the simulations simultaneously and if the simulations are partly replaced by accurate surrogate models.

9.3.2. Collaborations in European Programs, Except FP7 & H2020

Program: COST CA15140

Project acronym: ImAppNIO

Project title: Improving applicability of nature-inspired optimization by joining theory and practice

Duration: 2016-2019

Coordinator: Thomas Jansen

Abstract: The main objective of the COST Action is to bridge this gap and improve the applicability of all kinds of nature-inspired optimisation methods. It aims at making theoretical insights more accessible and practical by creating a platform where theoreticians and practitioners can meet and exchange insights, ideas and needs; by developing robust guidelines and practical support for application development based on theoretical insights; by developing theoretical frameworks driven by actual needs arising from practical applications; by training Early Career Investigators in a theory of nature-inspired optimisation methods that clearly aims at practical applications; by broadening participation in the ongoing research of how to develop and apply robust nature-inspired optimisation methods in different application areas.

9.3.3. Collaborations with Major European Organizations

MARO: University of Mons (BELGIUM), Parallel surrogate-assisted optimization, large-scale exact optimization

University of Ceara (BRAZIL), Large-scale GPU-accelerated tree-based optimization

University of Luxembourg (LUXEMBOURG), Energy-aware scheduling in Cloud computing systems

University of Oviedo (SPAIN), Optimization under uncertainty for fuzzy flow shop scheduling

University of Coimbra and University of Lisbon (PORTUGAL), Exact and heuristic multi-objective search

University of Manchester (UNITED KINGDOM), Local optimality in multi-objective optimization

University of Elche and University of Murcia (SPAIN), Matheuristics for DEA

9.4. International Initiatives

9.4.1. Inria International Labs

International Laboratory for Research in Computer Science and Applied Mathematics
Associate Team involved in the International Lab:

9.4.1.1. MOHA

Title: Mixed Multi-objective Optimization using Hybrid Algorithms: Application to smart grids

International Partner (Institution - Laboratory - Researcher):

Ecole Mohammadia d'Ingénieurs (Morocco) - LERMA (Laboratoire d'Etudes et de Recherches en Mathématiques Appliquées) - Rachid Ellaia

Start year: 2016

See also: https://ocm.univ-lille1.fr/~talbi/momh/

The key challenge of this project is to propose new optimization models and new hybrid algorithms to the demand side management of smart grids in a context of uncertainty and in the presence of several conflicting objectives.

Those complex optimization problems are also characterized by the presence of both continuous and discrete variables. We need to design new efficient optimization algorithms combining state of the art exact and metaheuristic algorithms from the global optimization and combinatorial optimization communities.

9.4.1.2. Other IL projects

Title: Frontiers in Massive Optimization and Computational Intelligence

International Partner (Institution - Laboratory - Researcher): Shinshu University (JAPAN)

Start year: 2017

See also: https://sites.google.com/view/lia-modo/

Abstract: The aim of MODO is to federate French and Japanese researchers interested in the dimensionality, heterogeneity and expensive nature of massive optimization problems. The team receives a yearly support for international exchanges and shared manpower (joint PhD students).

9.4.2. Inria Associate Teams Not Involved in an Inria International Labs

Title: Three-fold decomposition in multi-objective optimization (D^3MO)

International Partner (Institution - Laboratory - Researcher): University of Exeter, UK

Start year: 2018

9.4.3. Inria International Partners

9.4.3.1. Informal International Partners

- Collaboration with Université de Mons (UMONS). The collaboration consists mainly in the joint supervision of two Phds (M. Gobert and G. Briffoteaux)
- University of Elche, Spain

9.4.4. Participation in Other International Programs

Title: **Evolutionary many-objective optimization: application to smart cities and engineering design**

International Partner (Institution - Laboratory - Researcher): CINVESTAV-IPN (MEXICO)

Start year: 2016

Abstract: The project is co-funded by ECOS Nord (FRANCE) and ANUIES (MEXICO). Abstract to be extended ...

Title: **Bridging the gap between exact methods and heuristics for multi-objective search (MOCO-Search)**

International Partner (Institution - Laboratory - Researcher): University of Coimbra and University of Lisbon, Portugal

Start year: 2018

Website: http://sites.google.com/view/moco-search/

Abstract: This international project for scientific cooperation (PICS), funded by CNRS and FCT, aims to fill the gap between exact and heuristic methods for multi-objective optimization. The goal is to establish the link between the design principles of exact and heuristic methods, to identify features that make a problem more difficult to be solved by each method, and to improve their performance by hybridizing search strategies. Special emphasis is given to rigorous performance assessment, benchmarking, and general-purpose guidelines for the design of exact and heuristic multi-objective search.

9.5. International Research Visitors

9.5.1. Visits of International Scientists

- Kiyoshi Tanaka, Shinshu University (JAPAN), March 2018 and November 2018
- Hernan Aguirre, Shinshu University (JAPAN), Invited Professor Univ Lille, from March 2018 until April 2018
- Kalyan Deb, University of Michiga (USA), Oct 2018
- Rachid Ellaia, EMI University of Rabat, Morocco, April 2018

9.5.1.1. Internships

- Alexandre Jesus, University of Coimbra (Portugal)

CAGE Project-Team

8. Partnerships and Cooperations

8.1. National Initiatives

8.1.1. ANR

- ANR SRGI, for *Sub-Riemannian Geometry and Interactions*, coordinated by **Emmanuel Trélat**, started in 2015 and runs until 2020. Other partners: Toulon University and Grenoble University. SRGI deals with sub-Riemannian geometry, hypoelliptic diffusion and geometric control.
- ANR Finite4SoS, for *Commande et estimation en temps fini pour les Systèmes de Systèmes*, coordinated by Wilfrid Perruquetti, started in 2015 and runs until 2019. Other partners: Inria Lille, CAOR - ARMINES. Finite4SoS aims at developing a new promising framework to address control and estimation issues of Systems of Systems subject to model diversity, while achieving robustness as well as severe time response constraints.
- ANR QUACO, for *QUAntum COntrol: PDE systems and MRI applications*, coordinated by Thomas Chambrion, started in 2017 and runs until 2021. Other partners: Lorraine University. QUACO aims at contributing to quantum control theory in two directions: improving the comprehension of the dynamical properties of controlled quantum systems in infinite-dimensional state spaces, and improve the efficiency of control algorithms for MRI.

8.2. European Initiatives

8.2.1. H2020 Projects

Program: ERC Proof of Concept

Project acronym: ARTIV1

Project title: An artificial visual cortex for image processing

Duration: From April 2017 to September 2018.

Coordinator: Ugo Boscain

Abstract: The ERC starting grant GECOMETHODS, on which this POC is based, tackled problems of diffusion equations via geometric control methods. One of the most striking achievements of the project has been the development of an algorithm of image reconstruction based mainly on non-isotropic diffusion. This algorithm is bio-mimetic in the sense that it replicates the way in which the primary visual cortex V1 of mammals processes the signals arriving from the eyes. It has performances that are at the state of the art in image processing. These results together with others obtained in the ERC project show that image processing algorithms based on the functional architecture of V1 can go very far. However, the exceptional performances of the primary visual cortex V1 rely not only on the particular algorithm used, but also on the fact that such algorithm 'runs' on a dedicated hardware having the following features: 1. an exceptional level of parallelism; 2. connections that are well adapted to transmit information in a non-isotropic way as it is required by the algorithms of image reconstruction and recognition. The idea of this POC is to create a dedicated hardware (called ARTIV1) emulating the functional architecture of V1 and hence having on one hand a huge degree of parallelism and on the other hand connections among the CPUs that reflect the non-isotropic structure of the visual cortex V1.

8.3. International Research Visitors

8.3.1. Research Stays Abroad

Jean-Michel Coron was at EPFL (Switzerland) from January to June 2018.

CAGIRE Project-Team

9. Partnerships and Cooperations

9.1. Regional Initiatives

9.1.1. SEIGLE

Participants: Enrique Gutierrez Alvarez, Jonathan Jung, Vincent Perrier.

SEIGLE means "Simulation Expérimentation pour l'Interaction de Gouttes Liquides avec un Ecoulement fortement compressible". It is a 3-year program which has started since October 2017 and was funded by Régional Nouvelle-Aquitaine, ISAE-ENSMA, CESTA and Inria. The interest of understanding aerodynamic mechanisms and liquid drops atomization is explained by the field of applications where they play a key role, specially in the new propulsion technologies through detonation in the aerospace as well as in the securities field. The SEIGLE project was articulated around a triptych experimentation, modeling and simulation. An experimental database will be constituted. It will rely on a newly installed facility (Pprime), similar to a supersonic gust wind tunnel/ hypersonic from a gaseous detonation tube at high pressure. This will allow to test modeling approaches (Pprime / CEA) and numerical simulation (Inria / CEA) with high order schemes for multiphasic compressible flows, suitable for processing shock waves in two-phase media. Enrique Gutierrez Alvarez (post-doctoral) joined the team in October 2018 to work on this project.

9.1.2. HPC scalable ecosystem

Participants: Jonathan Jung, Vincent Perrier, [A two-year Post-doc starting in 2019 or 2020].

HPC scalable ecosystem is a 3-year program funded by Région Nouvelle-Aquitaine (call 2018), Airbus, CEA-CESTA, University of Bordeaux, INRA, ISAE-ENSMA and Inria. A two-year post-doc will be hired in 2019 or 2020. The objective is to extend the prototype developed in [47] to high order (discontinuous Galerkin) and non-reactive diffusive flows in 3d. The same basis will be developed in collaboration with Pprime for WENO based methods for reactive flows.

9.2. National Initiatives

9.2.1. GIS Success

Participant: Pascal Bruel.

We are members of the CNRS GIS Success (Groupement d'Intérêt Scientifique) organised around two of the major CFD codes employed by the Safran group, namely AVBP and Yales2. No scientific activity has been devoted around those codes during 2018, but a 2-day Yales2 training session held in Rouen was attended by Pascal Bruel. Some technical activity was also devoted to install Yales2 at Evora University (Portugal) in the framework of the on-going informal scientific cooperation with Dr. P. Correia.

9.2.2. ANR MONACO_2025

Participant: Rémi Manceau.

The ambition of the MONACO_2025 project, coordinated by Rémi Manceau, is to join the efforts made in *two different industrial sectors* in order to tackle the industrial simulation of transient, turbulent flows affected by buoyancy effects. It brings together two academic partners, the project-team Cagire hosted by the university of Pau, and the institute Pprime of the CNRS/ENSMA/university of Poitiers (PPRIME), and R&D departments of two industrial partners, the PSA group and the EDF group, who are major players of the automobile and energy production sectors, respectively.

- The main **scientific objective** of the project is to make a breakthrough in *the unresolved issue* of the modelling of turbulence/buoyancy interactions in transient situations, within the continuous hybrid RANS/LES paradigm, which consists in preserving a computational cost compatible with industrial needs by relying on statistical approaches where a fine-grained description of the turbulent dynamics is not necessary. The transient cavity flow experiments acquired during MONACO_2025 will provide the partners and the scientific community with *an unrivalled source of knowledge* of the physical mechanisms that must be accounted for in turbulence models.
- The main **industrial objective** is *to make available computational methodologies* to address dimensioning, reliability and security issues in buoyancy-affected transient flows. It is to be emphasized that such problems are *not tackled using CFD at present in the industry*. At the end of MONACO_2025, a panel of methodologies, ranging from simple URANS to sophisticated hybrid model based on improved RANS models, will be evaluated in transient situations, against the dedicated cavity flow experiments and a real car underhood configuration. This final benchmark exercise will form *a decision-making tool* for the industrial partners, and will thus pave the way towards high-performance design of low-emission vehicles and highly secure power plants. In particular, the project is in line with the *Full Digital 2025 ambition*, e.g., the declared ambition of the PSA group to migrate, within the next decade, to a design cycle of new vehicles nearly entirely based on CAE (computer aided engineering), without recourse to expensive full-scale experiments.

9.3. European Initiatives

9.3.1. FP7 & H2020 Projects

9.3.1.1. SOPRANO

Participants: Rémi Manceau, Pascal Bruel, [A one-year Post-doc starting in January 2019].

Topic: MG-1.2-2015 - Enhancing resource efficiency of aviation

Project acronym: SOPRANO

Project title: Soot Processes and Radiation in Aeronautical inNOvative combustors

Duration: 01/09/2016 - 31/08/2020

Coordinator: SAFRAN

Other partners:

- France: CNRS, CERFACS, INSA Rouen, SAFRAN SA, Snecma SAS, Turbomeca SA.
- Germany: DLR, GE-DE Gmbh, KIT, MTU, RRD,
- Italy: GE AVIO SRL, University of Florence
- United Kingdom: Rolls Royce PLC, Imperial College of Science, Technology and Medecine, Loughborough University.

Abstract: For decades, most of the aviation research activities have been focused on the reduction of noise and NOx and CO2 emissions. However, emissions from aircraft gas turbine engines of non-volatile PM, consisting primarily of soot particles, are of international concern today. Despite the lack of knowledge toward soot formation processes and characterization in terms of mass and size, engine manufacturers have now to deal with both gas and particles emissions. Furthermore, heat transfer understanding, that is also influenced by soot radiation, is an important matter for the

improvement of the combustor's durability, as the key point when dealing with low-emissions combustor architectures is to adjust the air flow split between the injection system and the combustor's walls. The SOPRANO initiative consequently aims at providing new elements of knowledge, analysis and improved design tools, opening the way to: • Alternative designs of combustion systems for future aircrafts that will enter into service after 2025 capable of simultaneously reducing gaseous pollutants and particles, • Improved liner lifetime assessment methods. Therefore, the SOPRANO project will deliver more accurate experimental and numerical methodologies for predicting the soot emissions in academic or semi-technical combustion systems. This will contribute to enhance the comprehension of soot particles formation and their impact on heat transfer through radiation. In parallel, the durability of cooling liner materials, related to the walls air flow rate, will be addressed by heat transfer measurements and predictions. Finally, the expected contribution of SOPRANO is to apply these developments in order to determine the main promising concepts, in the framework of current low-NOx technologies, able to control the emitted soot particles in terms of mass and size over a large range of operating conditions without compromising combustor's liner durability and performance toward NOx emissions.

In the SOPRANO project, our objective is to complement the experimental (ONERA) and LES (CERFACS) work by RANS computations of the flow around a multiperforated plate, in order to build a database making possible a parametric study of mass, momentum and heat transfer through the plate and the development of multi-parameter-dependent equivalent boundary conditions. This year, we attended the two ITR meetings in Stuttgart (Germany) and Bordes (France) and recruited a post-doc bound to start by mid-january 2019.

9.4. International Initiatives

9.4.1. Inria International Partners

9.4.1.1. Informal International Partners

- Institute of Mathematics, Almaty, Kazakhstan:

  Collaboration with Drs A. Beketaeva and A. Naïmanova for the RANS simulations of a supersonic jet in crossflow configuration for a wide range of pressure ratio (1 journal paper submitted in 2018). The low-Mach preconditioning of an in-house ENO based compressible flow solver was also further investigated. [PB] (one 13-day stay in Almaty).
- Collaboration with P. Correia (University of Evora, Portugal) related to the development of enhanced boundary conditions for the simulations of Mach zero flows with the artificial compressibility method and low Mach flows with a pressure-based approach. [PB] (two 5-day stays in Evora).
- Collaboration with S. Lardeau (Siemens Industry Software Computational Dynamics, Nuremberg, Germany) on the EB-RSM model and hybrid RANS/LES model for industrial applications. [RM]

9.4.2. Participation in International Programs

Participants: Pascal Bruel, Jonathan Jung, Rémi Manceau, Vincent Perrier.

- ECOS-Sud A17A07 project with UNC (Cordoba, Argentina): this is the first year of this project devoted to the simulations of the wind around aerial fuel tank. Jonathan Jung and Pascal Bruel spent several weeks at UNC in the framework of this project.

9.5. International Research Visitors

- Dr. Juan Pablo Saldia (University of Cordoba, Argentina) spent one month in the team in the framework of the A17A07 Ecos-Sud project.

CARDAMOM Project-Team

9. Partnerships and Cooperations

9.1. Regional Initiatives

9.1.1. CRA - Region Nouvelle Aquitaine EVE

Title : Virtual prototyping of EVE engines

Type : Co-funded from Region Aquitaine and Inria

Duration : 36 months

Starting : January 2017

Coordinator : P.M. Congedo

Abstract : The main objective of this thesis is the construction of a numerical platform, for permitting an efficient virtual prototyping of the EVE expander. This will provide EXOES with a numerical tool, that is much more predictive with respect to the tools currently available and used in EXOES, by respecting an optimal trade-off in terms of complexity/cost needed during an industrial design process.i Two research axes will be mainly developed. First, the objective is to perform some high-predictive numerical simulation for reducing the amount of experiments, thanks to a specific development of RANS tools (Reynolds Averaged Navier-Stokes equations) for the fluids of interest for EXOES. These tools would rely on complex thermodynamic models and a turbulence model that should be modified. The second axis is focused on the integration of the solvers of different fidelity in a multi-fidelity platform for performing optimization under uncertainties. The idea is to evaluate the system perfor- mances by using massively the low-fidelity models, and by correcting these estimations via only few calculations with the high-fidelity code.

9.1.2. CRA - Region Nouvelle Aquitaine SANSON

Title : CRA/15-CARDAMOM THESE SANSON-10199

Type : Co-funded from Region Aquitaine and Inria

Duration :

Starting :

Coordinator :

Abstract :

9.1.3. CRA - Region Aquitaine ETRURIA

Title : EvaluaTion des Risques de submersion côtière et Urbaine par Remaillage et déformatIon Adaptative de maillage (ETRURIA)

Type : Co-funded from Region Aquitaine and Inria

Duration : 36 months

Starting : November 2018

Coordinator : M. Ricchiuto

Abstract : the objective of this project is to develop improved tools for the simulation of coastal floods by combining mesh adaptation techniques based on remeshing and deformation, representations of the coastal structures allowing to mix exact meshing and embedded representations, and high order schemes. The tools developed will be used to study inundation of French coasts, and in particular coasts of the Nouvelle Aquitaine Region, in collaboration with BRGM, and the Rivages ProTech Center of SUEZ.

9.2. National Initiatives

9.2.1. ANR VISCAP

Title:

Type: ANR

Duration: 48 months

Starting date : 1st Jan 2018

Coordinator: Vignoles Gerard (Université de Bordeaux and LCTS - UMR 5801)

Abstract: Self-healing Ceramic-Matrix Composites (SH-CMCs) have extremely long lifetimes even under severe thermal, mechanical and chemical solicitations. They are made of ceramic fibres embedded in a brittle ceramic matrix subject to multi-cracking, yielding a ?damageable-elastic? mechanical behaviour. The crack network resulting from local damage opens a path to fibre degradation by corrosion and ultimately to failure of the composite, e.g. under static fatigue in high-temperature oxidative conditions. But these materials have the particularity of protecting themselves against corrosion by the formation of a sealing oxide that fills the matrix cracks, delaying considerably the fibres degradation. Applications encompass civil aeronautic propulsion engine hot parts and they represent a considerable market; however this is only possible if the lifetime duration of the materials is fully certified. Numerical modelling is an essential tool for such an aim, and very few mathematical models exist for these materials; fulfilling the needs requires a strong academic-level effort before considering industrial valorisation. Therefore, the ambition of this innovative project is to provide reliable, experimentally validated numerical models able to reproduce the behaviour of SH-CMCs. The starting point is an existing image-based coupled model of progressive oxidative degradation under tensile stress of a mini-composite (i.e. a unidirectional bundle of fibres embedded in multi-layered matrix). Important improvements will be brought to this model in order to better describe several physic-chemical phenomena leading to a non-linear behaviour: this will require an important effort in mathematical analysis and numerical model building. A systematic benchmarking will allow creating a large database suited for the statistical analysis of the impact of material and environmental parameter variations on lifetime. Experimental verifications of this model with respect to tests carried out on model materials using in-situ X-ray tomography ? in a specially adapted high-temperature environmental & mechanical testing cell ? and other characterizations are proposed. The extension of the modelling procedure to Discrete Crack Networks for the large-scale description of the material life will be the next action; it will require important developments on mesh manipulations and on mathematical model analysis. Finally, experimental validation will be carried out by comparing the results of the newly created software to tests run on 3D composite material samples provided by the industrial partner of the project. The project originality lies in a multidisciplinary character, mixing competences in physico-chemistry, mechanics, numerical and mathematical modelling, software engineering and high-performance computing. It aims creating a true computational platform describing the multi-scale, multidimensional and multi-physics character of the phenomena that determine the material lifetime. Important outcomes in the domain of civil aircraft jet propulsion are expected, that could relate to other materials than those considered in this study.

9.2.2. FUI ICARUS

Title: Intensive Calculation for AeRo and automotive engines Unsteady Simulations.

Type: FUI

Duration: January 2017 - December 2019

Coordinator: Turbomeca, Safran group

Abstract: Large Eddy Simulation is an accurate simulation tool for turbulent flows which is becoming more and more attractive as the parallel computing techniques and platforms become more and more efficient. This project aims at improving the performances of some existing simulation tools (such as AVBP, Yales and ARGO), at developing meshing/re-meshing tools tailored to LES simulations, at improving the ergonomy of these tools to the industrial world (improved interfaces, data handling, code coupling, etc), and validate the progress made on case studies representative of typical design simulations in the automotive and aeronautic industry

subsectionFUI ICARUS

Title: Intensive Calculation for AeRo and automotive engines Unsteady Simulations.

Type: FUI

Duration: January 2017 - December 2019

Coordinator: Turbomeca, Safran group

9.2.3. APP University of Bordeaux

Title : Modélisation d'un système de dégivrage thermique

Type : Project University of Bordeaux

Duration : 36 months

Starting : October 2016

Coordinator : H. Beaugendre and M. Colin

Abstract : From the beginning of aeronautics, icing has been classified as a serious issue : ice accretion on airplanes is due to the presence of supercooled droplets inside clouds and can lead to major risks such as aircrash for example. As a consequence, each airplane has its own protection system : the most important one is an anti-icing system which runs permanently. In order to reduce gas consumption, de-icing systems are developed by manufacturers. One alternative to real experiment consists in developing robust and reliable numerical models : this is the aim of this project. These new models have to take into account multi-physics and multi-scale environnement : phase change, thermal transfer, aerodynamics flows, etc. We aim to use thin films equations coupled to level-set methods in order to describe the phase change of water. The overall objective is to provide a simulation plateform, able to provide a complete design of these systems.

9.3. European Initiatives

9.3.1. FP7 & H2020 Projects

Program: FET-Future & emerging technologies

Project acronym: ExaQUte

Project title: EXAscale Quantification of Uncertainties for Technology and Science Simulation

Duration: 2018-2021

Coordinator: Riccardo Rossi (CIMNE, Barcelona)

Other partners: EPFL (Switzerland), UPC (Spain), TUM (Germany), VSB (Czech Republic), str.ucture GmbH (Germany)

The ExaQUte project aims at constructing a framework to enable Uncertainty Quantification (UQ) and Optimization Under Uncertainties (OUU) in complex engineering problems using computational simulations on Exascale systems. The stochastic problem of quantifying uncertainties will be tackled by using a Multi Level MonteCarlo (MLMC) approach that allows a high number of stochastic variables. New theoretical developments will be carried out to enable its combination with adaptive mesh refinement, considering both, octree-based and anisotropic mesh adaptation. Gradient-based optimization techniques will be extended to consider uncertainties by developing methods to compute stochastic sensitivities, This requires new theoretical and computational developments.

With a proper definition of risk measures and constraints, these methods allow high-performance robust designs, also maximizing the solution reliability. The description of complex geometries will be possible by employing embedded methods, which guarantee a high robustness in the mesh generation and adaptation steps, while allowing preserving the exact geometry representation. The efficient exploitation of Exascale system will be addressed by combining State-of-the-Art dynamic task-scheduling technologies with space-time accelerated solution methods, where parallelism is harvested both in space and time. The methods and tools developed in ExaQUte will be applicable to many fields of science and technology. The chosen application focuses on wind engineering, a field of notable industrial interest for which currently no reliable solution exists. This will include the quantification of uncertainties in the response of civil engineering structures to the wind action, and the shape optimization taking into account uncertainties related to wind loading, structural shape and material behavior. All developments in ExaQUte will be open-source and will follow a modular approach, thus maximizing future impact.

9.3.2. Collaborations in European Programs, Except FP7 & H2020

Program: Ocean ERANET

Project acronym: MIDWEST

Project title: Multi-fidelity decision making tools for wave energy systems

Duration: October 2015- October 2018

Coordinator: Mario Ricchiuto

Other partners: Chalmers University (Sweden), IST Lisbon (Portugal), DTU Compute (Denmark)

MIDWEST is a project starting in 2016 (kick-off in December 2015) and funded by the EU-OceaneraNET program by the French ADEME, by the Swedish SWEA, and by the Portuguese FCT, aiming at proposing new tools for the wave energy industry. Wave energy converters (WECs) design currently relies on low-fidelity linear hydrodynamic models. While these models disregard fundamental nonlinear and viscous effects â which might lead provide sub-optimal designs â high-fidelity fully nonlinear Navier-Stokes models are prohibitively computational expensive for optimization. The MIDWEST project will provide an efficient asymptotic nonlinear finite element model of intermediate fidelity, investigate the required fidelity level to resolve a given engineering output, construct a multi-fidelity optimization platform using surrogate models blending different fidelity models. Combining know how in wave energy technology, finite element modelling, high performance computing, and robust optimization, the MIDWEST project will provide a new efficient decision making framework for the design of the next generation WECs which will benefit all industrial actors of the European wave energy sector.

9.4. International Initiatives

9.4.1. Inria Associate Teams Not Involved in an Inria International Labs

9.4.1.1. HAMster

Title: High order Adaptive moving MeSh finiTE elements in immeRsed computational mechanics

International Partner (Institution - Laboratory - Researcher):

Duke (United States) - Civil & Environmental Engineering and Mechanical Engineering & Material Science - Guglielmo Scovazzi

Inria Bordeaux Sud-Ouest (France) - CARDAMOM team - Mario Ricchiuto

Start year: 2017

See also: https://team.inria.fr/athamster/

This project focuses on adaptive unstructured mesh finite element-type methods for fluid flows with moving fronts. These fronts may be interfaces between different fluids, or fluid/solid, and modelling or physical Â fronts (e.g. shock waves) present in the flow. The two teams involved in the project have developed over the years complementary strategies, Â one focusing more on an Eulerian description aiming at capturing fronts on adaptive unstructured grids, Â the other Â working more on Lagrangian approaches aiming at following exactly some of these features. Unfortunately, classical Lagrangian methods are at a disadvantage in the presence of complex deformation patterns, especially for fronts undergoing large deformations, since the onset of vorticity quickly leads to mesh rotation and eventually tangling. On the other end, capturing approaches, as well as Immersed Boundary/Embedded (IB/EB) methods, while providing Â enormous flexibility when considering complex cases, Â require a careful use of mesh adaptivity to guarantee an accurate capturing of interface physics. The objective of this team is to study advanced hybrid methods combining high order, adaptive, monotone capturing techniques developed in an Eulerian or ALE setting, with fitting techniques and fully Lagrangian approaches.

9.4.2. Inria International Partners

9.4.2.1. Informal International Partners

- We entertain since many years a collaboration with Ecole de Technologie SupÃ©rieure de MontrÃ©al (Quebec), and in particular with Prof. Francois Morency, on the modelling of wing icing
- Collaboration with Universitá La Sapienza i (Prof. Renato Paciorri) and Universitá della Basilicata (Prof. Aldo Bonfiglioli) on the development of shock fitting techniques. We have regular exchanges of mutual visits and of students (this year Mirco Ciallella)
- We collaborate with Politecnico di Milano (Prof. Alberto Guardone) on the development of adaptive mesh techniques for time dependent problems. Within this collaboration Luca Cirrottola has spend part of his PhD in CARDAMOM
- We work with DTU Compute in Denmark (Prof. Allan-Peter Engsig Karup) and with and RISE in Sweden (Dr. Claes Eskilsson) on the simulation of free surface flows with floating structures. The PhD of U. Bosi is partially (and informally) co-supervised by Prof. Engsig-Karup and Dr. Eskilsson
- We work with Alireza Mazaheri (NASA LaRC, Virginia) on high order adaptive discretizations for compressible flows. Marco Lorini visited the NASA center in March/April

9.5. International Research Visitors

9.5.1. Visits of International Scientists

- L. Nouveau
- G. Scovazzi, Professor at Duke University (Durham, NC), has visited Mario Ricchiuto in January and in June 2018 to work on high order embedded methods
- Aron Roland, CEO of BGS IT&E (Information Technology & Engineering) has visited Mario Ricchiuto in February 2018 to work on the simulation of flash floods
- Nicolas Perinet, Postdoctoral fellow at University of Chile has visited Mario Ricchiuto to work on the benchmarking of the SLOWS CODE. From Jul 2018 until Sep 2018
- Tatsuya Watanabe, Professor at Kyoto Sangyo University has visited Mathieu Collin to work on Born-Infeld theory in March 2018.
- Francois Morency, Professeur at Ecole de Technologie Supérieure de Montréal has visited Héloïse Beaugendre to work on aircraft icing, roughness modeling and performance degradation, on Jul 2018 and from Sep to Dec 2018

9.5.1.1. Internships

- Agnes Chan (Inria, M. Sc. Student). From Jun 2018 until Sep 2018.
- Beatrice Battisti (Inria, M. Sc. Student). From Apr 2018 until Sep 2018.
- Elie Solai (Inria, M. Sc. Student). From Mar 2018 until Aug 2018.
- Mirco Ciallella (Inria, M. Sc. Student). From Nov 2018.

COMMANDS Project-Team

9. Partnerships and Cooperations

9.1. National Initiatives

9.1.1. IPL

9.1.1.1. Algae in Silico

Inria Project Lab ALGAE IN SILICO (2014-2018) was dedicated to provide an integrated platform for numerical simulation of microalgae "from genes to industrial process". Commands joined the project in 2017 to tackle the optimization aspects. Our previous collaborations with teams Modemic and Biocore on bioreactors [31], [19] have been renewed in this framework, see [11]

9.1.1.2. Cosy

Inria Project Lab COSY (started in 2017) aims at exploiting the potential of state-of-art biological modelling, control techniques, synthetic biology and experimental equipment to achieve a paradigm shift in control of microbial communities. More precisely, we plan to determine and implement control strategies to make heterogeneous communities diversify and interact in the most profitable manner. Study of yeast cells has started in collaboration with team Lifeware (G. Batt) in the framework of the PhD of V. Andreani, and is pursued in the PhD of E. Weill (started 2018).

9.2. International Research Visitors

9.2.1. Visits of International Scientists

Several visits by L. Pfeiffer, U. Graz, and A. Kröner, U. Humboldt.

CQFD Project-Team

8. Partnerships and Cooperations

8.1. National Initiatives

8.1.1. ANR StocMC (2014-2018) of the program Project Blanc of the ANR

The involved research groups are Inria Rennes/IRISA Team SUMO; Inria Rocquencourt Team Lifeware; LIAFA University Paris 7; Bordeaux University.
The aim of this research project is to develop scalable model checking techniques that can handle large stochastic systems. Large stochastic systems arise naturally in many different contexts, from network systems to system biology. A key stochastic model we will consider is from the biological pathway of apoptosis, the programmed cell death.

8.1.2. ANR BNPSI: Bayesian Non Parametric methods for Signal and Image Processing

Statistical methods have become more and more popular in signal and image processing over the past decades. These methods have been able to tackle various applications such as speech recognition, object tracking, image segmentation or restoration, classification, clustering, etc. We propose here to investigate the use of Bayesian nonparametric methods in statistical signal and image processing. Similarly to Bayesian parametric methods, this set of methods is concerned with the elicitation of prior and computation of posterior distributions, but now on infinite-dimensional parameter spaces. Although these methods have become very popular in statistics and machine learning over the last 15 years, their potential is largely underexploited in signal and image processing. The aim of the overall project, which gathers researchers in applied probabilities, statistics, machine learning and signal and image processing, is to develop a new framework for the statistical signal and image processing communities. Based on results from statistics and machine learning we aim at defining new models, methods and algorithms for statistical signal and image processing. Applications to hyperspectral image analysis, image segmentation, GPS localization, image restoration or space-time tomographic reconstruction will allow various concrete illustrations of the theoretical advances and validation on real data coming from realistic contexts.

8.1.3. Gaspard Monge Program for Optimisation and Operational Research (2017-2019)

The involved research groups are Inria Bordeaux Sud-Ouest Team CQFD and Thales Optronique. This new collaboration with Thales Optronique that started in October 2017 is funded by the Fondation Mathématique Jacques Hadamard. This is the continuation of the PhD Thesis of A. Geeraert. The objective of this project is to optimize the maintenance of a multi-component equipment that can break down randomly. The underlying problem is to choose the best dates to repair or replace components in order to minimize a cost criterion that takes into account costs of maintenance but also the cost associated to the unavailability of the system for the customer. In the PhD thesis of A. Geeraert, the model under consideration was rather simple and only a numerical approximation of the value function was provided. Here, our objective is more ambitious. A more realistic model will be considered and our aim is to provide a tractable quasi-optimal control strategy that can be applied in practice to optimize the maintenance of such equipments.

8.2. European Initiatives

8.2.1. Collaborations in European Programs, Except FP7 & H2020

- Program: Direcion General de Investigacion Cientifica y Tecnica, Gobierno de Espana
- Project acronym: GAMECONAPX
- Project title: Numerical approximations for Markov decision processes and Markov games
- Duration: 01/2017 - 12/2019

- Coordinator: Tomas Prieto-Rumeau, Department of Statistics and Operations Research, UNED (Spain)
- Abstract:

  This project is funded by the Gobierno de Espana, Direcion General de Investigacion Cientifica y Tecnica (reference number: MTM2016-75497-P) for three years to support the scientific collaboration between Tomas Prieto-Rumeau, Jonatha Anselmi and Francois Dufour. This research project is concerned with numerical approximations for Markov decision processes and Markov games. Our goal is to propose techniques allowing to approximate numerically the optimal value function and the optimal strategies of such problems. Although such decision models have been widely studied theoretically and, in general, it is well known how to characterize their optimal value function and their optimal strategies, the explicit calculation of these optimal solutions is not possible except for a few particular cases. This shows the need for numerical procedures to estimate or to approximate the optimal solutions of Markov decision processes and Markov games, so that the decision maker can really have at hand some approximation of his optimal strategies and his optimal value function. This project will explore areas of research that have been, so far, very little investigated. In this sense, we expect our techniques to be a breakthrough in the field of numerical methods for continuous-time Markov decision processes, but particularly in the area of numerical methods for Markov game models. Our techniques herein will cover a wide range of models, including discrete- and continuous-time models, problems with unbounded cost and transition rates, even allowing for discontinuities of these rate functions. Our research results will combine, on one hand, mathematical rigor (with the application of advanced tools from probability and measure theory) and, on the other hand, computational efficiency (providing accurate and ?applicable? numerical methods). In this sense, particular attention will be paid to models of practical interest, including population dynamics, queueing systems, or birth-and-death processes, among others. So, we expect to develop a generic and robust methodology in which, by suitably specifying the data of the decision problem, an algorithm will provide the approximations of the value function and the optimal strategies. Therefore, the results that we intend to obtain in this research project will be of interest for researchers in the fields of Markov decision processes and Markov games, both for the theoretical and the applied or practitioners communities

8.3. International Initiatives

8.3.1. Inria International Partners

8.3.1.1. Declared Inria International Partners

Tree-Lab, ITT. TREE-LAB is part of the Cybernetics research line within the Engineering Science graduate program offered by the Department of Electric and Electronic Engineering at Tijuana's Institute of Technology (ITT), in Tijuana Mexico. TREE-LAB is mainly focused on scientific and engineering research within the intersection of broad scientific fields, particularly Computer Science, Heuristic Optimization and Pattern Analysis. In particular, specific domains studied at TREE-LAB include Genetic Programming, Classification, Feature Based Recognition, Bio-Medical signal analysis and Behavior-Based Robotics. Currently, TREE-LAB incorporates the collaboration of several top researchers, as well as the participation of graduate (doctoral and masters) and undergraduate students, from ITT. Moreover, TREE-LAB is actively collaborating with top researchers from around the world, including Mexico, France, Spain, Portugal and USA.

8.4. International Research Visitors

8.4.1. Visits of International Scientists

Oswaldo Costa (Escola Politécnica da Universidade de São Paulo, Brazil) collaborate with the team on the theoretical aspects of continuous control of piecewise-deterministic Markov processes. He visited the team during two weeks in december 2018.

Tomas Prieto-Rumeau (Department of Statistics and Operations Research, UNED, Madrid, Spain) visited the team during 2 weeks in 2018. The main subject of the collaboration is the approximation of Markov Decision Processes.

DEFI Project-Team

9. Partnerships and Cooperations

9.1. Regional Initiatives

9.1.1. EVE

- Title : Virtual prototyping of EVE engines
- Type : Co-funded from Region Aquitaine and Inria
- Duration : 36 months
- Starting : October 2018
- Coordinator : P.M. Congedo
- Abstract : The main objective of this thesis is the construction of a numerical platform, for permitting an efficient virtual prototyping of the EVE expander. This will provide EXOES with a numerical tool, that is much more predictive with respect to the tools currently available and used in EXOES, by respecting an optimal trade-off in terms of complexity/cost needed during an industrial design process.i Two research axes will be mainly developed. First, the objective is to perform some high-predictive numerical simulation for reducing the amount of experiments, thanks to a specific development of RANS tools (Reynolds Averaged Navier-Stokes equations) for the fluids of interest for EXOES. These tools would rely on complex thermodynamic models and a turbulence model that should be modified. The second axis is focused on the integration of the solvers of different fidelity in a multi-fidelity platform for performing optimization under uncertainties. The idea is to evaluate the system performances by using massively the low-fidelity models, and by correcting these estimations via only few calculations with the high-fidelity code.

9.2. European Initiatives

9.2.1. FP7 & H2020 Projects

9.2.1.1. UTOPIAE

Program: H2020 MSCA-ITN
Project acronym: UTOPIAE
Project title: Handling the unknown at the edge of tomorrow
Duration: January 2017- December 2020
Coordinator: M. Vasile (Strathclyde University)
Other partners: see http://utopiae.eu/ for additional details
UTOPIAE is a European research and training network looking at cutting edge methods bridging optimisation and uncertainty quantification applied to aerospace systems. The network will run from 2017 to 2021, and is funded by the European Commission through the Marie Skłodowska-Curie Actions of H2020. The network is made up of 15 partners across 6 European countries, including the UK, and one international partner in the USA, collecting mathematicians, engineers and computer scientists from academia, industry, public and private sectors.
Mission statement : To train, by research and by example, 15 Early Stage Researchers in the field of uncertainty quantification and optimisation to become leading independent researchers and entrepreneurs that will increase the innovation capacity of the EU. To equip the researchers with the skills they will need for successful careers in academia and industry. To develop fundamental mathematical methods and algorithms to bridge the gap between Uncertainty Quantification and Optimisation and between Probability Theory and Imprecise Probability Theory for Uncertainty Quantification to efficiently solve high-dimensional, expensive and complex engineering problems.

9.3. International Initiatives

9.3.1. Inria International Labs

P.M. Congedo is the Inria Coordinator of the CWI-Inria Inria International Lab.

IIL CWI-Inria

Associate Team involved in the International Lab:

9.3.1.1. COMMUNES

Title: Computational Methods for Uncertainties in Fluids and Energy Systems

International Partner (Institution - Laboratory - Researcher):

CWI (Netherlands) - Scientific Computing Group - Daan Crommelin

Start year: 2017

See also: https://project.inria.fr/inriacwi/projects/communes/

This project aims to develop numerical methods capable to take into account efficiently unsteady experimental data, synthetic data coming from numerical simulation and the global amount of uncertainty associated to measurements, and physical-model parameters. We aim to propose novel algorithms combining data-inferred stochastic modeling, uncertainty propagation through computer codes and data assimilation techniques. The applications of interest are both related to the exploitation of renewable energy sources: wind farms and solar Organic Rankine Cycles (ORCs).

9.3.1.2. Informal International Partners

University of Zurich : R. Abgrall. Collaboration on high order adaptive methods for CFD and uncertainty quantification.

Politecnico di Milano, Aerospace Department (Italy) : Pr. A. Guardone. Collaboration on ALE for complex flows (compressible flows with complex equations of state).

von Karman Institute for Fluid Dynamics (Belgium). With Pr. T. Magin we work on Uncertainty Quantification problems for the identification of inflow condition of hypersonic nozzle flows.

Rutgers University. Collaboration with Pr. F. Cakoni on transmission eigenvalues.

University of Delaware. Collaboration with Pr. D. Colton on inverse scattering theory

Ecole Nationale des Ingénieurs de Tunis. Collaboration with Pr. M. Moakher on Diffusion MRI

9.4. International Research Visitors

9.4.1. Visits of International Scientists

- Fioralba Cakoni, one month, July 15-August 14, 2018

DISCO Project-Team

7. Partnerships and Cooperations

7.1. National Initiatives

7.1.1. Industrial-Academic Institute

Guillaume Sandou is the head of the RISEGrid Institute. The Institute is dedicated to the study, modelling and simulation of smart electric distribution grids and their interactions with the whole electric power system. It is located in CentraleSupélec and gathers about 20 people (academic and industrial researchers, PhD students, post-doctoral researchers). The Institute has been renewed in 2018 for 5 new years.

7.2. European Initiatives

7.2.1. Collaborations in European Programs, Except FP7 & H2020

Program: **COST Action**

Project acronym: FRACTAL

Project title: Fractional-order systems; analysis, synthesis and their importance for future design

Duration: November 2016 - October 2020

Coordinator: Jaroslav Koton Czech Republic

Abstract: Fractional-order systems have lately been attracting significant attention and gaining more acceptance as generalization to classical integer-order systems. Mathematical basics of fractional-order calculus were laid nearly 300 years ago and since that it has gained deeply rooted mathematical concepts. Today, it is known that many real dynamic systems cannot be described by a system of simple differential equation or of integer-order system. In practice we can encounter such systems in electronics, signal processing, thermodynamics, biology, medicine, control theory, etc. The Action will favor scientific advancement in above mentioned areas by coordinating activities of academic research groups towards an efficient deployment of fractal theory to industry applications.

Program: **PHC BALATON**

Project acronym: SadHuB

Project title: Analysis of stabilizability of delayed dynamical system as function of the systems parameters and the time delays with applications to human balancing

Duration: 01/2018-12/2019

Coordinator: Islam Boussaada

Other partners: Budapest University of Technology and Economics, Hungary

Abstract: Motivated by a class of Time-delay systems occurring in modeling of many mechanical engineering applications, this project aims to associate researchers from control theory, applied mathematics and mechanical engineering to build together a general methodology for the analysis and control of mechanical/bio-mechanical structures. In particular, the human balance is often considered as a control system which operates in the presence of delays, primarily due to the time it takes to acquire the information needed for decision-making, to create control decisions, and to execute these decisions. A particular interest will be devoted to the delayed human balance, where a depthful study of the delay effect on the stability is expected.

Program: **PHC BRANCUSI**

Project acronym: Proco

Project title: systems with propagation: new approaches in control design for oscillations quenching

Duration: 01/2017-12/2018

Coordinator: Islam Boussaada

Other partners: Craiova University, Romania

Abstract: Propagation systems are met and analyzed in various fields, in natural sciences (Physics, Chemistry, Biology etc.) as well as in engineering sciences (energy, mechanics, electricity, optics etc.). According to projects research objectives, the general object of analysis is represented by the controlled systems with distributed parameters which are usually met in technology dynamical systems with parameter space variation along a single space variable. The standard physical phenomena that are modeled are: diffusion, transport and propagation, thus leading to partial differential equations of parabolic (diffusion), hyperbolic (propagation) and advection first order (transportation), respectively. According to the project main subject, the main application of the studies aimed at the automatically controlled processes in the field of energy in a domain where propagation phenomena are dominant. The scientific novelty of the studies arises from the consideration of the systems described by conservation laws in the following fields: oil drilling and extraction, co-generation (combined heat-electricity generation), energy production in hydroelectric plants.

Program: **PHC CARLOS J FINLEY (Cuba)**

Project title: Modélisation et commande pour les processus de cryoconservation.

Duration: June 2017 - December 2018

Coordinator: Sorin Olaru (France), Marcos Martinez Montero (Turkey).

Abstract: The aim of this project is to initiat a collaboration on subjects related to the mathematical modelling of the dynamics involved in the cryopreservations process. In particular, the viability analysis of the vegetal material subject to cryogeny is one of the main objectives. The approach will realy on the evaluation electric leakage properties.

7.3. International Initiatives

7.3.1. Inria International Partners

7.3.1.1. Informal International Partners

- Louisiana State University, Baton Rouge, USA
- School of Electrical Engineering at the Tel-Aviv University, Israel
- The University of Texas at Austin, Dept. of Aerospace Engineering & Engineering Mechanics, USA
- Blikent University, Turkey
- Universidad de Chile, Chile
- School of Mathematics, University of Leeds, U.K.
- University Federale Rio de Janeiro, Brazil
- UNICAMP, Brazil
- Kyoto University, Japan

7.3.2. Participation in Other International Programs

Giorgio Valmorbida is leading the CNRS funded IRN - SPaDisCo (International Research Network - Systèmes à Paramètres Distribués et Contraintes) composed by more than 50 researchers from Belgium, Czech Republic, France, Italy, Sweden, Turkey and the United Kingdom.

7.4. International Research Visitors

7.4.1. Visits of International Scientists

Stefanella Boatto, Federale University Rio de Janeiro, Brazil, 1 January- 2 March.

Pedro Luis Dias Peres, UNICAMP, Brazil, December 2018.

Valter Leite Junior, CEFET-MG, Brazil, May 2018.

Antonis Papachristodoulou, University of Oxford, UK, September 2018.

Yutaka Yamamoto, Kyoto University, Japan, 6 Sept - 6 Nov.

7.4.2. Visits to International Teams

7.4.2.1. Research Stays Abroad

Islam Boussaada spent one month during July 2018 as a Research Associate at the Department of Electronic Engineering at City University of Hong Kong. He started a research collaboration with Professor Jie Chen Team.

ECUADOR Project-Team

8. Partnerships and Cooperations

8.1. International Initiatives

8.1.1. Inria International Labs

Ecuador participates in the Joint Laboratory for Exascale Computing (JLESC) together with colleagues at Argonne National Laboratory.

ELAN Team

7. Partnerships and Cooperations

7.1. European Initiatives

7.1.1. FP7 & H2020 Projects

7.1.1.1. GEM

Title: from GEometry to Motion, inverse modeling of complex mechanical structures

Programm: H2020

Type: ERC

Duration: September 2015 - August 2021

Coordinator: Inria

Inria contact: Florence BERTAILS-DESCOUBES

With the considerable advance of automatic image-based capture in Computer Vision and Computer Graphics these latest years, it becomes now affordable to acquire quickly and precisely the full 3D geometry of many mechanical objects featuring intricate shapes. Yet, while more and more geometrical data get collected and shared among the communities, there is currently very little study about how to infer the underlying mechanical properties of the captured objects merely from their geometrical configurations. The GEM challenge consists in developing a non-invasive method for inferring the mechanical properties of complex objects from a minimal set of geometrical poses, in order to predict their dynamics. In contrast to classical inverse reconstruction methods, my proposal is built upon the claim that 1/ the mere geometrical shape of physical objects reveals a lot about their underlying mechanical properties and 2/ this property can be fully leveraged for a wide range of objects featuring rich geometrical configurations, such as slender structures subject to frictional contact (e.g., folded cloth or twined filaments). To achieve this goal, we shall develop an original inverse modeling strategy based upon a/ the design of reduced and high-order discrete models for slender mechanical structures including rods, plates and shells, b/ a compact and well-posed mathematical formulation of our nonsmooth inverse problems, both in the static and dynamic cases, c/ the design of robust and efficient numerical tools for solving such complex problems, and d/ a thorough experimental validation of our methods relying on the most recent capturing tools. In addition to significant advances in fast image-based measurement of diverse mechanical materials stemming from physics, biology, or manufacturing, this research is expected in the long run to ease considerably the design of physically realistic virtual worlds, as well as to boost the creation of dynamic human doubles.

7.2. International Initiatives

7.2.1. Inria International Partners

7.2.1.1. Declared Inria International Partners

- Long-term partnership with Rahul Narain (University of Minnesota, USA, and IIT Delhi, INDIA) and Rahul Narain's PhD student Jie Li (University of Minnesota, USA).
- Long-term partnership with Alexandre-Derouet-Jourdan (OLM Digital, JAPAN).

FACTAS Team

8. Partnerships and Cooperations

8.1. Regional Initiatives

- The team participates in the project WIMAG (Wave IMAGing) funded by the Idex UCA^{Jedi}. It aims at identifying and gathering the research and development by partners of UCA involved in wave imaging systems. Other partners are UNS and CNRS (GéoAzur, I3S, LEAT, LJAD), together with Orange Labs.
- The team co-advises a PhD (G. Bose) with the CMA team of LEAT (http://leat.unice.fr/pages/activites/cma.html) funded by the Labex UCN@Sophia on the co-conception of Antennas and Filters.
- The team participates in the transverse action C4PO funded by the Idex UCA^{Jedi}. This "Center for Planetary Origin" brings together scientists from various fields to advance and organize Planetary Science at the the University of Nice, and supports research and teaching initiatives within its framework, among which the workshop "Inverse problems and approximation techniques in planetary sciences" organized by members of Factas in May, about inverse problems in harmonic electromagnetism and approximation, with applications mainly dedicated to geomagnetism and paleomagnetism, see Section 9.1.1 .
- The team also participates in the project ToMaT, "Multiscale Tomography: imaging and modeling ancient materials, technical traditions and transfers", funded by the Idex UCA^{Jedi} ("programme structurant Matière, Lumière, Interactions"). This project brings together researchers in archaeological, physical, and mathematical sciences, with the purpose of modeling and detecting low level signals in 3-D images of ancient potteries. The other concerned scientists are from CEPAM-CNRS-UCA (project coordinator: Didier Binder), Nice http://www.cepam.cnrs.fr, the team Morpheme, CNRS-I3S-Inria http://www.inria.fr/equipes/morpheme, and IPANEMA, CNRS, Ministère de la Culture et de la Communication, Université Versailles Saint Quentin http://ipanema.cnrs.fr/. Since March 2018, they co-advise together the post-doctoral research of Vanna Lisa Coli, see Section 6.5 .

8.2. National Initiatives

8.2.1. ANR MagLune

The ANR project MagLune (Magnétisme de la Lune) has been approved July 2014. It involves the Cerege (Centre de Recherche et d'Enseignement de Géosciences de l'Environnement, joint laboratory between Université Aix-Marseille, CNRS and IRD), the IPGP (Institut de Physique du Globe de Paris) and ISTerre (Institut des Sciences de la Terre). Associated with Cerege are Inria (Apics, then Factas team) and Irphe (Institut de Recherche sur les Phénomènes Hors Équilibre, joint laboratory between Université Aix-Marseille, CNRS and École Centrale de Marseille). The goal of this project (led by geologists) is to understand the past magnetic activity of the Moon, especially to answer the question whether it had a dynamo in the past and which mechanisms were at work to generate it. Factas participates in the project by providing mathematical tools and algorithms to recover the remanent magnetization of rock samples from the moon on the basis of measurements of the magnetic field it generates. The techniques described in Section 6.1 are instrumental for this purpose.

8.2.2. ANR Cocoram

The ANR (Astrid) project Cocoram (Co-design et co-intégration de réseaux d'antennes actives multi-bandes pour systèmes de radionavigation par satellite) started January 2014 and ended October 2018. We were associated with three other teams from XLIM (Limoges University), geared respectively towards filters, antennas and amplifiers design. The core idea of the project was to realize dual band reception an emission chains by co-conceiving the antenna, the filters, and the amplifier. A complete chain has been synthesized using matching filters placed after each of the accesses of a network of 4 bi-polarized antennas, resulting in a substantial gain in energy effectiveness of 30%. This communication chain has been manufactured by our partner XLIM, and presented to the final meeting of the ANR in October.

8.3. European Initiatives

8.3.1. Collaborations with Major European Organizations

Apics is part of the European Research Network on System Identification (ERNSI) since 1992.

System identification deals with the derivation, estimation and validation of mathematical models of dynamical phenomena from experimental data.

8.4. International Initiatives

8.4.1. Inria Associate Teams Not Involved in an Inria International Labs

8.4.1.1. IMPINGE

Title: Inverse Magnetization Problems IN GEosciences.

International Partner (Institution - Laboratory - Researcher):

Massachusetts Institute of Technology (United States) - Department of Earth, Atmospheric and Planetary Sciences - Benjamin P. Weiss

Start year: 2016

See also: http://www-sop.inria.fr/apics/IMPINGE/

This proposal is concerned with the inverse problem of recovering a magnetization distribution from measurements of the magnetic field in a portion of space nearby. The application domain is to Earth and planetary sciences. Indeed, the remanent magnetization of rocks provides valuable information on their history. The proposal aims at renewing the existing "Équipe Associée" Impinge ending 2015, between Apics (now Factas) team at Inria and the Department of Earth, Atmospheric and Planetary Sciences at MIT (Cambridge, MA, USA), with the Department of Mathematics at Vanderbilt University (Nashville, TN, USA) as a secondary partner. Several research paths were broken towards magnetization recovery and promising numerical experiments have been conducted. This initial effort must be continued to achieve a reasonably complete methodology for reconstructing magnetizations and checking for hypotheses by geophysicists (e.g., unidirectionality of magnetization distributions).

8.4.2. Inria International Partners

8.4.2.1. Informal International Partners

MIT-France seed funding is a competitive collaborative research program ran by the Massachusetts Institute of Technology (Cambridge, Ma, USA). Together with E. Lima and B. Weiss from the Earth and Planetary Sciences dept. at MIT, Apics obtained two-years support from the above-mentioned program to run a project entitled: "Development of Ultra-high Sensitivity Magnetometry for Analyzing Ancient Rock Magnetism"

NSF Grant L. Baratchart, S. Chevillard and J. Leblond are external investigators in the NSF Grant 2015-2018, "Collaborative Research: Computational methods for ultra-high sensitivity magnetometry of geological samples" led by E. B. Saff (Vanderbilt Univ.) and B. Weiss (MIT).

8.5. International Research Visitors

8.5.1. Visits of International Scientists

- Axel Ringh (KTH Royal Institute of Technology, Stockholm, Sweden), June 11 -July 10.
- Elodie Pozzi (St Louis Univ., St. Louis, Missouri, USA), Brett Wick (Washington University, St. Louis, Missouri, USA), July 25.
- Cristobal Villalobos, Douglas Hardin, Edward Saff (Vanderbilt University, Nashville, Tennessee, USA), December, 6-19, 13-19, and 13-20 respectively.
- M. Olivi proposed with B. Hanzon and R. Peeters a Research in Pair event at CIRM « A state-space approach to parametrization of lossless and stable systems ». which was accepted and took place on August 27-31 https://conferences.cirm-math.fr/2126.html

8.6. List of international and industrial partners

- Collaboration under contract with Thales Alenia Space (Toulouse, Cannes, and Paris), CNES (Toulouse), XLIM (Limoges), LEAT (Sophia Antipolis), University of Bilbao (Universidad del País Vasco / Euskal Herriko Unibertsitatea, Spain), Flextronics.
- Regular contacts with research groups at UST (Villeneuve d'Asq), Universities of Bordeaux-I (Talence), Orléans (MAPMO), Aix-Marseille (CMI-LATP), Nice Sophia Antipolis (Lab. JAD), Grenoble (IJF and LJK), Paris 6 (P. et M. Curie, Lab. JLL), Inria Saclay (Lab. Poems, ENSTA), IMT Atlantique (Institut Mines-Télécom., Brest), Cerege-CNRS (Aix-en-Provence), CWI (the Netherlands), MIT (Boston, USA), Vanderbilt University (Nashville USA), Steklov Institute (Moscow), Michigan State University (East-Lansing, USA), Texas A&M University (College Station USA), Indiana University-Purdue University at Indianapolis, St Louis University and Washington University (St Louis, Missouri, USA), Cinvestav (Queretaro, Mexico), Politecnico di Milano (Milan, Italy), University of Trieste (Italy), RMC (Kingston, Canada), University of Leeds (UK), of Maastricht (the Netherlands), of Cork (Ireland), Vrije Universiteit Brussel (Belgium), TU-Wien and Universität Wien (Austria), TFH-Berlin and Technische Universität Bergakademie Freiberg (Germany), ENIT (Tunis), KTH (Stockholm), University of Cyprus (Nicosia, Cyprus), University of Macau (Macau, China), SIAE Microelettronica (Milano), Université Picardie Jules Verne (France), National and Kapodistrian University of Athens (Greece).
- The project is involved in the GDR-project AFHP (CNRS), in the ANR (Astrid program) project Cocoram (with XLIM, Limoges, and DGA), in the ANR (Défis de tous les savoirs program) project MagLune (with Cerege, IPGP, ISTerre, Irphe), in a MIT-France collaborative seed funding, in the Associate Inria Team IMPINGE (with MIT, Boston), and in a NSF grant (with Vanderbilt University and MIT).

GAMMA3 Project-Team

7. Partnerships and Cooperations

7.1. National Initiatives

7.1.1. ANR

7.1.1.1. ANR IMPACTS 2018-2021

Ideal Mesh generation for modern solvers and comPuting ArchiteCTureS.

- Coordinateur : Adrien Loseille
- The rapid improvement of computer hardware and physical simulation capabilities has revolutionized science and engineering, placing computational simulation on an equal footing with theoretical analysis and physical experimentation. This rapidly increasing reliance on the predictive capabilities has created the need for rigorous control of numerical errors which strongly impact these predictions. A rigorous control of the numerical error can be only achieved through mesh adaptivity. In this context, the role of mesh adaptation is prominent, as the quality of the mesh, its refinement, and its alignment with the physics are major contributions to these numerical errors. The IMPACTS project aims at pushing the envelope in mesh adaptation in the context of large size, very high fidelity simulations by proposing a new adaptive mesh generation framework. This framework will be based on new theoretical developments on Riemannian metric-field and on innovative algorithmic developments coupling a unique cavity-operator with an advancing-point techniques in order to produce high quality hybrid, curved and adapted meshes.

7.2. International Initiatives

7.2.1. Inria Associate Teams Not Involved in an Inria International Labs

7.2.1.1. AM2NS

Title: Advanced Meshing Methods for Numerical Simulations

International Partner (Institution - Laboratory - Researcher):

Mississippi State University (United States) - Center for Advanced Vehicular Systems - Computational Fluid Dynamics Dept. (CAVS-CFD) - Marcum David

Start year: 2017

See also: http://pages.saclay.inria.fr/frederic.alauzet/AssociateTeam_AM2NS/AT_am2ns.html

The purpose of the AM2NS Associate Team is to mutualize the knowledge of all teams in order to develop the next generation of meshing methods and their parallelization to address the new challenges in numerical simulations for industrial problems. The Associate Team is composed of four partners: Inria, Mississippi State University, The Boeing Company and Massachusetts Institute of Technology.

7.2.1.2. MODIS

Title: High-order discrete geometric modeling

International Partner (Institution - Laboratory - Researcher):

Polytechnique Montréal (Canada) - Computer Science - Franọis Guibault

Start year: 2017

See also: http://pages.saclay.inria.fr/patrick.laug/MODIS/MODIS.html

In the area of geometric modeling, major challenges are linked to the efficient visualization of CAD surfaces and to the generation of meshes adapted to numerical simulation. In this context, the conception of a discrete geometric model provides a simple and universal representation model, without the need for CAD. A first study has been carried out for the conception of a model of order 1 (one) defined by a 'triangulation' composed of quadrilaterals and triangles. The advantage of this model of order 1 lies in its geometric simplicity. However, in the case of complex surfaces, it may require a very large number of elements, and besides it is not sufficiently rich to give certain essential characteristics like geometric curvatures. The main goal of this project is to extend this discrete model of order 1 to higher orders.

GEOSTAT Project-Team

9. Partnerships and Cooperations

9.1. National Initiatives

- ANR project *Voice4PD-MSA*, led by K. Daoudi, which targets the differential diagnosis between Parkinson's disease and Multiple System Atrophy. The total amount of the grant is 468555 euros, from which GeoStat has 203078 euros. The duration of the project is 42 months. Partners: CHU Bordeaux (Bordeaux), CHU Toulouse, IRIT, IMT (Toulouse).
- PhD grant for G. Singh from IIT Roorkee, under co-supervision with D. Singh (IIT Roorkee).
- The PHC-Toubkal project "Caractérisation multi-capteurs et suivi spatio-temporel de l'Upwelling sur la côte atlantique marocaine par imagerie satellitaire", led by K. Daoudi, is in its second year. The partners in this project are: Faculté des sciences de Rabat, Centre Royal de Télédetection Spatiale, Mercator-Ocean and GEOSTAT.
- GEOSTAT is a member of ISIS (Information, Image & Vision) and AMF (Multifractal Analysis) GDRs.
- GEOSTAT is participating in the CNRS IMECO project *Intermittence multi-échelles de champs océaniques : analyse comparative d'images satellitaires et de sorties de modèles numériques*. CNRS call AO INSU 2018. PI: F. Schmitt, DR CNRS, UMR LOG 8187. Duration: 2 years.

9.2. European Initiatives

9.2.1. Collaborations in European Programs, Except FP7 & H2020

GENESIS Program: supported by Deutsche Forschungsgemeinde (DFG) and the Agence national de recherche (ANR). *GENeration and Evolution of Structures in the ISm.* Duration: start 1.5. 2017, 3 years. Coordinator: N. Schneider (I. Physik, Cologne). Other partners: Cologne (R. Simon, N. Schneider, V. Ossenkopf, M. Roellig), LAB (S. Bontemps, A. Roy, L. Bonne, F. Herpin, J. Braine, N. Brouillet, T. Jacq), ATN Canberra (Australia), LERMA Paris (France), MPIfR Bonn (Germany), CEA Saclay (France), ITA/ZAH Heidelberg (Germany), Institute of Astronomy, Cardiff (UK), ESO (Germany, Chile), CfA Harvard (USA), IPAG Grenoble (France), Argelander Institut Bonn (Germany), CASS San Diego (USA), University of Sofia (Bulgaria). Web site: link.

9.3. International Initiatives

9.3.1. Inria International Partners

9.3.1.1. IFCAM: Generalization for land cover identification. Geostat and the Indo-French Centre For Applied Mathematics

Land cover classification from satellite imagery is an important application for agriculture, environmental monitoring, tracking changes foremergency, etc. The typical methodology is to train a machine learning algorithm to recognize specified classes (urban, forest, fields, etc...) over regions of interest and classify new images when they become available. Yet, the generalization ability of such systems often not accounts for spatial consistency. High scores are obtained on the reference points, but nearby points of the same class are incorrectly classified. Local context, pixels around the selected one, may help in recovering that spatial consistency and increase the recognition rate. This may also induce spurious patterns and overfit the learning algorithm, which is especially the case for with Convolutional Networks trained on limited number of data. This proposal investigates how to use local context and how to best sample the data in order to provide the best generalization ability. Data will be sampled on reference locations and used for training and validation.

PIs: N. Brodu (Geostat) and D. Singh (IIT Roorkee).

Duration: 3 years. Starting 2018.

9.4. International Research Visitors

9.4.1. Visits of International Scientists

- S. Bogning Dongue [CNRS, from Dec 2018]
- K. Minaoui [Rabat University, Jul 2018]

I4S Project-Team

7. Partnerships and Cooperations

7.1. Regional Initiatives

7.1.1. Interactive Communication (InterCom): Massive random access to subsets of compressed correlated data

Participants: Jean Dumoulin, Antoine Crinière, Frederic Gillot.

Type: Labex COMINLABS

Objectif: Massive random access to large-scale sensor network (Smart Cities)

Duration: Since November 2016 to Nov. 2019.

Coordinator :Aline Roumy, Thomas Maugey (Sirocco), Jean Dumoulin (I4S)

Partners: Elsa Dupraz (Lab-STICC), Aline Roumy (IRISA, Sirocco team), Michel Kieffer (L2S), Thomas Maugey(IRISA, Sirocco team), CentraleSupelec, Univ. Paris Sud.

Inria contact: Jean Dumoulin

Abstract: This project aims to develop novel compression techniques allowing massive random access to large databases. Indeed, we consider a database that is so large that, to be stored on a single server, the data have to be compressed efficiently, meaning that the redundancy/correlation between the data have to be exploited. The dataset is then stored on a server and made available to users that may want to access only a subset of the data. Such a request for a subset of the data is indeed random, since the choice of the subset is user-dependent. Finally, massive requests are made, meaning that, upon request, the server can only perform low complexity operations (such as bit extraction but no decompression/compression).

Algorithms for two emerging applications of this problem will be developed: Free-viewpoint Television (FTV) and massive requests to a database collecting data from a large-scale sensor network (such as Smart Cities) in which I4S is involved. Compression of spatio-temporally correlated and massive georeferenced Data have been investigated [42].

7.1.2. MAG2C-Pont Tabarly

Participants: Ivan Guéguen, Jean Dumoulin.

Type: GIS

Objectif: bridge instrumentation

Duration: Since 2014

Coordinator: LIRGEC

Partners: IFSTTAR, CSTB, Nantes Métropole, Université de Nantes

Inria contact: Ivan Guéguen

Abstract: The project deals with the instrumentation of the Tabarly Bridge. In collaboration with Nantes Métropole, CSTB, and Université de Nantes, instrumentation of both dynamical and InfraRed properties of an operational bridge are investigated. These measures coupled with a wireless data transmission system will allow remote monitoring of the evolution of the structure. Objective is to couple different kind of measurement to achieve thermo-vibration monitoring of the structure. This is a big milestone for the team and our objective to mix thermo-vibration data.

7.1.3. MAG2C-MOSIWIND (MOnitoring of Structural Integrity of an onshore WIND turbine slab foundation and tower)

Participants: Xavier Chapeleau, Ivan Guéguen.

Type: GIS

Objectif: MOnitoring of Structural Integrity of an onshore WIND turbine slab foundation and tower

Duration: Since 2015

Coordinator : LIRGEC

Partners: IFSTTAR, CSTB, Nantes Métropole, Université de Nantes, ECN, Valorem, Valréa and Valémo

Inria contact: Xavier Chapeleau

Abstract: The project deals with the instrumentation of an onshore WIND turbine's slab foundation and tower. The aim is to experiment sensors and methods for structural integrity monitoring of an onshore wind turbine under real conditions and to qualify them over long term. Fiber optic sensors were installed in the slab foundation before casting and accelerometers were placed at several level in the tower of the wind turbine. Since July 2017, data from accelerometers were logged on a web data server.

7.1.4. Collaboration with GeM

Participants: Laurent Mevel, Michael Doehler, Md Delwar Hossain Bhuyan.

Md Delwar Hossain Bhuyan has done his PhD on damage localisation on civil structures in collaboration with GeM (Institute of Civil and Mechanical Engineering), Université de Nantes. The thesis is co-directed by L. Mevel, and F. Schoefs from GeM, with supervision shared with M. Doehler and Y. Lecieux from GeM. It is funded by the Brittany region for 3 years and has been successfully defended in November 2017. In 2018, a mockup of the Saint Nazaire bridge has been funded by GAM and tested for damage localization.

7.1.5. Collaboration with IETR

Participants: Vincent Le Cam, David Pallier.

The thesis is directed by Sébastien Pillement at IETR. It is funded by RFI WISE Electronique Professionnelle within the SENTAUR project.

The subject of the thesis is to study, implement, and propose a deterministic and reliable dating solution for wireless sensor networks. This solution must take into account both the risks of loss of synchronization signals, environmental hazards and the desire to achieve the most sober possible solution in energy.

7.2. National Initiatives

7.2.1. ANR Resbati

Participants: Ludovic Gaverina, Jean Dumoulin.

Type: ANR

Objectif: In-situ measurements of thermal wall resistance

Duration: 10/2016 to 10/2019

Coordinator: Laurent Ibos

Partners : IFSTTAR, CERTES, CEREMA, CSTB, LNE, THEMACS, AFNOR

Inria contact: Jean Dumoulin

Abstract: RESBATI is an applied research project whose objective is to develop a field measurement device that meets precise specifications to systematically measure the level of thermal insulation of building walls. The preferred metrological tool is infrared thermography [31]. A smart logger and a protype have been developed and presented [44].

7.3. European Initiatives

7.3.1. FP7 & H2020 Projects

7.3.1.1. INFRASTAR(Innovation and Networking for Fatigue and Reliability Analysis of Structures – Training for Assessment of Risk)

Participants: Xavier Chapeleau, Antoine Bassil.

Call: H2020-MSCA-ITN-2015 (Horizon 2020 Marie-Sklodowska Curie Actions Innovative Training Networks)

Type of Action: MSCA-ITN-ETN

Objective: Improve energy performance of building design

Duration: 48 months since 2016 May 1st

Coordinator: Odile Abraham (IFSTTAR)

Academic and industrial Partners: IFSTTAR, UNIVERSITY OF AALBORG, BAM, EPFL, GuD Consult Gmbh, COWI A/S, NeoStrain, PHIMECA

Inria contact: X. Chapeleau

Website: http://infrastar.eu/

Abstract: The aim of INFRASTAR project is to develop tools combining modeling and measurements for the prediction of the fatigue behavior of concrete structures (bridges and foundations of wind turbines) with the ultimate objective of establishing an efficient strategy for inspection and reinforcement operations. In the second half of 2016, 12 young researchers were recruited to carry out and cross-examine research on monitoring and auscultation (WP 1), structural models (WP 2) and reliability of approaches for decision-making (WP 3). In this project, a phd student (Antoine Bassil) was recruited (Nov. 2016) on the fatigue monitoring of concrete structure by fiber-optic sensors.

A state of the Art about distributed optical fiber sensor's technology for crack detection in concrete was done together with experimental tests to assess linear models. More precisely, three points bending tests were performed on reinforced concrete beams instrumented with fiber optic cables embedded and attached to the concrete surface. The analytical expressions of linear models were fitted to strain measurements to deduce the cracks opening during the test. The comparison of these results with those obtained with traditional extensometers placed around the cracks showed a good agreement for crack openings reaching 150νm in single crack case. This model was also validated in multiple neighboring crack case until 400νm. In order to focus more on the sensor/host material system properties, wedge-splitting tests made it possible to attend higher crack openings for a single crack case allowing us to better analyze the transition from elastic to post elastic behavior of the optical cable. The use of different types of cables with relatively different mechanical properties will allow us in the near future to choose the best cable configuration for monitoring of concrete structures.

7.3.1.2. DESDEMONA(DEtection of Steel Defects by Enhanced MONitoring and Automated procedure for self-inspection and maintenance)

Participants: Jean Dumoulin, Laurent Mevel, Michael Doehler, Xavier Chapeleau.

Call: H2020 -Call: RFCS-2017 (Call of the research programme of the Research Fund for Coal and Steel - 2017)

Type of Action: RFCS-RPJ (Research project)

Objective: DESDEMONA objective is the development of novel design methods, systems, procedure and technical solution, to integrate sensing and automation technologies for the purpose of self-inspection and self-monitoring of steel structures.

Duration: 36 months since 2018 June 1st

Coordinator: Pr. Vincenzo Gatulli (La Sapienza University of Rome)

Academic and industrial Partners: Sapienza Università di Roma (Italy), Universidad de Castilla – La Mancha, (Spain), Universidade do Porto (Portugal), Università di Pisa (Italy), IFSTTAR (France), Aiviewgroup srl (Italy), Sixense systems (France), Ecisa compania general de construcciones sa (Spain), Università di Cassino e del Lazio Meridionale (Italy), Universidad de Alicante (Spain), Inria (France).

Inria contact: J. Dumoulin and L. Mevel

Website: http://www.desdemonaproject.eu//

Abstract: DESDEMONA objective is the development of novel design methods, systems, procedure and technical solution, to integrate sensing and automation technologies for the purpose of self-inspection and self-monitoring of steel structures. The approach will lead to an increment of the service life of existing and new steel civil and industrial infrastructure and to a decrease in the cost associated to inspections, improving human activities performed in difficult conditions, safety and workers' potential by the use of advanced tools. The research aims to expand beyond the current state-of-the-art new high-quality standard and practices for steel structure inspection and maintenance through the interrelated development of the following actions: i) steel structure geometry and condition virtualization through data fusion of image processing, thermography and vibration measurements; ii) developing a procedure for steel defect detection by robotic and automatic systems such as Unmanned Aerial Vehicles (UAV) and ground mobile robots iii) embedding sensor systems to revalorize and transform steel elements and structures into self-diagnostic (smart) elements and materials even through nanotechnologies, iv) realizing an experimental lab-based apparatus and a series of case studies inspected by intelligent and robotic systems. The project outcome will have an impact on the reduction of the cost of steel structures inspection and maintenance and on the increase of user safety and comfort in industrial and civil environment. The proposal with a multidisciplinary approach fulfils the objectives of the Strategic Research Agenda of the European Steel Technology Platform.

7.3.2. Collaborations in European Programs, Except FP7 & H2020

7.3.2.1. COST Action TU 1402

Participants: Michael Doehler, Laurent Mevel.

L. Mevel is member of the management committee of the COST Action.

M. Doehler is co-leader of working group 2 "SHM strategies and structural performance" and member of the steering committee.

Type: COST

Objective: Quantifying the value of structural health monitoring

Duration: 11/2014 - 4/2019

Coordinator: S. Thoens (DTU Denmark)

Partner: 29 countries, see https://www.cost.eu/actions/TU1402

Inria contact: Laurent Mevel

Abstract: Since 2014, until 2018, the COST Action has altogether around 120 participants from over 25 countries. This Action aims to develop and describe a theoretical framework, together with methods, tools, guidelines, examples and educational activities, for the quantification of the value of SHM.

7.3.2.2. PROCOPE 37826QE

Participants: Michael Doehler, Laurent Mevel, Eva Viefhues, Frederic Gillot.

Type: PHC PROCOPE

Objective: Statistical damage localization for civil structures

Duration: 01/2017 - 12/2018

Coordinator: M. Doehler

Partner: BAM German Federal Institute for Materials Research and Testing

Inria contact: M. Doehler

Abstract: Our main objective is the development of a theoretically solid damage localization method that does not only work in simulations and lab experiments, but on structures in the field under real operational conditions. This German-French mobility grant is in support of Eva Viefhues' PhD thesis.

7.3.2.3. Innobooster

Participants: Michael Doehler, Laurent Mevel.

Type: Danish Innovation Fund

Objective: Methods for mode shape uncertainty quantification

Duration: 2017 - 2018

Coordinator: M. Doehler

Partner: Structural Vibration Solutions A/S, Denmark

Inria contact: M. Doehler

Abstract: With this grant for industrial research and transfer, methods for uncertainty quantification of mode shapes are developed with the objective of producing a prototype for transfer to SVS' ARTeMIS software.

7.4. International Initiatives

7.4.1. Collaboration with University of British Columbia, Canada

Participants: Laurent Mevel, Michael Doehler, Alexander Mendler.

Alexander Mendler's PhD thesis started in September 2018 co-supervised by M. Doehler and C. Ventura.

7.4.2. Collaboration with BAM, Germany

Participants: Laurent Mevel, Michael Doehler, Eva Viefhues.

Eva Viefhues is currently PhD student of Laurent Mevel and Michel Doehler in Berlin, financed by BAM. M. Doehler is also associate researcher of the BAM institut since 2016.

7.4.3. Collaboration with Technical University of Denmark (DTU)

Participant: Michael Doehler.

During COST Action TU 1402 and previously at BAM, collaboration with Sebastian Thöns from DTU in Denmark started on risk analysis and SHM based reliability updating. Also, DTU's PhD student Lijia Long is involved.

7.4.4. Collaboration with Aalborg University, Denmark

Participant: Michael Doehler.

Together with Structural Vibration Solutions, collaboration with Aalborg University (professor Lars Damkilde, Department of Civil Engineering) has started during the PhD of Szymon Gres on damage detection methods.

7.4.5. Collaboration with Laval University, Canada

Participant: Jean Dumoulin.

In the Framework of On Duty Project (http://www.ondutycanada.ca) we are working on Non Destructive Testing techniques and automation of inspection process.

7.5. International Research Visitors

Szymon Gres visited us for 3 months from April to June 2018 during his thesis.

7.5.1. Visits to International Teams

7.5.1.1. Research Stays Abroad

During INFRASTAR project, Antoine Bassil

- visited BAM (3 months in 2017) on the assesment the relevant of coupling fIber optics and CODA waves techniques to crack monitoring
- visited EPFL (3 months in 2018) on the issue of long term monitoring of a special material like Ultra High Performance Reinforced Concrete (UHPFRC) using a distributed fiber optic system.

INOCS Project-Team

9. Partnerships and Cooperations

9.1. Regional Initiatives

9.1.1. Lille

The ELSAT research program addresses the issues involved in sustainable transportation and mobility. Within ELSAT, INOCS is involved on two projects devoted to hybrid optimization methods in logistics and to city logistics in collaboration with LAMIH (University of Valenciennes), LGI2A (University of Artois) and LEOST (IFSTTAR). ELSAT is supported by the CPER 2015-2020 (State-Region Contract).

9.1.2. Brussels

ValueBugs is a citizen participatory research project, funded by INNOVIRIS (2018-2020). The objective of ValueBugs is to collectively develop a method for decentralized insect production in cities while enhancing the value of food waste on a small scale. In practical terms, peelings are consumed by insect larvae that have reached the end of their development and offer many promising outlets: feed for hens, farmed fish, pets... and much more! This new, totally innovative sector will be a new tool to be put in the hands of every citizen: we must therefore imagine it collectively.

9.2. National Initiatives

9.2.1. ANR

ANR project PI-Commodality "Co-modal freight transportation chains: an approach based on physical internet" in collaboration with CGS-ARMINES (Paris), LAAS (Toulouse), DHL (2016 - 2019). The PI-co-modality project aims to design new sustainable logistic services between preset origins and destinations. It is based on innovative approaches both in terms of: 1) Logistics and transportation services: by considering the PI-internet approach, specifically: mesh logistics and transportation networks based on available capacities, by designing consistent integrated co-modal chains; 2) Methodology: by addressing the underlying problems according to two approaches: centralized and decentralized, by proposing news realistic models relevant for practitioner taking into account the consistency, by developing state-of-the-art decision making algorithms.

9.2.2. F.R.S.-FNRS (Belgium)

Bilevel optimization is a branch of mathematical optimization that deals with problems whose constraints embed an auxiliary optimization problem. The F.R.S.-FNRS research project "bilevel optimization" (2018-2019) will study such bilevel problems with bilinear objectives and simple second level problems. Each follower chooses one strategy in a given fixed set of limited size. Two classes of such problems will be studied: Pricing Problems and Stackelberg Security Games.

In pricing problems, prices for products must be determined to maximize the revenue of a leader given specific behaviors of customers (followers). More precisely, we will consider the single minded pricing problem and the rank pricing problem.

In Stackelberg games, mixed strategies to cover targets,must be determined in order to maximize the defender expected payoff given that attackers (followers) attack targets that maximize their own payoffs.

9.3. International Initiatives

9.3.1. Inria International Labs

Inria Chile

Associate Team involved in the International Lab:

9.3.1.1. BIPLOS

Title: BIlevel Problems in LOgistics and Security

International Partner (Institution - Laboratory - Researcher):

Universidad de Chile (Chile) - Instituto Sistemas Complejos de Ingeieria (ISCI) - Ordonez Fernando

Start year: 2017

See also: https://project.inria.fr/biplos/

This projet is devoted to bilevel optimisation problems with application in the security and logistics domains. Stackelberg games, including one defender and several followers, and competitive location problems will be considered. Mixed integer linear optimisation models and efficient algorithms to solve them will be developed.

9.3.2. Inria Associate Teams Not Involved in an Inria International Labs

9.3.2.1. LOBI

Title: Learning within Bilevel Optimization

International Partner (Institution - Laboratory - Researcher):

Polytechnique Montréal (Canada) - Institut de Valorisation des Données (IVADO) - Gilles Savard

Start year: 2018

See also: https://team.inria.fr/lobi/

The interplay between optimization and machine learning is one of the most important developments in modern computational science. Simultaneously there is a tremendous increase in the availability of large quantities of data in a multitude of applications, and a growing interest in exploiting the information that this data can provide to improve decision-making. Given the importance of big data in business analytics, its explicit integration into an optimization process is a challenge with high potential impact. The innovative project is concerned with the interconnection between machine learning approaches and a particular branch of optimization called bilevel optimization in this “big data” context. More precisely, we will focus on the development of new approaches integrating machine learning within bilevel optimization (LOBI: “Learning au sein de l’Optimisation BIniveau”) for two important practical applications, the pricing problem in revenue management and the energy ressource aggregation problem in smart grids. The applications arise from current industry collaborations of the teams involved, and will serve as testbeds to demonstrate the potential impact of the proposed approach.

9.3.2.2. North-European associated team

Title: Physical-internet services for city logistics

International Partner (Institution - Laboratory - Researcher):

Norwegian School of Economics - Stein Wallace

Start year: 2017

In this project, we consider an urban logistic terminal and new logistics services which could be developed according to a Physical Internet approach. The main objective is to evaluate the services using optimization models created within the project. We are developing optimization models to identify win-win cooperation between carriers based on supply and demand. We aim to explore how to include stochasticity in the description of the supplies and demands, as well as travel times, and to what extent the plans within a day can improve by such knowledge. The second task is to develop solution algorithms for these models. These are real scientific challenges as we are facing stochastic mixed integer problems.

9.3.3. Inria International Partners

9.3.3.1. Informal International Partners

Department of Statistics and Operations Research, University of Vienna, Austria.

Centre for Quantitative Methods and Operations Management, HEC-Liège, Belgique.

Interuniversity Centre on Entreprise Networks, Transportation and Logistics (CIRRELT), Montreal, Canada.

Department of Industrial Engineering, Universidad de Talca, Curicó, Chile.

Instituto Sistemas Complejos de Ingeniería (ISCI), Santiago, Chile.

The Centre for Business Analytics, University College Dublin, Ireland.

Department of Electrical, Electronic, and Information Engineering, University of Bologna, Italy.

Department of Electrical and Information Engineering, University of Padova, Italy.

Department of Mathematics, University of Aveiro, Portugal.

Department of Statistics and Operations Research, University of Lisbon, Portugal.

Instituto de Matemáticas, University of Seville, Spain.

Departamento de Estadística e Investigación Operativa, Universidad de Murcia, Spain.

Dipartimento di Matematica, Universita degli studi di Padova, Italy.

9.4. International Research Visitors

9.4.1. Visits of International Scientists

9.4.1.1. Visiting Professors and Ph.D. students

Claudia Archetti, Professor at Universita de Brescia, December 2018.

Stein Wallace, Professor at NHH Norwegian School of Economics, October 2018.

Martin Schmidt, Professor at Erlangen University, August 2018.

Alejandro Jofre, Professor at Universidad de Chile, from June 2018 until July 2018.

Sebastián Dávila, Ph.D. student at Universidad de Chile, June 2018.

Vladimir Marianov, Professor at Pontificia Universidad Católica de Chile, June 2018.

Fernando Ordónez, Professor at Universidad de Chile, June 2018.

Alfredo Marin, Professor at Universidad de Murcia, March 2018.

Eduardo Alvarez Miranda, Professor at Universidad de Talca, January - February 2018.

9.4.1.2. Internships

Brou Koua, Esatic, Abidjan, Cote d'Ivoire, December 2018 - January 2019.

Lilian Lopez Vera, Autonomous University of Nuevo León, Monterrey, Mexico February-June 2018.

MATHERIALS Project-Team

8. Partnerships and Cooperations

8.1. National Initiatives

The project-team is involved in several ANR projects:

- S. Boyaval is the PI of the ANR JCJC project SEDIFLO (2016-2020) to investigate new numerical models of solid transport in rivers.
- V. Ehrlacher is a member of the ANR project ADAPT (2018-2022), PI: D. Lombardi, Inria REO team-project. This project is concerned with the parallelization of tensor methods for high-dimensional problems.
- F. Legoll is a member of the ANR project CINE-PARA (2015-2019), PI: Y. Maday, Sorbonne Université. This project is concerned with parallel-in-time algorithms.
- G. Stoltz is the PI of the ANR project COSMOS (2014-2019) which focuses on the development of efficient numerical techniques to simulate high-dimensional systems in molecular dynamics and computational statistics. It includes research teams from Institut Mines-Telecom, Inria Rennes and IBPC Paris.

Members of the project-team are participating in the following GdR:

- AMORE (Advanced Model Order REduction),
- CORREL (correlated methods in electronic structure computations),
- DYNQUA (time evolution of quantum systems, with applications to transport problems, nonequilibrium systems, etc.),
- EGRIN (gravity flows),
- MANU (MAthematics for NUclear applications),
- MASCOT-NUM (stochastic methods for the analysis of numerical codes),
- MEPHY (multiphase flows)
- REST (theoretical spectroscopy),
- CHOCOLAS (experimental and numerical study of shock waves).

The project-team is involved in two Labex: the Labex Bezout (started in 2011) and the Labex MMCD (started in 2012).

8.2. European Initiatives

The ERC consolidator Grant MSMATH (ERC Grant Agreement number 614492, PI T. Lelièvre) is running (it started in June 2014).

8.3. International Initiatives

T. Lelièvre, G. Stoltz and F. Legoll participate in the Laboratoire International Associé (LIA) CNRS / University of Illinois at Urbana-Champaign on complex biological systems and their simulation by high performance computers. This LIA involves French research teams from Université de Nancy, Institut de Biologie Structurale (Grenoble) and Institut de Biologie Physico-Chimique (Paris). The LIA has been renewed for 4 years, starting January 1st, 2018.

MATHRISK Project-Team

9. Partnerships and Cooperations

9.1. National Initiatives

- ANR Cosmos 2015-2018, Participant: B. Jourdain ; Partners : Ecole des Ponts, Telecom, Inria Rennes and IBPC
- Labex Bezout
  http://bezout.univ-paris-est.fr

9.1.1. Competitivity Clusters

Pôle Finance Innovation

9.2. International Initiatives

9.2.1. Informal International Partners

- Center of Excellence program in Mathematics and Life Sciences at the Department of Mathematics, University of Oslo, Norway, (B. Øksendal).
- Kings College, London (R. Dumitrescu)
- Department of Mathematics, University of Manchester (Tusheng Zhang, currently in charge of an EU-ITN program on BSDEs and Applications).
- Kensas University (Yaozhong Hu)
- Cornell University, ORIE department (Andreea Minca)
- Mannheim University (Alexander Schied, Chair of Mathematics in Business and Economics, Department of Mathematics)
- Roma Tor Vergata University (Lucia Caramellino)
- Ritsumeikan University (A. Kohatsu-Higa).

9.3. International Research Visitors

9.3.1. Visits of International Scientists

- Oleg Kudryavtsev, Rostov University (Russia)
- B. Stemper (Weierstrass Institute Berlin)
- A. Kohatsu Higa (Ritsumeikan University)

9.3.2. Internships

Oussama Bellalah, Inria, May-August

MCTAO Project-Team

9. Partnerships and Cooperations

9.1. National Initiatives

9.1.1. ANR

Sub-Riemannian Geometry and Interactions (SRGI). Started 2015 (decision ANR-15-CE40-0018), duration: 4 years. L. Rifford is a member.

Intéractions Systèmes Dynamiques Équations d'Évolution et Contrôle (ISDEEC). Started 2016 (decision ANR-16-CE40-0013), duration: 4 years. L. Rifford is a member.

Maximic: optimal control of microbial cells by natural and synthetic strategies. Started 2017, duration: 4 years. J.-B. Caillau, L. Giraldi, J.-B. Pomet are members.

9.1.2. Others

Défi InfIniti CNRS project, Control and Optimality of Magnetic Microrobots, (PI L. Giraldi). Started 2017, duration: 1 years. This project involves colleagues from Paris Sorbonne Université (around S. Régnier's team) and from University of Strasbourg (around C. Prud'Homme's team).

PGMO grant (2016-2018) on "Metric approximation of minimizing trajectories and applications" (PI J.-B. Caillau). This project involved colleagues from Université Paris Dauphine and has funding for two year (originally one, extended), including one intership (M2 level).

PGMO grant (2017-2019) on "Algebro-geometric techniques with applications to global optimal control for Magnetic Resonance Imaging (MRI)". B. Bonnard, A. Nolot and J. Rouot participate in this project, the PI is O. Cots, from ENSEIHHT, Toulouse.

The McTAO team participates in the GdR MOA, a CNRS network on Mathematics of Optimization and Applications.

J.-B. Caillau is associate researcher of the CNRS team Parallel Algorithms & Optimization at ENSEEIHT, Univ. Toulouse.

P. Lissy was the PI of a PEPS project JCJC (young researchers).

9.2. European Initiatives

9.2.1. Bilateral program with Portugal

Program: FCT (Fundação para a Ciência e a Tecnologia)

Grant no. : PTDC/MAT-CAL/4334/2014

Project title: "Extremal spectral quantities and related problems"

Duration: 05/2016-05/2019

Coordinator: P. Freitas (Univ. Lisbon)

Team member involved: J.-B. Caillau

Other partners: Univ. Lisbon, Univ. Luxembourg, Czech Nuclear Physics Institute, Univ. Bern

Link: https://team.inria.fr/mctao/fct-project-extremal-spectral-quantities-and-related-problems-2016-2019

9.2.2. Bilateral ANR-DFG program with Germany

Program: Projets de recherche collaborative-internationale ANR-DFG (Germany)

Grant no. : ANR-14-CE35-0013-01; DFG-Gl 203/9-1

Project title: "**Exploring the physical limits of spin systems (Explosys).**"

Duration: 11/2014-10/2018

Coordinator: D. Sugny (Univ. de Bourgogne) for France, Glaser (TU München) for Germany.

Team member involved: Bernard Bonnard.

Other partners: TU München, Univ. de Bourgogne (IMB and UCB).

This project involves specialists in physics and control theory in order to make important progresses in the use of spin dynamics, in particular for Magnetic Resonance Medical Imaging.

Link: http://www.agence-nationale-recherche.fr/fileadmin/aap/2014/selection/pa-2014-selection-franco-allemand-dfg.pdf

9.3. International Research Visitors

9.3.1. Visits of International Scientists

Zhen Chen, Technion. Two day visit in July, 2018. Gave a talk "Shortest Dubins Paths through Three Points" at McTAO seminar.

9.3.2. Visits to International Teams

Lamberto Dell'Elce visited Department of Aerospace Engineering at Technion (Haifa, Israel) for a week in July, 2018.

Pierre Lissy was invited one month at Fudan University (China) in March and June, 2018.

MEMPHIS Project-Team

8. Partnerships and Cooperations

8.1. Regional Initiatives

Leading team of the regional project "Investigation and Modeling of Suspensions with the LOMA and LOF labs in Bordeaux.

8.2. National Initiatives

We are part of the GDR AMORE on ROMs.

MEPHYSTO-POST Team

5. Partnerships and Cooperations

5.1. National Initiatives

5.1.1. ANR

A. de Laire is a member of the ANR ODA project.

Title: Dispersive and random waves.

ANR reference : ANR-18-CE40-0020-01.

Coordinator: Nikolay Tzvetkov, Université de Cergy-Pontoise.

A. Hardy is a member of the ANR BoB project.

Title: Inférence bayésienne à ressources limitées - données massives et modèles coûteux.

Programme ANR: (DS0705) 2016.

ANR reference: ANR-16-CE23-0003.

Coordinator: R. Bardenet, CNRS & Université de Lille.

Duration: October 2016 - October 2020.

M. Simon is a member of the ANR EDNHS project.

Title: Diffusion de l'énergie dans des système hamiltoniens bruités.

Type: Défi de tous les savoirs (DS10) 2014.

ANR reference: ANR-14-CE25-0011.

Coordinator: C. Bernardin, Université de Nice.

Duration: October 2014 - October 2019.

5.2. European Initiatives

M. Simon is a collaborator of the ERC Starting Grant HyLEF project.

Title: Hydrodynamic Limits and Equilibrium Fluctuations: universality from stochastic systems

Duration: May 2017 - April 2022

Coordinator: P. Gonçalves, Instituto Superior Técnico, Lisbon.

5.3. International Research Visitors

5.3.1. Visits to International Teams

5.3.1.1. Research Stays Abroad

S. De Bièvre spent two months at the Centre de Recherche Mathématiques in Montréal as Simons Professor. M. Simon has been invited as Junior Scientific Leader of the Simons Semester "PDEs/SPDEs and Functional Inequalities" at IMPAN in Warsaw, Poland, for one month.

MINGUS Project-Team

9. Partnerships and Cooperations

9.1. Regional Initiatives

- A. Crestetto is a member of the regional initiative "Pari Scientifique Exprodil".
- M. Lemou is the head of the project "MUNIQ" of ENS Rennes. This two-years project (2018-2019) intends to gather multiscale numerical methods and uncertainty quantification techniques. The MINGuS members are P. Chartier, N. Crouseilles, M. Lemou and F. Méhats and colleagues from university of Madison-Wisconsin also belongs to this project.

9.2. National Initiatives

9.2.1. ANR

Participants: François Castella, Philippe Chartier, Nicolas Crouseilles, Mohammed Lemou, Florian Méhats, Arnaud Debussche, Anais Crestetto.

ANR MOONRISE: 2015-2019

The project *Moonrise* submitted by Florian Méhats has been funded by the ANR for 4 years, for the period 2015-2019. This project aims at exploring modeling, mathematical and numerical issues originating from the presence of high-oscillations in nonlinear PDEs from the physics of nanotechnologies (quantum transport) and from the physics of plasmas (magnetized transport in tokamaks). The partners of the project are the IRMAR (Rennes), the IMT (Toulouse) and the CEA Cadarache. In the MINGuS team, François Castella, Philippe Chartier, Nicolas Crouseilles and Mohammed Lemou are members of the project Moonrise.

Postdocs

- Loïc Le Treust has been hired as a Postdoc, under the supervision of Philippe Chartier and Florian Méhats. His contract started in september 2015 and ended in august 2016. Loïc Le Treust is now assistant professor at the university of Marseille.
- Yong Zhang has been hired as a Postdoc, under the supervision of Philippe Chartier and Florian Méhats. His contract started in september 2015 and ended in august 2016. Yong Zhang is now professor at the Tianjin university.
- Xiaofei Zhao has been hired as a Postdoc from september 2015 to september 2016 under the supervision of Florian Méhats. Xiaofei Zhao is now postdoc in the MINGuS team.

ANR MFG: 2016-2020

Mean Field Games (MFG) theory is a new and challenging mathematical topic which analyzes the dynamics of a very large number of interacting rational agents. Introduced ten years ago, the MFG models have been used in many areas such as, e.g., economics (heterogeneous agent models, growth modeling,...), finance (formation of volatility, models of bank runs,...), social sciences (crowd models, models of segregation) and engineering (data networks, energy systems...). Their importance comes from the fact that they are the simplest (“stochastic control"-type) models taking into account interactions between rational agents (thus getting beyond optimization), yet without entering into the issues of strategic interactions. MFG theory lies at the intersection of mean field theories (it studies systems with a very large number of agents), game theory, optimal control and stochastic analysis (the agents optimize a payoff in a possibly noisy setting), calculus of variations (MFG equilibria may arise as minima of suitable functionals) and partial differential equations (PDE): In the simplest cases, the value of each agent is found by solving a backward Hamilton-Jacobi equation whereas the distribution of the agents’ states evolves according to a forward Fokker-Planck equation. The “Master" equation (stated in the space of probability measures) subsumes the individual and collective

behaviors. Finally, modeling, numerical analysis and scientific computing are crucial for the applications. French mathematicians play a world-leading role in the research on MFG: The terminology itself comes from a series of pioneering works by J.-M. Lasry and P.-L. Lions who introduced most of the key ideas for the mathematical analysis of MFG; the last conference on MFG was held last June in Paris and organized by Y. Achdou, P. Cardaliaguet and J.-M. Lasry. As testifies the proposal, the number of researchers working on MFG in France (and also abroad) is extremely fast-growing, not only because the theoretical aspects are exciting and challenging, but also because MFG models find more and more applications. The aim of the project is to better coordinate the French mathematical research on MFG and to achieve significant progress in the theory and its applications.

The partners of the project are the CEREMADE laboratory (Paris Dauphine), the IRMAR laboratory (Rennes I), the university of Nice and of Tours.

ANR MoHyCon: 2017-2021

The MoHyCon project is related to the analysis and simulation of numerical methods for multiscale models of semiconductors. As almost all current electronic technology involves the use of semiconductors, there is a strong interest for modeling and simulating the behavior of such devices, which was recently reinforced by the development of organic semiconductors used for example in solar panels or in mobile phones and television screens (among others).

There exists a hierarchy of semiconductors models, including mainly three classes, which correspond to different scales of observation: microscopic, mesoscopic and macroscopic. At the microscopic scale, the particles are described one by one, leading to a huge system almost impossible to study, both theoretically and numerically. Within MoHyCon, we are then rather interested in the two other scales. The considered models at the mesoscopic scale are kinetic, of Boltzmann type, describing a distribution of particles submitted to an electric field. These models describe accurately the behavior of the semiconductor, but can be intricate and highly time and resource consuming to solve numerically. Thus, when the mean free path becomes small, it is preferable to consider fluid models, describing macroscopic quantities. Depending on the considered number of moments, various models can be obtained. The more common ones are the energy transport model, describing the densities of electron and energy, and the more simple drift-diffusion model, where the temperature is assumed to be a given function of the electron density.

In this project and provided this context, our aim is to construct and study rigorously numerical methods for these multiscale models. To this end, we will consider two distinct approaches: “Asymptotic Preserving” (AP) methods and coupling methods. The idea of AP methods is to design only one scheme which will be able to treat accurately every scale, without imposing restrictive stability conditions on the discretization parameters. Regarding the coupling methods, they consist in decomposing the domain into different regions on which the more relevant model (kinetic or macroscopic) will be considered. After locating the kinetic and fluid domains, the main difficulty is to obtain correct coupling conditions at each interface between two regions.

Considering the AP approach, our aim is to construct schemes for the linear Boltzmann equation for semiconductors, asymptotic preserving at the limit given by the drift-diffusion model. We will start with a very simplified model, with a linearized BGK collision operator. The constructed scheme will tend to an implicit discretization of Scharfetter-Gummel type for the drift-diffusion equation. The main objective will be then to lead a complete and rigorous study of the AP property by adapting to the discrete framework some continuous techniques: establish a discrete dissipation property yielding uniform estimates on the approximate solution which will allow to pass to the diffusion limit in the scheme.

As regards the second approach, the aim is to build a hybrid model coupling the kinetic equation on weakly collisional regions with macroscopic models on the remaining domain. We will first study specifically discretizations for energy-transport model, since we are then going to couple them with kinetic and other macroscopic schemes in our hybrid method. A particular attention will be paid to the implementation in order to obtain a robust and efficient code.

This ANR project is headed by M. Bessemoulin (CNRS, Nantes).

9.3. International Initiatives

9.3.1. Inria International Labs

IPL FRATRES MINGuS is associated to IPL FRATRES which started in june 2015. The aim of this project is to organize Inria teams activities which develop mathematical and numerical tools in magnetically confined nuclear fusion. The ambition is to prepare the next generation of numerical modeling methodologies able to use in an optimal way the processing capabilities of modern massively parallel architectures. This objective requires close collaboration between a) applied mathematicians and physicists that develop and study mathematical models of PDE; b) numerical analysts developing approximation schemes; c) specialists of algorithmics proposing solvers and libraries using the many levels of parallelism offered by the modern architecture and d) computer scientists. The project road map ambitions to contribute in close connection with National and European initiatives devoted to nuclear Fusion to the improvement and design of numerical simulation technologies applied to plasma physics and in particular to the ITER project for magnetic confinement fusion.

The IPL FRATRES ends at the end of the year. The final meeting was organized in november during which X. Zhao (former IPL postdoc), G. Morel (IPL postdoc) and N. Crouseilles have presented the kinetic activities of the IPL project.

Postdoc

- Xiaofei Zhao has been hired as a postdoc, under the supervision of Nicolas Crouseilles and Sever Hirstoaga (Inria-Nancy). His contract started in october 2016 and ended in september 2017. Xiaofei Zhao is now postdoc in the MINGuS team.
- Guillaume Morel has been hired as a postdoc, under the supervision of Nicolas Crouseilles and Michel Mehrenberger (AMU). His contract started in october 2018 and ended in september 2019.

9.3.2. Inria Associate Teams Not Involved in an Inria International Labs

ANTIpODE

Title: Asymptotic Numerical meThods for Oscillatory partial Differential Equations with uncertainties

International Partner (Institution - Laboratory - Researcher):

University of Wisconsin-Madison, USA (United States) - DEPARTMENT MATHEMATICS - Shi Jin

Start year: 2018

See also: https://team.inria.fr/antipode/

The proposed associate team assembles the Inria team MINGuS and the research group led by Prof. Shi Jin from the Department of Mathematics at the University of Wisconsin, Madison. The main scientific objective of ANTIpODE consists in marrying uniformly accurate and uncertainty quantification techniques for multi-scale PDEs with uncertain data. Multi-scale models, as those originating e.g. from the simulation of plasma fusion or from quantum models, indeed often come with uncertainties. The main scope of this proposal is thus (i) the development of uniformly accurate schemes for PDEs where space and time high oscillations co-exist and (ii) their extension to models with uncertainties. Applications to plasmas (Vlasov equations) and graphene (quantum models) are of paramount importance to the project.

9.3.3. Inria International Partners

Informal International Partners The members of the MINGuS have several interactions with the following partners

- the group of W. Bao (university of Singapore).
- university of Maryland (S. Cerrai)
- university of Ferrare (G. Dimarco)
- university of Madison-Wisconsin (S. Jin and Q. Li)
- university of Geneva (G. Vilmart)

9.4. International Research Visitors

9.4.1. Visits of International Scientists

The following scientists came in Rennes to visit some MINGuS members

- Fernando Casas (Professor, University of Jaume I, Castellon, Spain): invited professor for five months, from september 2018 to january 2019, funded by the Labex (CHL) Center Henri Lebesgue, collaboration on dissipative equations, splitting methods and gradient descent methods with P. Chartier, N. Crouseilles, M. Lemou and F. Méhats.
- Molei Tao (Associate professor, Georgia Tech, Atlanta, USA): eigth-days visit in november, funded by the ANR Moorise, collaboration on highly-oscillatory differential equations with P. Chartier, M. Lemou and F. Méhats.
- Di Fang (PhD student, University of Wisconsin, USA): ten-days visit in december 2019, funded by the associated team ANTIpODE, collaboration on highly-oscillatory differential equations with P. Chartier, M. Lemou and F. Méhats.

9.4.2. Visits to International Teams

9.4.2.1. Research Stays Abroad

Here we list the members of the team who did some research stays abroad

- P. Chartier, N. Crouseilles, M. Lemou, F. Méhats and P. Navaro: invited working visit (Eric Sonnendrücker), Max Planck Institute, Garching, Germany, March 19th-23th, 2018.
- P. Chartier, M. Lemou and F. Méhats: working visit, university of Madison-Wisconsin, USA, october 10th-20th, 2018.
- P. Chartier: invited working visit (Christophe Besse), University of Toulouse 3, Toulouse, February 26th-28th, 2018.
- P. Chartier: invited working visit (Gilles Vilmart), University of Geneva, Geneva, Switzerland, January 19th-26th, 2018.
- P. Chartier: invited working visit (Ander Murua), University of the Basque Country, San-Sebastian, Spain, January 15th-19th, 2018.
- N. Crouseilles: invited working visit (Giacomo Dimarco), University of Ferrare, Italy, october 2018.
- A. Debussche: invited working visit (Sandra Cerrai), university of Maryland, USA, april 2018.
- M. Lemou and F. Méhats: invited working visit (Ana Maria Luz), University Federal of Fluminence, Niteroi, Brazil, April 3th-8th, 2018.

MISTIS Project-Team

9. Partnerships and Cooperations

9.1. National Initiatives

9.1.1. Grenoble Idex projects

MISTIS is involved in a transdiciplinary project **NeuroCoG** and in a newly accepted cross-disciplinary project (CDP) **Risk@UGA**. F. Forbes is also a member of the executive committee and responsible for the *Data Science for life sciences* work package in another project entitled **Grenoble Alpes Data Institute**.

- The main objective of the RISK@UGA project is to provide some innovative tools both for the management of risk and crises in areas that are made vulnerable because of strong interdependencies between human, natural or technological hazards, in synergy with the conclusions of Sendai conference. The project federates a hundred researchers from Human and Social Sciences, Information & System Sciences, Geosciences and Engineering Sciences, already strongly involved in the problems of risk assessment and management, in particular natural risks. The PhD thesis of Meryem Bousebata is one of the eleven PhDs funded by this project.
- The NeuroCoG project aims at understanding the biological, neurophysiological and functional bases of behavioral and cognitive processes in normal and pathological conditions, from cells to networks and from individual to social cognition. No decisive progress can be achieved in this area without an aspiring interdisciplinary approach. The interdisciplinary ambition of NeuroCoG is particularly strong, bringing together the best scientists, engineers and clinicians at the crossroads of experimental and life sciences, human and social sciences and information and communication sciences, to answer major questions on the workings of the brain and of cognition. One of the work package entitled InnobioPark is dedicated to Parkinson's Disease. The PhD thesis of Veronica Munoz Ramirez is one of the three PhDs in this work package.
- The Grenoble Alpes Data Institute aims at undertaking groundbreaking interdisciplinary research focusing on how data change science and society. It combines three fields of data-related research in a unique way: data science applied to spatial and environmental sciences, biology, and health sciences; data-driven research as a major tool in Social Sciences and Humanities; and studies about data governance, security and the protection of data and privacy. In this context, a 2-year multi-disciplinary projects has been granted in November 2018 to Mistis in collaboration with the Grenoble Institute of Neuroscience. The objective of this project is to develop a statistical learning technique that is able to solve a problem of tracking and analyzing a large population of single molecules. The main difficulties are: 1) the large number of observations to analyse, 2) the noisy nature of the signals, 3) the definition of a quality index to allow the elimination of poor-quality data and false positive signals. We also aim at providing a powerful, well-documented and open-source software, that will be user-friendly for non-specialists.

Also in the context of the Idex associated with the Université Grenoble Alpes, Alexandre Constantin was awarded half a PhD funding from IRS (Initiatives de Recherche Stratégique), 50 keuros.

9.1.2. Competitivity Clusters

The MINALOGIC VISION 4.0 project: MISTIS is involved in a three-year (2016-19) project. The project is led by VI-Technology, a world leader in Automated Optical Inspection (AOI) of a broad range of electronic components. The other partners are the G-Scop Lab in Grenoble and ACTIA company based in Toulouse. Vision 4.0 (in short Vi4.2) is one of the 8 projects labeled by Minalogic, the digital technology competitiveness cluster in Auvergne-Rhône-Alpes, that has been selected for the Industry 4.0 topic in 2016, as part of the 22nd call for projects of the FUI-Régions, for a total budget of the project of 3,4 Meuros.

Today, in the printed circuits boards (PCB) assembly industry, the assembly of electronic cards is a succession of ultra automated steps. Manufacturers, in constant quest for productivity, face sensitive and complex adjustments to reach ever higher levels of quality. Project VI4.2 proposes to build an innovative software solution to facilitate these adjustments, from images and measures obtained in automatic optical inspection (AOI). The idea is - from a centralized station for all the assembly line devices - to analyze and model the defects finely, to adjust each automatic machine, and to configure the interconnection logic between them to improve the quality. Transmitted information is essentially of statistical nature and the role of sc mistis is to identify which statistical methods might be useful to exploit at best the large amount of data registered by AOI machines. Preliminary experiments and results on the Solder Paste Inspection (SPI) step, at the beginning of the assembly line, helped determining candidate variables and measurements to identify future defects and to discriminate between them. More generally, the idea is to analyze two databases at both ends (SPI and Component Inspection) of the assembly process so as to improve our understanding of interactions in the assembly process, find out correlations between defects and physical measures and generate accordingly proactive alarms so as to detect as early as possible departures from normality.

9.1.3. Networks

MSTGA and AIGM INRA (French National Institute for Agricultural Research) networks: F. Forbes and J.B Durand are members of the INRA network called AIGM (ex MSTGA) network since 2006, http://carlit.toulouse.inra.fr/AIGM, on Algorithmic issues for Inference in Graphical Models. It is funded by INRA MIA and RNSC/ISC Paris. This network gathers researchers from different disciplines. MISTIS co-organized and hosted 2 of the network meetings in 2008 and 2015 in Grenoble. Thibaud Rahier and Brice Olivier participated as speakers to meetings of the network in 2018.

9.2. International Initiatives

9.2.1. Inria International Labs

International Laboratory for Research in Computer Science and Applied Mathematics
Associate Team involved in the International Lab:

9.2.1.1. SIMERG2E

Title: Statistical Inference for the Management of Extreme Risks, Genetics and Global Epidemiology

International Partner:

UGB (Senegal) - Abdou Kâ Diongue

Start year: 2018

See also: http://mistis.inrialpes.fr/simerge

SIMERG2E is built on the same two research themes as SIMERGE, with some adaptations to new applications: 1) Spatial extremes, application to management of extreme risks. We address the definition of new risk measures, the study of their properties in case of extreme events and their estimation from data and covariate information. Our goal is to obtain estimators accounting for possible variability, both in terms of space and time, which is of prime importance in many hydrological, agricultural and energy contexts. 2) Classification, application to genetics and global epidemiology. We address the challenge to build statistical models in order to test association between diseases and human host genetics in a context of genome-wide screening. Adequate models should allow to handle complexity in genomic data (correlation between genetic markers, high dimensionality) and additional statistical issues present in data collected from a family-based longitudinal survey (non-independence between individuals due to familial relationship and non-independence within individuals due to repeated measurements on a same person over time).

9.2.2. Inria International Partners

9.2.2.1. Informal International Partners

The context of our research is also the collaboration between MISTIS and a number of international partners such as the statistics department of University of Michigan, in Ann Arbor, USA, the statistics department of McGill University in Montreal, Canada, Université Gaston Berger in Senegal and Universities of Melbourne and Brisbane in Australia.

The main active international collaborations in 2018 are with:

- G. Stupfler, Nottingham University, UK.
- K. Qin, H. Nguyen and Kerrie Mengersen, D. Wraith resp. from Swinburne University and La Trobe university in Melbourne, Australia and Queensland University of Technology in Brisbane, Australia.
- E. Deme and S. Sylla from Gaston Berger university and IRD in Senegal.
- M. Houle from National Institute of Informatics, Tokyo, Japan.
- N. Wang and C-C. Tu from University of Michigan, Ann Arbor, USA.
- R. Steele, from McGill university, Montreal, Canada.
- Guillaume Kon Kam King, Stefano Favaro, Pierpaolo De Blasi, Collegio Carlo Alberto, Turin, Italy.
- Igor Prünster, Antonio Lijoi, and Riccardo Corradin Bocconi University, Milan, Italy.
- Bernardo Nipoti, Trinity College Dublin, Ireland.
- Yeh Whye Teh, Oxford University and DeepMind, UK.
- Stephen Walker, University of Texas at Austin, USA.

9.3. International Research Visitors

9.3.1. Visits of International Scientists

- Hien Nguyen, researcher at La Trobe University in Melbourne visited for a month in October 2018.
- Eric Marchand Professor at University of Sherbrook Canada, visited from March to June 2018.
- Riccardo Corradin, PhD student at Bocconi University, Milan, Italy visited for a month in March 2018.
- Aboubacrène Ag Ahmad, PhD student at Univ. Gaston Berger, Senegal visited from September 2018 until November 2018.

9.3.1.1. Internships

Caroline Lawless from University College Dublin visited for 2 months as part of her internship.

MODAL Project-Team

9. Partnerships and Cooperations

9.1. Regional Initiatives

9.1.1. Bilille partnership

Participant: Guillemette Marot.

Bilille, the bioinformatics platform of Lille, officially gathers from Nov. 2015 a few bioinformaticians, biostatisticians and bioanalysts from the following teams:

EA2694 (Univ. Lille, CHRU, Inria)

FRABIO, FR3688 (Univ. Lille,CNRS)

CBP / GFS (Univ. Lille, CHRU)

TAG (Univ. Lille, CNRS, INSERM, Institut Pasteur de Lille)

U1167 (Univ. Lille, CHRU, INSERM et Institut Pasteur de Lille)

U1011 (Univ. Lille, INSERM)

UMR8198 (Univ. Lille, CNRS)

LIGAN PM (Univ. Lille, CNRS)

BONSAI (Inria, Univ. Lille, CNRS).

These last teams are thus the main partners of Modal concerning biostatistics for bioinformatics. Guillemette Marot is the co-head of the platform and works in close collaboration with the following people for the leadership of the scientific strategy related to the platform:

H. Touzet, BONSAI, UMR 9189 (co-head of bilille)

P. Touzet, UMR 8198 (deputy head of bilille)

C. Bellenguez, U1167

M. Figeac, CBP / GFS

D. Hot, TAG

V. Leclère, Insitut Charles Viollette

M. Lensink, UMR 8576.

O. Sand, IFB-Core.

9.1.2. Bilille collaborations

Participants: Guillemette Marot, Vincent Vandewalle.

Guillemette Marot and Vincent Vandewalle have supervised the data analysis part or support in biostatistics tools testing for the following research projects involving engineers from bilille (only the names of the principal investigators of the project are given even if several partners are sometimes involved in the project):

CIIL, C. Faveeuw, Analysis of cytometry data

CIIL, P. Brodin, Analysis of phenotypic screening data

JPARC, J.M. Taymans, Analysis of translation chips

JPARC, M.C. Chartier-Harlin, RNA-Seq meta-analysis

JPARC, A. Vincent, Microarray analysis

UMR 1167, F. Pinet, Analysis of proteomic data.

9.2. National Initiatives

9.2.1. Programme of Investments for the Future (PIA)

Bilille is a member of two PIA "Infrastructures en biologie-santé":

France Génomique (https://www.france-genomique.org/spip/?lang=en)

IFB, French Institute of Bioinformatics (https://www.france-bioinformatique.fr/en)

As the leader of the platform, Guillemette Marot is thus involved in these networks.

9.2.2. RHU PreciNASH

Participant: Guillemette Marot.

RHU PreciNASH

Acronym: PreciNASH

Project title: Non-alcoholic steato-hepatitis (NASH) from disease stratification to novel therapeutic approaches

Coordinator: F. Pattou

Duration: 5 years

Partners: FHU Integra and Sanofi

Abstract: PreciNASH, project coordinated by Pr. F. Pattou (UMR 859, EGID), aims at better understanding non alcoholic stratohepatitis (NASH) and improving its diagnosis and care. In this RHU, Guillemette Marot supervises a 2 years post-doc, as her team EA 2694 is a member of the FHU Integra. EA 2694 is involved in the WP1 for the development of a clinical-biological model for the prediction of NASH. Other partners of the FHU are UMR 859, UMR 1011 and UMR 8199, these last three teams being part of the labex EGID (European Genomic Institute for Diabetes). Sanofi is the main industrial partner of the RHU PreciNASH. The whole project will last 5 years (2016-2021).

9.2.3. INS2I-CNRS project PEPS JCJC 2018 "PaRaFF"

Participant: Pascal Germain.

Projet PaRaFF: PAC-Bayesian Random Fourier Features

Coordinator: Emilie Morvant, Hubert Curien Lab, University Jean Monnet, Saint-Etienne

Year: 2018

Abstract: In data science, any method is based on a representation of the data. In this project, we study the learning of representation in the context of automatic learning methods called kernel methods. Our analysis is based on the Random Fourier Features, a method of approximating a kernel function based on a combination random attributes (combination defined by a probability distribution on the attributes). We aim to provide a theoretical understanding of this approach via PAC-Bayesian theory, and to propose a representation learning procedure by exploiting the specificities of this theory.

9.2.4. ANR

9.2.4.1. ANR APRIORI

Participants: Benjamin Guedj, Pascal Germain.

APRIORI 2019–2023, ANR PRC

PAC-Bayesian theory and algorithms for deep learning and representation learning.

Main coordinator of the project: Emilie Morvant, Université Jean Monnet.

Funding: 300k EUR.

2 partners - MODAL (Inria LNE), Hubert Curien Lab. (UMR CNRS 5516).

9.2.4.2. ANR BEAGLE

Participants: Benjamin Guedj, Pascal Germain.

BEAGLE 2019–2023, ANR JCJC

PAC-Bayesian theory and algorithms for agnostic learning

Main coordinator of the project: Benjamin Guedj

Funding: 180k EUR

The consortium also includes Pierre Alquier (ENSAE ParisTech), Peter Grünwald (CWI, The Netherlands), Rémi Bardenet (UMR CRIStAL 9189).

9.2.4.3. ANR SMILE

Participants: Christophe Biernacki, Vincent Vandewalle.

SMILE Project-2018-2022

ANR project (ANR SMILE - Statistical Modeling and Inference for unsupervised Learning at LargE-Scale)

Main coordinator of the project: Faicel Chamroukhi, LMNO, Université de Caen

4 partners - MODAL (Inria LNE), LMNO UMR CNRS 6139 (Caen), LMRS UMR CNRS 6085 (Rouen), LIS UMR CNRS 7020 (Toulon).

9.2.4.4. ANR ClinMine

Participants: Cristian Preda, Vincent Vandewalle.

ClinMine Project-2014-2017

ANR project (ANR TECSAN - Technologie de la santé)

Main coordinator of the project: Clarisse Dhaenens, CRIStAL, USTL

7 partners - EA 1046 (Maladie d'Alzheimer et pathologies vasculaires, Faculté de Médecine, Lille), EA 2694 (Centre d'Etudes et de Recherche en Informatique Médicale - Faculté de Médecine, Lille), MODAL (Inria LNE), Alicante (Entreprise), CHRU de Montpelier, GHICL (Groupe Hospitalier de l'Institut Catholique de Lille), CRIStAL, USTL.

9.2.4.5. ANR TheraSCUD2022

Participant: Guillemette Marot.

Acronym: TheraSCUD2022

Project title: Targeting the IL-20/IL-22 balance to restore pulmonary, intestinal and metabolic homeostasis after cigarette smoking and unhealthy diet

Coordinator: P. Gosset

Duration: 3 years

Partners: CIIL Institut Pasteur de Lille and UMR 1019 INRA Clermont-Ferrand

Abstract: TheraSCUD2022, project coordinated by P. Gosset (Institut Pasteur de Lille), studies inflammatory disorders associated with cigarette smoking and unhealthy diet (SCUD). Guillemette Marot is involved in this ANR project as head of bililleplatform, and will supervise 1 year engineer on integration of omic data. The duration of this project is 3 years (2017-2020).

9.2.5. Working groups

Sophie Dabo-Niang belongs to the following working groups:

- STAFAV (STatistiques pour l'Afrique Francophone et Applications au Vivant)
- ERCIM Working Group on computational and Methodological Statistics, Nonparametric Statistics Team
- Ameriska

Benjamin Guedj belongs to the following working groups (GdR) of CNRS:

- ISIS (local referee for Inria Lille - Nord Europe)
- MaDICS
- MASCOT-NUM (local referee for Inria Lille - Nord Europe).

Guillemette Marot belongs to the StatOmique working group.

9.2.6. Other initiatives

Participants: Serge Iovleff, Cristian Preda, Vincent Vandewalle.

Serge Iovleff is the head of the project CloHe granted in 2016 by the Mastodons CNRS challenge "Big data and data quality". The project is axed on the design of classification and clustering algorithms for mixed data with missing values with applications to high spatial resolution multispectral satellite image time-series. Website. Cristian Preda and Vincent Vandewalle are also members of the CloHe project.

9.3. European Initiatives

9.3.1. FP7 & H2020 Projects

Benjamin Guedj and Vincent Vandewalle are involved on the European H2020 porject PERF-AI

Program: H2020

Project acronym: PERF-AI

Project title: Enhance Aircraft Performance and Optimisation through utilisation of Artificial Intelligence

Duration: November 2018 - November 2020.

Coordinator: Safety Line

Other partners: Safety Line

Abstract: PERF-AI will apply Machine Learning techniques on flight data (parametric and non-parametric approaches) to accurately measure actual aircraft performance throughout its lifecycle.

Within current airline operations, both at flight preparation (on-ground) and at flight management (in-air) levels, the trajectory is first planned, then managed by the Flight Management System (FMS) using a single manufacturer's performance model that is the same for every aircraft of the same type, and also on weather forecast that is computed long before the flight. It induces a lack of accuracy during the planning phase with a flight route pre-established at specific altitudes and speeds to optimize fuel burn, from take-off to landing using aircraft performances that are not those of the real aircraft. Also, the actual flight will usually shift from the original plan because of Air Traffic Control (ATC) constraints, adverse weather, wind changes and tactical re-routing, without possibility for the flight crew, either using the FMS or through connected services to tactically recompute the trajectory in order to continuously optimize the flight path. This is in particular due to the limitations of the performance databases that the current systems are using.

Hence, PERF-AI is focusing on identifying adequate machine learning algorithms, testing their accuracy and capability to perform flight data statistical analysis and developing mathematical models to optimize real flight trajectories with respect to the actual aircraft performance, thus, minimizing fuel consumption throughout the flight.

The consortium consists of Safety-Line (FR) and Inria (FR), having full expertise at Aircraft Performance and Data Science, hence, able to fully propose, test and validate different statistical models that will allow to accurately solve some optimization challenges and implement them in an operational environment.

9.3.2. Collaborations with Major European Organizations

Sophie Dabo-Niang is vice-chair of EMS-CDC (European Mathematical Society-Committe of Developing Countries). She is also a member of the executive committee of CIMPA (International Centre of Pure and Applied Mathematics)

Alain Celisse is a member of a one-year EIT European project called SysBooster with ApSys and Nokia.

9.4. International Initiatives

9.4.1. Inria International Labs

IIL CWI-Inria
Associate Team involved in the International Lab:

9.4.1.1. 6PAC

Title: Making Probably Approximately Correct Learning Active, Sequential, Structure-aware, Efficient, Ideal and Safe

International Partner (Institution - Laboratory - Researcher):

CWI (Netherlands) - Machine Learning Group

PI: Benjamin Guedj

Consortium: Peter Grünwald (co-PI), Wouter Koolen (CWI), Emilie Kaufmann (Inria LNE EPI SequeL).

Start year: 2018 (until 2021)

Webpage: https://bguedj.github.io/6pac/index.html

This project roots in statistical learning theory, which can be viewed as the theoretical foundations of machine learning. The most common framework is a setup in which one is given n training examples, and the goal is to build a predictor that would be efficient on new (similar) data. This efficiency should be supported by PAC (Probably Approximately Correct) guarantees, e.g. upper bounds on the excess risk of a predictor that hold with high probability. Such guarantees however often hold under stringent assumptions which are typically never met in real-life application, e.g., independent, identically distributed data. More realistic modelling of data has triggered many research efforts in several directions: first, accommodating possible data (e.g., dependent, heavy-tailed), and second, in the direction of sequential learning, in which the predictor can be built on the fly, while new data is gathered. We believe that an ever more realistic paradigm is active learning, a setup in which the learner actively requests data (possibly facing constraints, such as storage, velocity, cost, etc.) and adapts its queries to optimize its performance. The 3-years objective of 6PAC (where 6 stands for Sequential, Active, Efficient, Structured, Ideal, Safe - the six research directions we intend to contribute to) is to pave the way to new PAC generalization and sample-complexity upper and lower bounds beyond batch learning. Our ambition is to contribute to several learning setups, ranging from sequential learning (where data streams are collected) to adaptive and active learning (where data streams are requested by the learning algorithm).

9.4.2. Participation in Other International Programs

Starting December 2018, Benjamin Guedj is on sabbatical leave at University College London, Computer Science department, to lead a research team within the UCL AI center.

9.4.2.1. SIMERGE

Title: Statistical Inference for the Management of Extreme Risks and Global Epidemiology

International Partner (Institution - Laboratory - Researcher):

UGB (Senegal) - LERSTAD - Abdou Ka Diongue

Serge Iovleff and Sophie Dabo-Niang are associated members of SIMERGE.

9.5. International Research Visitors

9.5.1. Visits to International Teams

9.5.1.1. Research Stays Abroad

Sophie Dabo-Niang visited the University of Kuala Lumpur, November 2018, the University of Melbourne (Australia), December 2018, and the University of Nador (Morroco), end of December 2018.

Serge Iovleff visited several institutions in Senegal (April 22 – May 18, 2018). He gave a lecture at University Gaston Berger (UGB) of Saint-Louis and collaborated with Cheikh Loucoubar, Seydou Nourou Syllla and Cheikh Loucoubar of the team G4BBM of the Pasteur Institute of Dakar.

MOKAPLAN Project-Team

7. Partnerships and Cooperations

7.1. National Initiatives

7.1.1. ANR

J-D. Benamou and G. Carlier are members of the ANR MFG (ANR-16-CE40-0015-01). Scientific topics of the project: Mean field analysis Analysis of the MFG systems and of the Master equation Numerical analysis Models and applications
J-D. Benamou G. Carlier F-X. Vialard and T. O. Gallouët are members of ANR MAGA (ANR-13-JS01-0007-01). The Monge-Ampère equation is a fully nonlinear elliptic equation, which plays a central role in geometry and in the theory of optimal transport. However, the singular and non-linear nature of the equation is a serious obstruction to its efficient numerical resolution. The first aim of the MAGA project is to study and to implement discretizations of optimal transport and Monge-Ampère equations which rely on tools from computational geometry (Laguerre diagrams). In a second step, these solvers will be applied to concrete problems from various fields involving optimal transport or Monge-Ampère equations such as computational physics: early universe reconstruction problem, congestion/incompressibility constraints economics: principal agent problems, geometry: variational problems over convex bodies, reflector and refractor design for non-imaging optics
T. O. Gallouët is member of the ANR GEOPOR (JCJC of C. Cancès) Scientific topic: geometrical approach, based on Wasserstein gradient flow, for multiphase flows in porous media. Theory and Numerics.
T. O. Gallouët is member of the ANR MESA (JCJC of M. Fathi) Scientific topic: Stein methods.

7.2. European Initiatives

7.2.1. FP7 & H2020 Projects

J-D. Benamou and G. Rukhaia are members of the ROMSOC ITN.

7.3. International Research Visitors

7.3.1. Visits of International Scientists

- Shuangjian Zhang, (PostDoc), Université de Toronto, June-August 2018.
- Clarice Poon, Imperial College London, January 2018
- Teresa Radice, Université de Naples, many short stays.

7.3.2. Visits to International Teams

7.3.2.1. Research Stays Abroad

- P. Pegon was invited for 10 days to Penn State College by Alberto Bressan in order to start a collaboration on the theory of ramified transport and applications to biology, and to give lectures (2) in the seminar series on Computational and Applied Mathematics.
- G. Carlier was a John von Neumann invited Professor at TUM (Munich) in 2018.

NACHOS Project-Team

8. Partnerships and Cooperations

8.1. European Initiatives

8.1.1. FP7 & H2020 Projects

8.1.1.1. EoCoE

Title: Energy oriented Centre of Excellence for computer applications

Program: H2020

See also: https://www.eocoe.eu

Duration: October 2015 - October 2018

Coordinator: CEA

Partners:

- Barcelona Supercomputing Center (Spain)
- CEA (France)
- CERFACS (France)
- CNR (Italy)
- The Cyprus Institute (Cyprus)
- ENEA (Italy)
- Fraunhofer–Gesellschaft (Germany)
- Instytut Chemii Bioorganicznej Polskiej Akademii Nauk (Poland)
- Forschungszentrum Julich (Germany)
- Max-Planck-Gesellschaft (Germany)
- University of Bath (United Kingdom)
- Universite Libre de Bruxelles (Belgium)
- Universita Degli Studi di Trento (Italy)

Inria contact: Michel Kern

The aim of the present proposal is to establish an Energy Oriented Centre of Excellence for computing applications, (EoCoE). EoCoE (pronounce “Echo”) will use the prodigious potential offered by the ever-growing computing infrastructure to foster and accelerate the European transition to a reliable and low carbon energy supply. To achieve this goal, we believe that the present revolution in hardware technology calls for a similar paradigm change in the way application codes are designed. EoCoE will assist the energy transition via targeted support to four renewable energy pillars: Meteo, Materials, Water and Fusion, each with a heavy reliance on numerical modelling. These four pillars will be anchored within a strong transversal multidisciplinary basis providing high-end expertise in applied mathematics and HPC. EoCoE is structured around a central Franco-German hub coordinating a pan-European network, gathering a total of 8 countries and 23 teams. Its partners are strongly engaged in both the HPC and energy fields; a prerequisite for the long-term sustainability of EoCoE and also ensuring that it is deeply integrated in the overall European strategy for HPC. The primary goal of EoCoE is to create a new, long lasting and sustainable community around computational energy science. At the same time, EoCoE is committed to deliver high-impact results within the first three years. It will resolve current bottlenecks in application codes, leading to new modelling capabilities and scientific advances among the four user communities; it will develop cutting-edge mathematical and numerical methods, and tools to foster the usage of Exascale computing. Dedicated services for laboratories and industries will be established to leverage this expertise and to foster an ecosystem around HPC for energy. EoCoE will give birth to new collaborations and working methods and will encourage widely spread best practices.

8.1.1.2. PRACE 5IP

Title: PRACE Fifth Implementation Phase (PRACE-5IP) project

See also: http://www.prace-ri.eu/prace-5ip

Duration: January 2017 - April 2019

Partners: see http://www.prace-ri.eu/member-systems

Inria contact: Stéphane Lanteri

The mission of PRACE (Partnership for Advanced Computing in Europe) is to enable high-impact scientific discovery and engineering research and development across all disciplines to enhance European competitiveness for the benefit of society. PRACE seeks to realise this mission by offering world class computing and data management resources and services through a peer review process. PRACE also seeks to strengthen the European users of HPC in industry through various initiatives. PRACE has a strong interest in improving energy efficiency of computing systems and reducing their environmental impact. The objectives of PRACE-5IP are to build on and seamlessly continue the successes of PRACE and start new innovative and collaborative activities proposed by the consortium. These include: assisting the transition to PRACE2 including ananalysis of TransNational Access; strengthening the internationally recognised PRACE brand; continuing and extend advanced training which so far provided more than 18 800 persontraining days; preparing strategies and best practices towards Exascale computing; coordinating and enhancing the operation of the multi-tier HPC systems and services; supporting users to exploit massively parallel systems and novel architectures.

8.1.1.3. EPEEC

Title: European joint effort toward a highly productive programming environment for heterogeneous exascale computing

Program: H2020

See also: https://epeec-project.eu

Duration: October 2018 - September 2021

Coordinator: Barcelona Supercomputing Center

Partner: Barcelona Supercomputing Center (Spain)

Coordinator: CEA

Partners:

- Fraunhofer–Gesellschaft (Germany)
- CINECA (Italy)
- IMEC (Blegium)
- INESC ID (Portugal)
- Appentra Solutions (Spain)
- Eta Scale (Sweden)
- Uppsala University (Sweden)
- Inria (France)
- Cerfacs (France)

Inria contact: Stéphane Lanteri

EPEEC's main goal is to develop and deploy a production-ready parallel programming environment that turns upcoming overwhelmingly-heterogeneous exascale supercomputers into manageable platforms for domain application developers. The consortium will significantly advance and integrate existing state-of-the-art components based on European technology (programming models, runtime systems, and tools) with key features enabling 3 overarching objectives: high coding productivity, high performance, and energy awareness. An automatic generator of compiler directives will provide outstanding coding productivity from the very beginning of the application developing/porting process. Developers will be able to leverage either shared memory or distributed-shared memory programming flavours, and code in their preferred language: C, Fortran, or C++. EPEEC will ensure the composability and interoperability of its programming models and runtimes, which will incorporate specific features to handle data-intensive and extreme-data applications. Enhanced leading-edge performance tools will offer integral profiling, performance prediction, and visualisation of traces. Five applications representative of different relevant scientific domains will serve as part of a strong inter-disciplinary co-design approach and as technology demonstrators. EPEEC exploits results from past FET projects that led to the cutting-edge software components it builds upon, and pursues influencing the most relevant parallel programming standardisation bodies.

8.2. International Initiatives

8.2.1. Participation in Other International Programs

8.2.1.1. International Initiatives

PHOTOM

Title: PHOTOvoltaic solar devices in Multiscale computational simulations

International Partners:

Center for Research in Mathematical Engineering, Universidad de Concepcion (Chile), Rodolfo Araya

Laboratório Nacional de Computação Científica (Brazil), Frédéric Valentin

Instituto de Matemáticas, PUCV (Chile), Diego Paredes

Duration: 2018 - 2019

Start year: 2018

See also: http://www.photom.lncc.br

The work consists of devising, analyzing and implementing new multiscale finite element methods, called Multiscale Hybrid-Mixed (MHM) method, for the Helmholtz and the Maxwell equations in the frequency domain. The physical coefficients involved in the models contain highly heterogeneous and/or high contrast features. The goal is to propose numerical algorithms to simulate wave propagation in complex geometries as found in photovoltaic devices, which are naturally prompt to be used in massively parallel computers. We demonstrate the well-posedness and establish the optimal convergence of the MHM methods. Also, the MHM methods are shown to induce a new face-based a posteriori error estimator to drive space adaptivity. An efficient parallel implementation of the new multiscale algorithm assesses theoretical results and is shown to scale on a petaflop parallel computer through academic and realistic two and three-dimensional solar cells problems.

8.2.2. Inria International Partners

8.2.2.1. Informal International Partners

Prof. Kurt Busch, Humboldt-Universität zu Berlin, Institut für Physik, Theoretical Optics & Photonics

Prof. Martijn Wubs, Technical University of Denmark (DTU), Structured Electromagnetic Materials Theory group

Dr. Urs Aeberhard and Dr. Markus Ermes, Theory and Multiscale Simulation, IEK-5 Photovoltaik, Forschungszentrum Jülich, Germany

8.3. International Research Visitors

8.3.1. Visits of International Scientists

Prof. Liang Li, School of Mathematical Sciences, University of Electronic Science and Technology of China, Chengdu. From July to August 2018.

Stéphane Lanteri and Théophile Chaumont-Frelet at LNCC, Petropolis, Brazil, March 12-16, 2018.

Stéphane Lanteri and Claire Scheid at UAM and CSIC, Spain, May 29-30, 2018.

Stéphane Lanteri and Claire Scheid at Humboldt-Universität zu Berlin, Berlin, Germany, July 12-13, 2018.

Stéphane Lanteri at Barcelona Supercomputing Center, Barcelona, Spain, July 23-24, 2018.

NANO-D Project-Team

7. Partnerships and Cooperations

7.1. Regional Initiatives

- Sergei Grudinin has obtained an IDEX UGA grant. It covers 2 years of post-doc of Didier Devaurs, starting from December 2018.
- Doctoral UGA grant covers PhD thesis of Maria Kadukova (supervised by Sergei Grudinin).

7.2. National Initiatives

7.2.1. ANR

In 2018, NANO-D had funding from one ANR program:

- **ANR PRCI**: covers PhD thesis of Guillaume Pages.

7.3. European Initiatives

7.3.1. Collaborations with Major European Organizations

Partner 1: The European Bioinformatics Institute (EMBL-EBI), Protein Data Bank in Europe (PDBe) team, Hinxton (UK)

We are collaborating on the integration of methods developed in the team into the PDBe web resource.

Partner 2: The Institute Laue-Langevin (ILL), the bioSANS team, Grenoble (France)

We are collaborating on the development of neutron small-angle scattering software.

Partner 3: The Ecole polytechnique fédérale de Lausanne (EPFL), Laboratory for Biomolecular Modeling, Lausanne (Switzerland)

We are collaborating on the integrative structural biology approaches.

7.4. International Initiatives

7.4.1. Inria International Partners

7.4.1.1. Declared Inria International Partners : BIOTOOLS

Title: Novel Computational Tools for Structural Bioinformatics

International Partner (Institution - Laboratory - Researcher):

MIPT (Russia (Russian Federation)) - Department of Control and Applied Mathematics - Vadim Strijov

Duration: 2016 - 2020

Start year: 2016

Abstract : The general scientific objectives of the forthcoming collaboration are the new developments of computational tools for structural bioinformatics. In particular, we plan to collaborate on several subjects: 1. Development of tractable approximations for intractable combinatorial problems in structural biology. 2. Development of new computational tools for scattering experiments. 3. Machine learning for structural bioinformatics.

7.4.1.2. Informal International Partners

- University of Stony Brook, lab of Dima Kozakov (USA). We have been collaborating on the development of novel protein docking methods.
- University of Vilnius, department of Bioinformatics (Lithuania). We have been collaborating on the development of novel protein docking methods.
- KU Copenhagen (Denmark), department of Chemistry. We collaborate on the integrative structural biology approaches.
- Autonomous University of Madrid (Spain), Bioinformatics Unit. We collaborate on the development of computational methods for protein flexibility.
- Francis Crick Institute, London (UK), Biomolecular Modelling Laboratory. We collaborate on the development of flexible protein docking methods.

7.4.2. Participation in Other International Programs

Our team has obtained the PHC Gilibert grant for a 2-year collaboration with the Vilnius University (Lithuania). Our partner is the Department of Bioinformatics, http://www.bti.vu.lt/en/departments/department-of-bioinformatics.

7.5. International Research Visitors

7.5.1. Visits of International Scientists

- Karina Dos Santos Machado, lecturer at the Federal University of Rio Grande (FURG, Brazil), Oct 2018 - Oct 2019.

7.5.1.1. Internships

- Amal Akkari (Mohammed V University, Rabat, Morocco), Jun 2018 - Nov 2018.
- Khalid Mustafin (MIPT Moscow, Russia), Sep 2018 - Feb 2019.

7.5.2. Visits to International Teams

Sergei Grudinin has visited and gave talks in the following research labs :

- Department of Bioinformatics, University of Vilnius, Lithuania, May 10-11, 2018.
- The team of Dima Kozakov,Stony Brook University, USA, November 12th-14th, 2018.
- The team of Simon Billinge, Columbia University, USA, November 15th, 2018.
- Department of Biology, University of Copenhagen, Denmark, November 19th, 2018.
- Department of Chemistry, University of Copenhagen, Denmark, November 22nd, 2018.
- Department of Bioinformatics, State Belorussian University, Minsk, Belarus, Dec 28, 2018.

NECS Project-Team

8. Partnerships and Cooperations

8.1. Regional Initiatives

8.1.1. Control of Cyber-Social Systems (C2S2)

C2C2 is a two-year project funded by the University Grenoble Alpes, MSTIC department. Evolving from recent research on network systems, this exploratory project has the objective to concentrate on cyber-social systems, that is, complex systems with interacting social and technological components. A strong motivation for this novel research direction comes from the need for innovative tools for the management of vehicular traffic. In this application, state-of-the-art approaches concentrate on hard control actions, like traffic lights: instead, future management methods should exploit soft control actions aimed at controlling the traffic demand, that is, the aggregated behaviors of the drivers.

8.1.2. Understanding data accidents for traffic safety (DATASAFE)

DATASAFE is a two years project funded by Grenoble Data Institute, with the aim to understand from real traffic data the behavior of traffic in the moments preceding an accident. The general approach is to use novel statistical techniques in order to learn traffic characteristics that can be used to develop new traffic models. Bayesian approaches are used to (supervised) classification and (unsupervised) clustering in order to respectively predict collision occurrences and discover traffic patterns.

8.1.3. Modeling autonomous vehicles in traffic flow (MAVIT)

MAVIT is a two year project funded by the University Grenoble Alpes, MSTIC department. The goal of this project is to develop a unified micro-macro approach for traffic management, involving human and autonomous vehicles drivers by providing analytical and numerical tools for traffic modeling, estimation and control. We will work towards field operational tests, by using instrumented cars to collect data on AVs trajectory and their interaction with the traffic flow with human drivers. The proposed research provides new mathematical models, computational/software tools, and engineering solutions for the control of human controlled vehicles via intelligently controlled AVs in the traffic stream. Moreover, the control of traffic via moving actuators provides a new alternative to contemporary control technologies, such as ramp metering and variable speed limits; even when AVs comprise a tiny fraction of the total fleet, these techniques may be viable, and rapidly configurable. This research considers new types of traffic models, new control algorithms for traffic flow regulation, and new sensing and control paradigms that are enabled by a small number of controllable systems anticipated in a flow. Specifically, the research focuses on new (1) micro-macro models to model few AVs in a flow; (2) estimation techniques for AV interactions with the traffic flow; (3) developing and assessing dynamical controllers to mitigate traffic events.

8.1.4. NanoSatellite Project: Advanced modelling and Control of attitude dynamics for quantum communication (SPACE)

SPACE is a two-year project funded by the IDEX University Grenoble Alpes. It aims to launch an exploratory study to find the required minimal data we need to collect and combine for software design of Nanosatellite Attitude Determination and Control System (ADCS).

8.1.5. caPture de mOuvements humainS par cenTrales inertielles/d'attitUde et smaRtphonEs : Vers l'analyse d'anomalies neurologiques et fonctions motrices (POSTURE)

POSTURE is a one-year project funded by CDP NeuroCog. The project is focused on 1) the identification and characterization of postures and reference movements in humans using appropriate algorithms of classification (machine learning), and 2) the analysis of the effects of the number, location and orientation of the inertial sensors on the performance of the methods of identification and classification of postures and movements.

8.2. National Initiatives

8.2.1. Models of Bubbles in Online Social Networks (MOB)

MOB is a PEPS S2IH INS2I 2018 interdisciplinary project. This exploratory project focuses on the effects of online recommendation systems on social dynamics, which may entail the formation of «filter bubbles» that distort the experience of the users. The project will develop a mathematical model to demonstrate these effects and propose designs for their mitigation. The research will be conducted by a blend of tools from dynamical systems, network theory, complex systems, and control systems.

8.2.2. AgileWorld-MRSEI

AgileWorld is an ANR-MRSEI project (2018-2020), which aims at building an European network for an innovative training on road transportation systems in a connected world. The funding will help to prepare and then submit a proposal for the MSCA-ITN 2019 call.

8.3. European Initiatives

8.3.1. Collaborations in European Programs, Except FP7 & H2020

8.3.1.1. Scale-FreeBack

Type: ERC Advanced Grant

Duration: Sep. 2016 to Aug. 2021

Coordinator: C. Canudas de Wit

Inria contact: C. Canudas de Wit

Abstract: The overall aim of Scale-FreeBack is to develop holistic scale-free control methods of controlling complex network systems in the widest sense, and to set the foundations for a new control theory dealing with complex physical networks with an arbitrary size. Scale-FreeBack envisions devising a complete, coherent design approach ensuring the scalability of the whole chain (modelling, observation, and control). It is also expected to find specific breakthrough solutions to the problems involved in managing and monitoring large-scale road traffic networks. Field tests and other realistic simulations to validate the theory will be performed using the equipment available at the Grenoble Traffic Lab center (see GTL), and a microscopic traffic simulator replicating the full complexity of the Grenoble urban network.

See also: http://scale-freeback.eu

8.4. International Initiatives

8.4.1. Inria Associate Teams Not Involved in an Inria International Lab

8.4.1.1. MEMENTO

Title: ModEling autonoMous vEhicles iN Traffic flOw

International Partner:

Vanderbilt University, Nashville (United States) - Dan Work

Start year: 2018

See also: http://necs.inrialpes.fr/memento/index.html

In recent years, the strategic priorities of automotive and transportation systems focus on research, development and adoption of automation-related technologies as they emerge. As these technology developments are introduced in the traffic stream, an open question is how the mathematical models that are at the heart of transportation planning and operations will need to be advanced to accommodate these changes. The goal of the NeCS-Vanderbilt, MEMENTO, associate team is to create a multidisciplinary environment to model autonomous vehicles (AV) in human traffic flow. Specifically, our goal is to develop a unified micro-macro approach for traffic management, involving human drivers and autonomous vehicles by providing analytical and numerical tools for traffic modeling, estimation and control. We will work towards field operational tests, by using instrumented cars to collect data on AVs trajectories and their interaction with the traffic flow with human drivers.

8.4.2. Participation in Other International Programs

8.4.2.1. TICO-MED

TicoMed (Traitement du signal, Traitement numérique multidimensionnel de l'Information avec applications aux Télécommunications et au génie Biomédical) is a French-Brazilian project funded by CAPES-COFECUB for the period 2015-2018. It involves University of Nice Sophia Antipolis (I3S Laboratory), CNAM, SUPELEC, University of Grenoble Alpes (Gipsa-Lab), Universidade Federal do Ceara, Universidade Federal do Rio de Janeiro, and Universidade Federal do Santa Catarina as partners.

8.5. International Research Visitors

8.5.1. Visits of International Scientists

Prof. Andrea Tosin (Politecnico di Torino, Italy) visited the team in February 2018 in the frame of the Scale-FreeBack ERC project. He gave a talk on "Control strategies for road risk mitigation in kinetic traffic modeling". He exchanged ideas with Carlos Canudas De Wit, Paolo Frasca, Stephane Mollier, Maria Laura Delle Monache and Thibault Liard.

Prof. Sandro Zampieri (Univ. Padova, Italy) visited the team in February 2018 in the frame of the Scale-FreeBack ERC project, to work with Carlos Canudas De Wit and Giacomo Casadei.

Prof. Karl Henrik Johansson (KTH, Stockholm, Sweden) visited the team in March 2018 in the frame of the Scale-FreeBack ERC project, and gave a talk on “Control of vehicle platoons and their influence on traffic”.

Prof. Dan Work (Vanderbilt University (USA)), visited the team in July 2018 to work with Maria Laura Delle Monache and Thibault Liard, in the framework of the associated team MEMENTO.

Mauro Franceschelli (University of Cagliari, Italy) visited the team in October 2018 to collaborate with P. Frasca.

Prof. Olga Lucia Quintero Montoya, Univ. EAFIT, Medellin, Colobmia, visited the team in September 2018. She worked with C. Canudas de Wit on the theoretical development of a normalized macroscopic fundamental diagram for urban traffic.

George Gunter and Raphael Stern (University of Illinois at Urbana-Champaign and Vanderbilt University (USA)) visited the team in November 2018 to work with Maria Laura Delle Monache and Thibault Liard, in the framework of the associated team MEMENTO.

Maolong Lyu is a PhD student from TU Delft (Netherlands) under the supervision of Prof. Simone Baldi. He visited the team for two months to work with M.L. Delle Monache and P. Frasca on string stability for microscopic traffic flow models describing mixed traffic (human drivers and autonomous vehicles).

Diego Deplano is a PhD student from Univ. Cagliari (Italy) under the supervision of Prof. Alessandro Giua. He is visiting the team since Sept. 2018, working with C. Canudas de Wit.

8.5.1.1. Internships

Alexandre Olikier, “Open multi-agent systems with fixed size and possibly not complete topologies”, December 2017–June 2018. Université catholique de Louvain, Belgium. Jointly advised by Paolo Frasca and Julien Hendrickx.

8.5.2. Visits to International Teams

8.5.2.1. Research Stays Abroad

P. Frasca is a Visiting Scientist at the IEIIT-CNR Institute, National Research Council CNR, Torino, Italy. By this collaboration, he performs research on distributed estimation in sensor networks and distributed control of social networks. He visited Torino three times in 2018.

P. Frasca is a Visiting Faculty at the Department of Applied Mathematics, University of Twente, Enschede, The Netherlands. By this collaboration, he performs research on vehicle platooning and on the dynamics of social media. He visited Enschede three times in 2018.

M. L. Delle Monache visited University of Alabama (USA) in April 2018.

M. L. Delle Monache visited Vanderbilt University (USA) in May 2018, and T. Liard visited the same university in May-June and December 2018. These visits are in the frame of the MEMENTO associate team.

F. Garin visited Rutgers University (Philadelphia, USA) in April 2018, to initiate a collaboration with Prof. Benedetto Piccoli and his students on metabolic networks.

A. Kibangou visited the University of Johannesburg (South Africa) in October 2018. During his stay, he gave a lecture to students of Department of Town and Regional Planning of Univ. of Johannesburg on Mobility and traffic management.

N. Martin visited Imura Laboratory at Tokyo University of Technology from June 20th to August 20th, in the frame of the JSPS summer program. The aim of this collaboration is to integrate controllability and/or observability notions in the network reduction problem at the core of this Ph.D. work.

M. U. B. Niazi visited Professor Jacquelien Scherpen at the University of Groningen, Netherlands, in October 2018, to work on model reduction for network systems.

NON-A POST Team

8. Partnerships and Cooperations

8.1. Regional Initiatives

Non-A POST team hosts CPER Data ControlHub (an on-line laboratory for control system experimentation) and participates at ContrATech subprogram of CPER ELSAT.

8.2. National Initiatives

- Inria Project Lab (IPL) IPL COSY.
- ANR project Finite4SoS (Finite time control and estimation for Systems of Systems), coordinator: W. Perruquetti, 2015-2020.
- ANR project WaQMoS (Coastal waters quality surveillance using bivalve mollusk-based sensors), coordinator: D. Efimov, 2015-2020.
- ANR project TurboTouch (High-performance touch interactions), coordinator: G. Casiez (MJOL-NIR team, Inria), 2014-2019.
- ANR project DIGITSLID (DIGITal set-valued and homogeneous SLIding mode control and Differentiators: the implicit approach), coordinator: Bernard Brogliato (TriPOP team, Inria), 2018-2022.
- ANR project ROCC-SYS (Robust Control of Cyber-Physical Systems), coordinator: L. Hetel (CNRS, EC de Lille), 2013-2018.
- We are also involved in several technical groups of the GDR MACS (CNRS, "Modélisation, Analyse de Conduite des Systèmes dynamiques", see http://www.univ-valenciennes.fr/GDR-MACS), in particular: Technical Groups "Identification", "Time Delay Systems", "Hybrid Systems", "Complex Systems, Biological Systems and Automatic Control," and "Control in Electrical Engineering".

8.3. European Initiatives

8.3.1. FP7 & H2020 Projects

UCoCoS: the objectives of the project are to create a control-oriented framework for complex systems, and to define a common language, common methods, tools and software for the complexity scientist. The principal investigators are: W. Michiels, J.-P. Richard and H. Nijmeijer.

8.4. International Initiatives

8.4.1. Inria Associate Teams Not Involved in an Inria International Labs

8.4.1.1. HoTSMoCE

Title: Homogeneity Tools for Sliding Mode Control and Estimation

International Partner (Institution - Laboratory - Researcher):

UNAM (Mexico)

Prof. Leonid Fridman

2016–2018

The team *Non-A POST* is developing an estimation theory, built around differential algebra and operational calculation on the one hand, and high gain algorithms (such as sliding mode) on the other hand. The Mexican partner team comes from "Sliding Mode Control" laboratory of UNAM. There exists a strong intersection of interests of both teams (application of homogeneity for design of sliding mode control and estimation algorithms, and analysis of finite-time stability). That is why there exists a long history of collaboration between these two teams. The goal of the project is development of control and estimation algorithms converging in fixed or in finite time by applying the last generation sliding mode techniques and the homogeneity theory. The project realization is planned in the form of short-time visits of permanent staff and visits of PhD students for a long period of stay. Such visits are very important for young scientists, and also help Non-A team to prepare and find good PhDs/post-docs for future.

8.4.2. Inria North European Lab

RECoT, "Robust Estimation and Control with Time Constraints", 2018–2020

International Partner: IBM Research, Dublin (Dr. Sergiy Zhuk)

Non-A Post team of Inria deals with control and estimation of on-line (dynamical) systems with applications to robotics, biological systems, human-machine interfaces and active ow control. The key feature of the developed algorithms is a robustness and a non-asymptotic convergence allowing to fulfill some time constraints. The main methodology is a homogeneity (dilation symmetry) approach. IBM Research team develops minimax algorithms for state estimation and identification of dynamical systems with applications to computational fluid dynamics and image assimilation problems. The key feature of the resulting algorithms is the exact or approximate description of the reachability set of the underlying dynamical system in finite or infinite dimensions. The methodology is relies upon duality and Lyapunov exponents. The objectives of the collaboration are an exchange of the scientific knowledge and the joint research of the following problems: homogeneous observers design using minimax approach; development of fast and consistent computational algorithms for digital implementation of homogeneous controllers and observers; extension of sliding mode control methodology to infinite-dimensional models using minimax approach; the minimax observer-based control design for turbulent flows.

8.4.3. Informal International Partners

- ITMO University, Saint-Petersburg, Russia
- Tel-Aviv University, Tel-Aviv, Israel
- CINVESTAV-IPN, Mexico, Mexico
- Hangzhou Dianzi University, Hangzhou, China
- Brandenburg University of Technology, Cottbus, Germany

QUANTIC Project-Team

7. Partnerships and Cooperations

7.1. Regional Initiatives

- **Paris EMERGENCE project ENDURANCE**: In the framework of the Paris Ile de France program “EMERGENCE”, Zaki Leghtas has received a funding for his research program "Multi-photon processes in superconducting circuits for quantum error correction". This grant of 230k euros has allowed us to purchase the experimental equipment to complement the experiment based at ENS.
- **DIM SIRTEQ project Sputthy**: Zaki Leghtas has received 50k euros from the DIM SIRTEQ to purchase a sputtering system. With this machine, we will fabricate high quality resonators made out of Niobium and high kinetic inductance material such as NbTiN.
- **DIM SIRTEQ PhD fellowship**: We have received funding from DIM SIRTEQ to cover half of the PhD of Jérémie Guillaud under supervision of Mazyar Mirrahimi.
- **FSMP postdoctoral fellowship**: Paolo Forni has been selected for a postdoctoral fellowship by the Fondation des Sciences Mathématiques de Paris (FSMP) for the academic year 2018-2019: this 12-month postdoc fellowship extends a previous one supported by the programme Math-PSL of PSL Research University.

7.2. National Initiatives

- **ANR project GEARED**: This four-year collaborative ANR project, entitled “Reservoir engineering quantum entanglement in the microwave domain” and coordinated by Mazyar Mirrahimi, started on October 2014 and ended on September 2018. The participants of the project were Mazyar Mirrahimi (QUANTIC project-team), Benjamin Huard (ENS Lyon), Daniel Esteve and Fabien Portier (Quantronics group, CEA Saclay), Nicolas Roch and Olivier Buisson (Institut Neel, Grenoble). This project deals with robust generation of entanglement as a key resource for quantum information processing (quantum simulation, computation and communication). QUANTIC receieved a funding of 114k in this framework.
- **ANR project ENDURANCE**: In the framework of the ANR program “Accueil de chercheur de haut niveau”, Zaki Leghtas has received a funding for his research program "Multi-photon processes in superconducting circuits for quantum error correction". This grant of 400k euros has allowed us to purchase the experimental equipment to build a new experiment based at ENS. The project started in March 2016 for 42 months.
- **ANR project HAMROQS**: In the framework of the ANR program JCJC, Alain Sarlette has received a funding for his research program "High-accuracy model reduction for open quantum systems". This grant of 212k euros will start on april 2019 and will run for 4 years.

7.3. European Initiatives

7.3.1. Collaborations with Major European Organizations

Partner 1: ENS Lyon

We are pursuing our interdisciplinary work about quantum control from theoretical aspects in direct collaboration with existing experiments (ENS Lyon) with the group of Benjamin Huard, former member of the QUANTIC team. Joint papers are published and underway. The ANR-JCJC project HAMROQS by Alain Sarlette has Benjamin Huard as external supporting collaborator.

Partner 2: Laboratoire Kastler Brossel

We have been collaborating with Samuel Deleglise and Emmanuel Flurin from Laboratoire Kastler Brossel to understand and analyze their experimental data. In this aim, we have developed new adiabatic elimination techniques for multi-partite open quantum systems with non-trivial zero-order dynamics.

Partner 3: University of Padova

Alain Sarlette has been pursuing a fruitful collaboration with the group of Francesco Ticozzi on "dynamical systems aspects of quantum systems". A novel line of work in the direction of quantum thermalization and quantum random walks has been explored, in the framework of the PhD of S. Apers (Ghent University) supervised by A. Sarlette.

Partner 4: Ghent University.

Alain Sarlette has been collaborating with applied mathematicians interested in quantum control at UGent (Dirk Aeyels, Lode Wylleman, Gert De Cooman) in the framework of thesis co-supervisions. Two PhD students have successfully defended their thesis this year (Arash Farnam, on distributed control of lattices; Simon Apers, on quantum walks). He is further coaching a Master thesis intern working on nonlinear deterministic structures in quantum SDEs.

7.4. International Initiatives

7.4.1. Inria Associate Teams Not Involved in an Inria International Labs

TAQUILLA: is an Inria associate team (between Quantic team and Yale university) with principal Inria investigator, Mazyar Mirrahimi, and principal Yale investigator Michel Devoret. In this framework we continued our collaborations between Inria and Yale in 2018. Jérémie Guillaud visited Yale for 3 months (Sept-Nov), and Mazyar Mirrahimi for 4 months (Sept-Dec). Clarke Smith and Steven Touzard, PhD students at Yale, visited us for 1 week at the occasion of PRACQSYS meeting. Clarke Smith joins Quantic team as a postdoc in January 2019.

7.4.2. Participation in Other International Programs

In the framework of the collaborations with Yale university, Quantic team has received a sub-award of 500k dollars over 4 years starting in 2018 from Yale university. This sub-award is part of an ARO (Army Research Office) grant received by our collaborators at Yale and covers the expenses related to our collaborations (hiring of new PhD students and postdocs at Inria and travels between Inria and Yale).

7.5. International Research Visitors

7.5.1. Visits of International Scientists

- In the framework of Inria's invited professor program, Tryphon Georgiou (University of California at Irvine) visited us for about 2 months. This visit had for subject to initiate collaborations on the subject of open quantum systems and quantum channels.
- Yves Bérubé-Lauzière (University of Sherbrooke, Institut Quantique) accompanied by two PhD students made a 6-month visit from March to August 2018 to investigate with Pierre Rouchon feedback protocols for stabilizing quantum states in a high-quality cavity.
- P.S. Pereira da Silva (Escola Politécnica, PTC, University of SaoPaulo, Brazil) made a 2-week visit (June 25 to July 6) to investigate with Pierre Rouchon motion planning issues based on Lyapunov tracking for quantum gate generations.

7.5.2. Visits to International Teams

7.5.2.1. Research Stays Abroad

In the framework of our collaborations with the group of Michel Devoret at Yale university, Jérémie Guillaud and Mazyar Mirrahimi visited Yale for 3 months and 4 months, respectively, in fall 2018.

RANDOPT Team

9. Partnerships and Cooperations

9.1. Regional Initiatives

- PGMO/FMJH project "AESOP: Algorithms for Expensive Simulation-Based Optimization", 7kEUR, 2017–2019

9.2. National Initiatives

9.2.1. ANR

- ANR project "Big Multiobjective Optimization (BigMO)", Dimo Brockhoff participates in this project through the Inria team BONUS in Lille (2017–2020)

9.3. International Research Visitors

9.3.1. Visitors to RandOpt

- Filip Matzner, October 15–19 and December 10-14, 2018

9.3.2. Internships

- Eugenie Marescaux, March–July 2018
- Xudong Zhang, March–August 2018

RAPSODI Project-Team

9. Partnerships and Cooperations

9.1. National Initiatives

9.1.1. ANR

C. Chainais-Hillairet is a member of the ANR MOONRISE project. The MOONRISE project aims at exploring modeling, mathematical, and numerical issues originating from the presence of high oscillations in nonlinear PDEs mainly from the physics of nanotechnologies and from the physics of plasmas.

Title: MOdels, Oscillations, and NumeRIcal SchEmes

Type: Fondements du numérique (DS0705) - 2014

ANR reference: ANR-14-CE23-0007

Coordinator: F. Méhats (Université de Rennes 1)

Duration: October 2014 - June 2019

C. Chainais-Hillairet and T. Rey are members of the ANR MOHYCON project. The MOHYCON project is related to the analysis and simulation of multiscale models of semiconductors. As almost all current electronic technology involves the use of semiconductors, there is a strong interest for modeling and simulating the behavior of such devices, which was recently reinforced by the development of organic semiconductors used for example in solar panels or in mobile phones and television screens (among others).

Title: multiscale MOdels and HYbrid numerical methods for semiCONductors

Type: Société de l'information et de la communication (DS07) - 2017

ANR reference: ANR-17-CE40-0027

Coordinator: M. Bessemoulin-Chatard (CNRS and Université de Nantes)

Duration: January 2018 - December 2020

9.1.2. LabEx CEMPI

Title: Centre Européen pour les Mathématiques, la Physique et leurs Interactions

Coordinator: S. De Bièvre (Université de Lille)

Duration: January 2012 - December 2019

Partners: Laboratoire Paul Painlevé and Laser Physics department (PhLAM), Université de Lille

The "Laboratoire d'Excellence" Centre Européen pour les Mathématiques, la Physique et leurs Interactions (CEMPI), a project of the Laboratoire de Mathématiques Paul Painlevé and the Laboratoire de Physique des Lasers, Atomes et Molécules (PhLAM), was created in the context of the "Programme d'Investissements d'Avenir" in February 2012.

The association Painlevé-PhLAM creates in Lille a research unit for fundamental and applied research and for training and technological development that covers a wide spectrum of knowledge stretching from pure and applied mathematics to experimental and applied physics.

One of the three focus areas of CEMPI research is the interface between mathematics and physics. This focus area encompasses three themes. The first is concerned with key problems of a mathematical, physical and technological nature coming from the study of complex behavior in cold atoms physics and non-linear optics, in particular fibre optics. The two other themes deal with fields of mathematics such as algebraic geometry, modular forms, operator algebras, harmonic analysis and quantum groups that have promising interactions with several branches of theoretical physics.

9.2. International Research Visitors

9.2.1. Visits of International Scientists

The RAPSODI project-team invited several scientists in 2018. The following people came for long visits:

- J. Venel (Université Polytechnique Hauts-de-France) visited Inria Lille until July;
- J. Fuhrmann (WIAS Berlin) was invited for 1 month between May and June, thanks to a support of the LabEx CEMPI;
- A. Vasseur (UT Austin) was invited for 1 month in June, also thanks to a support of the LabEx CEMPI.

The following people came for shorter visits:

- S. Krell (Université de Nice) came in Lille on February 12-15;
- M. Rodrigues (Université de Rennes 1) came in Lille on December 3-7;
- M. Breden (TU Munich) came on December 17-21.

9.2.2. Internships

N. Staili, PhD student in the Faculté des Sciences de Meknès, came in Lille for a three-month visit between January and April.

9.2.3. Visits to International Teams

C. Cancès visited D. Matthes (TU Munich) during 1 week on December 3-7 to collaborate on the variational derivation of multiphase flow models.

9.2.4. Research Stays Abroad

A. Zurek spent 2 months (October-November) in the research team of A. Jüngel at TU Vienna to collaborate on the numerical simulation of a biofilm model. He was supported by the Institut Français d'Autriche and by EKINOX CNRS grant (Laboratoire Paul Painlevé).

REALOPT Project-Team

9. Partnerships and Cooperations

9.1. Regional Initiatives

- **HPC scalable ecosystem**: This project is funded by Region Nouvelle Aquitaine for 4 years, starting in 2018. It is coordinated by Emmanuel Agullo (Hiepacs Inria project-team) and it gathers researchers from Inria, Inra, LaBRI but also from UPPA (University of Pau), Pprime Institute (Poitiers), CEA and Airbus. It aims at building a convergent approach between numerical simulation and HPC on the one hand, and Data Science and Big Data on the other hand. The goal is to study the feasibility of approaches based on runtime schedulers to achieve a high level of scalability.
- **SysNum Cluster** SysNum is a Cluster of Excellence of Bordeaux Idex that aims at bringing Bordeaux academic players in the digital sciences closer to each other around large-scale distributed digital systems. The cluster is organized around 4 methodological axes (Interconnected object systems; Reliability and safety; Modeling and numerical systems; Massive and heterogeneous data) and 3 application platforms around major societal issues (ecology, mobile systems, interconnected objects and data analysis).
  - François Clautiaux is leading the methodological WP on Interconnected object systems. Understanding and controlling the complexity of systems of interconnected objects is a major challenge for both industrial and everyday life applications. We think, in particular, to fields like robotics, car industry, energy distribution or smart buildings, where it is essential to tackle autonomous heterogeneous objects and to develop robust control tools to optimize their interconnections. Our research in this direction will be developed within three interconnected tasks.
  - Olivier Beaumont is leading the methodological WP on Modeling and numerical systems. Mathematical modeling and numerical simulation are by now highly important tools currently used in physics, chemistry, biology, medicine and humanities. The forthcoming development of exaflopic computers should allow to simulate with High Performance Computing new multi-scale and multi-physics phenomena, generating massive data (High Performance Data Analytics). One of the major challenges of the years to come is thus both to build new robust numerical modeling tools, working on several millions processors computers and to be able to accommodate on a single platform both HPC and BigData applications.

9.2. European Initiatives

9.2.1. FP7 & H2020 Projects

- **EXDCI-2**: EXDCI-2 is a H2020 project (type: CSA – Coordination & support action), coordinated by PRACE for a duration of 30 months, starting on March 2018.

  Through the joint action of PRACE and ETP4HPC, EXDCI-2 mobilises the European HPC stakeholders. The project participates in the support of the European HPC Ecosystem with two main goals:
  - Development and advocacy of a competitive European HPC Exascale Strategy by supporting the implementation of a common European HPC strategy, open to synergistic areas including High Performance Data Analytics (HPDA) and Artificial Intelligence (AI). The expertise of the partners and stakeholders will permit to elaborate a transversal prospective vision.

– Coordination of the stakeholder community for European HPC at the Exascale through joint community structuring and synchronisation. This entails ensuring EXDCI-2 stakeholder representation in the main development of the European HPC eco-system towards Exascale, such as: The development of relationships with other ecosystems including upstream technologies as photonics and electronics, High Performance Embedded Computing (HiPEAC) and Big Data (BDVA) In the context of the upcoming European Data Infrastructure (EDI) a road mapping activity toward future converged HPC, HPDA and AI needs and new services from PRACE users communities and CoE The continuation of BDEC activities, for international participation of European stakeholders on the integration from edge computing to HPC, including Data Analytics and AI The mapping and analysis of related national and international R&I research agendas EXDCI-2 gives particular attention to creating synergies with the CoEs – for example with the CSA FocusCoE – and to building on the outcomes of FET HPC projects.

Olivier Beaumont is involved the task that will work on building a consensus based transversal vision and aims at proposing Ecosystem level concepts. Recommendations implementing the vision will be proposed. The work will benefit from the CoE connection established in the first EXDCI CSA. It is on purpose implemented on the first year of the CSA in order to allow it to be taken into account in the other WP.

9.3. International Initiatives

9.3.1. Inria International Partners

9.3.1.1. Informal International Partners

We continue close collaboration with the LOGIS laboratory (Universidade Federal Fluminense, Niteroi, Brazil) after the end of the Inria Associate Team SAMBA. In 2018, we had two two-weeks visits of Prof. Eduardo Uchoa. Prof. Artur Pessoa spent his sabbatical of 11 months with us.

Orlando Rivera Letelier is pursuing a co-tutelle thesis (with Universidad Adolfo Ibáñez, Peñalolén, Santiago, Chile)

9.4. International Research Visitors

Prof. Artur Pessoa (Universidade Federal Fluminense, Niteroi, Brazil) spent his sabbatical of 11 months with us (February–December 2018).

SELECT Project-Team

8. Partnerships and Cooperations

8.1. Regional Initiatives

Sylvain Arlot and Pascal Massart co-organize a working group at ENS (Ulm) on statistical learning.

8.2. National Initiatives

8.2.1. ANR

SELECT is part of the ANR-funded MixStatSeq.

Sylvain Arlot and Matthieu Lerasle are part of the ANR grant FAST-BIG (Efficient Statistical Testing for high-dimensional Models: application to Brain Imaging and Genetics), which is lead by Bertrand Thirion (Inria Saclay, Parietal).

8.3. International Initiatives

Gilles Celeux is one of the co-organizers of the international working group on model-based clustering. This year this workshop took place in Ann Arbor (USA).

8.4. International Research Visitors

8.4.1. Visits to International Teams

8.4.1.1. Research Stays Abroad

Kevin Bleakley stayed at the Pasteur Institute, Cambodia, while working on several collaborations in dengue fever and encephalitis, from February–March 2018.

Jean-Michel Poggi: Universidad de la República (Montevideo, Uruguay), Facultad de Ingeniería, Instituto de Matemática y Estadística “Prof. Ing. Rafael Laguardia”, 17-28 February 2018.

SEQUEL Project-Team

9. Partnerships and Cooperations

9.1. National Initiatives

9.1.1. ANR BoB

Participant: Michal Valko.

- *Title*: Bayesian statistics for expensive models and tall data
- *Type*: National Research Agency
- *Coordinator*: CNRS (Rémi Bardenet)
- *Duration*: 2016-2020
- *Abstract*:

  Bayesian methods are a popular class of statistical algorithms for updating scientific beliefs. They turn data into decisions and models, taking into account uncertainty about models and their parameters. This makes Bayesian methods popular among applied scientists such as biologists, physicists, or engineers. However, at the heart of Bayesian analysis lie 1) repeated sweeps over the full dataset considered, and 2) repeated evaluations of the model that describes the observed physical process. The current trends to large-scale data collection and complex models thus raises two main issues. Experiments, observations, and numerical simulations in many areas of science nowadays generate terabytes of data, as does the LHC in particle physics for instance. Simultaneously, knowledge creation is becoming more and more data-driven, which requires new paradigms addressing how data are captured, processed, discovered, exchanged, distributed, and analyzed. For statistical algorithms to scale up, reaching a given performance must require as few iterations and as little access to data as possible. It is not only experimental measurements that are growing at a rapid pace. Cell biologists tend to have scarce data but large-scale models of tens of nonlinear differential equations to describe complex dynamics. In such settings, evaluating the model once requires numerically solving a large system of differential equations, which may take minutes for some tens of differential equations on today's hardware. Iterative statistical processing that requires a million sequential runs of the model is thus out of the question. In this project, we tackle the fundamental cost-accuracy trade-off for Bayesian methods, in order to produce generic inference algorithms that scale favorably with the number of measurements in an experiment and the number of runs of a statistical model. We propose a collection of objectives with different risk-reward trade-offs to tackle these two goals. In particular, for experiments with large numbers of measurements, we further develop existing subsampling-based Monte Carlo methods, while developing a novel decision theory framework that includes data constraints. For expensive models, we build an ambitious programme around Monte Carlo methods that leverage determinantal processes, a rich class of probabilistic tools that lead to accurate inference with limited model evaluations. In short, using innovative techniques such as subsampling-based Monte Carlo and determinantal point processes, we propose in this project to push the boundaries of the applicability of Bayesian inference.

9.1.2. ANR Badass

Participants: Odalric Maillard, Émilie Kaufmann.

- *Title*: BAnDits for non-Stationarity and Structure
- *Type*: National Research Agency
- *Coordinator*: Inria Lille (O. Maillard)
- *Duration*: 2016-2020

- *Abstract*: Motivated by the fact that a number of modern applications of sequential decision making require developing strategies that are especially robust to change in the stationarity of the signal, and in order to anticipate and impact the next generation of applications of the field, the BADASS project intends to push theory and application of MAB to the next level by incorporating non-stationary observations while retaining near optimality against the best not necessarily constant decision strategy. Since a non-stationary process typically decomposes into chunks associated with some possibly hidden variables (states), each corresponding to a stationary process, handling non-stationarity crucially requires exploiting the (possibly hidden) structure of the decision problem. For the same reason, a MAB for which arms can be arbitrary non-stationary processes is powerful enough to capture MDPs and even partially observable MDPs as special cases, and it is thus important to jointly address the issue of non-stationarity together with that of structure. In order to advance these two nested challenges from a solid theoretical standpoint, we intend to focus on the following objectives: *(i)* To broaden the range of optimal strategies for stationary MABs: current strategies are only known to be provably optimal in a limited range of scenarios for which the class of distribution (structure) is perfectly known; also, recent heuristics possibly adaptive to the class need to be further analyzed. *(ii)* To strengthen the literature on pure sequential prediction (focusing on a single arm) for non-stationary signals via the construction of adaptive confidence sets and a novel measure of complexity: traditional approaches consider a worst-case scenario and are thus overly conservative and non-adaptive to simpler signals. *(iii)* To embed the low-rank matrix completion and spectral methods in the context of reinforcement learning, and further study models of structured environments: promising heuristics in the context of e.g. contextual MABs or Predictive State Representations require stronger theoretical guarantees.

  This project will result in the development of a novel generation of strategies to handle non-stationarity and structure that will be evaluated in a number of test beds and validated by a rigorous theoretical analysis. Beyond the significant advancement of the state of the art in MAB and RL theory and the mathematical value of the program, this JCJC BADASS is expected to strategically impact societal and industrial applications, ranging from personalized health-care and e-learning to computational sustainability or rain-adaptive river-bank management to cite a few.

9.1.3. ANR ExTra-Learn

Participants: Jérémie Mary, Michal Valko.

- *Title*: Extraction and Transfer of Knowledge in Reinforcement Learning
- *Type*: National Research Agency (ANR-9011)
- *PI*: M. Valko
- *Duration*: 2014-2018
- *Abstract*: ExTra-Learn is directly motivated by the evidence that one of the key features that allows humans to accomplish complicated tasks is their ability of building knowledge from past experience and transfer it while learning new tasks. We believe that integrating transfer of learning in machine learning algorithms will dramatically improve their learning performance and enable them to solve complex tasks. We identify in the reinforcement learning (RL) framework the most suitable candidate for this integration. RL formalizes the problem of learning an optimal control policy from the experience directly collected from an unknown environment. Nonetheless, practical limitations of current algorithms encouraged research to focus on how to integrate prior knowledge into the learning process. Although this improves the performance of RL algorithms, it dramatically reduces their autonomy. In this project we pursue a paradigm shift from designing RL algorithms incorporating prior knowledge, to methods able to incrementally discover, construct, and transfer "prior" knowledge in a fully automatic way. More in detail, three main elements of RL algorithms would significantly benefit from transfer of knowledge. *(i)* For every new task, RL algorithms need exploring the environment for a long time, and this corresponds to slow learning processes for large environments. Transfer learning would enable RL algorithms to dramatically reduce the exploration

of each new task by exploiting its resemblance with tasks solved in the past. *(ii)* RL algorithms evaluate the quality of a policy by computing its state-value function. Whenever the number of states is too large, approximation is needed. Since approximation may cause instability, designing suitable approximation schemes is particularly critical. While this is currently done by a domain expert, we propose to perform this step automatically by constructing features that incrementally adapt to the tasks encountered over time. This would significantly reduce human supervision and increase the accuracy and stability of RL algorithms across different tasks. *(iii)* In order to deal with complex environments, hierarchical RL solutions have been proposed, where state representations and policies are organized over a hierarchy of subtasks. This requires a careful definition of the hierarchy, which, if not properly constructed, may lead to very poor learning performance. The ambitious goal of transfer learning is to automatically construct a hierarchy of skills, which can be effectively reused over a wide range of similar tasks.

9.1.4. Grant of Fondation Mathématique Jacques Hadamard

Participants: Michal Valko, Matteo Pirotta, Alessandro Lazaric, Ronan Fruit.

- *Title*: Theoretically grounded efficient algorithms for high-dimensional and continuous reinforcement learning
- *Type*: PGMO-IRMO, funded by Criteo
- *PI*: M. Valko
- *Criteo contact*: Marc Abeille
- *Duration*: 2018-2020
- *Abstract*: While learning how to behave optimally in an unknown environment, a reinforcement learning (RL) agent must trade off the exploration needed to collect new information about the dynamics and reward of the environment, and the exploitation of the experience gathered so far to gain as much reward as possible. A good measure of the agent's performance is the regret, which measures the difference between the performance of optimal policy and the actual rewards accumulated by the agent. Two common approaches to the exploration-exploitation dilemma with provably good regret guarantees are the optimism in the face of uncertainty principle and Thompson Sampling. While these approaches have been successfully applied to small environments with a finite number of states and action (tabular scenario), existing approach for large or continuous environments either rely on heuristics and come with no regret guarantees, or can be proved to achieve small regret but cannot be implemented efficiently. In this project, we propose to make a significant contribution in the understanding of large and/or continuous RL problems by developing and analyzing new algorithms that perform well both in theory and practice. This research line can have a practical impact in all the applications requiring continuous interaction with an unknown environment. Recommendation systems belong to this category and, by definition, they can be modeled has a sequence of repeated interaction between a learning agent and a large (possibly continuous) environment.

9.1.5. National Partners

- ENS Paris-Saclay
  - M. Valko collaborated with V. Perchet on structured bandit problem. They co-supervise a PhD student (P. Perrault) together.
- Institut de Mathématiques de Toulouse, then Ecole Normale Supérieure de Lyon
  - E. Kaufmann collaborated with Aurélien Garivier on sequential testing and structured bandit problems.
- Centrale-Supélec Rennes
  - E. Kaufmann co-advises Lilian Besson, who works at CentraleSupélec with Christophe Moy on MAB for cognitive radio and Internet-of-Things communications.

- Participation to the Inria Project Lab (IPL) "HPC – Big Data". Started in 2018, this IPL gathers a dozen Inria team-projects, mixing researchers in HPC with researchers in machine learning and data science. SEQUEL contribution in this project is about how we can take advantage of HPC for our computational needs regarding deep learning and deep reinforcement learning, and also how such learning algorithms might be redesigned or re-implemented in order to take advantage of HPC architectures.

9.2. European Initiatives

9.2.1. FP7 & H2020 Projects

9.2.1.1. H2020 BabyRobot

Program: H2020

Project acronym: BabyRobot

Project title: Child-Robot Communication and Collaboration

Duration: 01/2016 - 12/2018

Coordinator: Alexandros Potamianos (Athena Research and Innovation Center in Information Communication and Knowledge Technologies, Greece)

Other partners: Institute of Communication and Computer Systems (Greece), The University of Hertfordshire Higher Education Corporation (UK), Universitaet Bielefeld (Germany), Kunlgliga Tekniska Hoegskolan (Sweden), Blue Ocean Robotics ApS (Denmark), Univ. Lille (France), Furhat Robotics AB (Sweden)

Abstract: The crowning achievement of human communication is our unique ability to share intentionality, create and execute on joint plans. Using this paradigm we model human-robot communication as a three step process: sharing attention, establishing common ground and forming shared goals. Prerequisites for successful communication are being able to decode the cognitive state of people around us (mind reading) and building trust. Our main goal is to create robots that analyze and track human behavior over time in the context of their surroundings (situational) using audio-visual monitoring in order to establish common ground and mind-reading capabilities. On BabyRobot we focus on the typically developing and autistic spectrum children user population. Children have unique communication skills, are quick and adaptive learners, eager to embrace new robotic technologies. This is especially relevant for special education where the development of social skills is delayed or never fully develops without intervention or therapy. Thus our second goal is to define, implement and evaluate child-robot interaction application scenarios for developing specific socio-affective, communication and collaboration skills in typically developing and autistic spectrum children. We will support not supplant the therapist or educator, working hand-in hand to create a low risk environment for learning and cognitive development. Breakthroughs in core robotic technologies are needed to support this research mainly in the areas of motion planning and control in constrained spaces, gestural kinematics, sensorimotor learning and adaptation. Our third goal is to push beyond the state-of-the-art in core robotic technologies to support natural human-robot interaction and collaboration for edutainment and healthcare applications. Creating robots that can establish communication protocols and form collaboration plans on the fly will have impact beyond the application scenarios investigated here.

9.2.1.2. CHIST-ERA DELTA

Participants: Michal Valko, Émilie Kaufmann.

Program: CHIST-ERA

Project acronym: DELTA

Project title: Dynamically Evolving Long-Term Autonomy

Duration: October 2017 - December 2021

Coordinator: Anders Jonsson (PI)

Inria Coordinator: Michal Valko

Other partners: UPF Spain, MUL Austria, ULG Belgium

Abstract: Many complex autonomous systems (e.g., electrical distribution networks) repeatedly select actions with the aim of achieving a given objective. Reinforcement learning (RL) offers a powerful framework for acquiring adaptive behavior in this setting, associating a scalar reward with each action and learning from experience which action to select to maximise long-term reward. Although RL has produced impressive results recently (e.g., achieving human-level play in Atari games and beating the human world champion in the board game Go), most existing solutions only work under strong assumptions: the environment model is stationary, the objective is fixed, and trials end once the objective is met. The aim of this project is to advance the state of the art of fundamental research in lifelong RL by developing several novel RL algorithms that relax the above assumptions. The new algorithms should be robust to environmental changes, both in terms of the observations that the system can make and the actions that the system can perform. Moreover, the algorithms should be able to operate over long periods of time while achieving different objectives. The proposed algorithms will address three key problems related to lifelong RL: planning, exploration, and task decomposition. Planning is the problem of computing an action selection strategy given a (possibly partial) model of the task at hand. Exploration is the problem of selecting actions with the aim of mapping out the environment rather than achieving a particular objective. Task decomposition is the problem of defining different objectives and assigning a separate action selection strategy to each. The algorithms will be evaluated in two realistic scenarios: active network management for electrical distribution networks, and microgrid management. A test protocol will be developed to evaluate each individual algorithm, as well as their combinations.

9.2.1.3. CHIST-ERA IGLU

Program: CHIST-ERA

Project acronym: IGLU

Project title: Interactively Grounded Language Understanding

Duration: 11/2015 - 10/2018

Coordinator: Jean Rouat (Université de Sherbrooke, Canada)

Other partners: UMONS (Belgique), Inria (France), Univ-Lille (France), KTH (sweden), Universidad de Zaragoza (Spain)

Abstract: Language is an ability that develops in young children through joint interaction with their caretakers and their physical environment. At this level, human language understanding could be referred as interpreting and expressing semantic concepts (e.g. objects, actions and relations) through what can be perceived (or inferred) from current context in the environment. Previous work in the field of artificial intelligence has failed to address the acquisition of such perceptually-grounded knowledge in virtual agents (avatars), mainly because of the lack of physical embodiment (ability to interact physically) and dialogue, communication skills (ability to interact verbally). We believe that robotic agents are more appropriate for this task, and that interaction is a so important aspect of human language learning and understanding that pragmatic knowledge (identifying or conveying intention) must be present to complement semantic knowledge. Through a developmental approach where knowledge grows in complexity while driven by multimodal experience and language interaction with a human, we propose an agent that will incorporate models of dialogues, human emotions and intentions as part of its decision-making process. This will lead anticipation and reaction not only based on its internal state (own goal and intention, perception of the environment), but also on the perceived state and intention of the human interactant. This will be possible through the development of advanced machine learning methods (combining developmental, deep and reinforcement learning) to handle large-scale multimodal inputs, besides leveraging state-of-the-art technological

components involved in a language-based dialog system available within the consortium. Evaluations of learned skills and knowledge will be performed using an integrated architecture in a culinary use-case, and novel databases enabling research in grounded human language understanding will be released.

9.3. International Initiatives

9.3.1. Inria Associate Teams Not Involved in an Inria International Labs

9.3.1.1. Allocate

Participants: Pierre Perrault, Julien Seznec, Michal Valko, Émilie Kaufmann, Odalric Maillard.

Title: Adaptive allocation of resources for recommender systems

Inria contact: Michal Valko

International Partner (Institution - Laboratory - Researcher):

Otto-von-Guericke-Universität Magdeburg A. Carpentier

Start year: 2017

We plan to improve a practical scenario of *resource allocation in market surveys*, such as product appraisals and music recommendation. In practice, the market is typically divided into segments: geographic regions, age groups, ...These groups are then queried for preference with some fixed rule of a number of queries per group. This testing is *costly and non-adaptive*. The reason is some groups are easier to estimate than others, but this is impossible to know a priori. Our challenge is **adaptively allocate the optimal number of samples** to each group and improve the efficient of market studies, by providing *sample-efficient* solutions. In 2018 we made big advances that resulted in two new research results, currently under review.

9.3.2. Inria International Partners

9.3.2.1. Declared Inria International Partners

SequeL

Title: The multi-armed bandit problem

International Partner (Institution - Laboratory - Researcher):

University of Leoben (Austria) Peter Auer

Duration: 2014 - 2018

Start year: 2014

In a nutshell, the collaboration is focusing on nonparametric algorithms for active learning problems, mainly involving theoretical analysis of reinforcement learning and bandits problems beyond the traditional settings of finite-state MDPs (for RL) or i.i.d. rewards (for bandits). Peter Auer from University of Leoben is a worldwide leader in the field, having introduced the UCB approach around 2000, along with its finite-time analysis. Today, SequeL is likely to be the largest research group working in this field in the world, enjoying worldwide recognition. SequeL and P. Auer's group have been collaborating for a couple of years now; they have co-authored papers, visited each other (sabbatical stay, post-doc), coorganized workshops; the STREP Complacs partially funds this very active collaboration.

9.3.2.2. CWI

We also collaborate with P. Grunwald, and W. Koolen through the associate team headed by Benjamin Guedj from Modal.

9.3.3. Participation in Other International Programs

In 2017, we mentioned many collaborations with: Adobe, MIT, Stanford, Leoben, ...

Massachusetts Institute of Technology

Victor-Emmanuel Brunel *Collaborator*

M. Valko collaborated with V.-E. Brunel on the estimation of low rank determinantal point processes useful for diverse recommender systems.

Otto-von-Guericke-Universität Magdeburg

Alexandra Carpentier *Collaborator*

M. Valko collaborated with A. Carpentier on adaptive estimation of the block-diagonal matrices with application to market segmentations. This collaboration formalized in September 2017 by creating a north-european associate team. which results in two finished results.

Adobe Research

Y. Abbasi-Yadkori *Collaborator*

M. Valko collaborated on learning in unpredictable but potentially easy environment. This led to a publication in COLT 2018.

University of California, Berkeley

Peter Bartlett *Collaborator*

Victor Gabillon *Collaborator*

Alain Malek *Collaborator*

M. Valko collaborated with P.Barlett, V. Gabillon, and A. Malek on the sample complexities in unknown type of environments.

DeepMind London

Rémi Munos *Collaborator*

M. Valko collaborated with R. Munos on Brownian motion maximization, important for stock value predictions. This led to a publication in NIPS 2018.

Mila, Université de Montréal

A. Courville *Collaborator*

A. Touati *Collaborator*

F. Strub and O. Pietquin collaborate on deep reinforcement learning for language acquisition. This led to several papers at IJCAI, CVPR, and NIPS, as well as the Guesswhat?! dataset and protocol, and the HOME dataset.

M. Valko collaborates on faster learning in submodular learning with limited feedback. This setting has application in marketing when we want to select the inventory while maximizing the profit.

McGill University, Montreal

A. Durand, J. Pineau *Collaborator*

A. Durand and OA. Maillard collaborate on a project of structured bandits, with application in physics (calibration).

Northeastearn University, Boston

M. Aziz, J. Anderton, J. Aslam *Collaborator*

E. Kaufmann collaborate with M. Aziz, J. Anderton and J. Aslam on a project on infinite bandits, which led to an ALT 2018 publication. E. Kaufmann also collaborates with M. Aziz on bandits for phase I clinical trials. This led to the submission of a paper to the Biometrics journal.

9.4. International Research Visitors

9.4.1. Visits of International Scientists

- Xiotian Yu, 1 week, the Chinese University of Hong-Kong
- Junpei Komiyama, 6 weeks, Tokyo University
- Abbas Mehrabian, 1 week, McGill University
- Audrey Durand, 2 weeks, McGill University
- Andrea Locatelli, 2 weeks, Otto-von-Guericke-Universität Magdeburg, Germany
- Jill-Jênn Vie, 1 week, RIKEN AIP, Tokyo, Japan
- Peter Grünwald, 2 times two days (8 hour lectures), CWI and Leiden University, Amsterdam, Netherlands
- Wouter Koolen, 1 week, CWI, Amsterdam, Netherlands

9.4.1.1. Internships

- Quentin Burthier, ENSTA ParisTech, from Jun 2018 until Aug 2018
- Edouard Dendauw, from May 2018 until Jul 2018
- Thibault Felicite, Jul 2018
- Robert Lindland, MIT, from May 2018 until Aug 2018
- Jian Qian, ENS, from May 2018 until Oct 2018
- Hassan Saber, Centrale Paris, from Apr 2018 until Aug 2018
- Benoit Schmitt, Centrale Nantes, from Mar 2018 until Aug 2018
- Han Shao, PhD student from the Chinese University in Hong-Kong, from Oct 2018 until Nov 2018
- Annie Yun, MIT, from May 2018 until Aug 2018
- Arnaud Fanthomme, ENS, from Apr 2018 until Aug 2018

9.4.2. Visits to International Teams

9.4.2.1. Other visits

- OA. Maillard: August, Visit of Aufrey Durand at Mc Gill University (2 weeks)
- OA. Maillard: Novembre, Invited visit of Junya Honda at Tokyo University (4 days)
- E. Kaufmann: March, April, Visit of Wouter Koolen at CWI, Amsterdam (2 times 1 week)

SIERRA Project-Team

9. Partnerships and Cooperations

9.1. National Initiatives

Alexandre d'Aspremont: IRIS, PSL "Science des données, données de la science".

9.2. European Initiatives

- **ITN Spartan**
  Title: Sparse Representations and Compressed Sensing Training Network
  Type: FP7
  Instrument: Initial Training Network
  Duration: October 2014 to October 2018
  Coordinator: Mark Plumbley (University of Surrey)
  Inria contact: Francis Bach
  Abstract: The SpaRTaN Initial Training Network will train a new generation of interdisciplinary researchers in sparse representations and compressed sensing, contributing to Europe's leading role in scientific innovation. By bringing together leading academic and industry groups with expertise in sparse representations, compressed sensing, machine learning and optimisation, and with an interest in applications such as hyperspectral imaging, audio signal processing and video analytics, this project will create an interdisciplinary, trans-national and inter-sectorial training network to enhance mobility and training of researchers in this area. SpaRTaN is funded under the FP7-PEOPLE-2013-ITN call and is part of the Marie Curie Actions — Initial Training Networks (ITN) funding scheme: Project number - 607290
- **ITN Macsenet**
  Title: Machine Sensing Training Network
  Type: H2020
  Instrument: Initial Training Network
  Duration: January 2015 - January 2019
  Coordinator: Mark Plumbley (University of Surrey)
  Inria contact: Francis Bach
  Abstract: The aim of this Innovative Training Network is to train a new generation of creative, entrepreneurial and innovative early stage researchers (ESRs) in the research area of measurement and estimation of signals using knowledge or data about the underlying structure. We will develop new robust and efficient Machine Sensing theory and algorithms, together methods for a wide range of signals, including: advanced brain imaging; inverse imaging problems; audio and music signals; and non-traditional signals such as signals on graphs. We will apply these methods to real-world problems, through work with non-Academic partners, and disseminate the results of this research to a wide range of academic and non-academic audiences, including through publications, data, software and public engagement events. MacSeNet is funded under the H2020-MSCA-ITN-2014 call and is part of the Marie Sklodowska- Curie Actions — Innovative Training Networks (ITN) funding scheme.

- **ERC Sequoia** Title: Robust algorithms for learning from modern data
  Programm: H2020
  Type: ERC
  Duration: 2017-2022
  Coordinator: Inria
  Inria contact: Francis Bach
  Abstract: Machine learning is needed and used everywhere, from science to industry, with a growing impact on many disciplines. While first successes were due at least in part to simple supervised learning algorithms used primarily as black boxes on medium-scale problems, modern data pose new challenges. Scalability is an important issue of course: with large amounts of data, many current problems far exceed the capabilities of existing algorithms despite sophisticated computing architectures. But beyond this, the core classical model of supervised machine learning, with the usual assumptions of independent and identically distributed data, or well-defined features, outputs and loss functions, has reached its theoretical and practical limits. Given this new setting, existing optimization-based algorithms are not adapted. The main objective of this project is to push the frontiers of supervised machine learning, in terms of (a) scalability to data with massive numbers of observations, features, and tasks, (b) adaptability to modern computing environments, in particular for parallel and distributed processing, (c) provable adaptivity and robustness to problem and hardware specifications, and (d) robustness to non-convexities inherent in machine learning problems. To achieve the expected breakthroughs, we will design a novel generation of learning algorithms amenable to a tight convergence analysis with realistic assumptions and efficient implementations. They will help transition machine learning algorithms towards the same widespread robust use as numerical linear algebra libraries. Outcomes of the research described in this proposal will include algorithms that come with strong convergence guarantees and are well-tested on real-life benchmarks coming from computer vision, bioin- formatics, audio processing and natural language processing. For both distributed and non-distributed settings, we will release open-source software, adapted to widely available computing platforms.

9.3. International Initiatives

9.3.1. BigFOKS2

Title: Learning from Big Data: First-Order methods for Kernels and Submodular functions

International Partner (Institution - Laboratory - Researcher):

IISc Bangalore (India) - Computer Science Department - Chiranjib Bhattacharyya

Start year: 2016

See also: mllab.csa.iisc.ernet.in/indo-french.html

Recent advances in sensor technologies have resulted in large amounts of data being generated in a wide array of scientific disciplines. Deriving models from such large datasets, often known as “Big Data”, is one of the important challenges facing many engineering and scientific disciplines. In this proposal we investigate the problem of learning supervised models from Big Data, which has immediate applications in Computational Biology, Computer vision, Natural language processing, Web, E-commerce, etc., where specific structure is often present and hard to take into account with current algorithms. Our focus will be on the algorithmic aspects. Often supervised learning problems can be cast as convex programs. The goal of this proposal will be to derive first-order methods which can be effective for solving such convex programs arising in the Big-Data setting. Keeping this broad goal in mind we investigate two foundational problems which are not well addressed in existing literature. The first problem investigates Stochastic Gradient Descent Algorithms in the context of First-order methods for designing algorithms for Kernel based prediction functions on Large Datasets. The second problem involves solving discrete optimization problems arising in Submodular formulations in Machine Learning, for which first-order methods have not reached the level of speed required for practical applications (notably in computer vision).

9.4. International Research Visitors

- Vijaya Bollapragada from Northwestern University, Chicago, IL, United States, Apr - Jul 2018.
- Aaron De Fazio from Facebook Research NY, New York, United States, Feb 2018.
- Gauthier Gidel from University of Montreal - MILA, Montreal, Canada, Jan 2018.
- Sharan Vaswani from University of British Columbia, Vancouver, Canada, Apr - Jul 2018
- Simon Lacoste-Julien from University of Montreal - MILA, Montreal, Canada, Aug 2018.

SIMSMART Team

8. Partnerships and Cooperations

8.1. Regional Initiatives

Inter-Labex SEACS: V. Monbet, F. Le Gland, C. Herzet and Thi Tuyet Trang Chau (PhD student) are part of the *inter Labex Cominlabs-Lebesgue-Mer SEACS, https://seacs.cominlabs.u-bretagneloire.fr/*, which stands for Stochastic modEl-dAta-Coupled representationS for the analysis, simulation and reconstruction of upper ocean dynamics. This project which concerns mainly Objectives 2 and 3, aims at exploring novel statistical and stochastic methods to address the emulation, reconstruction and forecast of fine-scale upper ocean dynamics.maths-computer-sea science for ocean dynamics.

CMEMS 3DA (2018-2019): C. Herzet is part of the project *CMEMS 3DA* on data assimilation of oceanographic events with non-parametric data assimilation methods. The goal of the project is to demonstrate the relevance of data-driven strategies to improve satellite derived interpolated products and especially the geostrophic surface currents. The project is made in collaboration with IMT Atlantique Brest, Ifremer and the Institue of Geosciences and Environment in Grenoble.

Action Exploratoire – Labex Cominlabs: C. Herzet is part of a project on sparse representations in continuous dictionaries. Partners: R. Gribonval (Inria Rennes PANAMA), A. Drémeau (IMT Atlantique) and P. Tandeo (IMT Atlantique).

8.2. National Initiatives

8.2.1. ANR

ANR COSMOS (2014-2018): F. Cérou and A. Guyader are part of *ANR Cosmos* on molecular simulation and statistics (PI G. Stoltz of MATHERIALS). COSMOS aims at developing numerical techniques dedicated to the sampling of high-dimensional probability measures describing a system of interest. There are two application fields of interest: computational statistical physics (a field also known as molecular simulation), and computational statistics, both sharing a common history and mathematical tools. Our specific role in the project is to study the theoretical aspects of the simulation of reactive trajectories (short trajectories linking two metastable states of the system), which can be viewed as a special type of rare event. These algorithms are then incorporated in molecular simulation softwares by members of MATHERIALS team. They also contribute to popularize them within the wider computational statistical physics community.

ANR Geronimo (2014-2018): C. Herzet (PI) and P. Héas are part of the ANR Geronimo. Its objective is the conception of new techniques for the construction of geophysical reduced-order models (ROMs) from image data. The project both arises from the crucial need of accurate low-order descriptions of highly-complex geophysical phenomena and the recent numerical revolution which has supplied the geophysical scientists with an unprecedented volume of image data. As the output of the project, we devised several methodologies to build effective reduced-order models from data. The research objectives of Objective 4 are in the continuation of the Geronimo project. In particular, we intend to tackle model-order reduction in a probabilistic setup and provide new tools to address the non-linear case.

8.3. European Initiatives

8.3.1. FP7 & H2020 Projects

ERC MsMaths (2015-2019): M. Rousset is part of *ERC MSMaths* on molecular simulation (PI T. Lelièvre). With the development of large-scale computing facilities, simulations of materials at the molecular scale are now performed on a daily basis. The objective of the MSMath ERC project is to develop and study efficient algorithms to simulate such high-dimensional systems over very long, macroscopic times. ERC MsMaths especially focus on the computational issues related to 'metastable' states, that is to say specific molecular configurations that do evolve only on very large time scales. This results in a multi-timescale computational bottleneck that needs to be addressed by specific algorithms.

8.3.2. Collaborations with Major European Organizations

The agency European Organization for the Exploitation of Meteorological Satellites (EUMETSAT) of Darmstadt. The transfer focuses on the estimation of atmospheric 3D winds from the future hyperspectral instrument (IRS on MTG-S, developed by ESA and IASI-NG on Metop-SG developed by CNES). The work consists in the design of an efficient and physically-based methodology for the estimation of vertically resolved 3D atmospheric motion vector (AMV) fields at various altitude levels. The estimation is based on image sequence observations, depicting temperature, specific humidity or ozone fields at different pressure levels. The final objective is the operational production of 3D AMV fields, which should be used by the different international institutes of meteorology, such as *Meteo France* or the *Met Office*. It is expected that these image-based wind estimates will significantly impact data-assimilation for weather forecasts or climate studies. We mention that the problem of 3D AMVs estimation has several specificities which makes it particularly challenging (high-dimensionality, non-convex and non-differentiable problem). We are working on an overall algorithmic solution to address this problem. Type of collaboration: supervision of an engineer with one or two week-long visits per year. A first prototype (free software licence LGPL 2.1) is currently under evaluation.

8.4. International Initiatives

8.4.1. Participation in Other International Programs

ECOS ARGENTINE (2018-2021): V. Monbet has obtained a funding program through the ECOS Sud - MINCyT intiative (http://www.univ-paris13.fr/cofecub-ecos/). The program involves a collaboration with the French-Argentinian Climate Institute (http://www.cima.fcen.uba.ar/UMI/), and focuses on non-parametric, analog methods, combined with data assimilation techniques to reconstruct complex meteorological dynamics (Objective 3).

SPHINX Project-Team

8. Partnerships and Cooperations

8.1. Regional Initiatives

8.1.1. Lorraine Université d'Excellence

Thomas Chambrion is deputy head of working group 2 of the Deepsurf project (a project of LUE). ...

8.2. National Initiatives

8.2.1. ANR

- **Project Acronym :** IFSMACS
  Project Title : Fluid-Structure Interaction: Modeling, Analysis, Control and Simulation
  Coordinator: Takéo Takahashi
  Participants: Julien Lequeurre, Alexandre Munnier, Jean-François Scheid, Takéo Takahashi
  Duration : 48 months (starting on October 1st, 2016)
  Other partners: Institut de Mathématiques de Bordeaux, Inria Paris, Institut de Mathématiques de Toulouse
  Abstract: The aim of this project is to analyze systems composed by structures immersed in a fluid. Studies of such systems can be motivated by many applications (motion of the blood in veins, fish locomotion, design of submarines, etc.) but also by the corresponding challenging mathematical problems. Among the important difficulties inherent to these systems, one can quote nonlinearity, coupling, free-boundaries. Our objectives include asymptotic analyses of FSIS, the study of controllability and stabilizability of FSIS, the understanding of locomotion of self-propelled structures and the analyze and development of numerical tools to simulate fluid-structure system.
  URL: http://ifsmacs.iecl.univ-lorraine.fr/
- **Project Acronym:** QUACO
  Project title: use of geometrical tools for the control of quantum system and application to MRI.
  Coordinator: Thomas Chambrion
  Duration: 48 months (starting January 1st 2018).
  URL: http://www.iecl.univ-lorraine.fr/~Thomas.Chambrion/QUACO/index.html
- **Project acronym:** ISDEEC
  Project title: Interaction entre Systèmes Dynamiques, Equations d'Evolution et Contrôle
  Coordinator: Romain Joly
  Participant: Julie Valein
  Other partners: Institut Fourier, Grenoble; Département de Mathématiques d'Orsay
  Duration: 36 months (2017-2020)
  URL: http://isdeec.math.cnrs.fr/

8.2.2. CNRS

Thomas Chambrion is the coordinator of the Research Project from CNRS Inphynity "DISQUO" (5300 euros, 2017).

8.3. International Initiatives

8.3.1. Participation in International Programs

8.3.1.1. Indo-French Center of Applied Mathematics

Analysis, Control and Homogenization of Complex Systems

International Partner: TIFR CAM, Bangalore

Heads: Takéo Takahashi (France) and Mythily Ramaswamy (India).

Duration: 2018 - 2021

scientific objectives

- Study the well-posedness of models arising from either structure in the fluid or structure on the boundary of the domain containing the fluid.
- Explore Controllability, Optimal Control and Stabilization of such fluid-structure interaction problems.
- Study systems describing fluid flows in a time dependent domain with a rapidly oscillating boundary using Homogenization Theory. The rapid oscillations of the boundary takes into account, the rough character of the boundary and its movements may take into account the displacement of a deformable body into a fluid flow.
- Carry out Finite Element Analysis for such models, including elastic structures as well as rigid ones.

8.4. International Research Visitors

8.4.1. Visits to International Teams

8.4.1.1. Research Stays Abroad

- Xavier Antoine was invited
  - to Beijing CSRC, Beijing + Department of Mechanics and Engineering Science, Beijing, July 2018 (one week);
  - to the Department of Mathematics, Sichuan University, Chengdu, Augutst 2018 (3.5 weeks);
  - to the Department of Mathematics, Sichuan University, Chengdu, January 2019 (2 weeks).
- Julie Valein staid for 10 days in Valparaiso (Chile) and gave a talk to the workshop ICoPS 2018; she staid in Santiago (2-14 December 2018) to collaborate with E. Cerpa.

TAU Team

9. Partnerships and Cooperations

9.1. National Initiatives

9.1.1. ANR

- **ACTEUR** 2014-2018 (236kEuros). Cognitive agent development for urban simulations,
  Coordinator: P. Taillandier (IDEES, Univ Rouen)
  Participant: Philippe Caillou
- **EPITOME** 2017-2020 (225kEuros), *Efficient rePresentatIon TO structure large-scale satellite iMagEs* (Section 7.5.2).
  Coordinator: Yuliya Tarabalka (Titane team, Inria Sophia-Antipolis)
  Participant: Guillaume Charpiat

9.1.2. Others

- **E-LUCID** 2014-2018 (194 kEuros), anomaly detection in network packets.
  Coordinator: Thales Communications & Security S.A.S
  Participants: Marc Schoenauer, Cyril Furtlehner, Luis Marti (until 12/2017)
- **Nutriperso** 2017-2020, 87 kEuros. Personalized recommendations toward healthier eating practices (Section 7.3.2).
  U. Paris-Saclay IRS (*Initiative de Recherche Stratégique*)
  Partners: INRA (coordinator), INSERM, Agro Paristech, Mines Telecom
  Participants: Philippe Caillou, Flora Jay, Michèle Sebag, Paola Tubaro
- **PIA Adamme** 2015-2018 (258 kEuros) Machine Learning on a mass-memory architecture.
  Coordinator: Bruno Farcy (Bull SAS)
  Participants: Marc Schoenauer, Guillaume Charpiat, Cécile Germain-Renaud, Yasmina Bouzbiba, Etienne Brame
- **NEXT** 2017-2021 (675 kEuros). Simulation, calibration, and optimization of regional or urban power grids (Section 4.2).
  ADEME (Agence de l'Environnement et de la Maîtrise de l'Energie)
  Coordinator: ARTELYS
  Participants Isabelle Guyon, Marc Schoenauer, Michèle Sebag, Victor Berger (PhD), Herilalaina Rakotoarison (PhD), Berna Bakir Batu (Post-doc)
- **DATAIA Vadore** 2018-2020 (105 kEuros) VAlorizations of Data to imprOve matching in the laboR markEt, with CREST (ENSAE) and Pôle Emploi (Section 7.3.1).
  Coordinator: Michèle Sebag
  Participants: Philippe Caillou, Isabelle Guyon
- **PIA JobAgile** 2018-2021 (379 kEuros) *Evidence-based Recommandation pour l'Emploi et la Formation* (Section 7.3.1).
  Coordinator: Michèle Sebag and Stéphanie Delestre (Qapa)
  Participants: Philippe Caillou, Isabelle Guyon
- **HADACA** 2018-2019 (50 kEuros), within EIT Health, for the organization of challenges toward personalized medicine (Section 7.6).
  Coordinator: Magali Richard (Inria Grenoble)
  Participants: Isabelle Guyon

- **IPL HPC-BigData** 2018-2022 (100 kEuros) High Performance Computing and Big Data (Section 7.5.5)
  Coordinator: Bruno Raffin (Inria Grenoble)
  Participants: Guillaume Charpiat, Loris Felardos (PhD)

9.2. European Initiatives

9.2.1. Collaborations with Major European Organizations

MLSpaceWeather 2015-2019. Coupling physics-based simulations with Artificial Intelligence (Section 7.5.3).
Coordinator: CWI
Participants: Aurélien Decelle, Cyril Furtlehner, Michèle Sebag

9.3. International Initiatives

9.3.1. Inria International Labs

IIL CWI-Inria
Associate Team involved in the International Lab:

9.3.1.1. MDG-TAO

Title: Data-driven simulations for Space Weather predictions

International Partner (Institution - Laboratory - Researcher):

CWI (Netherlands) - Multiscale Dynamics Group - Enrico Camporeale

Start year: 2017

See also: http://pages.saclay.inria.fr/cyril.furtlehner/html/mdg-tao.html and Section 7.5.3 .

We propose an innovative approach to Space Weather modeling: the synergetic use of state-of-the-art simulations with Machine Learning and Data Assimilation techniques, in order to adjust for errors due to non-modeled physical processes, and parameter uncertainties. We envision a truly multidisciplinary collaboration between experts in Computational Science and Data assimilation techniques on one side (CWI), and experts in Machine Learning and Data Mining on the other (Inria). Our research objective is to realistically tackle long-term Space Weather forecasting, which would represent a giant leap in the field. This proposal is extremely timely, since the huge amount of (freely available) space missions data has not yet been systematically exploited in the current computational methods for Space Weather. Thus, we believe that this work will result in cutting-edge results and will open further research topics in space Weather and Computational Plasma Physics.

9.3.2. Inria International Partners

9.3.2.1. Declared Inria International Partners

Isabelle Guyon partner of Google Zurich *Preparation of a competition AutoDL: Automatic Deep Learning*. See Section 7.6 .

9.3.2.2. Informal International Partners

Marc Schoenauer partner of the ARC-DP (Australian Research Council Discovery Project) *Bio-inspired computing methods for dynamically changing environments*. Coordinator: University of Adelaide (Frank Neumann), 5 years from Nov. 2015, 400 k$-AUS. Visit to Adelaide: 2 weeks in Feb. 2017, 2 weeks planned in 2019.

Isabelle Guyon Partner of UC Berkeley *Fingerprint verification with deep siamese neural networks using ultratonic sensor data.* Co-advisor of a master student (Baiyu Chen). Partners: Alyosha Efros, Bernhard Boser.

Guillaume Charpiat partner of Boulder University *Hurricane trajectory prediction*. Co-advisor of a master student (Mo Yang). Partners: Sophie Giffard-Roisin, Claire Monteleoni. See Section 7.5.6 .

TOSCA Project-Team

7. Partnerships and Cooperations

7.1. Regional Initiatives

- A. Lejay is a member of the Executive board of LUE Impact digistrust on citizens' trust in the digital world (grant of the i-site, U. Lorraine), since 2018.

7.2. National Initiatives

7.2.1. ANR

N. Champagnat is member of the ANR NONLOCAL (Phénomènes de propagation et équations non locales, 2014–2018) coordinated by F. Hamel (Univ. Aix-Marseille).

7.2.2. GDR

A. Lejay is leader of the GdR Project TRAG on rough path. This project has been accepted in October and should start on January 1st, 2019.

7.2.3. ITMO project

N. Champagnat, C. Fritsch and D. Villemonais are involved in an ITMO Cancer project (INSERM funding) on "Modeling ctDNA dynamics for detecting targeted therapy resistance" (2017-2020), involving researchers from IECL (Institut Elie Cartan de Lorraine), the Inria teams BIGS and TOSCA, ICL (Institut de Cancérologie de Lorraine), CRAN (Centre de Recherche en Automatique de Nancy) and CHRU Strasbourg (Centre Hospitalier Régional Universitaire). This project is coordinated by N. Champagnat.

7.2.4. PEPS

D. Villemonais has obtained a "PEPS jeune chercheur" grant.

7.3. European Initiatives

7.3.1. FP7 & H2020 Projects

- Mireille Bossy is involved in the VIMMP H2020 project, started in January 2018, as responsible for the partner Inria. VIMMP is a four years development for a software platform and simulation market place on the topic of complex multiscale CFD simulations.

7.4. International Initiatives

7.4.1. Participation in Other International Programs

7.4.1.1. International Initiatives

Discrelongmem (C15E05)

Title: On discretization procedures in Non-Gaussian long memory processes with applications in non parametric statistics and time series analysis (C15E05)

International Partner (Institution - Laboratory - Researcher):

Universidad de Valparaiso (Chile) - CIMFAV – Facultad de Ingenieria

PI: E. Tanré (France), S. Torrès (Chile)

Duration: 2016 - 2018

Start year: 2016

Keywords: Approximations of non-Gaussian long-memory processes. Fractional Poisson processes (fPp). Skew Fractional Process (SfP).

BRN

Title: Biostochastic Research Network

International Partner (Institution - Laboratory - Researcher):

Universidad de Valparaiso (Chile) - CIMFAV – Facultad de Ingenieria - Soledad Torres, Rolando Rebolledo

CNRS, Inria & IECL - Institut Élie Cartan de Lorraine (France) - N. Champagnat, A. Lejay, D. Villemonnais, R. Schott.

Duration: 2018 - 2022

Start year: 2018

7.5. International Research Visitors

7.5.1. Visits of International Scientists

- A. Kohatsu-Higa (Ritsumeikan University, Japan) - 1 month, with an invited professor position.

7.5.1.1. Internships

- Walid El Wahabi

  subject: processus de fragmentation pour les avalanches

  date: sept. 2018 - june. 2019

  institution: École des Mines de Nancy

- Vincent Hass

  Subject: Modèles de diffusion et estimation des dynamiques d'ADN tumoral circulant pour la détection d'une résistance à une thérapie ciblée

  Date: April 2018 - Sept. 2018

  Institution: Université Paris Sud

- Azer Mimouni

  subject: Méthodes de signature en apprentissage statistique

  date: sept. 2018 - june. 2019

  institution: École des Mines de Nancy

7.5.1.2. Sabbatical programme

D. Villemonais has obtained a *délégation CNRS* starting in September.

TRIPOP Team

8. Partnerships and Cooperations

8.1. National Initiatives

8.1.1. ANR

B. Brogliato coordinates the ANR project Digitslid (PRC, ANR-18-CE40-0008-01), Differentiateurs et commandes homogenes par modes glissants en temps discret: l'approche implicite. Partners: LS2N (Ecole Centrale de Nantes), Inria Lille Nord Europe (team Non-A-Post), and Tripop. October 2018-September 2021. 12 participants overall (3 post-doc students recruited by the project, 3 Ph.D. students supported by other means). Total financial support by the ANR: 338 362 euros (100 762 for Tripop, 18 months of post-doc to be recruited in 2019).

8.1.2. FUI Modeliscale.

https://team.inria.fr/modeliscale/

The ModeliScale FUI focuses on the modeling, simulation and analysis of large cyber-physical systems. It federates the research activities of several teams, covering a broad spectrum of topics, namely hybrid systems modeling & verification, numerical analysis, programming language design and automatic control. Our research agenda includes the following tracks:

- New compilation techniques for Modelica modelers: structural analysis of multimode DAE (Differential Algebraic Equations) systems, modular compilation, combining state-machines and non-smooth dynamical systems (complementarity dynamical systems and Filippov differential inclusions), contract-based specification of cyber-physical systems requirements, requirements capture using under-/over-determined DAE systems.
- Simulation of large cyber-physical systems: distributed simulation, discretization methods for non-smooth dynamical systems, space-/time-adaptive discretization methods for multimode DAE systems, quantized state solvers (QSS).
- Guaranteed numerics: guaranteed simulation of non-smooth and hybrid dynamical systems, numerical methods preserving invariant properties of hybrid systems, contract-based reasoning methods.

8.1.3. Inria Project Lab (IPL): ModeliScale, Languages and Compilation for Cyber-Physical System Design

https://team.inria.fr/modeliscale/

The project gathers researchers from three Inria teams, and from three other research labs in Grenoble and Paris area.

The main objective of ModeliScale is to advance modeling technologies (languages, compile-time analyses, simulation techniques) for CPS combining physical interactions, communication layers and software components. We believe that mastering CPS comprising thousands to millions of components requires radical changes of paradigms. For instance, modeling techniques must be revised, especially when physics is involved. Modeling languages must be enhanced to cope with larger models. This can only be done by combining new compilation techniques (to master the structural complexity of models) with new mathematical tools (new numerical methods, in particular).

ModeliScale gathers a broad scope of experts in programming language design and compilation (reactive synchronous programming), numerical solvers (nonsmooth dynamical systems) and hybrid systems modeling and analysis (guaranteed simulation, verification). The research program is carried out in close cooperation with the Modelica community as well as industrial partners, namely, Dassault Systèmes as a Modelica/FMI tool vendor, and EDF and Engie as end users.

Table 1. Member of IPL Modeliscale

Name	Team	Inria Center or Laboratory
Vincent Acary	Bipop	Inria Grenoble Rhône Alpes
Bernard Brogliato		
Albert Benveniste	Hycomes Inria Rennes	
Benoît Caillaud		Bretagne Atlantique
Khalil Ghorbal		
Marc Pouzet	Parkas	ENS
Tim Bourke		Inria Paris
Goran Frehse	Tempo	Verimag-univ. Grenoble Alpes
Antoine Girard		L2S-CNRS, Saclay
Eric Goubault	Cosynus	LIX, École Polytechnique,
Sylvie Putot		Saclay

8.2. International Research Visitors

8.2.1. Visits of International Scientists

- Mathias Legrand (McGill University, Mechanical Engineering).

TROPICAL Project-Team

9. Partnerships and Cooperations

9.1. National Initiatives

9.1.1. ANR

- Projet ANR MALTHY (Méthodes ALgébriques pour la vérification de modèles Temporisés et HYbrides), responsable T. Dang. Partenaires : Verimag, CEA LIST, Inria Rennes, Inria Saclay, VISEO/Object Direct.
- Projet ANR DEMOCRITE ("DEmonstrateur d'un MOteur de Couverture des Risques sur un TErritoire), responsable Emmanuel Lapébie (CEA). Partenaires : CEA-GRAMAT, BSPP, Inria Saclay (Maxplus), Institut PPRIME - UPR3346 (CNRS, Univ. Poitiers, ISAE-ENSMA), IPSIS, SYSTEL, ARMINES-E.M. Alès-ISR, CERDACC (Univ. de Haute-Alsace).
- Projet ANR JCJC CAPPS ("Combinatorial Analysis of Polytopes and Polyhedral Subdivisions"), responsable Arnau Padrol (IMJ-PRG, Sorbonne Université). Partenaires : IMJ-PRG (Sorbonne Université), Inria Saclay (Tropical), LIGM (Université Paris-Est Marne-la-Vallée), LIF (Université Aix-Marseille), CERMICS (École Nationale des Ponts et Chaussées), LIX (École Polytechnique).

9.1.2. Programme Gaspard Monge pour l'Optimisation

- Projet intitulé "Méthodes tropicales pour l'optimisation", responsable X. Allamigeon, faisant intervenir M. Akian, V. Boeuf, S. Gaubert, A.Hochart, R. Katz, et M. Skomra.

9.2. European Initiatives

9.2.1. Collaborations with Major European Organizations

- Partner: Michael Joswig, TU-Berlin.
- Topic : Tropical geometry.

9.3. International Initiatives

9.3.1. Inria International Partners

9.3.1.1. Informal International Partners

- Collaboration with Ricardo D. Katz, CIFASIS-CONICET, Rosario (Argentina). Research invitation at CMAP during 2 months.
- Collaboration with Shmuel Friedland, University of Illinois at Chicago (invitation or Stéphane Gaubert at Chicago of one week in May 2018).
- Collaboration with Alejandro Jofre, CMM, University of Chili, Santiago: invitation of Paulin Jacquot of two months (May-June) 2018.
- Collaboration with Zheng Qu, Math. Department, Hongk Kong University.

9.3.2. Participation in Other International Programs

- Collaboration with Gleb Koshevoy, Poncelet Laboratory, Moscow (research invitation of Gleb Koshevoy at CMAP during one week).
- Collaboration with Aris Daniilidis, from CMM, University of Chile, Santiago.

9.4. International Research Visitors

9.4.1. Visits of International Scientists

- Aris Daniilidis, from CMM, University of Chile, Santiago, Sept-Dec 2018. Invited to École polytechnique within the Gaspard Monge Visiting Professor Program (GMVP) of École polytechnique, with the support of Fondation de l'École polytechnique.
- Roberto Bobadilla Solari, invited PhD student, University of Chile, Santiago, from Sep 2018 until Nov 2018, funded by Inria, associated to the visit of Aris Daniilidis.
- Gonzalo Flores Garcia, invited PhD student, University of Chile, Santiago, from Sep 2018 until Dec 2018, associated to the visit of Aris Daniilidis.
- Sebastian Tapia Garcia, invited PhD student, University of Chile, Santiago, funded by GMVP, associated to the visit of Aris Daniilidis.
- Francisco Javier Antonio Venegas Martinez, invited PhD student, University of Chile, Santiago, from Sep 2018 until Nov 2018, funded by Inria, associated to the visit of Aris Daniilidis.
- Rajendra Bhatia (Ashoka University, India), June 2018.
- Gleb Koshevoy (Russian Academy of Siences), Nov 2018.

9.4.1.1. Internships

- Raphael Pellegrin (Imperial College, London), research summer internship, on tropical positivstellensätze.
- Marin Boyet (École Nationale Supérieure des Mines de Paris), research internship, colorful interior of convex bodies and solvability of tropical polynomial systems.

9.4.2. Visits to International Teams

9.4.2.1. Research Stays Abroad

- Marianne Akian, Institut Mittag Leffler, Jan 15-March 3, 2018.
- Stéphane Gaubert, Institut Mittag Leffler, Jan 15-March 3, 2018.
- Stéphane Gaubert, joint invitation by the Statistics Department of University of Chicago (Lek Heng Lim) and the Maths and Computer Science Department of University of Illinois at Chicago (Shmuel Friedland), May 20-26, 2018.

ABS Project-Team

6. Partnerships and Cooperations

6.1. International Research Visitors

6.1.1. Visits of International Scientists

6.1.1.1. Internships

- Internship of Maria Guramare, Harvard University, Cambridge, Massachusetts. Supervision: Frédéric Cazals and Dorian Mazauric. *Shortest Paths under Constraints Problem with Application for Structural Alignments.*
- Internship of Xuchun Zhang, École Polytechnique de l'Université Nice Sophia Antipolis, filière Mathématiques Appliquées et Modélisation, year 4 (Master 1). Supervision: Jean-Baptiste Caillau (Inria project-team McTao), Enzo Giusti (startup Oui!Greens), Dorian Mazauric, and Joanna Moulierac (Inria/I3S project-team Coati). *Problèmes d'affectations d'annonces dans un réseau anti gaspillage !*
- Project of Ruiqing Chang and Xuchun Zhang, École Polytechnique de l'Université Nice Sophia Antipolis, Filière Mathématiques Appliquées et Modélisation, year 4 (Master 1). Supervision: Jean-Baptiste Caillau (Inria project-team McTao), Enzo Giusti (startup Oui!Greens), Dorian Mazauric, and Joanna Moulierac (Inria/I3S project-team Coati). *Problèmes d'affectations d'annonces dans un réseau anti gaspillage !*
- Internship of Nguyen Thi Viet Ha, Master 2 Fundamental Computer Science, École Normale Supérieure de Lyon. Supervision: Frédéric Havet (Inria/I3S project-team Coati), Dorian Mazauric, and Rémi Watrigant (École Normale Supérieure de Lyon and Université Claude Bernard Lyon 1). *Graph Algorithms for low resolution model of large protein assemblies.*
- Internship of Timothée O'Donnell, Master 2 University Paris Saclay, Master bioinformatique. *Structural modeling of FMRP dimers in solution*. Supervision: F. Cazals.

AIRSEA Project-Team

8. Partnerships and Cooperations

8.1. Regional Initiatives

C. Prieur is co-leader of work-package 3 of the cross-disciplinary-project Trajectories from Idex Grenoble.

8.2. National Initiatives

8.2.1. ANR

A 4-year contract : ANR COCOA (COmprehensive Coupling approach for the Ocean and the Atmosphere). PI: E. Blayo. (Jan. 2017 - Dec. 2020). Other partners: Laboratoire des Sciences du Climat et de l'Environnement (UMR8212, Gif-sur-Yvette), Laboratoire de Météorologie Dynamique (UMR8539, Paris), Laboratoire d'Océanographie Physique et Spatiale (UMR6523, Brest), Centre National de Recherche Météorologique (UMR3589, Toulouse), Cerfacs (Toulouse). This project aims at revisiting the overall representation of air-sea interactions in coupled ocean-atmosphere models, and particularly in climate models, by coherently considering physical, mathematical, numerical and algorithmic aspects.

A 4-year contract : ANR HEAT (Highly Efficient ATmospheric modelling) http://www.agence-nationale-recherche.fr/?Project=ANR-14-CE23-0010.

A 4-year contract : ANR ADOM (Asynchronous Domain decomposition methods)

A 5-year contract with the French Navy (SHOM) on the improvment of the CROCO ocean model http://www.croco-ocean.org.

C. Prieur and E. Arnaud are involved as experts in project High-Tune http://www.agence-nationale-recherche.fr/Projet-ANR-16-CE01-0010 funded by ANR.

8.2.2. Other Initiatives

A. Vidard leads a group of projects gathering multiple partners in France and UK on the topic "Variational Data Assimilation for the NEMO/OPA9 Ocean Model", see 5.3 .

C. Prieur chaired GdR MASCOT NUM 2010-2017, in which are also involved M. Nodet, E. Blayo, C. Helbert, E. Arnaud, L. Viry, S. Nanty, L. Gilquin. She is still strong involved in thie group (co-chair) http://www.gdr-mascotnum.fr/doku.php.

LEFE/GMMC CASIS, Coupled Assimilation Strategies for the Initialisation of an ocean- atmospheric boundary layer System, A. Vidard en collaboration avec Mercator océan

8.3. European Initiatives

8.3.1. FP7 & H2020 Projects

H2020 project IMMERSE (Improving Models for Marine EnviRonment SErvices) is funded from 2018-12-01 to 2022-11-30 (Inria contact: Florian Lemarié, coordinator: J. Le Sommer, CNRS). The overarching goal of the project is to ensure that the Copernicus Marine Environment Monitoring Service (CMEMS) will have continuing access to world-class marine modelling tools for its next generation systems while leveraging advances in space and information technologies, therefore allowing it to address the ever-increasing and evolving demands for marine monitoring and prediction in the 2020s and beyond.

See also https://cordis.europa.eu/project/rcn/218810/factsheet/fr

8.3.2. Collaborations with Major European Organizations

Partner: European Center for Medium Range Weather Forecast. Reading (UK)

World leading Numerical Weather Center, that include an ocean analysis section in order to provide ocean initial condition for the coupled ocean atmosphere forecast. They play a significant role in the NEMOVAR project in which we are also partner.

Partner: Met Office (U.K) National British Numerical Weather and Oceanographic service. Exceter (UK).

We do have a strong collaboration with their ocean initialization team through both our NEMO, NEMO-ASSIM and NEMOVAR activities. They also are our partner in the NEMOVAR consortium.

8.4. International Initiatives

8.4.1. Inria Associate Teams Not Involved in an Inria International Labs

8.4.1.1. UNQUESTIONABLE

Title: UNcertainty QUantification is ESenTIal for OceaNic & Atmospheric flows proBLEms.

International Partner:

Massachusetts Institute of Technology (United States) - Aerospace Computational Design Laboratory - Youssef Marzouk

Start year: 2018

See also: https://team.inria.fr/unquestionable/

The ability to understand and predict the behavior of geophysical flows is of greatest importance, due to its strong societal impact. Numerical models are essential to describe the evolution of the system (ocean + atmosphere), and involve a large number of parameters, whose knowledge is sometimes really poor. The reliability of the numerical predictions thus requires a step of parameter identification. The Inria-AIRSEA team has a strong expertise in variational approaches for inverse problems. An alternative is the use of particle filters, whose main advantage is their ability to tackle non-gaussian frameworks. However, particle filters suffer from the curse of dimensionality. The main objective of the collaboration we propose between the Inria-AIRSEA team and the MIT UQ group is the understanding of potential low-dimensional structure underlying geophysical applications, then the exploitation of such structures to extend particle filter to high-dimensional applications.

F. Lemarié is involved in the Inria associate team NEMOLOCO with Santiago University (Chile)

8.4.2. Inria International Partners

8.4.2.1. Informal International Partners

C. Prieur collaborates with Jose R. Leon (Universdad de la república de Uruguay, Montevideo).

C. Prieur collaborates with K. Bertin (CIMFAV, Valparaíso).

F. Lemarié and L. Debreu collaborate with Hans Burchard and Knut Klingbeil from the Leibniz-Institut für Ostseeforschung in Warnemünde (Germany).

8.5. International Research Visitors

8.5.1. Visits of International Scientists

Tiangang Cui, associate professor at Monash University (Melbourne, Australia), has visited the AIRSEA team during two weeks in December 2018. The purpose of this visit is to continue the collaboration with O. Zahm on the question of the dimension reduction for Bayesian inverse problems. Tiangang Cui also gave a presentation in the "Bayes in Grenoble" seminar at Inria-Montbonnot (3rd Dec. 2018).

Nicholas Kevlahan, from McMaster University (Canada) is a visiting scientist of the AIRSEA team for 10 months starting September 2018.

8.5.2. Visits to International Teams

Olivier Zahm was invited by Prof. Fabio Nobile to spend one week at EPFL to discuss the possible future collaboration

Clémentine Prieur visited Durham (US) in the framework of the SAMSI program on Quasi-Monte Carlo and High-Dimensional Sampling Methods for Applied Mathematics (QMC). She was invited for a tutorial at the Opening Workshop : August 28 – September 1, 2018. I take part to several working groups of the program.

Clémentine Prieur visited the Isaac Newton Institute for Mathematical Sciences in Cambridge in June 2018. She was invited in the framework of a semester on Uncertainty quantification for complex systems : theory and methodologies.

F.-X. Le Dimet visited the Florida State University during 2 weeks in May 2018. He made one presentation

F.-X. Le Dimet visited the University of Wisconsin during one week in June 2018. He made 2 presentations.

F.-X. Le Dimet visited the Harbin Institute of Technology during two weeks. He gave a 16 hours cours on the Data Assimilation.

ANGE Project-Team

9. Partnerships and Cooperations

9.1. National Initiatives

9.1.1. ANR MFG (2016-2021)

Participant: Julien Salomon.

Project acronym: MFG

Project title: Mean Field Games

Coordinator: Sébastien Boyaval (LHSV/ENPC)

Funding: 299 160 euros.

CMean field game theory (MFG) is a new and active field of mathematics, which analyses the dynamics of a very large number of agents. Introduced about ten years ago, MFG models have been used in different fields: economics, finance, social sciences, engineering,... MFG theory is at the intersection of mean field theory, mathematical game theory, optimal control, stochastic analysis, variation calculation, partial differential equations and scientific calculation. Drawing on an internationally recognized French team on the subject, the project seeks to obtain major contributions in 4 main directions: the "medium field" aspect (i.e., how to obtain macroscopic models from microscopic models); the analysis of new MFG systems; their numerical analysis; the development of new applications. In this period of rapid expansion of MFG models, the project seeks to foster French leadership in the field and attract new researchers from related fields.

9.1.2. ANR INFAMIE (2015-2019)

Participant: Boris Haspot.

Program: ANR Défi de tous les savoirs (DS10) 2015

Project acronym: INFAMIE

Project title: INhomogeneous Flows : Asymptotic Models and Interfaces Evolution

Coordinator: Raphaël Danchin (Univ. Paris-Est)

Funding: 232 960 euros.

Our project aims at a better mathematical understanding of several models for the evolution of inhomogeneous flows. Through three main lines of research (see below), we will pursue a twofold final objective. First, we want to develop the current theory of regular solutions for several equations for the evolution of fluids, proposing a new approach and developing tools that are likely to be efficient in various areas of PDEs. Second, for a few selected concrete systems that describe flows in the earth environment or in astrophysics, we wish to use this general approach to extract as much information as possible concerning the qualitative behavior of the solutions.

9.1.3. ANR SEDIFLO (2015-2019)

Participants: Emmanuel Audusse, Martin Parisot.

Program: ANR Défi 1 “Gestion sobre des ressources et adaptation au changement climatique” (JCJC)

Project acronym: SEDIFLO

Project title: Modelling and simulation of solid transport in rivers

Coordinator: Sébastien Boyaval (LHSV/ENPC)

Based on recent theoretical and experimental results, this project is aimed at modelling transport of sediments within rivers. It will rely on innovations from the point of view of rheology as well as advanced mathematical tools (asymptotic model reduction, PDE discretisation).

9.1.4. ANR Hyflo-Eflu (2016-2019)

Participants: Jérémy Ledoux, Martin Parisot, Jacques Sainte-Marie, Julien Salomon.

ANR project call: Energies marines renouvelables

Project acronym: Hyflo-Eflu

Project title: Hydroliennes flottantes et énergie fluviale

Coordinator: Julien Salomon

The project is a collaboration between the Inria-team ANGE, specialist of free surface flow and optimisation, and the industrial developers of the turbine, HYDROTUBE ENERGIE. The objective of the project HyFlo-EFlu is to deliver a numerical software able to simulate the dynamic of a floating water turbine in real context. For the academic partner, the main challenge is in the simulation of the floating structure at the scale of the river, and the modelling of the vertical and horisontal axis turbine. For the industrial partner, the objective is the validation of the stability of the structure and the performance in term of energy production.

9.1.5. ANR CHARMS (2016-2020)

Participant: Cindy Guichard.

ANR project call: Transformations et inter-conversions énergétiques

Project acronym: CHARMS

Project title: Modèles de réservoirs quantitatifs pour les systèmes hydrothermaux complexes

Coordinator: Simon Lopez (BRGM)

Funding: 73k euros for LJLL (in 767k euros for the whole project)

CHARMS ANR project is focused on the mathematical methods and software tools dedicated to the simulation of the physical models issued from geothermal engineering. The final objective is the achievement of a highly parallel code, validated on realistic cases.

9.1.6. CNRS Mocha (2017-2018)

Participant: Martin Parisot.

CNRS project call: LEFE

Project acronym: MOCHA

Project title: Multi-dimensiOnal Coupling in Hydraulics and data Assimilation

Coordinator: Martin Parisot

Funding: 14k euros

In collaboration with S. Barthélémy, N. Goutal, S. Ricci, M. Hoang Le.

Multi-dimensionnal coupling in river hydrodynamics offers a conveninent solution to properly model complex flow while limiting the computational cost and making the most of pre-exsiting models. The project aims to adapt the lateral interface coupling proposed in [35] to the implicit version and test it on real data for the Garonne River.

9.1.7. Inria Project Lab "Algae in Silico" (2015-2018)

Participants: Marie-Odile Bristeau, Yohan Penel, Jacques Sainte-Marie, Fabien Souillé.

In the aftermath of the ADT In@lgae (2013–2015), we developed a simulation tool for microalgae culture. An Inria Project Lab "Algae in Silico" has started in collaboration with Inria teams BIOCORE and DYLISS. It concerns microalgae culture for biofuel production and the aim is to provide an integrated platform for numerical simulation "from genes to industrial processes".

9.1.8. Inria Project Lab "CityLab" (2015-2018)

Participants: Vivien Mallet, Raphaël Ventura.

CityLab@Inria studies ICT solutions toward smart cities that promote both social and environmental sustainability.

9.1.9. GdR EGRIN (2017–2021)

Participants: Emmanuel Audusse, Bernard Di Martino, Nicole Goutal, Cindy Guichard, Anne Mangeney, Martin Parisot, Jacques Sainte-Marie.

EGRIN stands for Gravity-driven flows and natural hazards. J. Sainte-Marie is the head of the scientific committee of this CNRS research group and A. Mangeney is a member of the committee. Other members of the team involved in the project are local correspondents. The scientific goals of this project are the modelling, analysis and simulation of complex fluids by means of reduced-complexity models in the framework of geophysical flows.

9.1.10. ANR FireCaster (2017-2020)

Participants: Frédéric Allaire, Vivien Mallet.

ANR project call: DS0104

Project acronym: FireCaster

Project title: Plateforme de prévision incendie et de réponse d'urgence

Coordinator: Jean-Baptiste Filippi (Univ. Corse)

Funding: 442k euros

The goal of the FireCaster project is to prototype a fire decision support system at the national scale to estimate upcoming fire risk (H+24 to H+48) and in case of crisis, to predict fire front position and local pollution (H+1 to H+12).

9.1.11. ANR CENSE (2017-2020)

Participants: Antoine Lesieur, Vivien Mallet.

ANR project call: DS0601

Project acronym: CENSE

Project title: Caractérisation des environnements sonores urbains : vers une approche globale associant données libres, mesures et modélisations

Coordinator: Judicaël Picaut (IFSTTAR)

Funding: 856k euros

The CENSE project aims at proposing a new methodology for the production of more realistic noise maps, based on an assimilation of simulated and measured data through a dense network of low-cost sensors.

9.1.12. ANR RAVEX (2017-2020)

Participant: Anne Mangeney.

ANR project call: DS0106

Project acronym: RAVEX

Project title: Développement d'une approche intégrée pour la réduction des Risques Associés au Volcanisme EXplosif, de la recherche sur l'aléa aux outils de gestion de crise : le cas de la Martinique

Coordinator: Olivier Roche (IRD)

Funding: 619k euros

9.1.13. ANR CINE-PARA (2015-2019)

Participant: Julien Salomon.

ANR project call: DS0708
Project acronym: CINE-PARA
Project title: Méthodes de parallélisation pour cinétiques complexes
Coordinator: Yvon Maday (LJLL)

9.2. European Initiatives

9.2.1. FP7 & H2020 Projects

9.2.1.1. ERC Consolidator Grant (2013-2018)

Participants: Anne Mangeney, Hugo Martin.

The project SLIDEQUAKES is about detection and understanding of landslides by observing and modelling gravitational flows and generated earthquakes and is funded by the European Research Council (2 million euros). More precisely, it deals with the mathematical, numerical and experimental modelling of gravitational flows and generated seismic waves coupled with field measurements to better understand and predict these natural hazards and their link with volcanic, seismic and climatic activities.

9.2.1.2. EoCoE (2015-2018)

Participant: Vivien Mallet.

Title: Energy oriented Centre of Excellence for computer applications
Program: H2020
Duration: October 2015 - October 2018
Coordinator: Édouard Audit (CEA)
Partners: CEA (Commissariat à l'Énergie Atomique et aux Énergies Alternatives, France), Forschungszentrum Julich (Germany), Max Planck Gesellschaft (Germany), ENEA (Agenzia Nazionale Per le Nuove Tecnologie, l'energia E Lo Sviluppo Economico Sostenibile, Italy), CERFACS (European Centre for Research and Advanced Training in Scientific Computing, France), Instytut Chemii Bioorganicznej Polskiej Akademii Nauk (Poland), Universita Degli Studi di Trento (Italy), Fraunhofer Gesellschaft (Germany), University of Bath (United Kingdom), CYL (The Cyprus Institute, Cyprus), CNR (National Research Council of Italy), Université Libre de Bruxelles (Belgium), BSC (Centro Nacional de Supercomputacion, Spain)
Inria contact: Michel Kern (Serena team)
Abstract: The aim of the projevt is to establish an Energy Oriented Centre of Excellence for computing applications (EoCoE). EoCoE (pronounce "Echo") will use the prodigious potential offered by the ever-growing computing infrastructure to foster and accelerate the European transition to a reliable and low carbon energy supply. To achieve this goal, we believe that the present revolution in hardware technology calls for a similar paradigm change in the way application codes are designed. EoCoE will assist the energy transition via targeted support to four renewable energy pillars: Meteo, Materials, Water and Fusion, each with a heavy reliance on numerical modelling. These four pillars will be anchored within a strong transversal multidisciplinary basis providing high-end expertise in applied mathematics and HPC. EoCoE is structured around a central Franco-German hub coordinating a pan-European network, gathering a total of 8 countries and 23 teams. Its partners are strongly engaged in both the HPC and energy fields; a prerequisite for the long-term sustainability of EoCoE and also ensuring that it is deeply integrated in the overall European strategy for HPC. The primary goal of EoCoE is to create a new, long lasting and sustainable community around computational energy science. At the same time, EoCoE is committed to deliver high-impact results within the first three years. It will resolve current bottlenecks in application codes, leading to new modelling capabilities and scientific advances among the four user communities; it will develop cutting-edge mathematical and numerical methods, and tools to foster the usage of Exascale computing. Dedicated services for laboratories and industries will be established to leverage this expertise and to foster an ecosystem around HPC for energy. EoCoE will give birth to new collaborations and working methods and will encourage widely spread best practices.

9.2.2. Collaborations with Major European Organisations

9.2.2.1. CNRS PICS NHML (2017-2019)

Participants: Martin Parisot, Yohan Penel, Jacques Sainte-Marie.

Program: CNRS PICS (projet international de collaboration scientifique)

Project acronym: NHML

Project title: non-hydrostatic multilayer models

Duration: 01/17-12/19

Coordinator: Yohan Penel (Inria)

Other partners: IMUS (Sevilla, Spain)

Other Participants: Enrique Fernández-Nieto (Sevilla), Tomas Morales de Luna (Cordoba)

Funding: 12k euros

Abstract: This collaboration aims at designing a hierarchy of multilayer models with a non-hydrostatic pressure as a discretisation along the vertical axis of the Euler equations. The hierarchy relies on the degree of approximation of the variables discretised with a Discontinuous Galerkin method for the vertical direction. These innovative models will imply a theoretical study and the development of numerical tools in dimensions 1 and 2 before the modelling of other physical phenomena (viscosity effects, ...).

9.3. International Initiatives

9.3.1. Informal International Partners

Four collaborations with foreign colleagues are to be mentioned:

- **Spain** - A collaboration with Spanish researchers has been initiated in 2016 to derive accurate models and effecient algorithms for free surface flows including non-hydrostatic effects. ANGE applied in 2018 to the Inria Associate Team programme in order to strenghten the collaboration.
- **USA** A joint work with R. LeVeque (Univ. Seattle) and M. Berger (New York Univ.) consists in modelling the impact of asteroids on the generation of tsunamis.
- **Germany** A collaboration with researchers from the University of Constance has been initiated in 2018 about domain decomposition and identifaction algorithms (G. Ciaramella, S. Volkwein).
- **Hong-Kong** A collaboration with F. Kwok on time parallelization for assimilation algorithm has been initiated in 2018.

9.4. International Research Visitors

- Y. Penel spent twice two weeks (May, October)at the university of Sevilla (Spain) to collaborate with E. Fernández-Nieto.

9.4.1. Visits of International Scientists

- G. Ciaramella visited J. Salomon (28.05-01.06) to work on a reduction method for identification problem.

ARAMIS Project-Team

9. Partnerships and Cooperations

9.1. National Initiatives

9.1.1. ANR

9.1.1.1. ANR-NIH-NSF NETBCI

Participants: Fabrizio de Vico Fallani [Correspondant], Mario Chavez, Denis Schwartz.

Project acronym: NETBCI

Project title: Modeling and predicting brain-computer interface learning from dynamic networks

Duration: Avr 2016 - Avr 2020

Amount: 322k€

Coordinator: Fabrizio De Vico Fallani

Other partners: Complex system group, UPenn, USA

Abstract: This project will bring together expertise in computational and experimental neuroscience, signal processing and network science, statistics, modeling and simulation, to establish innovative methods to model and analyze temporally dynamic brain networks, and to apply these tools to develop predictive models of brain-computer interface (BCI) skill acquisition that can be used to improve performance. Leveraging experimental data and interdisciplinary theoretical techniques, this project will characterize brain networks at multiple temporal and spatial scales, and will develop models to predict the ability to control the BCI as well as methods to engineer BCI frameworks for adapting to neural plasticity. This project will enable a comprehensive understanding of the neural mechanisms of BCI learning, and will foster the design of viable BCI frameworks that improve usability and performance.

9.1.1.2. ANR-NIH-NSF HIPLAY7

Participants: Olivier Colliot [Correspondant], Marie Chupin, Stanley Durrleman, Anne Bertrand.

Project acronym: HIPLAY7

Project title: Hippocampal layers: advanced computational anatomy using very high resolution MRI at 7 Tesla in humans

Duration: Jan 2017 - Jan 2020

Amount: 770k€

Coordinator: Olivier Colliot and Pierre-François Van de Moortele

Other partners: University of Minnesota, Neurospin

Abstract: The overall goal of this proposal is to develop a coherent mathematical framework for computational anatomy of the internal structures of the hippocampus based on cutting edge MRI acquisition techniques at 7 Tesla. These mathematical and computational approaches are expected to significantly advance the field of computational anatomy of the human brain, breaking down the millimeter barrier of conventional brain morphometry and providing a coherent analysis framework for anatomical data at ultra-high spatial resolution.

9.1.1.3. ANR PREV-DEMALS

Participants: Olivier Colliot [Correspondant], Marie Chupin, Stanley Durrleman, Anne Bertrand.

Project acronym: PREV-DEMALS

Project title: Predict to prevent frontotemporal lobar degeneration (FTLD) and amyotrophic lateral sclerosis (ALS)

Duration: Avr 2015 - Avr 2019

Amount: 487k€

Coordinator: Isabelle Le Ber

Other partners: ICM, AP-HP, CHR de Lille, CHU Limoges, CHU Rouen, Laboratory of Biomedical Imaging

Abstract: The project focuses on C9ORF72, the most frequent genetic form of frontotemporal lobar degeneration (FTLD) and amyotrophic lateral sclerosis (ALS). Since 2006, major discoveries have helped elucidate the pathological bases and linked FTLD and ALS: 1) TDP-43 aggregates in neurons and 2) C9ORF72 mutations in both disorders. Two major pathological subtypes are now defined in FTLD, FTLD-TDP and FTLD-TAU. C9ORF72 mutations (associated to FTLD-TDP) are the most frequent genetic causes of FTLD (15%), FTLD-ALS (65%) and ALS (40%). No curative treatment actually exists, but therapeutics emerged against tau aggregation. The objectives of the project are to develop appropriate cognitive, brain imaging markers and peripheral biomarkers of the early phase of FTLD, to follow disease progression and to guide future targeted therapeutic trials. To address this questions, we will conduct a multimodal study (cognition, brain structural MRI, brain metabolism - FDG-PET) in C9ORF72 families. The cohort will be followed at 3-time points (M0, M18, M36). Longitudinal analyses will aim at characterizing the trajectory of decline across time. Brain structural changes will be evaluated by 1) morphometric analysis to assess global brain atrophy, cortical thickness and study of the cortical sulci; 2) functional connectivity analysis of resting-state MR data; 3) structural connectivity analysis of diffusion-weighted MRI. Brain metabolism will be evaluated with FDG-PET. We will use the most recent RNA sequencing technology to detect gene expression and RNA splicing alterations in lymphocytes of patients and presymptomatic carriers. The discovery of new markers involved in FTLD will have practical consequences for early and accurate diagnosis of FLD and ALS disease.

9.1.1.4. ANR IVMRS

Participants: Anne Bertrand [Correspondant], Alexandra Petiet, Mathieu Santin, Francesca Branzoli, Benoit Delatour, Marc Sanson.

Project acronym: IVMRS

Project title: Implantable miniaturized probe for In-vivo Magnetic Resonance Spectroscopy: Application to Murine models of Alzheimer's disease and Gliomas.

Duration: Oct 2016 - Oct 2020

Amount: 633k€

Coordinator: Luc Hebrard

Other partners: ICube - Unistra, Strasbourg; ISA Laboratory, Lyon; NYU School of Medicine, NY, USA.

Abstract: During the development of new therapeutics against brain diseases, the pre-clinical phase, i.e. the validation of treatment delivery, safety and efficacy in animal models of the disease, represents a crucial step. Magnetic Resonance Imaging (MRI) is a method of particular interest at this stage, as it provides non-invasive surrogate endpoints that can help selecting appropriate candidates during the process of drug development. Single Voxel Magnetic Resonance Spectroscopy (SVS) provides non-invasive, in-vivo quantitative measurements of brain metabolites, which reflects functional changes at the cellular and subcellular levels, and can be repeated longitudinally. As high-field MRI has become the benchmark in preclinical research on animal models, it appears possible

to investigate the cerebral metabolomics changes in animals, and to use it as a surrogate marker in preclinical therapeutic trials. However, the number of relevant metabolites is much higher than the low number of measurable metabolites with conventional in-vivo high-field SVS. Moreover, considering also the subtle changes of these metabolites at the early stage of the disease, the use of conventional high-field SVS in preclinical studies remains strongly limited. The high volume of the Voxel-of-Interest (VOI), ranging from 10 to 30mm3, which is required to have a usable signal in conventional SVS, and the inherent variability of longitudinal SVS measurement due to the variable position of the VOI in the successive experiments, remain the two major issues when looking during time for small changes in metabolic concentrations and metabolites ratios in a specific small region of the animal brain. The IvMRS project aims at filling this gap by developing the first chronic implantable MRS micro-probe, minimally invasive, exhibiting very high signal sensitivity, and sharp spectral peaks, from sub-millimetric VOI. Such a probe will allow detecting a much higher number of metabolites than conventional in-vivo SVS. The probe will work at frequencies ranging from 300MHz to 500MHz in ultra-high field Magnetic Resonance Imaging scanners, 7T and 11.7T. It will embed a specific micro-coil antenna, a low-noise signal conditioning circuit designed in CMOS microelectronics technology, as well as an accurate on-chip positioning sensor. It will be dedicated to the study of changes in brain metabolite markers of two major diseases, Alzheimer's disease and cerebral gliomas, and to the assessment of effective therapeutic strategies.

9.1.2. Inria Project Labs

9.1.2.1. IPL Neuromarkers

Participants: Stanley Durrleman [Correspondant], Olivier Colliot [Correspondant], Fabrizio de Vico Fallani, Anne Bertrand, Stéphane Epelbaum.

Project acronym: Neuromarkers

Project title: Design of imaging biomarkers of neurodegenerative diseases for clinical trials and study of their genetic associations

Duration: 2017-2021

Coordinators: Stanley Durrleman and Olivier Colliot

Other partners: Inria GENSCALE, Inria BONSAI, Inria DYLISS, Inria XPOP, ICM, IHU/ICM iConics

Abstract: The Inria Project Lab Neuromarkers aims to develop new statistical and computational approaches to integrate multimodal imaging and omics data and to demonstrate their potential to identify early alterations and predict progression of neurodegenerative diseases. To tackle this challenge, the project brings together multidisciplinary expertise from Inria and ICM (Brain and Spine Institute) in the fields of statistical learning, brain imaging, bioinformatics, knowledge modeling, genomics and neurodegenerative diseases.

9.1.3. IHU

9.1.3.1. General program

Participants: Olivier Colliot, Stanley Durrleman, Didier Dormont, Ninon Burgos, Stéphane Epelbaum, Fabrizio de Vico Fallani.

Project acronym: IHU-A-ICM

Project title: Institute of Translational Neuroscience

Founded in 2011

General Director: Bertrand Fontaine

The IHU-A-ICM program was selected, in 2011, in a highly competitive national call for projects. A 10-year, 55M€ program, has been implemented by a recently created foundation for scientific cooperation. Based on the clinical and scientific strenghts of the ICM and the hospital Department of Nervous System Diseases, it mainly supports neuroscience research, but is also invested in improving care and teaching. ARAMIS is strongly involved in the IHU-A-ICM project, in particular in WP6 (neuroimaging and electrophysiology), WP7 (biostatistics), WP2 (Alzheimer) and WP5 (epilepsy). We have started collaborations with the new bioinformatics/biostatistics platform (IHU WP7, head: Ivan Moszer), in particular through a joint project on the integration of imaging and genomics data.

9.1.3.2. ICM-Internal Research projects

Participants: Anne Bertrand [Correspondant], Takoua Kaaouana, Benoit Delatour, Alexandra Petiet, Olivier Colliot, Arnaud Marcoux.

Project title: The Histo-MRI project: targeting MR signature of tauopathy from micro- to macroscopy

Started in 2014

Coordinator: Anne Bertrand

Identifying morphological MR signatures of brain diseases usually follows a top-down process, which starts by describing a pattern of MR signal changes in patients, hypothesizes an underlying pathological mechanism, and confirms this mechanism by correlating the observed MR signal changes with histological lesions on post-mortem examination. This top-down process, relevant for large, centimetric brain lesions, becomes inappropriate when targeting the MR signal intensity changes associated with microscopic lesions. Our project aims at developing an MR biomarker of NFT using a new bottom-up approach. We will start by identifying the MR signal changes associated with the presence of NFT at the level of the histological slice, and utilize these findings to develop a method of NFT quantification on clinical, millimetric 3D MR images. To achieve this goal, we will develop and implement a 11.7T histological coil dedicated to the scanning of histological slices, which allows both ultra-high resolution MR imaging (up to 33 microns in-plane) and perfect co-registration with histological staining, performed subsequently on the same slice. This method has the potential to provide a novel biomarker of tauopathy that could not have been identified using the usual top-down approach. It also envisions the possibility to describe and understand new MRI contrasts in other neurodegenerative diseases associated with microscopic deposition of various proteins.

9.1.3.3. ICM-Internal Research projects

Participants: Mario Chavez, Fabrizio de Vico Fallani [Correspondant].

Project title: Non-invasive manipulation of brain synchrony to enhance brain function and rehabilitate faulty cognition in humans: A proof of concept

Started in 2014

Coordinator: Antoni Valero Cabre (ICM-team “Dynamiques Cérébrales, Plasticité et Rééducation”)

Other partners: Service des Urgences Cérébro-Vasculaires de l’Hôpital Pitié-Salpêtrière, Paris.

The long-term goal of this project is to develop the use of non-invasive manipulation of abnormal cerebral oscillations underlying cognitive activity to restore brain function in neurological patients. Cognitive functions emerge from large distributed networks organized in space and time. The short-term goal of this application is to study the causal role played by oscillatory activity in visual awareness and test whether their manipulation by non-invasive brain stimulation has the potential to restore its function in stroke patients.

9.1.3.4. ICM BBT Program - project PredictICD

Participants: Olivier Colliot [Correspondant], Jean-Christophe Corvol [Correspondant], Johann Faouzi.

Project title: Predict impulse control disorders in Parkinson’s disease (PREDICT-ICD)

Started in 2018

Coordinators: Olivier Colliot and Jean-Christophe Corvol (ICM)

In Parkinson’s disease (PD), the therapeutic strategy is based on the dopamine replacement therapy. Although available since the 1960s’, it is only relatively recently that behavioral disorders associated with these drugs have been described. Gathered under the term of “behavioral addiction”, they include impulse control disorders (ICDs), dopamine dysregulation syndrome (DDS), and punding. Interestingly, whereas addiction to L-dopa itself occurs quasi exclusively with L-dopa, ICDs appear electively under dopamine agonist (DA) therapy. The objectives of this project are: i) to elucidate the genetic basis of DA induced ICDs in PD patients from several international cohorts; ii) to develop and validate a machine learning model to predict the occurrence of ICDs from the combination of clinical and genetic data.

9.1.3.5. ICM BBT Program - project DYNAMO

Participants: Stanley Durrleman [Correspondant], Harald Hampel [Correspondant], Sabrina Fontanella, Simone Lista, Olivier Colliot, Stephanie Allassonniere, Jean-Baptiste Schiratti, Bruno Dubois, Hovagim Bakardjian, Remi Genthon, Enrica Cavedo, Katrine Rojkowa.

Project title: Dynamic models of disease progression across Alzheimer's disease stages informed by multimodal neuroimaging and biological data

Started in 2016

Coordinator: Stanley Durrleman and Harald Hampel

Other partners: Institut de la Mémoire et de la maladie d'Alzheimer

The estimation of data-driven models of disease progression for neurodegenerative diseases, including Alzheimer's disease (AD), is crucial to confirm, refine and extend the current hypothetical models. The estimation of such quantitative models from longitudinal data sets is notably difficult because of the lack of principled methodological frameworks for the analysis of spatiotemporal data.

The project builds on an innovative mathematical, statistical, and computational framework to automatically align the dynamics and the direction of individual trajectories of the evolving pathology, and then to infer a normative scenario of disease progression across different disease stages. The estimated scenario will combine spatiotemporal maps of lesion propagation, such as maps of amyloid deposition or cortical atrophy, and global measurements such as levels of CSF biomarkers. It will be possible to estimate not only a normative scenario but also the inter-individual variability in the values, dynamics and direction of both topographical and pathophysiological biomarkers changes during the course of the disease.

The application of this technology to publicly available and in-house longitudinal data sets of individuals from the asymptomatic at risk to the prodromal and dementia stages will yield new insights into the pathophysiology of AD from the preclinical to the AD dementia stages. This quantitative data-driven approach will be exploited to assess and refine the current qualitative hypothetical models of AD progression. Notably, it will complement these models with typical pathways of lesion propagation in the brain during disease progression. It will also highlight the effect of the known risk factors of AD such as apolipoprotein E genotype on the disease progression profile.

The project will open up the concrete possibility to derive a computer-aided diagnosis, staging, and prognosis tool for a better recruitment of patients in clinical studies and to assist clinicians in the diagnosis and the monitoring of both disease progression and treatment efficacy.

9.1.3.6. ICM BBT Program - project SEMAPHORE

Participants: Stanley Durrleman [Correspondant], Stéphane Lehéricy [Correspondant], Jean-Christophe Corvol, Marie Vidailhet, Raphael Couronné, Safia Said.

Project title: Personalized progression model of Parkinson's disease

Started in 2018

Coordinator: Stanley Durrleman and Stéphane Lehéricy

Other partners: Neurology and Neuro-radiology departments, Pitié-Salpêtrière Hospital, AP-HP

The aim of this project is to build a personalizable model of Parkinson's disease (PD) progression integrating the complex dynamical interplay between phenotypic, imaging, genetic and metabolic alterations. We will identify and validate markers for monitoring of progression of brain damage in early and prodromal PD and identify conversion markers in subjects at risk of PD (idiopathic rapid eye movement sleep behavior disorders iRBD, PD- related mutation carriers). We will describe the appearance, characterize clinical phenotypes of PD, and identify modifier genes of disease phenotype. To this aim, we will relie on a novel statistical learning method using Bayesian non-linear mixed-effects model allowing to combine and realign short term sequence data to estimate

a long-term scenario of disease progression. This method is able to estimate individual stages of disease progression and to analyze automatically non-linear spatiotemporal patterns of data change. It estimates both a group-average scenario of PD progression as well as the inter-individual variability of this model in terms of age at onset, pace of disease progression and variability in the spatiotemporal trajectory of data changes. We will analyse the effect of genetic variants in the modulation of these non-linear progression patterns, and assess the statistical power of the individual parameters encoding for these patterns. The method will be applied to two sets of longitudinal data from the local prospective NUCLEIPARK (60 PD patients, 20 patients with iRBD, 60 controls) and ICEBERG studies (200 early idiopathic PD, 50 iRBD, 30 GBA and LRRK2 PD-related mutation carriers, 50 controls). Examinations included clinical, biological, and neurophysiological data, and multimodal 3T MRI, DATScan, and skin and salivary gland biopsies. The models of PD progression for each category of subjects will be released to the community, as well as the software for reproducibility purposes.

9.1.3.7. ICM BBT Program - project ATTACK

Participants: Fabrizio de Vico Fallani [Correspondant], Charlotte Rosso [Correspondant], Marie-Constance Corsi, Laurent Hugueville.

Project title: ATTACK Brain Network Models Of Motor Recovery After Stroke

Started in 2018

Coordinator: Fabrizio De Vico Fallani, Charlotte Rosso

Other partners: Neurology and Stroke departments, Pitié-Salpêtrière Hospital, AP-HP

Like in other connected systems, studying the structure of the interactions between different brain regions has profound implications in the comprehension of emergent complex phenomena as, for example, the capability of the human brain to functionally reorganize after cerebrovascular "attacks" or stroke. This dynamic skill, which is known in neuroscience as neural plasticity, is not only interesting from a network science perspective, but it also plays a crucial role in determining the motor/cognitive recovery of patients who survive a stroke. As a critical innovation, this project proposes to develop a systematic and rigorous approach based on neuroimaging techniques, signal processing, and network science for the modeling and analysis of temporally dynamic neural processes that characterize motor recovery after stroke. To achieve these goals, this project is organized around the following objectives: i) acquiring a comprehensive longitudinal dataset of brain and behavioral/clinical data after stroke, ii) developing new analytic tools to characterize and generate temporally dynamic brain networks, iii) building network-based models of motor recovery after stroke, accounting for individual patients. These objectives involve an intensive gathering of heterogeneous mass data, their processing, the subsequent outcome interpretation and statistical simulation, as well as the development of longitudinal models and network-based diagnostics of the patient's motor recovery progress. Results will be first characterized from pure network-theoretic and neuroscience perspectives, so as to highlight fundamental research challenges, and then validated to clarify the importance and the applicability to the clinical scenario. Our results will unveil multiscale properties of dynamic brain networks and identify predictive neuromarkers for motor recovery after stroke. This project has a two-fold impact on the society. On the one hand, it will provide new methods and robust tools to properly characterize and model temporally dynamic networks in neuroscience. On the other hand, it will provide longitudinal models of motor recovery in stroke patients that can potentially unveil the neural substrate that underpins rehabilitation, improve prognosis, and eventually lower cost of hospitalization time. From a broader perspective this interdisciplinary project proposes a transformative approach to analyze large-scale neural systems.

9.1.4. National Networks

- GdR Statistics and Medicine - http://gdr-stat-sante.math.cnrs.fr/spip/
- GdR (MaDICS) Masses de Données, Informations et Connaissances en Sciences Big Data - Data ScienceStatistics and Medicine - http://www.madics.fr/reseaux/

- F. De Vico Fallani participated to the GdR (HANDICAP) in the framework of the future strategy of Inria
- F. De Vico Fallani was founding member of the CORTICO national network for brain-computer interfaces

9.1.5. Other National Programs

9.1.5.1. Programme Hospitalier de Recherche Clinique (PHRC)

Participants: Olivier Colliot, Stanley Durrleman, Didier Dormont.

- PHRC PredictPGRN, co-funding by Alzheimer Plan, *Caractérisation multimodale prospective de la démence frontotemporale dûe à des mutations du gène PGRN à un stade symptomatique et présymptomatique*. (Coordinator : A. Brice)
- PHRC ImaBio3, co-funding by Roche (pharmaceutical industry), *Rôle des réactions cellulaires sanguines, inflammatoires et immunitaires anti-amyloïde centrales et périphériques dans la maladie d'Alzheimer débutante*. (Coordinator : M. Sarazin)
- PHRC CAPP, *Caractérisation linguistique, anatomique/métabolique et biologique des différentes formes d'aphasie primaire progressive : vers le rationnel pour des essais pharmacologiques et des rééducations du langage ciblées*. (Coordinator: M. Teichmann)

9.1.5.2. Institut Universitaire d'Ingénierie pour la Santé (IUIS)

Participants: Mario Chavez, Xavier Navarro.

Project acronym: DYSPEV

Project title: Dépistage de la dyspnée par potentiels évoqués visuels

Funded in 2014

Amount: 38K€

Coordinator: Thomas Similowski

Other partners: UPMC, Inserm UMR 1158

Abstract: Steady state visual evoked potentials (SSVEP) have been widely utilized in brain computer interfacing (BCI) in last years. In this project, we explore the possibilities of SSVEP to manage the communication between patients suffering from respiratory disorders and health care providers. By imposing different breathing constraints, we use a SSVEP-based brain computer interface to help those subjects to communicate their breathing sensations (breathing well/breathing bad).

9.2. European Initiatives

9.2.1. FP7 & H2020 Projects

9.2.1.1. H2020 - Project EuroPOND

Participants: Olivier Colliot, Stanley Durrleman, Manon Ansart, Igor Koval, Alexandre Bône.

Project acronym: EuroPOND

Project title: Data-driven models for Progression Of Neurological Disease

Duration: Jan 2016 - Dec 2019

Amount: 6M€

Coordinator: Daniel Alexander

Other partners: University College London (UK), EMC Rotterdam (The Netherlands), VUMC (The Netherlands), Fate Bene Fratelli (Italy), Carol Besta Institute (Italy), Université de Genève (Switzerland), Icometrix (Belgium)

Abstract: EuroPOND will develop a data-driven statistical and computational modeling framework for neurological disease progression. This will enable major advances in differential and personalized diagnosis, prognosis, monitoring, and treatment and care decisions, positioning Europe as world leaders in one of the biggest societal challenges of 21st century healthcare. The inherent complexity of neurological disease, the overlap of symptoms and pathologies, and the high comorbidity rate suggests a systems medicine approach, which matches the specific challenge of this call. We take a uniquely holistic approach that, in the spirit of systems medicine, integrates a variety of clinical and biomedical research data including risk factors, biomarkers, and interactions. Our consortium has a multidisciplinary balance of essential expertise in mathematical/statistical/computational modelling; clinical, biomedical and epidemiological expertise; and access to a diverse range of datasets for sporadic and well-phenotyped disease types.The project will devise and implement, as open-source software tools, advanced statistical and computational techniques for reconstructing long-term temporal evolution of disease markers from cross-sectional or short-term longitudinal data. We will apply the techniques to generate new and uniquely detailed pictures of a range of important diseases. This will support the development of new evidence-based treatments in Europe through deeper disease understanding, better patient stratification for clinical trials, and improved accuracy of diagnosis and prognosis. For example, Alzheimer's disease alone costs European citizens around €200B every year in care and loss of productivity. No disease modifying treatments are yet available. Clinical trials repeatedly fail because disease heterogeneity prevents bulk response. Our models enable fine stratification into phenotypes enabling more focussed analysis to identify subgroups that respond to putative treatments.

9.2.1.2. FET Flagship - Human Brain Project

Participants: Olivier Colliot, Stanley Durrleman.

Project acronym: HBP

Project title: Human Brain Project

Sub-project: SP8 - Medical Informatics Platform

Duration: 2016-

Abstract: The Human Brain Project (HBP) is a European Commission Future and Emerging Technologies Flagship. The HBP aims to put in place a cutting-edge, ICT-based scientific Research Infrastructure for brain research, cognitive neuroscience and brain-inspired computing. The Project promotes collaboration across the globe, and is committed to driving forward European industry. Our team is involved in the Subproject SP8 (Medical Informatics Platform). The Medical Informatics Platform (MIP) is an innovative data management system that gives researchers the means to access and analyse large amounts of anonymized clinical neuroscience data. Within that framework, we will develop and implement a method to construct disease progression models from longitudinal biomarkers. The method will use statistical learning techniques to infer a long-term disease progression model from multiple short term data from a series of individuals. The model will account for variability in age at disease onset, pace of disease progression and trajectories of biomarkers changes across individuals in the observed population.

9.2.1.3. ERC - LEASP

Participant: Stanley Durrleman.

Project acronym: LEASP

Project title: Learning Spatiotemporal Patterns in Longitudinal Image Data Sets of the Aging Brain

Duration: 2016-2021

Abstract: Time-series of multimodal medical images offer a unique opportunity to track anatomical and functional alterations of the brain in aging individuals. A collection of such time series for several individuals forms a longitudinal data set, each data being a rich iconic-geometric representation of the brain anatomy and function. These data are already extraordinary complex and variable across individuals. Taking the temporal component into account further adds difficulty, in that each individual follows a different trajectory of changes, and at a different pace. Furthermore, a disease is here a progressive departure from an otherwise normal scenario of aging, so that one could not think of normal and pathologic brain aging as distinct categories, as in the standard case-control paradigm.

Bio-statisticians lack a suitable methodological framework to exhibit from these data the typical trajectories and dynamics of brain alterations, and the effects of a disease on these trajectories, thus limiting the investigation of essential clinical questions. To change this situation, we propose to construct virtual dynamical models of brain aging by learning typical spatiotemporal patterns of alterations propagation from longitudinal iconic-geometric data sets.

By including concepts of the Riemannian geometry into Bayesian mixed effect models, the project will introduce general principles to average complex individual trajectories of iconic-geometric changes and align the pace at which these trajectories are followed. It will estimate a set of elementary spatiotemporal patterns, which combine to yield a personal aging scenario for each individual. Disease-specific patterns will be detected with an increasing likelihood.

This new generation of statistical and computational tools will unveil clusters of patients sharing similar lesion propagation profiles, paving the way to design more specific treatments, and care patients when treatments have the highest chance of success.

9.3. International Initiatives

9.3.1. Informal International Partners

- F. De Vico Fallani has a collaboration with the University Penn, Philadelphia, US (Prof. Danielle Bassett).
- F. De Vico Fallani has a collaboration with the University of Rome, Italy (Prof. Stefania Colonnese).
- O. Colliot has an enduring collaboration with the Center for Magnetic Resonance Research, University of Minnesota, USA (P-F Van de Moortele, T. Henry).
- S. Durrleman and O. Colliot have a collaboration with the Center for Medical Image Computing (CMIC) at University College London (UCL), London, UK (D. Alexander, H. Zhang).

9.4. International Research Visitors

9.4.1. Visits of International Scientists

- Dr. Sarah-Christine Villeneuve spent a year from the 4th of December 2017 to the 30th of November 2018 as a clinical research fellow in Pitié Salpêtrière Hospital under the supervision of Stéphane Epelbaum (Sabbatical program).

ATHENA Project-Team

7. Partnerships and Cooperations

7.1. Regional Initiatives

7.1.1. Université Côte d'Azur projects

7.1.1.1. Tech-ICOPA

Participants: Maureen Clerc, Théodore Papadopoulo, Sofiane Guebba, Marie-Hélène Soriani [CHU Nice], Mariane Bruno [CHU Nice], Violaine Guy [CHU Nice].

Duration: 24 months

Improving autonomy is a main priority for people with disabilities. The goal of this project is to create a version usable by patients at their home of a brain-computer interface (BCI) research prototype system developped in our project-team. Making this technology actually usable in the context of pathology inducing severe disabilities such as ALS (Amyotrophic Lateral Sclerosis) is a challenge. Tackling this challenge would allow both to meet the expectations of dependent people and to envision a more widespread use of this technology. To reach this goal, several technological advances and industrial developments are needed : (i) developing a suitable ergonomic headset, wireless, functional, comfortable, incorporating a miniaturized amplifier (Nice University Hospital Center - ALS Center), (ii) reducing the number of electrodes while maintaining signal quality (Inria - UCA) and (iii) testing the prolonged use of dry electrodes. In addition to these technological advances, the Tech-ICOPA translational project aims at (1) improving the use of BCI in communication, in accessing the digital world, home automation and robotics and (2) enhancing the use of BCI in commercial applications.

7.1.1.2. EPI-ANALYSE

Participants: Fabrice Duprat [IPMC], Théodore Papadopoulo, Massimo Mantegazza [IPMC], Maureen Clerc.

Duration: 12 months

This project aims at developing two complementary analysis softwares dedicated to the detection of epileptic seizures in mice in order to study epileptogenesis and the consequences of spontaneous seizures. The first software will be the adaptation to the mouse EEG of a powerful algorithm based on a dictionary learning method developed by our project-team. We will use video-EEG recordings already made and analyzed at the IPMC to optimize and validate the new software. This will allow a detailed analysis of seizures and events occurring between seizures (e.g., interictal spikes). The second software deals with the analysis of video recordings of 3 models of mice not recordable until now with EEG. The implementation, recordings and the analysis of the 3 models will be carried out during this project. A prototype of this software already exists at IPMC (in Python, with OpenCV) but the analysis algorithm must be optimized. Semi-automatic video analysis will allow an easy identification of temporal segments corresponding to epileptic seizures. This will help the experimenter to classify the behavioral severity of seizures.

7.1.1.3. MICADome

Participants: Maureen Clerc, Michel Pascal [CNR Nice].

Duration: 24 months

The MICA-Dome project (MICA : Musique Interactive Côte d'Azur) initiates collaborative research between arts, science and humanities within a laboratory for exploring the sound spatialization in 3D, and its usage for an immersive music composition. For this MICADome will be equipped with a "Dome" of loudspeakers for 3D spatialization. Our team collaborates in MICADome in order to develop and anlyze EEG experiments to analyze the neural correlates of spatial auditory attention.

7.2. National Initiatives

7.2.1. Inria Project Lab

7.2.1.1. IPL BCI-LIFT

Participants: Maureen Clerc, Théodore Papadopoulo, Nathalie Gayraud, Federica Turi, Romain Lacroix.

Duration: *January 2015 to December 2018*

The Inria Project-Lab BCI-LIFT is an Inria-funded reasearch consortium to foster collaborative research on Brain-Computer Interfaces on the topic of Learning, Interaction, Feedback and Training. It is coordinated by Maureen Clerc. Its members are from 6 Inria teams: ATHENA, CAMIN, HYBRID, MJOLNIR, NEUROSYS, POTIOC, and from Dycog team from CRNL Lyon, and University of Rouen. The goal is to reach a next generation of non-invasive Brain-Computer Interfaces (BCI), more specifically BCI that are easier to appropriate, more efficient, and suit a larger number of people. For more information, refer to the BCI-LIFT website.

7.2.2. ANR

7.2.2.1. ANR NeuroRef

Participants: Demian Wassermann [Inria Parietal], Antonia Machlouziredes, Guillermo Gallardo Diez, Rachid Deriche.

Duration: *October 2016 to September 2019*
Call: *NSF-ANR Program Collaborative Research in Computational Neuroscience 2015*

This project is a collaboration with Pr. S. Bouix and his team at the Psychiatry NeuroImaging Lab, Dept of Radiology, Brigham and Women's Hospital, Harvard Medical School (USA) to build MRI reference atlases to analyze brain trauma and post-traumatic stress. The goal is to develop a robust framework to perform subject-specific neuroimaging analyses of Diffusion MRI (dMRI), as this modality has shown excellent sensitivity to brain injuries and can locate subtle brain abnormalities that are not detected using routine clinical neuroradiological readings.

7.2.2.2. ANR MOSIFAH

Participants: Rachid Deriche, Abib Olushola Yessouffou Alimi, Rutger Fick [TheraPanacea, Paris], Demian Wassermann [Inria Parietal], Théodore Papadopoulo.

Duration: *October 2013 to September 2018*
Call: *ANR Numerical Models 2013*

This ANR project is about multimodal and multiscale modelling and simulation of the fiber architecture of the human heart. It started on October 2013 and involves three partners: Creatis Team, INSA, Lyon (I. Magnin, Y. Zhu); TIMC-IMAG, CNRS, Grenoble (Y. Uson) and the ATHENA project team.

It consists in modelling and simulating the ex vivo and in vivo 3D fiber architectures at various scales using multiphysical data from different imaging modalities working at different spatial resolutions. To this end, the myocardium of the human heart will be imaged using respectively Polarized Light Imaging (PLI) and dMRI.

7.2.2.3. ANR VIBRATIONS

Participants: Théodore Papadopoulo, Maureen Clerc, Rachid Deriche, Demian Wassermann [Inria Parietal].

Duration: *February 2014 to February 2019*
Call:ANR Programme de Recherche Translationnelle en Santé (PRTS) 2013

The VIBRATIONS project proposes to simulate in a biologically realistic way MEG and EEG fields produced by different configurations of brain sources, which will differ in terms of spatial and dynamic characteristics. The research hypothesis is that computational and biophysical models can bring crucial information to clinically interpret the signals measured by MEG and EEG. In particular, they can help to efficiently address some complementary questions faced by epileptologists when analyzing electrophysiological data.

7.2.3. ADT

7.2.3.1. ADT BCI-Browser

Participants: Théodore Papadopoulo, Maureen Clerc.

Duration: 1 year

Most often, BCI techniques are demonstrated in simple toy applications made. The only "few" real BCI applications are specific developments and are not used much as they lack of functionality, maintenance, ... The goal of this development contract is to demonstrate a new approach to BCI, in which BCI interactions are integrated in existing applications. Ideally, the original software is not modified and not even recompiled. It is modified by providing either modified GUI libraries or providing extensions as plugins. As a proof of concept, we aim at modifying C++/Qt applications with a focus on web browsing, by redefining some of its basic interactions (mouse clicks, keyboard, ...) using some BCI components. In this manner, it might be possible to drive standard and state-of-the-art application using BCI and at a limited maintenance cost.

This contract is part of the AMDT initiative.

7.2.3.2. ADT BOLIS 2

Participants: Théodore Papadopoulo, Juliette Leblond [FACTAS project-team], Jean-Paul Marmorat [CMA Ecole des Mines Paritech].

Duration: *6 months.*

This contract is a follow-up of ADT BOLIS which aimed at building a sofware platform dedicated to inverse source localisation, building upon the elements of software found in FindSources3D. The platform is modular, ergonomic, accessible and interactive and offers a detailed visualisation of the processing steps and the results. Its goal is to provide a convenient graphical interface and a tool that can be easily distributed and used by professionals (target audience: clinicians and researchers). BOLIS 2 aims at simplifying some maintenance aspects of the software.

This contract is part of the AMDT initiative.

7.2.3.3. ADT OpenMEEG

Participants: Théodore Papadopoulo, Maureen Clerc, Kostiantyn Maksymenko, Alexandre Gramfort [PARIETAL], Joan Massich [PARIETAL].

Duration: *24 months.*

The OpenMEEG ADT aims at improving OpenMEEG along 3 main directions:

1. Offer a user interface for the creation and verification of head models most importantly for a simpler management of non-nested head models.
2. Improve the Python interface (extension and reliability). This will also be useful to develop new research axes (in connection with point 3).
3. Enrich the available operators and refactor the code to offer new possibilities in OpenMEEG and reduce the cost of maintenance.

In addition to the expected gains in code maintenance, these improvements will allow a number of new – more sophisticated – applications as well as open OpenMEEG to a larger audience with a simplified interface for classical use-cases.

This contract is part of the AMDT initiative.

7.3. European Initiatives

7.3.1. FP7 & H2020 Projects

7.3.1.1. ERC AdG CoBCoM

Program: H2020-EU.1.1. (ERC-ADG-2015 - ERC Advanced Grant)

Project acronym: CoBCoM - **ID:** 694665

Project title: *Computational Brain Connectivity Mapping*

Start date: 2016-09-01, End date: 2021-08-31

P.I. : R. Deriche

Partners: ATHENA project-team

Abstract:

One third of the burden of all the diseases in Europe is due to problems caused by diseases affecting brain. Although exceptional progress has been obtained for exploring it during the past decades, **the brain is still terra-incognita** and calls for specific research efforts to better understand its architecture and functioning.

CoBCoM is our response to this great challenge of modern science with the overall goal to **develop a joint Dynamical Structural-Functional Brain Connectivity Network** (DSF-BCN) solidly grounded on advanced and integrated methods for diffusion Magnetic Resonance Imaging (dMRI) and Electro & Magneto-Encephalography (EEG & MEG).

To take up this grand challenge and achieve new frontiers for brain connectivity mapping, we will develop a new generation of computational models and methods for identifying and characterizing the structural and functional connectivities that will be at the heart of the DSF-BCN. Our strategy is to break with the tradition to incrementally and separately contributing to structure or function and develop **a global approach involving strong interactions between structural and functional connectivities.** To solve the limited view of the brain provided just by one imaging modality, our models will be developed under a rigorous computational framework integrating complementary non invasive imaging modalities: dMRI, EEG and MEG.

CoBCoM will push far forward the state-of-the-art in these modalities, developing **innovative models and ground-breaking processing tools** to provide in-fine a joint DSF-BCN solidly grounded on a detailed mapping of the brain connectivity, both in space and time.

Capitalizing on the strengths of dMRI, MEG & EEG methodologies and building on the **bio-physical and mathematical foundations** of our new generation of computational models, CoBCoM will be applied to high-impact diseases, and its **ground-breaking computational nature and added clinical value** will open new perspectives in neuroimaging.

7.3.1.2. ChildBrain ETN

ATHENA is an Associated Partner in the ChildBrain European Training Network: the team participates in training workshops and receive PhD students in secondments.

Program: European Training Network

Project acronym: ChildBrain

Project title: Advancing brain research in children's developmental neurocognitive disorders

Duration: March 2015 to March 2019

Coordinator: Prof. Paavo Leppänen, University of Jyväskylä, Finland

Other partners: University of Leuven (Belgium), University of Münster (Germany), Rabboud University (The Netherlands), Aston University (United Kingdom), IcoMetrix (Belgium), Elekta (Finland), BESA (Germany)

Abstract: The purpose of the ChildBrain ETN is to train young scientists, i.e. Early Stage Researchers (ESRs), to utilise evidence-based neuroscientific knowledge for helping children, especially those at high risk for dropout due to neurocognitive disorders, to meet future educational and societal demands.

7.4. International Initiatives

7.4.1. Inria International Partners

7.4.1.1. Declared Inria International Partners

- Sherbrooke University, CA (M. Descoteaux)
- CMRR, University of Minnesota, USA (C. Lenglet)
- Verona University, It (G. Menegaz)
- Department of CISE, the University of Florida, Gainesville, USA (B. C. Vemuri)
- Centre for Medical Image Computing (CMIC), Dept. Computer Science, UCL, UK (D. Alexander)
- SBIA, University of Pennsylvania Medical School, USA (R. Verma).
- EEMagine company on EEG/MEG hardware.

7.4.1.2. Informal International Partners

- University Houari Boumedienne (USTHB, Algiers) (L. Boumghar) and University of Boumerdes, (D. Cherifi), Algeria.

7.5. International Research Visitors

7.5.1. Visits of International Scientists

- Dr. Ragini Verma, Section of Biomedical Image Analysis, Center for Biomedical Image Computing and Analytics, Department of Radiology, University of Pennsylvania, USA (Oct 1st, 2018 - Dec 21st, 2018)
- Dr. Moo K. Chung, Waisman Laboratory for Brain Imaging and Behavior, University of Wisconsin-Madison, From Sept.10 to 14, 2018

7.5.1.1. Internships

- Rebecca Bonham-Carter - Queen's University, Kingston, Canada, From early May to late July, 2918.
- Max Amatsuji-Berry - Queen's University, Kingston, Canada, From early May to late July, 2918.
- Etienne Saint-Onge - Sherbrooke University, From Early Feb. to early June 2018.

BEAGLE Project-Team

8. Partnerships and Cooperations

8.1. Regional Initiatives

- Lipuscale (2018-2019): Hybrid simulation of lipid digestion and absorption, a two-year project funded by the Rhône-Alpes Institute for Complex Systems (IXXI). With Marie-Caroline Michalski (CarMeN, INSERM U1060, INRA U1397) and Samuel Bernard (Institut Camille Jordan and Inria Dracula team). Participant: Carole Knibbe.

8.2. National Initiatives

8.2.1. ANR

Dopaciumcity (2014-2018): Dopamine modulation of calcium influx underlying synaptic plasticity, a 4-year project funded by a grant from the ANR-NSF-NIH Call for French-US Projects in Computational Neuroscience. With L. Venance, College de France, CIRB, CNRS/UMR 7241 - INSERM U1050, Paris, France and K Blackwell, Krasnow Institute of Advanced Studies, George Mason University, Fairfax, VA, USA. Supervisor: L Venance (for France) and K.L. Blackwell (for US). Participants: H Berry, I Prokin, A Foncelle

Dallish (2016-2020): Data Assimilation and Lattice LIght SHeet imaging for endocytosis/exocytosis pathway modeling in the whole cell, Call AAPG ANR 2016. With C. Kervrann (Inria Rennes), J. Salamero (Institute Curie, Paris), B. Laroche (INRA, Jouy-en-Josas). Participants: H. Berry.

Storiz (2018-2020): Horizontal transfers as documents from extinct or unknown species. Call ANR JCJC 2018. Leaded by Damien de Vienne (LBBE, Lyon) Participant: Eric Tannier

LncEvoSys (2017-2019): An evolutionary systems approach to understand long non-coding RNA functionality, Call ANR JCJC 2017. Leaded by Anamaria Necsulea (LBBE, Lyon). Participant: Eric Tannier

8.2.2. Inria

ADT Phylophile (2016-2018). Participants: E Tannier, in collaboration with D Parsons, Inria, V Daubin, B Boussau, CNRS, Université de Lyon 1. This project aims at producing an easy to use software integrating modern algorithmic methods to build gene trees. It has been funded by Inria by a 24 month software engineer.

Naviscope (Inria Project Lab, 2018-2022): image-guided Navigation and VIsualization of large data sets in live cell imaging and microSCOPy. Nowadays, the detection and visualization of important localized events and process in multidimensional and multi-valued images, especially in cell and tissue imaging, is tedious and inefficient. Specialized scientists can miss key events due to complexity of the data and the lack of computer guidance. In Naviscope we develop original and cutting-edge visualization and navigation methods to assist scientists, enabling semi-automatic analysis, manipulation, and investigation of temporal series of multi-valued volumetric images, with a strong focus on live cell imaging and microscopy application domains. We build Naviscope upon the strength of scientific visualization and machine learning methods in order to provide systems capable to assist the scientist to obtain a better understanding of massive amounts of information. Such systems will be able to recognize and highlight the most informative regions of the dataset by reducing the amount of information displayed and guiding the observer attention. Head: C. Kervrann (Serpico), other EPIs: Aviz, Beagle, Hybrid, Morpheme, Mosaic, Parietal, and MaIage (INRA unit).

8.3. International Initiatives

8.3.1. Inria International Partners

8.3.1.1. Informal International Partners

- Anton Crombach collaborates with Dr. Alexander Fleischmann, who moved this year from CIRB, College de France (Paris), to Brown University, USA.
- Carole Knibbe collaborates with Kirsty Spalding and Peter Arner from Karolinska University Hospital in Stockholm, Sweden.
- Eric Tannier collaborates with Gergerly Szollosi, Eotvos University, Budapest, Cedric Chauve, SFU, Vancouver, Igor Sharakov, from Virginia Tech, Rob Waterhous, Univ Lausanne, Tom Williams, Univ Bristol, ...
- Eric Tannier has leaded the publication of a collaborative paper on a phylogenetic format co-signed by 27 researchers from 10 nationalities.

8.3.2. Participation in Other International Programs

Program: CNRS-Royal society

Project title: Modeling lateral gene transfer on a new bacterial tree

Duration: 2018

Coordinator: Bastien Boussau

Other partners: Eric Tannier (Beagle), LBBE (Lyon), Eotvos University (Budapest), University of Bristol (UK)

Abstract: Bacteria play a major role in human health and in the functioning of all ecosystems. Most of the genomes available in public databases come from Bacteria. However, we understand little of their evolution: both their phylogeny and their timeline of diversification are highly uncertain. This is due in great part to the difficulty of reconstructing events that happened billions of years ago, and also to the fact that individual genes are often transferred across species and therefore have a history that differs from that of the species that contain them. Recently we have proposed novel methods for dealing with the very problems that make reconstructing the bacterial phylogeny challenging. This proposal aims to support a joint project that will reconstruct and date the bacterial phylogeny by combining novel methods (Boussau, Lyon) with existing skills in microbial phylogenetics, genomics and evolution (Williams, Bristol).

8.4. International Research Visitors

8.4.1. Visits to International Teams

Audrey Denizot stayed 4 months in Okinawa, OIST University, Erik de Schutter's team, from june to october 2018

BIGS Project-Team

8. Partnerships and Cooperations

8.1. National Initiatives

- GDR 3475 Analyse Multifractale, Funding organism: CNRS, Leader: S. Jaffard (Université Paris-Est), Céline Lacaux
- GDR 3477 Géométrie stochastic, Funding organism: CNRS, Leader: P. Calka (Université Rouen), Céline Lacaux
- FHU CARTAGE (Fédération Hospitalo Universitaire Cardial and ARTerial AGEing ; leader : Pr Athanase Benetos), Jean-Marie Monnez
- RHU Fight HF (Fighting Heart Failure ; leader : Pr Patrick Rossignol), located at the University Hospital of Nancy, Jean-Marie Monnez
- Project "Handle your heart", team responsible for the creation of a drug prescription support software for the treatment of heart failure, head: Jean-Marie Monnez
- A. Gégout-Petit, N. Sahki, S. Mézières are involved in the learning aspect of the clinical protocol "EOLEVAL" with Assistance Publique des Hopitaux de Paris (APHP)
- "ITMO Physics, mathematics applied to Cancer" (2017-2019): "Modeling ctDNA dynamics for detecting targeted therapy", Funding organisms: ITMO Cancer, ITMO Technologies pour la santé de l'alliance nationale pour les sciences de la vie et de la santé (AVIESAN), INCa, Leader: N. Champagnat (Inria TOSCA), Participants: A. Gégout-Petit, A. Muller-Gueudin, P. Vallois.
- PEPS AMIES (2018-2019), Etude Biométrique en foetopathologie et développement de l'enfant, Collaboration Institut Elie Cartan avec le CRESS INSERM, S. Ferrigno.
- Modular, multivalent and multiplexed tools for dual molecular imaging (2017-2020), Funding organism: ANR, Leader: B Kuhnast (CEA). Participant: T. Bastogne.
- Sophie Mézières belongs to GDR 720 ISIS, Funding organism: CNRS, leader: Laure Blanc-Féraud.

8.2. European Initiatives

8.2.1. Collaborations in European Programs, Except FP7 & H2020

T. Bastogne participates to the ASCATIM Project (project FEDER), leaded by N. Tran and J.-P. Jehl (2018-2021).

BIOCORE Project-Team

9. Partnerships and Cooperations

9.1. National Initiatives

9.1.1. National programmes

- **ANR-Phycover:** The overall objective of the PHYCOVER project (2014-2018) is to identify a modular wastewater treatment process for the production of biogas. The method combines three modules. First, a high-rate algal pond is dedicated to the treatment of municipal wastewater. Then, an anaerobic digester capable of co-digesting biomass products (and others organic matter resources) to significantly reduce biological and chemical contaminants while producing a sustainable energy as biogas is analysed. A final module transforms the residual carbon, nitrogen and phosphorus into high-value microalgae dedicated to aquaculture and green chemistry.
- **ITE-OPALE:** The goal of the Institut de la Transition Énergétique - OPALE project (2016-2019) is to increase the lipid content of microalgae by specific selection pressure. The project relies on the strain already selected during the Facteur 4 project, whose productivity was 4 times higher than the wild type. We expect to still increase strain performances up to 10 times the productivity of the wild type.
- **ANR-FunFit:** The objective of this project (2013-2018) is to develop a trait-based approach linking individual fitness of fungal plant pathogens to ecological strategies. The idea is to derive eco-epidemiological strategies from fitness optimization in colonized environments and during colonization, as well as understanding the coexistence of sibling species. This project is co-coordinated by F. Grognard.
- **ANR-TripTic:** The objective of this project (2014-2018) is to document the biological diversity in the genus of the minute wasps *Trichogramma*, and to study the behavioral and populational traits relevant to their use in biological control programs.
- **ANR-ICycle:** This project (2016-2020) aims at understanding the communication pathways between the cell division cycle and the circadian clock, using mathematical modeling and control theory to construct and implement two coupled synthetic biological oscillators. Project coordinated by M. Chaves.
- **ANR - Maximic:** The goal of the project (2017-2021) is to design and implement control strategies in a bacterium from producing at maximal rate a high value product. It is coordinated by H. de Jong (IBIS Grenoble), and involves members of Biocore and McTao.
- **Plan Cancer - Imodrez:** The objective of this project (2018-2021) is to understand cancer drug response heterogeneity using tumor single-cell dynamics and developing mathematical models and computational approaches. A project coordinated by J. Roux (IRCAN) and funded by Inserm - Plan Cancer.
- **SIGNALIFE:** Biocore is part of this Labex (scientific cluster of excellence) whose objective is to build a network for innovation on Signal Transduction Pathways in life Sciences, and is hosted by the University of Nice Sophia Antipolis.
- **UMT FIORIMED:** FioriMed is a Mixed Technology Unit created in January 2015 to strengthen the production and dissemination of innovation to the benefit of ornamental horticulture. Horticultural greenhouses are seen as a "laboratory" for the actual implementation of agroecology concepts with the possibility of generic outcomes being transfered to other production systems. The main partners of UMT FioriMed are ASTREDHOR (National Institute of Horticulture) and the ISA Joint Research Unit of INRA-CNRS-Univ. Nice.

- **ADEME Phytorecolt:** The goal of this project (2017-2019) is to develop an automated and optimized procedure for microalgae harvesting. A project coordinated by H. Bonnefond.

9.1.2. Inria funding

- **Inria Project Lab, Algae** ***in silico*****:** (2014-2018) The Algae in silico Inria Project Lab, funded by Inria and coordinated by O. Bernard, focuses on the expertise and knowledge of biologists, applied mathematicians and computer scientists to propose an innovative numerical model of microalgal culturing devices. The latest developments in metabolic modeling, hydrodynamic modeling and process control are joined to propose a new generation of advanced simulators in a realistic outdoor environment. The project gathers 5 Inria project teams and 3 external teams.
- **Inria Project Lab, Cosy:** (2017-...) This proposal aims at exploiting the potential of state-of-art biological modeling, control techniques, synthetic biology and experimental equipment to achieve a paradigm shift in control of microbial communities. We will investigate, design, build and apply an automated computer-driven feedback system for control of synthetic microbial communities, not just accounting for but rather leveraging population heterogeneity in the optimal accomplishment of a population-level task. The development of methodologies of general applicability will be driven by and applied to two different applications closely connected with real-world problems in the biomedical and biotechnological industry. The consortium is composed of the four Inria project-teams IBIS, BIOCORE, COMMANDS, NON-A, the Inria Action Exploratoire INBIO, as well as the external partners BIOP (Université Grenoble Alpes, including members of IBIS), MaIAge (INRA), and YoukLAB (TU Delft).

9.1.3. INRA funding

- **MoGeR:** “From knowledge to modeling: towards a user-friendly simulation tool to test crop resistance management scenarios in the Phoma-oilseed rape case study”, INRA Metaprogramme SMaCH, 2017–2019. This is a follow-up of the K-Masstec project, which focused on sustainable strategies for the deployment of genetic resistance in the field, based on molecular knowledge on avirulence genes.
- **ABCD:** INRA SPE is funding the project ABCD "Augmentative Biological Control; optimizing natural ennemies Deployment" (2017-2019) in which Biocore is a partner with INRA Sophia Antipolis.

9.1.4. Networks

- **GDR Invasions Biologiques:** The objectives of this GDR are to encourage multidisciplinary research approaches on invasion biology. It has five different thematic axes: 1) invasion biology scenarios, 2) biological invasions and ecosystem functioning, 3) environmental impact of invasive species, 4) modeling biological invasions, 5) socio-economics of invasion biology. L. Mailleret is a member of the scientific comittee of the GDR .
- **ModStatSAP:** The objective of this INRA network is to federate researchers in applied mathematics and statistics and to promote mathematical and statistical modeling studies in crop and animal health. S. Touzeau is a member of the scientific committee.
- **Seminar:** BIOCORE organizes a regular seminar “Modeling and control of ecosystems” at the station zoologique of Villefranche-sur-Mer, at INRA-ISA or at Inria.

9.2. European Initiatives

9.2.1. Collaborations in European Programs, Except FP7 & H2020

Program: **PHC-Pessoa** Partenariat Hubert Curien with Portugal, managed by Campus France

Project acronym: **LTSB**

Project title: Logic Tools for Systems Biology

Duration: 01/2018 - 12/2018

Coordinator: M. Chaves

Other partners: M.A. Martins, University of Aveiro

Abstract: This project aims at developing Boolean, piecewise linear and other hybrid tools for analysis of biological networks.

9.2.2. Collaborations with Major European Organizations

Imperial college, Department of Chemical engineering (UK),

Modeling and optimization of microalgal based processes.

University of Padova, Italy.

Modeling and control of microalgal production at industrial scale.

9.3. International Initiatives

9.3.1. Inria International Labs

Associate Team involved in the International Lab: **Inria Chile**

9.3.1.1. GREENCORE

Title: Modeling and control for energy producing bioprocesses

International Partners (Institution - Laboratory - Researcher):

PUCV (Chile) - Escuela de Ingenieria Bioquimica (EIB) - David Jeison

UTFSM (Chile) - Departamento de Matematica - Pedro Gajardo

Univ. Chile (Chile) - Centro de modelacion matematica - Hector Ramirez

Inria coordinator: O. Bernard

Start year: 2014

See also: https://team.inria.fr/eagreencore/

The worldwide increasing energy needs together with the ongoing demand for CO2 neutral fuels represent a renewed strong driving force for the production of energy derived from biological resources. In this scenario, the culture of oleaginous microalgae for biofuel and the anaerobic digestion to turn wastes into methane may offer an appealing solution. The main objective of our proposal is to join our expertise and tools, regarding these bioprocesses, in order to implement models and control strategies aiming to manage and finally optimize these key bioprocesses of industrial importance. By joining our expertise and experimental set-up, we want to demonstrate that closed loop control laws can significantly increase the productivity, ensure the bioprocess stability and decrease the environmental footprint of these systems. This project gathers experts in control theory and optimization (BIOCORE, UTFSM) together with experts in bioprocesses (PUCV and CMM) and software development.

Associate Team involved in the International Lab: **LIRIMA**, International Laboratory for Research in Computer Science and Applied Mathematics

9.3.1.2. EPITAG

Title: Epidemiological Modeling and Control for Tropical Agriculture

International Partner (Institution - Laboratory - Researcher):

Université de Douala (Cameroon) - Department of Mathematics and Computer Science - Samuel Bowong

Inria coordinator: S. Touzeau

Start year: 2017

See also: https://team.inria.fr/epitag/

EPITAG gathers French and Cameroonian researchers, with a background in dynamical systems and control and with an interest in crop diseases. Crop pests and pathogens are responsible for considerable yield losses. Their control is hence a major issue, especially in Cameroon, where agriculture is an important sector in terms of revenues and employment. To help design efficient strategies for integrated pest management, mathematical models are particularly relevant. Our main objective is to study the epidemiology and management of tropical crop diseases, with a focus on Cameroon and Sub-Saharan Africa. Our approach consists in developing and analysing dynamical models describing plant-parasite interactions, in order to better understand, predict and control the evolution of damages in crops. To ensure the relevance of our models, "end users" are closely associated. We focus on various pathosystems, such as cocoa plant mirids, coffee berry borers, coffee leaf rust and plantain plant-parasitic nematodes.

9.3.2. Inria International Partners

- NTNU (Norwegian University of Science and Technology), Trondheim, Norway. The project involves turning wastes into bioenergy with anaerobic digestion.
- University Ben Gurion : Microalgal Biotechnology Lab (Israel), Member of the ESSEM COST Action ES1408 European network for algal-bioproducts (EUALGAE). Modeling of photosynthesis.
- University of Manitoba: Department of Mathematics (Canada). Julien Arino hosted Nicolas Bajeux for 5 months. Invasion in metapopulations.

9.4. International Research Visitors

9.4.1. Visits of International Scientists

Luca Scardovi, University of Toronto, Canada, from Feb 2018 until June 2018. Long-term visit, to establish a new collaboration on the coupling and synchronization of biological oscillators.

Daniel Figueiredo, University of Aveiro, Portugal, 17-25 Oct 2018. Visit in the context of PHC-Pessoa project to work on the development of logical tools for systems biology.

Israël Tankam Chedjou, University of Yaoundé 1, Cameroon, April-August 2018. 5-month stay in the context of the EPITAG associate team.

Yves Fotso Fotso, University of Dschang, Cameroon, April-September 2018. 5-month stay in the context of the EPITAG associate team.

Clotilde Djuikem, University of Douala, Cameroon, May-July 2018. 3-month stay in the context of the EPITAG associate team.

9.4.2. Visits to International Teams

9.4.2.1. Sabbatical programme

O. Bernard is currently spending a one year sabbatical at NTNU (Norwegian University of Science and Technology), Trondheim, Norway. He works on a project to turn wastes into bioenergy with anaerobic digestion. Many challenges must be solved, from the theoretical stage up to the implementation.

9.5. Other Visits

Hussein Kanso, PhD student at INRA Avignon, a 2-week visit in the context of the work on modeling of sugar metabolism in peach fruit (collaboration with V. Baldazzi).

9.6. Project-team seminar

BIOCORE organized a 3-day seminar in September in Bauduen (Var). On this occasion, every member of the project-team presented his/her recent results and brainstorming sessions were organized.

BIOVISION Project-Team

8. Partnerships and Cooperations

8.1. Regional Initiatives

8.1.1. Modélisation Théorique et Computationnelle en Neurosciences et Sciences Cognitives

The Biovision team is a member of this "Axe Interdisciplinaire de Recherche de l'Université de Nice – Sophia Antipolis" and of the Institute Neuromod of neuroscience modelling . Biovision team has participated to the Rencontre C@UCA 2018 in Fréjus (June 2018). This axe is partly funding our work on retinal waves.

8.2. National Initiatives

8.2.1. ANR

8.2.1.1. Trajectory

Title: Encoding and predicting motion trajectories in early visual networks

Programme: ANR

Duration: October 2015 - September 2020

Coordinator: Invibe Team, Institut des Neurosciences de la Timone, Frédéric Chavane,

Partners:

Institut de Neurosciences de la Timone (CNRS and Aix-Marseille Université, France)

Institut de la Vision (Paris, France)

Universidad Tecnico Federico Santa María (Electronics Engineering Department, Valparaíso, Chile)

Inria contact: Bruno Cessac

Global motion processing is a major computational task of biological visual systems. When an object moves across the visual field, the sequence of visited positions is strongly correlated in space and time, forming a trajectory. These correlated images generate a sequence of local activation of the feed-forward stream. Local properties such as position, direction and orientation can be extracted at each time step by a feed-forward cascade of linear filters and static non-linearities. However such local, piecewise, analysis ignores the recent history of motion and faces several difficulties, such as systematic delays, ambiguous information processing (e.g., aperture and correspondence problems) high sensitivity to noise and segmentation problems when several objects are present. Indeed, two main aspects of visual processing have been largely ignored by the dominant, classical feed-forward scheme. First, natural inputs are often ambiguous, dynamic and non-stationary as, e.g., objects moving along complex trajectories. To process them, the visual system must segment them from the scene, estimate their position and direction over time and predict their future location and velocity. Second, each of these processing steps, from the retina to the highest cortical areas, is implemented by an intricate interplay of feed-forward, feedback and horizontal interactions. Thus, at each stage, a moving object will not only be processed locally, but also generate a lateral propagation of information. Despite decades of motion processing research, it is still unclear how the early visual system processes motion trajectories. We, among others, have proposed that anisotropic diffusion of motion information in retinotopic maps can contribute resolving many of these difficulties. Under this perspective, motion integration, anticipation and prediction would be jointly achieved through the interactions between feed-forward, lateral and feedback propagations within a common spatial reference frame, the retinotopic maps. Addressing this question is particularly challenging, as it requires to probe these sequences of events at multiple

scales (from individual cells to large networks) and multiple stages (retina, primary visual cortex (V1)). “TRAJECTORY” proposes such an integrated approach. Using state-of-the-art micro- and mesoscopic recording techniques combined with modeling approaches, we aim at dissecting, for the first time, the population responses at two key stages of visual motion encoding: the retina and V1. Preliminary experiments and previous computational studies demonstrate the feasibility of our work. We plan three coordinated physiology and modeling work-packages aimed to explore two crucial early visual stages in order to answer the following questions: How is a translating bar represented and encoded within a hierarchy of visual networks and for which condition does it elicit anticipatory responses? How is visual processing shaped by the recent history of motion along a more or less predictable trajectory? How much processing happens in V1 as opposed to simply reflecting transformations occurring already in the retina? The project is timely because partners master new tools such as multi-electrode arrays and voltage-sensitive dye imaging for investigating the dynamics of neuronal populations covering a large segment of the motion trajectory, both in retina and V1. Second, it is strategic: motion trajectories are a fundamental aspect of visual processing that is also a technological obstacle in computer vision and neuroprostheses design. Third, this project is unique by proposing to jointly investigate retinal and V1 levels within a single experimental and theoretical framework. Lastly, it is mature being grounded on (i) preliminary data paving the way of the three different aims and (ii) a history of strong interactions between the different groups that have decided to join their efforts.

8.3. European Initiatives

- Program: Leverhulme Trust
- Project acronym:
- Project title: A novel approach to functional classification of retinal ganglion cells
- Duration: 2017-2020
- Coordinator: Evelyne Sernagor, Institute of Neuroscience (ION, Newcastle, UK)
- Inria contact: Bruno Cessac
- Other partners:

  Melissa Bateson Institute of Neuroscience (ION, Newcastle, UK)

  Matthias Hennig Institute for Adaptive and Neural Computation (ANC, School of Informatics University of Edinburgh, UK)
- Abstract: Vision begins with photoreceptors converting light from different parts of the visual scene into electrical signals, compressing our visual world into a parsimonious code of impulses at the retinal output level, the retinal ganglion cells (RGCs). This information is sent to the brain via only $\approx$1m RGCs (45,000 in mouse). Amazingly, the brain can recreate images from interpreting these “barcodes” or trains of impulses. This ability is partly due to the astonishing functional diversity of RGCs, each interpreting a different feature of the visual scene. It is all these parallel streams of information that impart the complexity of visual scenes to our brain visual areas. At present, at least 30 RGC subtypes have been identified. Classification is typically based on common anatomical features, or on basic functions (e.g. whether cells respond to the onset or offset of the light, or whether they are sensitive to motion direction) and it has recently progressed to include molecular markers. Recent studies have successfully characterised common physiological properties between RGCs sharing gene expression, suggesting that their molecular signature may indeed be a good indicator of function. However, according to mouse genetics repositories (e.g., the Allen Brain Project) many genes are expressed in subpopulations of RGCs for which we have no phenotype yet. Genes that are expressed in most RGCs probably do not reflect specific functional populations, but some other genes are expressed only in sparse RGC groups. Each gene-specific class exhibits a distinct spatial mosaic pattern across the retina, suggesting that the cells belong to a common group. Many classes, even sparse, exhibit asymmetric distributions across the retina, e.g., with larger

numbers on the ventral or dorsal side, suggesting specific roles in ecological vision, e.g., specialised in detecting moving objects in the sky (ventral) or on the ground (dorsal).

We propose to develop a multidisciplinary approach to functionally phenotype "new" RGC subclasses sharing gene expression. Rather than inferring knowledge about the entire population from studying individual cells, we will take a global approach based on large-scale, high-density pan-retinal recordings, pharmacogenetics (allowing us to selectively silence defined cell populations at will) and high-resolution imaging combined with computational approaches and behaviour. This novel approach necessitates collaboration between retinal neurophysiologists, animal behaviour specialists (Newcastle) and modellers (Inria) who specialise in visual processing and have sophisticated mathematical tools and software to handle and interpret the encoding of visual information at the pan-retinal level.

8.4. International Initiatives

8.4.1. International Research Network to Study Predictive Coding in the Retina

Program: CHILEAN SUPPORT OF INTERNATIONAL NETWORKING BETWEEN RESEARCH CENTRES

Project title: International Research Network to Study Predictive Coding in the Retina

Duration: 2018-2020

Coordinator: Maria-José Escobar, Advanced Center for Electrical and Electronic Engineering, Universidad Técnica Federico Santa María, Chile

Other partners:

Advanced Center for Electrical and Electronic Engineering (Valparaiso, Chili)

Centro Interdisciplinario de Neurociencia de Valparaíso (CINV, Valparaíso, Chile)

Abstract: The retina, a well-structured multilayer neural system, encodes the visual information of the environment from an input of photon flux to a series of electrical pulses that are ultimately readout by the brain to create perception and program motor actions. The retina, from an engineering point of view, can be seen as a series of circuits computing visual features from the visual world in parallel encoding only informative inputs that are then sent to the brain. Regarding all the visual features that can be detected from the outer world, motion processing represents a fundamental visual computation ruling many visuomotor behaviours. Motion sensitive neurons have been early reported in the retina, but recently additional features have been added to the pool of capabilities present in this organ: especially motion direction selectivity and predictive coding. Motion processing presents predictive coding characteristics, in the sense that there is an anticipatory response of the visual system when an object in motion follows a trajectory in the visual field. Motion anticipation is fundamental for survival. Interestingly, this mechanism, observed in the visual cortex, has been also reported in the retina. Understanding how the visual system accumulates information along a certain trajectory raises fundamental questions about neural computation, its dynamics, and implementation. This understanding could be also extended to new algorithms to image/video processing, and also, autonomous navigation of robots.

In this project, we propose the formal establishment of a collaborative network between the AC3E Biomedical System group (AC3E-UTFSM), Centro Interdisciplinario de Neurociencia de Valparaíso (CINV -UV) and Biovision team (Inria Sophia-Antipolis Mediterranée), gathering together skills related with physiological recording in the retina, data analysis and theoretical tools to implement functional and biophysical models. This network aims to study the anticipatory response observed in the mammalian retina, characterizing its underlying mechanisms and the predictive coding capabilities present in this part of the nervous system.

8.4.2. Inria International Partners

8.4.2.1. Declared Inria International Partners

Institute of Neuroscience (ION, Newcastle, UK)

Institute for Adaptive and Neural Computation (ANC, School of Informatics University of Edinburgh, UK)

Universidad Tecnico Federico Santa María (Electronics Engineering Department, Valparaíso, Chile)

Centro Interdisciplinario de Neurociencia de Valparaíso (CINV, Valparaíso, Chile)

University of Genoa (DIBRIS, Genoa, Italy)

8.5. International Research Visitors

8.5.1. Visits of International Scientists

Prof. Sarah Barman (School of Computer Science and Mathematics, Kingston University)

Dr Matteo Di Volo (Unité de Neurosciences Information et Complexité, Gif sur Yvette, France)

Dr Cyril Eleftheriou (IIT, Genova)

Dr Maria-José Escobar (Universidad Tecnico Federico Santa María (Electronics Engineering Department, Valparaíso, Chile))

8.5.1.1. Internships

Téva Andréoletti (Apr–Aug 2018)

Adrianna Janik (Oct 2017–Mar 2018)

Paula Pawlowski (Apr–Sept 2018)

BONSAI Project-Team

7. Partnerships and Cooperations

7.1. National Initiatives

7.1.1. ANR

- ANR Transipedia: The purpose of Transipedia is to provide means of identifying relevant transcriptomic events within thousands of RNA sequencing experiments. This project will be achieved in collaboration with I2BC (principal investigator) in Paris Saclay and IRMB in Montpellier.
- ANR ASTER: ASTER is a national project that aims at developing algorithms and software for analyzing third-generation sequencing data, and more specifically RNA sequencing. BONSAI is the principal investigator in this ANR. Other partners are Erable (LBBE in Lyon) and two sequencing and analysis platforms that have been very active in the MinION Access Program (Genoscope and Institut Pasteur de Lille).
- PIA France Génomique: National funding from "Investissements d'Avenir" (call *Infrastructures en Biologie-Santé*). France Génomique is a shared infrastructure, whose goal is to support sequencing, genotyping and associated computational analysis, and increases French capacities in genome and bioinformatics data analysis. It gathers 9 sequencing and 8 bioinformatics platforms. Within this consortium, we are responsible for the work package devoted to the computational analysis of sRNA-seq data, in coordination with the bioinformatics platform of Génopole Toulouse-Midi-Pyrénées.

7.1.2. ADT

- ADT SeedLib (2017–2019): The SeedLib ADT aims to consolidate existing software developments in Bonsai, into an existing and well-engineered framework. Bonsai has published several new results on spaced seeds and developed several tools that integrate custom implementations of spaced seeds. In parallel, the GATB project is a C++ software library that facilitates the development of next-generation sequencing analysis tools. It is currently maintained by a collaboration between the GenScale team at Inria Rennes and the Bonsai team. Many users from other institutions (including the Erable team at Inria Rhones-Alpes) actively develop tools using GATB. The core object in GATB is k-mers, which can be seen as the predecessor of spaced seeds. The goal of this ADT is to integrate existing space seeds formalisms into GATB, therefore further expanding the features offered by the library, and at the same time provide visibility for tools and results in the Bonsai team.

7.2. European Initiatives

7.2.1. Collaborations in European Programs, Except FP7 & H2020

- International ANR RNAlands (2014-2018): National funding from the French Agency Research (call *International call*). Our objective is the fast and efficient sampling of structures in RNA Folding Landscapes. The project gathers three partners: Amib from Inria Saclay, the Theoretical Biochemistry Group from Universität Wien and BONSAI.
- Interreg Va (France-Wallonie-Vlaanderen): Portfolio "SmartBioControl", including 5 constitutive projects and 25 partners working together towards sustainable agriculture.

7.3. International Research Visitors

7.3.1. Visits of International Scientists

7.3.1.1. Internships

- Inria MITACS 3-month internship of D. Martchenko (PhD student, Trent University)

CAMIN Team

8. Partnerships and Cooperations

8.1. Regional Initiatives

We have obtained a financial support from Occitanie Region for the CIFRE PhD thesis (Xynue Lu) with NEURORESP Company "PILE CIFRE" BREATHLOOP.

8.2. National Initiatives

- Inria ADT STIMBIO

  Participants : Christine Azevedo, Daniel Simon, Ronan Le Guillou, Benoît Sijobert.

  A 1-year engineer (R. LeGuillou) was funded by Inria ADT on the development of an architecture dedicated to FES-cycling platform.
- I-SITE MUSE COMPANIES AND CAMPUS grant

  Collaboration with academic local partners (CHU, IES) and NEURINNOV company on the spinal stimulation for bladder and bowel functions restoration. This is linked to an ongoing collaboration with Oslo University (Norway).
- LABEX NUMEV MEDITAPARK

  Collaboration with Montpellier Hospital (Neurology service) and the Montpellier Mindfulness Center to analyze the impact of meditation on upper limb tremor.
- EDF Foundation

  Collaboration with La Châtaigneraie Hospital on FES-assisted cycling. Financial support for a study on FES-cycling training method and performance otimization on individuals with complete spinal cord injury.
- I-SITE MUSE - EXPLORE

  Support for the visit of Henrique Resende (UFMG, Brazil) and Emersion Fachin (UNB, Brazil) as guest researchers from December to February 2019. Completed with a LIRMM laboratory financial aid.

8.3. European Initiatives

Program: EIT Health

Project acronym: Agilis

Project title: Restoration of Hand Functions in Tetraplegia through Selective Neural Electrical Stimulation

Duration: Jan. 2019 - June 2020

Coordinator: Camin Inria

Other partners: APHP, Univ. Heidelberg, CRF La Châtaigneraie, Neurinnov.

Abstract: Complete tetraplegia leads to inability to move, thus use, both hands. To date, there is no solution to restore this absolutely needed function for very common daily activities such as social interactions, washing, eating or self catheterizing. We aim at an innovative implanted stimulation of only two nerves associated with an intuitive interface. It will provide functional grasping without a third person and thus will drastically increase the autonomy of such people for the rest of their life.

8.4. International Initiatives

8.4.1. Inria Associate Teams Not Involved in an Inria International Labs

8.4.1.1. CACAO

Title: Lower limb electrical stimulation for function restoration

International Partner (Institution - Laboratory - Researcher):

UNB Brasilia (Brazil), Physiotherapy department, Emerson Fachin Martins.

Start year: 2016

See also: https://team.inria.fr/cacao/

Electrical stimulation (ES) can activate paralyzed muscles to support rehabilitation. ES applied to fully or partially paralyzed muscles artificially induces muscle contraction substituting or completing the normal volitional control. In CACAO team we join our efforts and specific expertise to develop approaches of lower limb function restoration in spinal cord injured individuals. Two main applications have been addressed: 1) Functional Electrical Stimulation (FES) to assist SCI individuals to perform pivot transfers and 2) FES-assisted cycling. We aim at proposing solutions that can have an effect on patients' quality of life, thus our choices intend to be realistic form a practical point of view.

8.4.1.2. Informal International Partners

CAMIN collaborates with Dr JL Boulland (Norwegian Center for Stem Cell Research at Oslo University Hospital in Norway) on FES-assisted bladder and bowel functions restoration.

8.5. International Research Visitors

Henrique Resende (UFMG, Brazil) and Emerson Fachin (UNB, Brazil) will spend 3 months in CAMIN team from December 2018 to February 2019 to work on FES-cycling project.

CAPSID Project-Team

8. Partnerships and Cooperations

8.1. Regional Initiatives

8.1.1. CPER – IT2MP

Participants: Marie-Dominique Devignes [contact person], Malika Smaïl-Tabbone, David Ritchie.

Project title: *Innovations Technologiques, Modélisation et Médecine Personnalisée*; PI: Faiez Zannad, Univ Lorraine (Inserm-CHU-UL). Value: 14.4 M€ ("SMEC" platform – Simulation, Modélisation, Extraction de Connaissances – coordinated by Capsid and Orpailleur teams for Inria Nancy – Grand Est, with IECL and CHRU Nancy: 860 k€, approx); Duration: 2015–2020. Description: The IT2MP project encompasses four interdisciplinary platforms that support several scientific pôles of the university whose research involves human health. The SMEC platform supports research projects ranging from molecular modeling and dynamical simulation to biological data mining and patient cohort studies.

8.1.2. LUE-FEDER – CITRAM

Participants: Marie-Dominique Devignes [contact person], Isaure Chauvot de Beauchêne, Bernard Maigret, Philippe Noël, David Ritchie.

Project title: *Conception d'Inhibiteurs du Transfert de Résistances aux agents Anti-Microbiens: bio-ingénierie assistée par des approches virtuelles et numériques, et appliquée à une relaxase d'élément conjugatif intégratif*; PI: N. Leblond, Univ Lorraine (DynAMic, UMR 1128); Other partners: Chris Chipot, CNRS (SRSMSC, UMR 7565); Value: 200 k€ (Capsid: 80 k€); Duration: 2017–2018. Description: This project follows on from the 2016 PEPS project "MODEL-ICE". The aim is to investigate protein-protein interactions required for initiating the transfer of an ICE (Integrated Conjugative Element) from one bacterial cell to another one, and to develop small-molecule inhibitors of these interactions.

8.1.3. PEPS – DynaCriGalT

Participants: Isaure Chauvot de Beauchêne [contact person], Bernard Maigret, David Ritchie.

Project title: *Criblage virtuel et dynamique moléculaire pour la recherche de bio-actifs ciblant la β4GalT7, une enzyme de biosynthèse des glycosaminoglycanes*; PI: I. Chauvot de Beauchêne, Capsid (Inria Nancy – Grand Est); Partners: Sylvie Fournel-Gigleux, INSERM (IMoPA, UMR 7365); Value: 15 k€; Duration: 2017–2018. Description: The β4GalT7 glycosyltransferase initiates the biosynthesis of glycosaminoglycans (GAGs), and is a therapeutical target for small molecules which might correct a defect in the synthesis and degradation of GAGs in rare genetic diseases. Classical approaches to propose active molecules have failed for this target. The DynaCriGalT project combines molecular dynamics modelling of the GAG active site with virtual screening in order to propose a diverse set of small molecules for *in vitro* compound testing.

8.1.4. PEPS – InterANRIL

Participant: Isaure Chauvot de Beauchêne [contact person].

Project title: *TBA* Duration: 2017–2018. Description: *TBA*

Project title: *Identification et modélisation des interactions nécessaires à l'activité du long ARN non-codant ANRIL dans la régulation épigénétique des gènes*; PI: Sylvain Maenner, Univ Lorraine (IMoPA, UMR 7365); Value: 20 k€; Duration: 2017–2018. Description: ANRIL is a long non-coding RNA (lncRNA) which has been identified as an important factor in the susceptibility cardiovascular diseases. ANRIL is involved in the epigenetic regulation of the expression of a network of genes via mechanisms that are still largely unknown. This project aims to identify and model the protein-RNA and/or DNA-RNA interactions that ANRIL establishes within the eukaryotic genome.

8.1.5. GlycoEst

Participant: Isaure Chauvot de Beauchêne [contact person].

GlycoEst is an informal working group which was recently created to develop an interdisciplinary regional network of Glyco-scientists. Isaure Chauvot de Beauchêne gave a talk on her protein-GAG docking method at the first meeting of this group in March 2018.

8.2. National Initiatives

8.2.1. FEDER – SB-Server

Participants: David Ritchie [contact person], Bernard Maigret, Isaure Chauvot de Beauchêne, Sabeur Aridhi, Marie-Dominique Devignes.

Project title: *Structural bioinformatics server*; PI: David Ritchie, Capsid (Inria Nancy – Grand Est); Value: 24 k€; Duration: 2015–2020. Description: This funding provides a small high performance computing server for structural bioinformatics research at the Inria Nancy – Grand Est centre.

8.2.2. ANR

8.2.2.1. Fight-HF

Participants: Marie-Dominique Devignes [contact person], Malika Smaïl-Tabbone [contact person], Bernard Maigret, Sabeur Aridhi, Kévin Dalleau, Claire Lacomblez, David Ritchie.

Project title: *Combattre l'insuffisance cardiaque*; PI: Patrick Rossignol, Univ Lorraine (FHU-Cartage); Partners: multiple; Value: 9 m€ (Capsid and Orpailleur: 450 k€, approx); Duration: 2015–2019. Description: This "Investissements d'Avenir" project aims to discover novel mechanisms for heart failure and to propose decision support for precision medicine. The project has been granted € 9M, and involves many participants from Nancy University Hospital's Federation "CARTAGE" (http://www.fhu-cartage.com/). In collaboration with the Orpailleur Team, Marie-Dominique Devignes is coordinating a work-package on network-based science and drug discovery for this project.

8.2.2.2. IFB

Participants: Marie-Dominique Devignes [contact person], Sabeur Aridhi, Isaure Chauvot de Beauchêne, David Ritchie.

Project title: *Institut Français de Bioinformatique*; PI: Claudine Médigue and Jacques van Helden (CNRS UMS 3601); Partners: multiple; Value: 20 M€ (Capsid: 126 k€); Duration: 2014–2021. Description: The Capsid team is a research node of the IFB (Institut Français de Bioinformatique), the French national network of bioinformatics platforms (http://www.france-bioinformatique.fr). The principal aim is to make bioinformatics skills and resources more accessible to French biology laboratories.

8.2.3. Collaborations with Major European Organizations

EBI: European Bioinformatics Institute, Maria Martin team (UK). We are working with the EBI team to validate and improve our graph-based approaches for protein function annotation.

8.2.4. PEPS-INS2I – ORCA 3D

Participants: Isaure Chauvot de Beauchêne [contact person], Agnibha Chandra, Rohit Roy.

Protect Title: *Oligo-RNA Combinatorial Assembly for 3D modeling of protein-RNA complexes.* PI: Isaure Chauvot de Beauchêne. Value: 8k€. Description: The project aimed at improving our fragment-based ssRNA docking method, of which we already provided a proof of principle. It mainly provided grants for two internship students to work on (i) a new ssRNA-protein scoring function and (ii) docking with constraints specific to the geometry of ssRNA in RNA loops.

8.3. International Initiatives

8.3.1. TempoGraphs

Participants: Sabeur Aridhi [contact person], Marie-Dominique Devignes, Malika Smaïl-Tabbone, David Ritchie, Bishnu Sarker, Wissem Inoubli.

Project title: *Analyzing big data with temporal graphs and machine learning: application to urban traffic analysis and protein function annotation.* PI: Sabeur Aridhi; Partners: LORIA/Inria NGE, Federal University of Ceará (UFC); Value: 20 k€; Duration: 2017–2020. Description: This project aims to investigate and propose solutions for both urban traffic-related problems and protein annotation problems. In the case of urban traffic analysis, problems such as traffic speed prediction, travel time prediction, traffic congestion identification and nearest neighbors identification will be tackled. In the case of protein annotation problem, protein graphs and/or protein–protein interaction (PPI) networks will be modeled using dynamic time-dependent graph representations.

8.3.1.1. Informal International Partners

Participant: David Ritchie; Project: *Integrative Modeling of 3D Protein Structures and Interactions;* Partner: Rocasolano Institute of Physical Chemistry, Spain. Funding: Inria Nancy – Grand Est ("Nancy Emerging Associate Team").

Participant: Bernard Maigret; Project: *Characterization, expression and molecular modeling of TRR1 and ALS3 proteins of Candida spp., as a strategy to obtain new drugs with action on yeasts involved in nosocomial infections;* Partner: State University of Maringá, Brazil.

Participant: Bernard Maigret; Project: *Fusarium graminearum target selection;* Partner: Embrapa Recursos Geneticos e Biotecnologia, Brazil.

Participant: Bernard Maigret; Project: *The thermal shock HSP90 protein as a target for new drugs against paracoccidioidomicose;* Partner: Brasília University, Brazil.

Participant: Bernard Maigret; Project: *Protein-protein interactions for the development of new drugs;* Partner: Federal University of Goias, Brazil.

8.4. International Research Visitors

8.4.1. Visits of International Scientists

Ghania Khensous from the University of Sciences and Technologies in Oman visited the team to develop a tabu-based search algorithm for flexible protein-ligand docking, under the supervision of Bernard Maigret.

Patricia Alves from the University of Brasilia is visiting the team to carry out drug repositioning on several target fungus proteins under the supervision of Bernard Maigret.

8.4.1.1. Internships

Agnibha Chandra from the Indian Institute of Engineering Science & Technology visited the team to optimize a force-field for ssRNA-protein docking, under the supervision of Isaure Chauvot de Beauchêne.

Ismail El Fadli from the Mohammed V University of Rabat visited the team to adapt our RNA-protein docking method to DNA-protein systems, under the supervision of Isaure Chauvot de Beauchêne.

Aichata Niang from the University of Paris Diderot visited the team to to apply modeling and virtual screening of a galactosyl-transferase enzyme in order to find new inhibitors, under the supervision of Isaure Chauvot de Beauchêne.

Rohit Roy from the Indian Institute of Technology at Kharagpur visited the team in order to include geometric constrains in our docking algorithm for docking RNA loops, under the supervision of Isaure Chauvot de Beauchêne.

Giammarco Mastronardi from the University of Lorraine visited the team to carry out a virtual screening study of small-molecule inhibitors of a bacterial polyketide synthase module, under the supervision of Bernard Maigret and David Ritchie.

Wissem Inoubli from the University of Tunis El Manar visited the team to work on his PhD thesis on distributed graph processing under the supervision of Sabeur Aridhi.

Damien Vantourout from the University of Lorraine visited the team to develop a tool for protein function annotation using semantic protein networks and deep neural networks under the supervision of Sabeur Aridhi.

Xavier Farchetto from the University of Lorraine visited the team to work on the segmentation of images in Crohn's disease under the supervision of Malika Smaïl-Tabbone and Chedy Raissy (Orpailleur team).

Maxime Guyot from the University of Lorraine (Telecom Nancy stage 2A) visited the team to perform statistical analyses on KBDock and to develop a scoring function for protein-protein interaction subgraphs extracted from a knowledge graph database.

CARMEN Project-Team

7. Partnerships and Cooperations

7.1. Regional Initiatives

7.1.1. PhD thesis O. Bouhamama

L. Weynans and L. Bear (Liryc) obtained funding for a PhD thesis from the Université de Bordeaux, for a project titled "Méthodes numériques pour la résolution du problème inverse en électrocardiographie dans le cas d'anomalies structurelles du tissu cardiaque." Candidate O. Bouhamama started in October 2018.

7.1.2. CALM

The project "Cardiac Arrhythmia Localization Methods," granted by the Région Nouvelle-Aquitaine, with matching from funds held by our clinical collaboraters H. Cochet and P. Jaïs, has started. The purpose of this project is to develop a tool that can predict the exit site of an arrhythmia with moderate accuracy (1 cm) in an absolute sense, with respect to the anatomy of the heart in situ, and with a resolution of about 2 mm in a relative sense, with respect to a nearby pacing site. This tool must fulfill the following criteria:

- it uses only data that are already recorded in the cathlab by other systems: ECG data and electroanatomical mapping data;
- it must work in nearly real-time; catheter displacement advice must be available within 5 seconds after a paced beat;
- it must work automatically, requiring the operator only to indicate which ECG data correspond to the target arrhythmia; and
- it must be safe and easy to operate.

We will in the first place test a number of proposed methods using synthetic data, produced with our realistic models of cardiac electrophysiology and accurate geometric models of different patients. This in-silico testing phase will answer a number of important practical questions. Subsequently we will use offline clinical data, and within 2 years we aim to build a clinical prototype that can be tested (without interfering in the procedure) in the cathlab. In order to work real-time we will initially use very simple methods. However, the clinical prototype and the collectoin of synthetic data that we created will later serve also as a platform to test also more sophisticated inverse methods.

7.2. National Initiatives

7.2.1. ANR EXACARD

We started a collaboration with the STORM team at Inria Bordeaux Sud-Ouest to work on further scaling of the Propag code, to push the limit from about 10^4 to 10^6 parallel processors. A proposal for this project was funded this year by ANR. It allows a postdoc to be employed for 2 years.

7.2.2. ANR MITOCARD

The MITOCARD project (Electrophysiology of Cardiac Mitochondria), coordinated by S. Arbault (Université de Bordeaux, ISM), was granted by the ANR in July 2017. The objective of MITOCARD is to improve understanding of cardiac physiology by integrating the mitochondrial properties of cell signaling in the comprehensive view of cardiac energetics and rhythm pathologies. It was recently demonstrated that in the heart, in striking contrast with skeletal muscle, a parallel activation by calcium of mitochondria and myofibrils occurs during contraction, which indicates that mitochondria actively participate in Ca2+ signaling in the cardiomyocyte. We hypothesize that the mitochondrial permeability transition pore (mPTP), by rhythmically depolarizing inner mitochondrial membrane, plays a crucial role in mitochondrial Ca2+ regulation and, as

a result, of cardiomyocyte Ca2+ homeostasis. Moreover, mitochondrial reactive oxygen species (ROS) may play a key role in the regulation of the mPTP by sensing mitochondrial energetics balance. Consequently, a deeper understanding of mitochondrial electrophysiology is mandatory to decipher their exact role in the heart's excitation-contraction coupling processes. However, this is currently prevented by the absence of adequate methodological tools (lack of sensitivity or selectivity, time resolution, averaged responses of numerous biological entities). The MITOCARD project will solve that issue by developing analytical tools and biophysical approaches to monitor kinetically and quantitatively the Ca2+ handling by isolated mitochondria in the cardiomyocyte.

MITOCARD is a multi-disciplinary project involving 4 partners of different scientific fields: the CARMEN team as well as

- **ISM**, the largest chemistry laboratory of the Université de Bordeaux, where the necessary measurement methods will be developed;
- **Liryc**, where mitochondria are studied at all levels of integration from the isolated mitochondrion to the intact heart; and
- **LAAS**, the MiCrosystèmes d'Analyse (MICA) group at the Laboratory of Analysis and Architecture of Systems, which develops the biological microsensors for this project.

The project will

- develop chips integrating 4 different electrochemical microsensors to monitor in real-time key mitochondrial signaling parameters: Ca2+, membrane potential, quinone reduction status, O2 consumption, and ROS production;
- develop microwell arrays integrating ring nanoelectrodes to trap single mitochondria within micrometric chambers and measure locally by combined fluorescence microscopy and electrochemical techniques intra- (by fluorescence) and extra-mitochondrial (electrochemistry) metabolites; and
- develop a mathematical model of mitochondrial Ca2+ and ROS handling built on existing knowledge, new hypotheses, and the measured data.

The model may serve both to assess biological assumptions on the role of mitochondria in Ca2+ signaling and to integrate pathological data and provide clues for their global understanding.

7.2.3. GENCI

GENCI (*grand équipement national de calcul intensif*) is the agency that grants access to all national high-performance resources for scientific purposes in France. GENCI projects have to be renewed yearly. Our project renewal *Interaction between tissue structure and ion-channel function in cardiac arrhythmia*, submitted in September 2018, has been granted 8 million core-hours on the three major systems Irene, Occigen, and Turing. This compute time is primarily destined for our research into the interaction between ionic and structural heart disease in atrial fibrillation, Brugada syndrome, and early repolarisation syndrome [7] [65], and for new HPC developments [27].

7.3. European Initiatives

7.3.1. Collaborations with Major European Organizations

BCAM (Basque Center for Applied Mathematics), Bilbao, Spain: L. Gerardo-Giorda.

We develop surrogate models of Radiofrequency Catheter Ablation for machine learning purposes, with the ambition to provide real-time estimations of lesion depths to clinicians (M. Leguèbe, Y. Coudière).

7.4. International Initiatives

7.4.1. Inria International Labs

International Laboratory for Research in Computer Science and Applied Mathematics

Associate Team involved in the International Lab:

7.4.1.1. EPICARD

Title: inversE Problems In CARDiac electrophysiology

International Partner (Institution - Laboratory - Researcher):

ENIT (Tunisia) - Department of Intelligence Science and Technology - Nabil Gmati

Start year: 2018

See also: https://team.inria.fr/carmen/epicard/

Model personalization is a very challenging question in the numerical modeling community, especially for medical applications like cardiac electrophysiology. Our main idea is to adapt the input data like model parameters and boundary conditions of the electrophysiological measurements. There are two mathematical problems raising from this challenge. The first issue is the identifiability of the parameters and the sensitivity of the identification problem to the measured data. The question is: For given measurements, could we prove that there exist a set of parameters that allows to fit these measurements? The second issue is, how can we estimate parameters, when they are identifiable,? Our idea is to provide a theoretical analysis for the identification of each of the parameters and to construct suitable numerical methods to estimate them.

7.4.2. Inria International Partners

7.4.2.1. Informal International Partners

Y. Coudière works with the group of Prof. Y. Bourgault from the Department of Mathematics and Statistics of the University of Ottawa (Canada). Some results on the numerical analysis of time-stepping methods from C. Douanla's PhD were carried out together, as well as some theoretical results on parameter identification in the PhD of A. Gérard.

M. Potse works with the group of Prof. U. Schotten at Maastricht University (The Netherlands) and the Center for Computational Medicine in Cardiology at the *Università della Svizzera italiana* (Lugano, Switzerland) on simulation studies of atrial fibrillation [56]. The Maastricht group was partially funded by the FP7 project EUTRAF and our simulations were supported by GENCI (section 7.2.3).

N. Zemzemi works with Cesare Corrado at King's College London on the development of new eikonal models allowing conduction velocity adaptation [16].

CASTOR Project-Team

8. Partnerships and Cooperations

8.1. National Initiatives

8.1.1. Inria Project Lab: FRATRES (Fusion Reactors Research and Simulation)

- Participants : Inria project-teams : CASTOR, IPSO, TONUS,
- Partners : IRFM-CEA, Max Planck Institute-IPP Garching, LJLL-Jussieu, IMT-Toulouse

Controlled nuclear fusion can be considered as an example of grand challenge in many fields of computational sciences from physical modelling, mathematical and numerical analysis to algorithmics and software development and several Inria teams and their partners are developing mathematical and numerical tools in these areas.
Since january 2015, H. Guillard is coordinating the Inria Project Lab FRATRES (https://team.inria.fr/ipl-fratres/) to organize these developments on a collaborative basis in order to overcome the current limitations of today numerical methodologies. The ambition is to prepare the next generation of numerical modelling methodologies able to use in an optimal way the processing capabilities of modern massively parallel architectures. This objective requires close collaboration between a) applied mathematicians and physicists that develop and study mathematical models of PDE; b) numerical analysts developing approximation schemes; c) specialists of algorithmic proposing solvers and libraries using the many levels of parallelism offered by the modern architecture and d) computer scientists. This Inria Project Lab will contribute in close connection with National and European initiatives devoted to nuclear Fusion to the improvement and design of numerical simulation technologies applied to plasma physics and in particular to the ITER project for magnetic confinement fusion.

Contact : Hervé Guillard

8.1.2. Defi : Infiniti : INterFaces Interdisciplinaires NumérIque et ThéorIque

- Participants: HervéGuillard, AnnaDegioanni[LAMPEA Aix-en-Provence], SilvanaCondemi[ADES, Marseille], ZhenyuXu

In the framework of the "Defi : Infiniti : INterFaces Interdisciplinaires NumérIque et ThéorIque" of the “Mission pour l’Interdisciplinarité” of CNRS, this work has associated Hervé Guillard to Anna Degioanni of the Laboratory LAMPEA - Laboratoire Méditerranéen de Préhistoire Europe-Afrique of Aix-en-Provence and Silvana Condemi of the ADES (Anthropologie bio-culturelle, droit, éthique et santé - UMR 7268) laboratory in Marseille. The purpose of this work was to propose a numerical model and to realize a software allowing paleo-anthropologist and pre-historians to study numerically the propagation and diffusion of Homo Sapiens in Europe between 50 000 and 30 000 years BP. A 6 month internship of Ms Zhenyu Xu, 3rd year student at the polytech’Nice school of engineers has been devoted to this project and the results have been presented at the "Journée de restitution 2018 du Défi Infiniti", (http://www.cnrs.fr/mi/spip.php?article1440&lang=fr)

8.2. European Initiatives

8.2.1. FP7 & H2020 Projects

8.2.1.1. EoCoE

Title: Energy oriented Centre of Excellence for computer applications

Programm: H2020

Duration: October 2015 - October 2018

Coordinator: CEA

Partners:

- Barcelona Supercomputing Center - Centro Nacional de Supercomputacion (Spain)
- Commissariat A L Energie Atomique et Aux Energies Alternatives (France)
- Centre Europeen de Recherche et de Formation Avancee en Calcul Scientifique (France)
- Consiglio Nazionale Delle Ricerche (Italy)
- The Cyprus Institute (Cyprus)
- Agenzia Nazionale Per le Nuove Tecnologie, l'energia E Lo Sviluppo Economico Sostenibile (Italy)
- Fraunhofer Gesellschaft Zur Forderung Der Angewandten Forschung Ev (Germany)
- Instytut Chemii Bioorganicznej Polskiej Akademii Nauk (Poland)
- Forschungszentrum Julich (Germany)
- Max Planck Gesellschaft Zur Foerderung Der Wissenschaften E.V. (Germany)
- University of Bath (United Kingdom)
- Universite Libre de Bruxelles (Belgium)
- Universita Degli Studi di Trento (Italy)

Inria contact: Michel Kern

The aim of the present proposal is to establish an Energy Oriented Centre of Excellence for computing applications, (EoCoE). EoCoE (pronounce "Echo") will use the prodigious potential offered by the ever-growing computing infrastructure to foster and accelerate the European transition to a reliable and low carbon energy supply. To achieve this goal, we believe that the present revolution in hardware technology calls for a similar paradigm change in the way application codes are designed. EoCoE will assist the energy transition via targeted support to four renewable energy pillars: Meteo, Materials, Water and Fusion, each with a heavy reliance on numerical modelling. These four pillars will be anchored within a strong transversal multidisciplinary basis providing high-end expertise in applied mathematics and HPC. EoCoE is structured around a central Franco-German hub coordinating a pan-European network, gathering a total of 8 countries and 23 teams. Its partners are strongly engaged in both the HPC and energy fields; a prerequisite for the long-term sustainability of EoCoE and also ensuring that it is deeply integrated in the overall European strategy for HPC. The primary goal of EoCoE is to create a new, long lasting and sustainable community around computational energy science. At the same time, EoCoE is committed to deliver high-impact results within the first three years. It will resolve current bottlenecks in application codes, leading to new modelling capabilities and scientific advances among the four user communities; it will develop cutting-edge mathematical and numerical methods, and tools to foster the usage of Exascale computing. Dedicated services for laboratories and industries will be established to leverage this expertise and to foster an ecosystem around HPC for energy. EoCoE will give birth to new collaborations and working methods and will encourage widely spread best practices.

8.2.2. Collaborations in European Programs, Except FP7 & H2020

EuroFusion Consortium

CASTOR participates to the following EuroFusion consortium projects :

Enabling research contract 2014-2018. (B. Nkonga, H. Guillard, A. Sangam) CfP-WP15-ENR-01/IPP-05, Grant agreement No 633053. «Global non-linear MHD modeling in toroidal X-point geometry of disruptions, edge localized modes, and techniques for their mitigation and suppression »

EUROfusion WPCD (Working Package Code Development):

- ACT1: Extended equilibrium and stability chain (participation)
- ACT2: Free boundary equilibrium and control (participation and coordination)

8.3. International Initiatives

8.3.1. Inria International Partners

8.3.1.1. Informal International Partners

- The team collaborates with TUC (Technical University of Crete, Prof. Argyris Delis) on extension of the shallow water model to turbulent flows. These common works overlap with the collaboration with Taiwan in the framework of the former AMOSS associate team.
- Collaboration with TIFR-Bangalore on MHD, one month invited at Bangalore (B. Nkonga and A. Bhole) C. Praveen will have 2months as invited professor at UCA in 2019.

8.3.2. Participation in Other International Programs

ITER Contracts (B. Nkonga):

- ITER IO/17/CT/4300001505: 2017-2019, "Non-linear MHD simulations for ITER QH-mode plasma with and without 3D magnetic field perturbations from in-vessel ELM control coils". (150KE)

COFFEE Project-Team

9. Partnerships and Cooperations

9.1. Regional Initiatives

The team is involved in the IDEX project UCA-JEDI.

- PhD of Laurence Beaude (october 2015 - december 2018) co-funded by BRGM and Region PACA and dealing with the simulation of geothermal systems, supervised by Roland Masson, Konstantin Brenner from LJAD-Inria and by Simon Lopez, Farid Smai from BRGM.

9.2. National Initiatives

9.2.1. ANR

- ANR CHARMS (Quantitative Reservoir Models for Complex Hydrothermal Systems), Roland Masson and Konstantin Brenner: december 2016 - december 2020, partners BRGM (leader), LJAD-Inria, Storengy, MdS, LJLL.
- ANR JCJC PRECIS (Effect of a shock wave on a structure with contact using mesh refinement and parallelism), Laurent Monasse: april 2018 - april 2021, partners Inria (leader), Ecole des Ponts, CEA, Université Paris-Est.

9.2.2. National and European networks

- GdR MANU.

  The research group MANU has activities centered around scientific computing, design of new numerical schemes and mathematical modelling (upscaling, homogenization, sensitivity studies, inverse problems,...). Its goal is to coordinate research in this area, as well as to promote the emergence of focused groups around specific projects
- S. Junca is involved in GdR 3437 DYNOLIN “Dynamique non linéaire” and GdR MecaWave.
- LJAD-Inria and BRGM are the French partners of the Norvergian, German French project InSPiRE "International Open Source Simulation Software Partnership in Research and Education” which has just been accepted by the Research Council of Norway with the code ComPASS as one of the softwares of this project together with Dune, Dumux and OPM.

9.3. International Research Visitors

9.3.1. Visits of International Scientists

- Martin Gander (Genève), UCA invited professor 18/06 – 18/07, collaboration on reduced fracture models and DDM for coupling liquid gas Darcy and free gas flows. Co-organisation with Martin Gander, Stella Krell, Victorita Dolean, Roland Masson of the summer school on DDM: 19,20,21/06 https://math.unice.fr/~krell/ColloqueDD/index.php
- Felix Kwok (Hong Kong): 11/06 – 25/06 on nonlinear domain decomposition for the Richards equation.

DRACULA Project-Team

6. Partnerships and Cooperations

6.1. National Initiatives

6.1.1. ANR

- ANR SinCity "Single cell transcriptomics on genealogically identified differentiating cells", 2017-2020.
  Participant: Olivier Gandrillon [Coordinator].
- Olivier Gandrillon participates in the ANR MEMOIRE (head Jacqueline Marvel) dedicated to "MultiscalE MOdeling of CD8 T cell Immune REsponses". 2018-2021.
- Fabien Crauste participates in the ANR MEMOIRE (head Jacqueline Marvel) dedicated to "MultiscalE MOdeling of CD8 T cell Immune REsponses". 2018-2021.
- Thomas Lepoutre is a member of the ANR KIBORD (head L. Desvillettes) dedicated to “kinetic and related models in biology". 2014-2018: https://www.ljll.math.upmc.fr/kibord/.

6.1.2. Other projects

- Association France Alzheimer Sciences Médicales: PAMELA “Prion et Alzheimer : Modélisation et Expérimentation d’une Liaison Agressive”, 2014-2017 (https://www.youtube.com/watch?v=X0mLf8IJhV4).
  Participants: Mostafa Adimy, Samuel Bernard, Thomas Lepoutre, Laurent Pujo Menjouet [Coordinator], Léon Tine.
- Thomas Lepoutre is a member of the ERC MESOPROBIO (head V. Calvez) dedicated to "Mesoscopic models for propagation in biology". 2015-2020: .

6.2. European Initiatives

6.2.1. FP7 & H2020 Projects

Fabien Crauste and Olivier Gandrillon participates in the EU RTN network COSMIC (head Antpoine. van Kampen) dedicated to "Combatting disorders of adaptive immunity with systems medicine"). 2018-2021. https://cosmic-h2020.eu

6.3. International Initiatives

6.3.1. MODELLING_LEUKEMIA

Title: Modeling quiescence and drug resistance in Chronic Myeloid Leukemia

International Partner (Institution - Laboratory - Researcher):

University of Maryland (United States) - Center for Scientific Computation and Mathematical Modeling (CSCAMM) - Levy Doron

Start year: 2016

See also: http://dracula.univ-lyon1.fr/modelling_leukemia.php

This project is dedicated to the mathematical modelling of chronic myeloid leukemia and treatment effects. We focus especially on the interplay between the immune response and treatment. This has a potential impact on the study of treatment cessation. This work is conducted in close collaboration with a clinician.

6.3.2. Participation in Other International Programs

6.3.2.1. Indo-French Center of Applied Mathematics

Mathematical modeling of hematopoiesis process in application to chronic and acute myelogenous leukemia

Title: Mathematical modeling of hematopoiesis process in application to chronic and acute myelogenous leukemia

International Partner (Institution - Laboratory - Researcher):

(India)- Subhas Khajanchi

Duration: 2018 - 2021

Start year: 2018

6.4. International Research Visitors

6.4.1. Visits of International Scientists

Antone dos Santos Benedito, PHD student on Adding temperature and anthropogenic actions in the study of spatial-temporal behavior of insectplague Chrysodeixis Includens. Institute of Biosciences, São Paulo State University (UNESP), Botucatu, Brazil not a team member but visiting for 6 months (from September 1st 2018 to February 28, 2019)

6.4.2. Visits to International Teams

Paul Lemarre is visiting University of Merced in 2018-2019.

DYLISS Project-Team

9. Partnerships and Cooperations

9.1. Regional Initiatives

9.1.1. Ecosyst (Brittany region)

Participants: Marie Chevallier, Clémence Frioux, Anne Siegel.

This project aims at creating a regional research network related to the emerging topic of *systems ecology*, together with the development of tools to be shared by the researchers. It is co-leaded by OSUR (environmental lab) and Dyliss. 2016-2018. Total grant: 100k€

9.1.2. Ph.D. fundings from Université, Inria Rennes and Inserm

The team benefits from the funding of Ph.D. theses by Univ. Rennes (L. Bourneuf, 2016-2019 – H. Talibart, 2017-2020 – N. Guillaudeux, 2018-2021), by Inria (C. Frioux, 2015-2018), by Inserm (M. Louarn, 2017-2019, Inria-Inserm PhD Grant program), and by our collaborators from IRSET (M. Conan, 2017-2020 - P. Vignet, 2018-2020).

9.2. National Initiatives

9.2.1. IDEALG (ANR/PIA-Biotechnology and Bioresource)

Participants: Meziane Aite, Arnaud Belcour, Marie Chevallier, François Coste, Clémence Frioux, Jeanne Got, Jacques Nicolas, Anne Siegel.

The project gathers 18 partners from Station Biologique de Roscoff (coordinator), CNRS, IFREMER, UEB, UBO, UBS, ENSCR, University of Nantes, INRA, AgroCampus, and the industrial field in order to foster biotechnology applications within the seaweed field. Dyliss is co-leader of the WP related to the establishment of a virtual platform for integrating omics studies on seaweed and the integrative analysis of seaweed metabolism. Major objectives are the building of brown algae metabolic maps, metabolic flux analysis and the selection of symbiotic bacteria for brown algae. We will also contribute to the prediction of specific enzymes (sulfatases and haloacid dehalogenase) [More details]. 2012-20. Total grant: 11M€. Dyliss grant: 534k€.

9.2.2. PEPS: a platform for supporting studies in pharmaco-epidemiology using medico-administrative databases (ANSM)

Participants: Olivier Dameron, Yann Rivault.

The project involves EHESP (coordinator) (public health, Rennes), Univ. Rennes 1 (including the Dyliss), INSERM, CESP and CHU Rennes. The project goal is to develop generic methods supporting efficient and semantically-rich queries for pharmaco-epidemiology studies on medico-administrative databases. 2015-2018. Total grant: 3,6M€. Lacodam & Dyliss grant: 145k€.

9.2.3. TGFSysBio (ITMO Cancer)

Participants: Olivier Dameron, Maxime Folschette, Vijay Ingalalli, Jacques Nicolas, Anne Siegel, Nathalie Théret, Pierre Vignet.

Partners are INSERM (coordinator) (IRSET, Univ. Rennes 1) CNRS (Dyliss team) and Inria (Antique, Paris). The TGFSYSBIO project aims at developing the first model of extracellular and intracellular TGF-beta system by combining a ruled-based modelling approach (kappa) and a Petri net modelling approach (cadbiom). 2015-18. Total grant: 418k€. Dyliss grant: 129k€.

9.2.4. Programs funded by Inria

9.2.4.1. IPL Algae in silico

Participants: Meziane Aite, Arnaud Belcour, François Coste, Jeanne Got, Anne Siegel.

This project involves mainly the inria teams BIOCORE (coordinator), ANGE and DYLISS. Microalgae are recognized for the extraordinary diversity of molecules they can contain: proteins, lipids (for biofuel or long chain polyunsaturated fatty acids for human health), vitamins, antioxidants, pigments. The project aims at predicting and optimizing the productivity of microalgae. Dyliss is in charge of the identification of physiological functions for microalgae based on their proteomes, which is undergone through the reconstruction of the metabolic network of the *T. lutea* microalgae. Dyliss is also working with the the inria team PLEIADE on learning and predicting the specificities of desaturase enzymes in *Ostreococcus tauri* green algae. 2014-18.

9.2.4.2. IPL Neuromarkers

Participants: Olivier Dameron, Anne Siegel.

This project involves mainly the inria teams Aramis (coordinator) Dyliss, Genscale and Bonsai. The project aims at identifying the main markers of neurodegenerative pathologies through the production and the integration of imaging and bioinformatics data. Dyliss is in charge of facilitating the interoperability of imaging and bioinformatics data. 2017-20.

9.2.4.3. FederatedQueryScaler (Exploratory Research Action)

Participants: Olivier Dameron, Xavier Garnier, Vijay Ingalalli.

This project is coordinated by Dyliss and is a common project with the WIMMICS Inria team. This project aims at developing automatic generation of abstractions for biological data and knowledge in order to scale federated queries in the context of semantic web technologies. 2017-2018.

9.2.4.4. Askomics (ADT)

Participants: Olivier Dameron, Xavier Garnier, Guillaume Alviset, Anne Siegel.

AskOmics [url] is a visual SPARQL query interface supporting both intuitive data integration and querying while avoiding the user to face most of the technical difficulties underlying RDF and SPARQL. The underlying motivation is that even though Linked (Open) Data now provide the infrastructure for accessing large corpora of data and knowledge, life science end-users seldom use them, nor contribute back their data to the LOD cloud by lack of technical expertise. AskOmics aims at bridging the gap between end users and the LOD cloud. 2018-2020.

9.3. European Initiatives

9.3.1. Collaborations in European Programs, Except FP7 & H2020

Program: Polish National Science Center

Project acronym: NCN 2016/21/B/ST6/02158

Project title: Grammatical inference methods in classification of amyloidogenic proteins

Duration: January 2017 - January 2020

Coordinator: Olgierd Unold, Politechnika Wroclawska

Other partners: Politechnika Wroclawska (Polland)

Abstract: The objective is to develop the methods for induction of context-free and probabilistic grammars to describe a language matching amyloidogenic protein sequences.

9.3.2. Collaborations with Major European Organizations

Partner: University of Potsdam, Computer science department (Germany)

Title: Modeling combinatorial and hybrid problems with Answer Set Programming

9.4. International Initiatives

9.4.1. IIL projects

We have a cooperation with Univ. of Chile (MATHomics, A. Maass) on methods for the identification of biomarkers and software for biochip design. It aims at combining automatic reasoning on biological sequences and networks with probabilistic approaches to produce biomarkers of extremophile bacteria. In this context, IntegrativeBioChile was an Associate Team between Dyliss and the Laboratory of Bioinformatics and Mathematics of the Genome hosted at Univ. of Chile funded from 2011 to 2016. The collaboration is now supported by Chilean programs.

9.5. International Research Visitors

9.5.1. Visits of International Scientists

- **Niger**. University of Maradi [O. Abdou-Arbi]
- **Poland**. Politechnika Wroclawska [W. Dyrka]

9.5.2. Visits to International Teams

- **Chile**. University of Chile [A. Siegel, C. Frioux, M. Aite, M. Louarn]
- **Poland**. Politechnika Wroclawska [F. Coste]

9.5.2.1. Research Stays Abroad

- **Germany**. University of Potsdam [L. Bourneuf, 3 months (nov 2017 - jan 2018)]

EPIONE Project-Team

8. Partnerships and Cooperations

8.1. Regional Initiatives

- N. Ayache and P. Robert are principal investigators of the project MNC3 (Médecine Numérique, Cerveau, Cognition, Comportement) funded by Idex Jedi UCA (2017-2021, 450k€). M. Lorenzi (Inria) actively participates to the supervision of this project with the help of V. Manera (ICP).
- Hervé Delingette is the principal investigator of the LungMark project funded by Idex Jedi UCA (2018-2021).
- Hervé Delingette is the principal investigator of the CIMPLE project, funded by Idex Jedi UCA (2018-2021), the region PACA and Oticon Medical. The region PACA and Oticon Medical are co-funding the Phd of Zihao Wang.
- Marco Lorenzi is principal investigator of the project Big Data for Brain Research, funded during 2017-20 by the Département des Alpes Maritimes.
- Marco Lorenzi is principal investigator of the project MetaImaGen, funded by Idex Jedi UCA (2018-2020, 37k€).
- Maxime Sermesant is principal investigator of the project "The Digital Heart" and the innovation action "Digital Heart Phantom" with General Electrics, funded by Idex UCA Jedi. These projects gather the local cardiac research in academia, clinics and industry.

8.2. National Initiatives

8.2.1. Consulting for Industry

- Nicholas Ayache is a scientific consultant for the company Mauna Kea Technologies (Paris).
- Marco Lorenzi is a scientific consultant for the company MyDataModels (Sophia Antipolis).
- Xavier Pennec is a scientific consultant for the company Median Technologies (Sophia Antipolis)
- Maxime Sermesant is a scientific consultant for the company inHEART (Bordeaux)

8.2.2. Collaboration with national hospitals

The Epione-project team collaborates with the following 3 French IHU (University Hospital Institute): the IHU-Strasbourg (Pr J. Marescaux and L. Soler) on image-guided surgery, the IHU-Bordeaux (Pr M. Haïssaguere and Pr P. Jaïs) on cardiac imaging and modeling and the IHU-Pitié Salpétrière (Dr. O. Colliot and S. Durrleman) on neuroimaging.

We also have long term collaborations with the CHU Nice and Centre Antoine Lacassagne in Nice.

8.3. European Initiatives

8.3.1. FP7 & H2020 Projects

8.3.1.1. ERC ECSTATIC

Title: Electrostructural Tomography – Towards Multiparametric Imaging of Cardiac Electrical Disorders

Programm: H2020

Type: ERC

Duration: 2017 - 2022

Coordinator: U. Bordeaux

Inria contact: Maxime Sermesant

Cardiac electrical diseases are directly responsible for sudden cardiac death, heart failure and stroke. They result from a complex interplay between myocardial electrical activation and structural heterogeneity. Current diagnostic strategy based on separate electrocardiographic and imaging assessment is unable to grasp both these aspects. Improvements in personalized diagnostics are urgently needed as existing curative or preventive therapies (catheter ablation, multisite pacing, and implantable defibrillators) cannot be offered until patients are correctly recognized.

ECSTATIC aims at achieving a major advance in the way cardiac electrical diseases are characterized and thus diagnosed and treated, through the development of a novel non-invasive modality (Electrostructural Tomography), combining magnetic resonance imaging (MRI) and non-invasive cardiac mapping (NIM) technologies.

The approach will consist of: (1) hybridising NIM and MRI technologies to enable the joint acquisition of magnetic resonance images of the heart and torso and of a large array of body surface potentials within a single environment; (2) personalising the inverse problem of electrocardiography based on MRI characteristics within the heart and torso, to enable accurate reconstruction of cardiac electrophysiological maps from body surface potentials within the 3D cardiac tissue; and (3) developing a novel disease characterisation framework based on registered non-invasive imaging and electrophysiological data, and propose novel diagnostic and prognostic markers.

This project will dramatically impact the tailored management of cardiac electrical disorders, with applications for diagnosis, risk stratification/patient selection and guidance of pacing and catheter ablation therapies. It will bridge two medical fields (cardiac electrophysiology and imaging), thereby creating a new research area and a novel semiology with the potential to modify the existing classification of cardiac electrical diseases.

8.3.1.2. ERC G-statistics

Title: Biophysical Modeling and Analysis of Dynamic Medical Images

Programme: FP7

Type: ERC

Period: 2018-2023

Coordinator: Inria

Inria contact: Xavier Pennec

G-Statistics aims at exploring the foundations of statistics on non-linear spaces with applications in the Life Siences. Invariance under gauge transformation groups provides the natural structure explaining the laws of physics. In life sciences, new mathematical tools are needed to estimate approximate invariance and establish general but approximate laws. Rephrasing Poincaré: a geometry cannot be more true than another, it may just be more convenient, and statisticians must find the most convenient one for their data. At the crossing of geometry and statistics, G-Statistics aims at grounding the mathematical foundations of geometric statistics and to exemplify their impact on selected applications in the life sciences.

So far, mainly Riemannian manifolds and negatively curved metric spaces have been studied. Other geometric structures like quotient spaces, stratified spaces or affine connection spaces naturally arise in applications. G-Statistics will explore ways to unify statistical estimation theories, explaining how the statistical estimations diverges from the Euclidean case in the presence of curvature, singularities, stratification. Beyond classical manifolds, particular emphasis will be put on flags of subspaces in manifolds as they appear to be natural mathematical object to encode hierarchically embedded approximation spaces.

In order to establish geometric statistics as an effective discipline, G-Statistics will propose new mathematical structures and characterizations of their properties. It will also implement novel generic algorithms and illustrate the impact of some of their efficient specializations on selected

applications in life sciences. Surveying the manifolds of anatomical shapes and forecasting their evolution from databases of medical images is a key problem in computational anatomy requiring dimension reduction in non-linear spaces and Lie groups. By inventing radically new principled estimations methods, we aim at illustrating the power of the methodology and strengthening the "unreasonable effectiveness of mathematics" for life sciences.

8.3.2. Collaborations in European Programs, Except FP7 & H2020

Program: ERA CoSysMed
Project acronym: SysAFib
Project title: Systems medicine for diagnosis and stratification of atrial fibrillation
Duration: Mai 2016 - Mai 2019
Coordinator: Simula, Norway
Inria contact: Maxime Sermesant
Other partners: Inria, Helmholtz Zentrum München, Oslo University Hospital, Maastricht University, CardioCentro Ticino/CCMC
Abstract: Atrial fibrillation (AF) sharply increases the risk of stroke and is associated with a number of other severe complications, including heart failure. The SysAFib project aims to combine advanced data analysis and computer simulations with classical clinical approaches to create a decision support tool for treating AF. Diverse data sources, such as the individual patient's medical history, clinical measurements and genetic data will be combined into a single tool for optimizing and personalizing AF therapy. SysAFib's ultimate goal is to deliver the right treatment to the right patient at the right time, stopping AF in its tracks and ending the need for repeat invasive procedures.

8.4. International Initiatives

8.4.1. Inria International Labs

Inria@SiliconValley
Associate Team involved in the International Lab:

8.4.1.1. GeomStats

Title: Geometric Statistics in Computational Anatomy: Non-linear Subspace Learning Beyond the Riemannian Structure
International Partner (Institution - Laboratory - Researcher):
Stanford (United States) - Department of Statistics - Susan Holmes
Start year: 2018
See also: http://www-sop.inria.fr/asclepios/projects/GeomStats/
The scientific goal of the associated team led by X. Pennec is to develop the field of geometric statistics with key applications in computational anatomy. Computational anatomy is an emerging discipline at the interface of geometry, statistics, image analysis and medicine that aims at analysing and modelling the biological variability of the organs shapes at the population level. An important application in neuroimaging is the spatial normalization of subjects that is necessary to compare anatomies and functions through images in populations with different clinical conditions. Following the developments of the last 3 years of the associated team GeomStat, the new research directions have been broken into three axes. The first axis aims at continuing the progresses in theoretical and applied Geometric statistics, with a first theme studying the impact of curvature on the estimation with a finite sample, and a second axis extending the current work on Barycentric Subspace Analysis (BSA), notably with algorithms. The second axis aims at developing a hierarchical atlas of the brain anatomy based on the stratification of the space of image orbits under diffeomorphisms. The third axis explores three important applications of low-dimensional subspace learning in manifolds using BSA in neuroscience: the approximation of EEG signals for brain-computer interfaces (BCI); the acceleration and robustification of Tensor Distribution Functions (TDF) estimation in diffusion images; and the efficient inference in spaces of rank-deficient symmetric matrices for imaging-genetics from multi-centric databases.

8.4.2. Inria Associate Teams Not Involved in an Inria International Labs

8.4.2.1. PersoCardioLearn

Title: Personalization of Cardiac Models using Experimental Data and Machine Learning

International Partner (Institution - Laboratory - Researcher):

University of Toronto (Canada) - Sunnybrook Research Institute - Mihaela Pop

Start year: 2017

See also: https://team.inria.fr/asclepios/research/associated-team-persocardiolearn/

Multi-scale computer modelling is a powerful tool that could be used to simulate in silico cardiac electrical activity and biomechanical function of individual heart. Imaging and 3D heart models built from images can help us understand the basis of structurally-diseased hearts at organ level and to predict in silico the changes in electro-mechanical function as a consequence of muscle remodelling in pathologic state (e.g. chronic infarction, a major cause of death). We hypothesize that MRI-based predictive models can help us identify new opportunities to intervene or to predict the outcome of ablation therapy, which currently has low clinical success. However, these predictive models need to be validated and thoroughly tested in preclinical experiments prior to their integration into the clinical stage. Hence, the next logical step for our joint Inria-SB efforts is to expand our experimental-theoretical framework and to personalize fast 3D heart models from in vivo MR-EP data. This translational step involves numerous challenging tasks from the modelling perspective since the in vivo imaging and physiological signals are rather noisy and obtained at a poor spatial resolution, potentially leading to erroneous customization of mathematical model parameters. However, this collaboration employs a rare combination of experiments and modelling specialists. Moreover, the originality of the proposed approach is to build upon machine-learning techniques rather than on data assimilation methods that are more explored in the literature but have inherent limitations (robustness to noise, local minima...).

8.4.3. Inria International Partners

8.4.3.1. Informal International Partners

8.4.3.1.1. St Thomas' Hospital, King's College London, United Kingdom

Maxime Sermesant is a visiting lecturer in the Division of Imaging Sciences and Biomedical Engineering, St Thomas' Hospital, King's College London lead by Pr Reza Razavi. The XMR facility within this hospital is a unique opportunity to validate and exploit the cardiovascular modelling work.

8.4.3.1.2. Massachusetts General Hospital, Boston

A collaboration with Dr Jan Unklebach, Assistant Professor of Radiation Oncology and Dr Jayashree Kalpathy-Cramer, radiology instructor was initiated in 2013 around the topics of tumor growth modeling, radiotherapy planning and edema characterization from MRI.

8.4.3.1.3. University College London (UCL), London, UK

Marco Lorenzi is collaborator of the Translational Imaging Group of UCL, and with the UCL Institute od Ophtalmology. His collaboration is around the topic of spatio-temporal analysis of medical images, with special focus on brain imaging analysis and biomarker development. He is also collaborating with the "Progression Over Neurodegenerative Disorders" (POND) group (Prof. Daniel Alexander) for developing new computational models and techniques for learning characteristic patterns of disease progression using large longitudinal clinical data sets, with special focus on dementias.

8.4.3.1.4. Imaging Genetics Center (IGC), University of Southern California (USC), CA, USA

Marco Lorenzi is currently collaborator of IGC for the investigation of the complex relationship between brain atrophy and genetics in Alzheimer's disease, in particular for demonstrating the effectiveness of multivariate statistical models in providing a meaningful description of the relationship between genotype and brain phenotype.

8.4.3.1.5. Other International Hospitals

Collaborations with several other European hospitals have been established through the European projects VP2HF, MD PAEDIGREE and SysAFib.

8.5. International Research Visitors

8.5.1. Visits of International Scientists

8.5.1.1. Internships

- Svenja Hüning, PhD student with Johannes Wallner at Graz University in Austria visited the Epione team in November 2018 to work with Xavier Pennec on subdivision schemes on manifolds.
- Santiago Smith Silva Rincon, Master student at the National University of Bogota (CO), visited the Epione team from May to October 2018 to work with Marco Lorenzi on distributed learning methods in imaging-genetics.

ERABLE Project-Team

8. Partnerships and Cooperations

8.1. Regional Initiatives

8.1.1. Muse

- Title: Multi-Omics and Metabolic models iNtegration to study growth Transition in *Escherichia coli*
- Coordinators: Delphine Ropers (EPI Ibis) and Marie-France Sagot
- ERABLE participants: Marie-France Sagot and Arnaud Mary.
- Type: IXXI Project (2018-2019).
- Web page: none for now.

8.2. National Initiatives

8.2.1. ANR

8.2.1.1. Aster

- Title: Algorithms and Software for Third gEneration Rna sequencing
- Coordinator: Hélène Touzet, University of Lille and CNRS.
- ERABLE participants: Vincent Lacroix (ERABLE coordinator), Clara Benoît-Pilven, Audric Cologne, Alex di Genova, Leandro I. S. de Lima, Arnaud Mary, Marie-France Sagot, Camille Sessegolo, Blerina Sinaimeri.
- Type: ANR (2016-2020).
- Web page: http://bioinfo.cristal.univ-lille.fr/aster/.

8.2.1.2. ExHyb

- Title: Exploring genomic stability in hybrids
- Coordinator: C. Vieira
- ERABLE participant(s): C. Vieira
- Type: ANR (2014-2018)
- Web page: Not available

8.2.1.3. GraphEn

- Title: Enumération dans les graphes et les hypergraphes : Algorithmes et complexité
- Coordinator: D. Kratsch
- ERABLE participant(s): A. Mary
- Type: ANR (2015-2019)
- Web page: http://graphen.isima.fr/

8.2.1.4. GrR

- Title: Graph Reconfiguration
- Coordinator: N. Bousquet
- ERABLE participant(s): A. Mary
- Type: ANR JCJC (2019-2021)
- Web page: Not available

8.2.1.5. Green

- Title: Deciphering host immune gene regulation and function to target symbiosis disturbance and endosymbiont control in insect pests
- Coordinator: A. Heddi
- ERABLE participant(s): M.-F. Sagot, C. Vieira
- Type: ANR (2018-2021)
- Web page: Not yet available

8.2.1.6. Hmicmac

- Title: Host-microbiota co-adaptations: mechanisms and consequences
- Coordinator: F. Vavre
- ERABLE participant(s): F. Vavre
- Type: ANR PRC (2017-2020)
- Web page: Not available

8.2.1.7. IMetSym

- Title: Immune and Metabolic Control in Intracellular Symbiosis of Insects
- Coordinator: A. Heddi
- ERABLE participant(s): H. Charles, S. Colella
- Type: ANR Blanc (2014-2017)
- Web page: Not available

8.2.1.8. Resist

- Title: Rapid Evolution of Symbiotic Interactions in response to STress: processes and mechanisms
- Coordinator: N. Kremer
- ERABLE participant(s): F. Vavre
- Type: ANR JCJC (2017-2020)
- Web page: Not available

8.2.1.9. Suzukill

- Title: Managing cold tolerance and quality of mass-produced *Drosophila suzukii* flies to facilitate the application of biocontrol through incompatible and sterile insect techniques
- Coordinator: H. Colinet
- ERABLE participant(s): F. Vavre
- Type: ANR PCRI (2015-2018)
- Web page: Not available

8.2.1.10. Swing

- Title: Worldwide invasion of the Spotted WING Drosophila: Genetics, plasticity and evolutionary potential
- Coordinator: P. Gibert
- ERABLE participant(s): C. Vieira
- Type: ANR PCR (2016-2020)
- Web page: Not available

8.2.1.11. U4atac-brain

- Title: Rôle de l'épissage mineur dans le développement cérébral
- Coordinator: Patrick Edery, Centre de Recherche en Neurosciences de Lyon.

- ERABLE participants: Vincent Lacroix (ERABLE coordinator), Clara Benoît-Pilven, Audric Cologne.
- Type: ANR (2018-2021).
- Web page: Not available.

8.2.2. Idex

8.2.2.1. Micro-be-have

- Title: Microbial Impact on insect behaviour: from niche and partner selection to the development of new control methods for pests and disease vectors
- Coordinator: F. Vavre
- ERABLE participant(s): F. Vavre
- Type: AO Scientific Breakthrough (2018-2021)
- Web page: Not available

8.2.3. ADT Inria

8.2.3.1. ADT Inria Kirikomics

- Main objective: Development of a portal to increase the visibility of the tools and resources elaborated by ERABLE around the analysis – using omics data – of metabolic networks modelled by hypergraphs, and enable to visualise the results. (the web page is for now private, it will be made public later in the project).
- Duration: 2016-2017, renewable one more year.
- Person responsible for ADT: Arnaud Mary with David Parsons (Inria).
- Beneficiary of ADT: Martin Wannagat.
- Funds received: Salary for engineer.

8.2.4. Others

Notice that were included here national projects of our members from Italy and the Netherlands when these have no other partners than researchers from the same country.

8.2.4.1. Advanced computational methodologies for the analysis of biomedical data

- Title: Advanced computational methodologies for the analysis of biomedical data
- Coordinator: P. Milazzo
- ERABLE participant(s): R. Grossi, N. Pisanti
- Type: PRA, MIUR PRIN, Italian Ministery of Research National Projects (2017-2018)
- Web page: Not available

8.2.4.2. Advanced Tools and Techniques for the analysis of criminal networks

- Title: Advanced Tools and Techniques for the analysis of criminal networks
- Coordinator: G. Italiano
- ERABLE participant(s): G. Italiano
- Type: LEONARDO SpA (2015-2018)
- Web page: Not available

8.2.4.3. Open Innovation: Digital Innovation for Driving

- Title: Open Innovation: Digital Innovation for Driving
- Coordinator: G. Italiano
- ERABLE participant(s): G. Italiano
- Type: Bridgestone (2018-2019)

- Web page: Not available

8.2.4.4. CMACBioSeq

- Title: Combinatorial Methods for analysis and compression of biological sequences
- Coordinator: G. Rosone
- ERABLE participant(s): N. Pisanti
- Type: SIR, MIUR PRIN, Italian Ministery of Research National Projects (2015-2019)
- Web page: http://pages.di.unipi.it/rosone/CMACBioSeq.html

8.2.4.5. Statistical Models for Structural Genetic Variants in the Genome of the Netherlands

- Title: Statistical Models for Structural Genetic Variants in the Genome of the Netherlands
- Coordinator: A. Schönhuth
- ERABLE participant(s): A. Schönhuth
- Type: Nederlandse Wetenschappelijke Organisatie (NWO) (2013-2018)
- Web page: Not available

8.2.4.6. TALS and splicing

- Title: Development of bioinformatic methods for the analysis of splicing events in patients with the Taybi-Linder Syndrome (TALS)
- Coordinator: P. Edery
- ERABLE participant(s): C. Benoît-Pilven, Audric Cologne, V. Lacroix
- Type: INSERM
- Web page: Not available

8.3. European Initiatives

8.3.1. FP7 & H2020 Projects

8.3.1.1. MicroWine

- Title: Microbial metagenomics and the modern wine industry
- Duration: January 2015 - January 2019
- Coordinator: Lars Hestbjerg Hansen, University of Copenhagen
- ERABLE participant(s): A. Marchetti-Spaccamela, A. Mary, H. T. Pusa, M.-F. Sagot, L. Stougie
- Type: H2020-MSCA-ETN-2014
- Web page: https://team.inria.fr/erable/en/microwine/ and http://www.microwine.eu/

8.3.2. Collaborations in European Programs, Except FP7 & H2020

8.3.2.1. Combinatorics of co-evolution

- Title: The combinatorics of co-evolution
- Duration: 2015 - 2018
- Coordinator: Katharina Huber, University of Warwick, UK
- ERABLE participant(s): M.-F. Sagot, B. Sinaimeri
- Type: The Royal Society
- Web page: not available

8.3.3. Collaborations with Major European Organizations

By itself, ERABLE is built from what initially were collaborations with some major European Organisations (CWI, Sapienza University of Rome, Universities of Florence and Pisa, Free University of Amsterdam) and now has become a European Inria Team.

8.4. International Initiatives

8.4.1. Inria Associate Teams Not Involved in an Inria International Labs

Compasso

- Title: COMmunity Perspective in the health sciences: Algorithms and Statistical approacheS for explOring it
- Duration: 2018, renewable from 2 to 5 years more
- Coordinator: On the Portuguese side, Susana Vinga, IST, Lisbon, Portugal; on the French side, Marie-France Sagot
- ERABLE participant(s): R. Andrade, M. Ferrarini, G. Italiano, A. Marchetti-Spaccamela, A. Mary, H. T. Pusa, M.-F. Sagot, B. Sinaimeri, L. Stougie, A. Viari, I. Ziska
- Web page: http://team.inria.fr/erable/en/projects/inria-associated-team-compasso/

8.4.2. Participation in International Programs

ERABLE is coordinator of a CNRS-UCBL-Inria Laboratoire International Associé (LIA) with the Laboratório Nacional de Computação Científica (LNCC), Petrópolis, Brazil. The LIA has for acronym LIRIO ("Laboratoire International de Recherche en bIOinformatique") and is coordinated by Ana Tereza Vasconcelos from the LNCC and Marie-France Sagot from BAOBAB-ERABLE. The LIA was created in January 2012 for 4 years, renewable once for 4 more years. A web page for the LIA LIRIO is available at this address: http://team.inria.fr/erable/en/cnrs-lia-laboratoire-international-associe-lirio/.

ERABLE also participated to the BASIS project. This was funded by the European Community Seventh Framework Programme (Grant 242006 - 2010-2015). It was led by Dr. Mike Stratton and involved six European countries. It was primarily focused on ER+/HER2- breast cancers, but during the course of the project, was merged with the HER2+ French-ICGC and triple negative UK-ICGC projects, resulting in the analysis of the whole spectrum of breast cancers. The French group was initiated by Dr. Gilles Thomas and was pursued by Alain Viari after the loss of Dr. Thomas in 2014. The project resulted in the sequencing and thorough analysis of 560 breast cancer whole genomes (Nik-Zainai *et al.*, *Nature*, 534:47-54, 2016), including 75 HER2+ performed by the French working group (Ferrari *et al.*, *Nature Communications*, 7, 2016) and funded by the Institut National du Cancer and by Inserm.

Finally, Marie-France Sagot participates in a Portuguese FCT project, Perseids for "Personalizing cancer therapy through integrated modeling and decision" (2016-2019), with Susana Vinga and a number of other Portuguese researchers. The budget of Perseids is managed exclusively by the other Portuguese partner.

8.5. International Research Visitors

8.5.1. Visits of International Scientists

In 2018, ERABLE greeted the following International scientists:

- In France: Alexander Stuart Ralph (University of Melbourne), Katharina Huber and Vincent Moulton (University of Warwick, UK), Ifigeneia Kyrkou (Aarhus University, Danemark), Ana Tereza Vasconcelos from the LNCC, Brazil), Nuno Mira (IST Portugal), May Alzamel and Costas Iliopoulos (King's College, London, UK), Simona Rombo (University of Palermo, Italy).
- In Italy: Loukas Georgiadis (University of Ioannina, Greece), Matthias Mnich (University of Bonn, Germany), Adam Karczmarcz (University of Warsaw, Poland).
- In the Netherlands: Solon Pissis (King's College, UK).

8.5.1.1. Internships

In 2018, ERABLE in France greeted the following Internships:

- Gabriela Paludo, Federal University of Mato Grosso do Sul, Brazil, from Dec 1st 2017 to June 30 2018, funds for 6 months from Capes, Brazil, and for the last month from ERABLE;
- Rafael Nahat, University of São Paulo, Brazil, from June 1st 2018 to Dec 15, 2018.

In the Netherlands, ERABLE greeted the following Internship: Luca Denti, University Bicocca of Milano, Italy, from October 1 to January 2019.

8.5.2. Visits to International Teams

8.5.2.1. Research Stays Abroad

In 2018, two members of ERABLE from France did research stays at Sapienza University of Rome. These were Marie-France Sagot and Blerina Sinaimeri, both funded by Sapienza, M.-F. Sagot as senior scientist for a visit of one month, and B. Sinaimeri as a junior scientist for a visit of three months. The visits took place at the beginning of 2018, Jan-Feb for M.-F. Sagot, and Jan-Apr for B. Sinaimeri. In the context of her visit to Sapienza, Blerina furthermore gave a mini-course (9h) at the University.

FLUMINANCE Project-Team

8. Partnerships and Cooperations

8.1. National Initiatives

8.1.1. Comins'lab: SEACS : Stochastic modEl-dAta-Coupled representationS for the analysis, simulation and reconstruction of upper ocean dynamics

Participant: Etienne Mémin.

duration 48 months. The SEACS project whose acronym stands for: "Stochastic modEl-dAta-Coupled representationS for the analysis, simulation and reconstruction of upper ocean dynamics" is a Joint Research Initiative between the three Britanny clusters of excellence of the "Laboratoires d'Excellence" program: Cominlabs, Lebesgue and LabexMer centered on numerical sciences, mathematics and oceanography respectively. Within this project we aim at studying the potential of large-scale oceanic dynamics modeling under uncertainty for ensemble forecasting and satellite image data assimilation.

8.1.2. ANR BECOSE : Beyond Compressive Sensing: Sparse approximation algorithms for ill-conditioned inverse problems.

Participant: Dominique Heitz.

duration 48 months. The BECOSE project aims to extend the scope of sparsity techniques much beyond the academic setting of random and well-conditioned dictionaries. In particular, one goal of the project is to step back from the popular L1-convexification of the sparse representation problem and consider more involved nonconvex formulations, both from a methodological and theoretical point of view. The algorithms will be assessed in the context of tomographic Particle Image Velocimetry (PIV), a rapidly growing imaging technique in fluid mechanics that will have strong impact in several industrial sectors including environment, automotive and aeronautical industries. The consortium gathers the Fluminance and Panama Inria research teams, the Research Center for Automatic Control of Nancy (CRAN), The Research Institute of Communication and Cybernetics of Nantes (IRCCyN), and ONERA, the French Aerospace Lab.

8.1.3. ANDRA project

Participants: Jocelyne Erhel, Tangi Migot.

Contract with ANDRA (National Agency for Nuclear Waste) Duration: three years from November 2015. Title: reactive transport in fractured porous media Coordination: Jocelyne Erhel. Partners: Geosciences Rennes. Abstract: Even in small numbers, fractures must be carefully considered for the geological disposal of radioactive waste. They critically enhance diffusivity, speed up solute transport, extend mixing fronts and, in turn, modify the physicochemical conditions of reactivity around possible storage sites. This year, we studied geochemistry models, which could be coupled with flow and transport models.

8.1.4. IFPEN project

Participants: Jocelyne Erhel, Bastien Hamlat.

Contract with IFPEN (Institut Français du Pétrole et Energies Nouvelles) Duration: three years from October 2016. Title: Fully implicit Formulations for the Simulation of Multiphase Flow and Reactive Transport Coordination: Jocelyne Erhel. Abstract: Modeling multiphase flow in porous media coupled with fluid-rock chemical reactions is essential in order to understand the origin of sub-surface natural resources and optimize their extraction. This project aims to determine optimal strategies to solve the coupled transport and chemical reaction equations describing the physical processes at work in reactive multiphase flow in porous media. Three different formulations show great potential to accurately solve these equations. Two are fully implicit ("Reactive Coats" and "Semi-smooth Newton") and one is an operator splitting approach. These formulations are still incomplete at the moment. The work will focus on extending the existing formulations to more complex physical phenomena, study their stability, convergence and theoretical equivalence. Another objective is to provide practical solutions to efficiently solve the resulting non-linear systems.

8.1.5. ANR-MN: H2MNO4 project

Participants: Yvan Crenner, Benjamin Delfino, Jean-Raynald de Dreuzy, Jocelyne Erhel, Lionel Lenôtre.

Contract with ANR, program Modèles Numériques
Duration: four years from November 2012 until April 2017.
Title: Original Optimized Object Oriented Numerical Model for Heterogeneous Hydrogeology.
Coordination: Jocelyne Erhel and Géraldine Pichot, with Fabienne Cuyollaa.
Partners: Geosciences Rennes, University of Poitiers, University of Lyon 1, Andra, Itasca.
International collaborations: University of San Diego (USA), UPC, Barcelona (Spain)
Web page: http://h2mno4.inria.fr/
Abstract: The project H2MNO4 develops numerical models for reactive transport in heterogeneous media. It defines six mathematical and computational challenges and three applications for environmental problems with societal impact.

8.1.6. GDR MANU

Participants: Yvan Crenner, Jocelyne Erhel, Bastien Hamlat.

Title: Mathematics for Nuclear industry
Duration: From 2016 to 2019
Coordination: C. Cancès
Webpage: http://gdr-manu.math.cnrs.fr/
Abstract: The working group MANU is a follow-up to the group MOMAS. It covers many subjects related to mathematical modeling and numerical simulations for problems arising from nuclear industry and nuclear waste disposal. The team organizes a workshop on reactive transport, Paris, February 2018.

8.1.7. LEFE MANU: MSOM

Participants: Etienne Mémin, Long Li.

Title: Multiple Scale Ocean Model
Duration: From 2018 to 2021
Coordination: Bruno Deremble (CNRS LMD/ENS Paris)
Abstract: The objective of this project is to propose a numerical framework of a multiscale ocean model and to demonstrate its utility in the understanding of the interaction between the mean current and eddies.

8.2. International Initiatives

8.2.1. Inria Associate Teams Not Involved in an Inria International Labs

8.2.1.1. LFD-FLU

Title: Large-scale Fluid Dynamics analysis from FLow Uncertainty

International Partner (Institution - Laboratory - Researcher):

Universidad de Buenos Aires (Argentina) - Faculty of Engineering - Guillermo Artana

Start year: 2016

See also: http://www.irisa.fr/prive/memin/LFD-FLU/

The first objective of this associate team is primarily concerned with the establishment of efficient fluid flow image data analysis procedures. This concerns for instance data assimilation issues to reconstruct meaningful numerical representation of experimental fluid flows for analysis purpose. The second objective focuses on the incorporation of uncertainties in the flow dynamical evolution models.

8.2.1.2. Informal International Partners

Imperial College, London (UK), Collaboration with Dan Crişan and Darryl Holm on Stochastic transport for the upper ocean dynamics

Chico California State University (USA), We have pursued our collaboration with the group of Shane Mayor on the GPU implementation of wavelet based motion estimator for Lidar data. This code is developped in coproperty between Inria and Chico.

8.2.2. Participation in Other International Programs

Royal Society funding, collaboration between Dominique Heitz, Etienne Mémin and Sylvain Laizet (Imperial College) on Stochastic large-eddies simulation and data assimilation for the reconstruction of 3D turbulent flows.

8.2.3. Participation in Other International Programs

8.2.3.1. International Initiatives

MATH-GEO

Title: MATHematical methods for GEOphysical flows

International Partners (Institution - Laboratory - Researcher):

Universidad de Buenos Aires (Argentina) - CIMA (Centro de investigaciones del mar y de la Atmósfera) - Juan Ruiz

Universidad de la Republica Uruguay (Uruguay) - IMFIA: Instituto de Mecánica de los Fluidos e Ingeniería Ambiental, INCO: Instituto de Computación, Facultad de Ingeniería - Mónica Fossati

CMM (Chile) - Center for Mathematical Modeling - Axel Osses

Universidad San Ignacio de Loyola (USIL) (Peru) - Faculty of Engineering Alejandro Paredes

Duration: 2018 - 2019

Start year: 2018 http://mathgeo.cima.fcen.uba.ar

Nonlinear processes, such as advection and turbulent mixing, play a central role in geophysical sciences. The theory of nonlinear dynamical systems provides a systematic way to study these phenomena. Its stochastic extension also forms the basis of modern data analysis techniques, predictability studies and data assimilation methods. Contributions in the field of Topology and Dynamics of Chaos include methods conceived to unveil the structure organizing flows in phase space, building the gap between data and low-dimensional modeling. Low-order models in climate dynamics are highly desirable, since they can provide solutions in cases where high-resolution numerical simulations cannot be implemented, as in short-term wind forecasting. At the same time, the procedure provides a tool-kit for model validation, emulation or inter-model comparison, with interesting prospects in all fields of oceanographic and atmospheric sciences, including climate detection and attribution. The strategy constitutes an unprecedented and promising perspective, offering an original approach to the subject, with mathematical concepts that are not necessarily widespread in the geophysics scientific community. This proposal gathers specialists with a know-how in the most challenging aspects of the focused research field: coherent structure detection in fluid flows for the exploration and interactive visualization of scientific data (LIMSI France), data assimilation and fluid motion analysis from image sequences (Inria Rennes), numerical models and data assimilation (CMM-Chile) stochastic models for climate dynamics with application to El Niño Ocean models (USIL-Peru), mathematical methods for weather and climate (CIMA-UBA & IMIT / IFAECI, Argentina), geophysical flows and dynamical systems (LMD France), mixing structures and Lagrangian analysis of multisatellite data (LOCEAN France), marine and estuarine hydrodynamic and water properties numerical models (INCO & IMFIA-Uruguay), in situ measurements of oceanographic conditions (CEBC France, in program with CNES France and CONAE Argentina), global modelling technique and topological characterization of flows (CORIA with CESBIO, France).

8.3. International Research Visitors

8.3.1. Visits of International Scientists

- 1 week visit of Souhila Sabit (Researcher University of Tiaret, Algeria) to work with Jocelyne Erhel.
- 3 weeks visit of Alejandro Gronskis (Researcher Conicet Argentina) to work with Dominique Heitz, Etienne Mémin and Pranav Chandramouli within the associate team LFD
- 3 weeks visit of Guillermo Artana (Professor U. of Buenos Aires) to work with Dominique Heitz, Christophe Collewet and Johan Carlier within the associate team LFD
- 10 days visit of Georg Gottwald (Professor U. of Sydney) to work with Etienne Mémin.

GALEN-POST Team

9. Partnerships and Cooperations

9.1. National Initiatives

9.1.1. ANR

Program: ANR PRC

Project acronym: CoMeDIC

Project title: Convergent Metrics for DIscrete Calculus

Duration: 2016-2021

Coordinator: J.-O. Lachaud (Univ. Rhones Alpes Savoie Mont-Blanc), Local: H. Talbot

Program: ANR PRCE

Project acronym: R-Vessel-X

Project title: Extraction et interprétation robustes des réseaux vasculaires dans les images biomédicales hépatiques

Duration: 2018-2022

Coordinator: A. Vacavant (Univ. Clermont Auvergne), local: H. Talbot

Program: ANR JCJC

Project acronym: LearnCost

Project title: Learning Model Constraints for Structured Prediction

Duration: 2014-2018

Coordinator: M. Blaschko

Program: ANR JCJC

Project acronym: MajIC

Project title: Majorization-Minimization Algorithms for Image Computing

Duration: 2017-2021

Coordinator: E. Chouzenoux

Program: ANR JCJC

Project acronym: AVENUE

Project title: A Visual memory network for scene understanding

Duration: 2018-2022

Coordinator: Dr. Karteek Alahari (Inria Grenoble - Rhône-Alpes). Local: F. Malliaros.

9.1.2. Others

Program: CNRS MASTODONS
Projet acronym: TABASCO
Project title: Traitement du bruit non Gaussien en spectroscopie
Duration: 2016-2018
Coordinator: E. Chouzenoux

Program: CNRS-CEFIPRA
Project acronym: NextGenBP
Project title: Looking Beyond Backpropagation in Deep Learning
Duration : 2017-2019
Coordinator: E. Chouzenoux

Program: CNRS MI
Projet acronym: SUPREMA
Project title: Super-résolution en microscopie biphotonique
Duration: 2018
Coordinator: E. Chouzenoux
Program: PHC - Campus France
Projet acronym: POLONIUM
Project title: When Poisson and Gauss meet in imaging
Duration: 2018-2020
Coordinator: E. Chouzenoux

9.2. European Initiatives

9.2.1. H2020 Projects

Program: H2020 ITN Marie Sklodowska-Curie
Project acronym: SUNDIAL
Project title: SUrvey Network for Deep Imaging Analysis and Learning
Duration: 2017-2021
Coordinator: R. Peletier (Univ. Groningen, NL), local: H. Talbot

9.3. International Initiatives

9.3.1. Informal International Partners

Sup'Com Tunis - Pr. Amel Benazza-Benhayia. Collaboration Topic: Multispectral imaging.
University of Patras, Greece - Dr. V. Megalooikonomou. Collaboration Topic: Biosignal analysis.
University of Pennsylvania - Prof. Aristeidis Sotiras. Collaboration Topic: Higher Order Graphs in biomedical image analysis.
University of Montréal, MILA - Dr. Eugene Belilovsky, Pr. Simon Lacoste-Julien. Collaboration Topic : Deep learning, scattering transform.
Berkeley University - Dr. Michael Eickenberg and Dr. Damien Scieur. Collaboration Topic : Deep learning.
KU Leuven - Pr. Matthew Blashcko. Collaboration Topic : Scattering transform.
University of Amsterdam - Dr. Jörn Jacobsen. Collaboration Topic : Deep learning.
Aristotle University of Thessaloniki, Greece - Prof. Apostolos N. Papadopoulos. Collaboration Topic: Graph mining and learning.
Indraprastha Information Institute Technology, Delhi, India - Dr. Angshul Majumdar. Collaboration Topic: Dictionary learning.
Universidad Técnica Federico Santa María, Valparaíso, Chile - Dr. Luis M. Briceño-Arias. Collaboration Topic: Stochastic optimization.
North Carolina State University - Prof. Patrick Louis Combettes. Collaboration Topic: Stochastic optimization.

9.4. International Research Visitors

9.4.1. Visits of International Scientists

Dr. Luis M. Briceño-Arias, Universidad Técnica Federico Santa María, Valparaíso, Chile, 1 Jun. - 1 Jul. 2018, 21 Nov. - 21 Dec. 2018
Jyoti Maggu (PhD student), IIIT New Delhi, India, 05 Mar.-28 May 2018
Vanika Singhal (PhD student), IIIT New Delhi, India, 05 Mar.-20 Apr. 2018
Georgios Panagopoulos (PhD student), Ecole Polytechnique, 15 Jun. - 31 Jul. 2018

9.4.2. Visits to International Teams

9.4.2.1. Research Stays Abroad

M.C. Corbineau, Department of Physics, Informatics and Mathematics, Universita degli studi di Modena e Reggio Emilia, Modena, Italy, 20 Sep. - 20 Oct. 2018.

GENSCALE Project-Team

9. Partnerships and Cooperations

9.1. Regional Initiatives

9.1.1. Project Thermin: Differential characterization of strains of a bacterial species, Streptococcus thermophilus, with a Nanopore Minion

Participants: Jacques Nicolas, Emeline Roux, Gregoire Siekaniec, Dominique Lavenier.

Coordinator: J. Nicolas (Inria/Irisa, GenScale, Rennes)
Duration: 36 months (Oct. 2018 – Sept. 2021)
Partners: INRA (STLO, Agrocampus Rennes, E. Guédon and Y. Le Loir).

The Thermin project aims at exploring the capacities of a low cost third generation sequencing device, the Nanopore Minion, for rapid and robust pan-genome dicrimination of bacterial strains and their phenotypes. It has started at the end of this year with the recruitment (délégation Inria) of E. Roux, a biochemist from Lorraine University and G. Siekaniec (INRA -Inria collaboration, INRA grant), a new PhD student. We will study pan-genomic representations of multiple genomes and the production of characteristic signatures of each genome in this context.

9.2. National Initiatives

9.2.1. ANR

9.2.1.1. Project HydroGen: Metagenomic applied to ocean life study

Participants: Dominique Lavenier, Pierre Peterlongo, Claire Lemaitre.

Coordinator: P. Peterlongo (Inria/Irisa, GenScale, Rennes)
Duration: 42 months (Nov. 2014 – Apr. 2018)
Partners: CEA (Genoscope, Evry), INRA (AgroParisTech, Paris – MIG, Jouy-en-Jossas).

The HydroGen project aims to design new statistical and computational tools to measure and analyze biodiversity through comparative metagenomic approaches. The support application is the study of ocean biodiversity based on the analysis of seawater samples available from the Tara Oceans expedition.

9.2.1.2. Project SpeCrep: speciation processes in butterflies

Participants: Dominique Lavenier, Jeremy Gauthier, Fabrice Legeai, Claire Lemaitre, Pierre Peterlongo.

Coordinator: M. Elias (Museum National d'Histoire Naturelle, Institut de Systématique et d'Evolution de la Biodiversité, Paris)
Duration: 48 months (Jan. 2015 – Dec. 2018)
Partners: MNHN (Paris), INRA (Versailles-Grignon), Genscale Inria/IRISA Rennes.

The SpeCrep project aims at better understanding the speciation processes, in particular by comparing natural replicates from several butterfly species in a suture zone system. GenScale's task is to develop new efficient methods for the assembly of reference genomes and the evaluation of the genetic diversity in several butterfly populations.

9.2.1.3. Project Supergene: The consequences of supergene evolution.

Participants: Dominique Lavenier, Fabrice Legeai, Claire Lemaitre, Pierre Peterlongo.

Coordinator: M. Joron (Centre d'Ecologie Fonctionnelle et Evolutive (CEFE) UMR CNRS 5175, Montpellier)
Duration: 48 months (Nov. 2018 – Oct. 2022)
Partners: CEFE (Montpellier), MNHN (Paris), Genscale Inria/IRISA Rennes.

The Supergene project aims at better understanding the contributions of chromosomal rearrangements to adaptive evolution. Using the supergene controlling adaptive mimicry in a polymorphic, ubiquitous butterfly from the Amazon basin (H. numata), the project will investigate the evolution of inversions involved in adaptive polymorphism and their consequences on population biology. GenScale's task is to develop new efficient methods for the detection and genotyping of inversion polymorphism with several types of re-sequencing data.

9.2.2. PIA: Programme Investissement d'Avenir

9.2.2.1. RAPSODYN: Optimization of the rapeseed oil content under low nitrogen

Participants: Dominique Lavenier, Claire Lemaitre, Sebastien Letort, Pierre Peterlongo, Guendal Virlet.

Coordinator: N. Nesi (Inra, IGEPP, Rennes)
Duration: 99 months (2012-2020)
Partners: 5 companies, 9 academic research labs.

The objective of the Rapsodyn project is the optimization of the rapeseed oil content and yield under low nitrogen input. GenScale is involved in the bioinformatics work package to elaborate advanced tools dedicated to polymorphism and application to the rapeseed plant. (http://www.rapsodyn.fr)

9.2.3. Programs from research institutions

9.2.3.1. Inria Project Lab: Neuromarkers

Participants: Dominique Lavenier, Pierre Peterlongo, Claire Lemaitre, Celine Le Beguec.

Coordinator: O. Colliot (Inria, Aramis, Paris)
Duration: 4 years (2017-2020)
Partners: Inria (Aramis, Bonsai, Dyliss, GenScale, XPOP), ICM

The IPL Neuromarkers aims to design imaging bio-markers of neuro-degenerative diseases for clinical trials and study of their genetic associations. In this project, GenScale bring its expertise in the genomics field. More precisely, given a case-control population, a first step is to locate small genetic variations (SNPs, small indels) from their genomes. Then, having these variations together with brain images (also partitioned into case-control data sets), the challenge is to select variants that present potential correlation with brain images.

9.3. European Initiatives

9.3.1. Collaborations in European Programs

Program: ITN (Initiative Training Network)

Project acronym: IGNITE

Project title: Comparative Genomics of Non-Model Invertebrates

Duration: 48 months (April 2018, March 2022)

Coordinator: Gert Woerheide

Partners: Ludwig-Maximilians-Universität München (Germany), Centro Interdisciplinar de Investigação Marinha e Ambiental (Portugal), European Molecular Biology Laboratory (Germany), Université Libre de Bruxelles (Belgium), University of Bergen (Norway), National University of Ireland Galway (Ireland), University of Bristol (United Kingdom), Heidelberg Institute for Theoretical Studies (Germany), Staatliche Naturwissenschaftliche Sammlungen Bayerns (Germany), INRA Rennes (France), University College London (UK), University of Zagreb (Croatia), Era7 Bioinformatics (Spain), Pensoft Publishers (Bulgaria), Queensland Museum (Australia), Inria, GenScale (France), Institut Pasteur (France), Leibniz Supercomputing Centre of the Bayerische Akademie der Wissenschaften (Germany), Alphabiotoxine (Belgium)

Abstract: Invertebrates, i.e., animals without a backbone, represent 95 per cent of animal diversity on earth but are a surprisingly underexplored reservoir of genetic resources. The content and architecture of their genomes remain poorly characterised, but such knowledge is needed to fully appreciate their evolutionary, ecological and socio-economic importance, as well as to leverage the benefits they can provide to human well-being, for example as a source for novel drugs and biomimetic materials. IGNITE will considerably enhance our knowledge and understanding of animal genome knowledge by generating and analyzing novel data from undersampled invertebrate lineages and by developing innovative new tools for high-quality genome assembly and analysis.

9.4. International Initiatives

9.4.1. Inria Associate Teams

9.4.1.1. HipcoGen

Title: High-Performance Combinatorial Optimization for Computational Genomics

International Partner (Institution - Laboratory - Researcher):

LANL (United States)

Information Science department

Hristo Djidjev

Start year: 2017

See also: https://team.inria.fr/genscale/presentation/associated-team/

Genome sequencing and assembly, the determination of the DNA sequences of a genome, is a core experiment in computational biology. During the last decade, the cost of sequencing has decreased dramatically and a huge amount of new genomes have been sequenced. Nevertheless, most of recent genome projects stay unfinished and nowadays the databases contain much more incompletely assembled genomes than whole stable reference genomes. The main reason is that producing a complete genome, or an as-complete-as-possible-genome, is an extremely difficult computational task (an NP-hard problem) and, in spite of the efforts and the progress done by the bioinformatics community, no satisfactory solution is available today. New sequencing technologies (such as PacBio or Oxford Nanopore) are being developed that tend to produce longer DNA sequences and offer new opportunities, but also bring significant new challenges. The goal of this joint project–a cooperation between Los Alamos National Laboratory, US and Inria, is to develop a new methodology and tools based on novel optimization techniques and massive parallelism suited to these emerging technologies and able to tackle the complete assembly of large genomes.

9.4.1.2. Informal International Partners

- Free University of Brussels, Belgium: Genome assembly [P. Perterlongo, D. Lavenier]

9.5. International Research Visitors

9.5.1. Visits of International Scientists

- Visit of Hristo Djidjev from Los Alamos National Laboratory, USA, June 2018.
- Visit of Bernardo Clavijo from the Earlham Institute, United Kingdom, February 2018.
- Visit of Nicole Van Dam from Institute of Ecology, Jena university, June 2018.

9.5.2. Visits to International Teams

9.5.2.1. Research Stays Abroad

- Visit of R. Andonov at Los Alamos National Laboratory, USA, from March 23 to April 30th, 2018.
- Visit of S. Francois at Los Alamos National Laboratory, USA, from March 23 to April 23th, 2018.

IBIS Project-Team

7. Partnerships and Cooperations

7.1. Regional Initiatives

Project name	MuSE: MUlti-Omics and Metabolic models integration to study growth transition in Escherichia coli
Coordinator	D. Ropers
IBIS participants	D. Ropers, T. Etienne
Type	IXXI/BioSyl project (2018-2020)
Web page	http://www.biosyl.org/news/muse-2013-multi-omics-and-metabolic-models-integration-to-study-growth-transition-in-escherichia-coli

Project name	RNAfluo: Quantification d'ARN régulateurs *in vivo*
Coordinator	S. Lacour
IBIS participants	S. Lacour
Type	AGIR project Univ Grenoble Alpes (2016-2019)

7.2. National Initiatives

Project name	MEMIP – Modèles à effets mixtes de processus intracellulaires : méthodes, outils et applications
Coordinator	G. Batt
IBIS participants	E. Cinquemani, A. Marguet, D. Ropers
Type	ANR project (2016-2020)

Project name	ENZINVIVO – Détermination in vivo des paramètres enzymatiques dans une voie métabolique synthétique
Coordinator	G. Truan
IBIS participants	J. Geiselmann, H. de Jong
Type	ANR project (2016-2020)

Project name	MAXIMIC: Optimal control of microbial cells by natural and synthetic strategies
Coordinator	H. de Jong
IBIS participants	C. Boyat, E. Cinquemani, J. Geiselmann, H. de Jong, A. Pavlou, C. Pinel, D. Ropers
Type	ANR project (2017-2021)
Web page	https://project.inria.fr/maximic

Project name	RIBECO (RIBonucleotide ECOnomy): Engineering RNA life cycle to optimize economy of microbial energy
Coordinator	M. Cocaign-Bousquet
IBIS participants	E. Cinquemani, T. Etienne, D. Ropers
Type	ANR project (2018-2022)
Web page	https://project.inria.fr/ribeco/

Project name	COSY: real-time COntrol of SYnthetic microbial communities
Coordinator	E. Cinquemani
IBIS participants	E. Cinquemani, H. de Jong, J. Geiselmann, M. Mauri, T. Muszbek, C. Pinel, D. Ropers
Type	Inria Project Lab (2017-2021)
Web page	https://project.inria.fr/iplcosy/

Project name	CoSoft: Control software for a system of mini-bioreactors
Coordinator	E. Cinquemani
IBIS participants	E. Cinquemani, H. de Jong, J. Geiselmann, T. Muszbek
Type	Inria Hub (2017-2018)

Project name	AlgeaInSilico: Prédire et optimiser la productivité des microalgues en fonction de leur milieu de croissance
Coordinator	O. Bernard
IBIS participants	H. de Jong, N. Giordano
Type	Inria Project Lab (2015-2019)
Web page	https://project.inria.fr/iplalgaeinsilico/

Project name	Analyse intégrative de la coordination entre stabilité des ARNm et physiologie cellulaire chez Escherichia coli
Coordinators	D. Ropers, M. Cocaign-Bousquet (Inra, LISBP)
IBIS participants	T. Etienne, D. Ropers
Type	Contrat Jeune Scientifique Inra-Inria (2016-2019)

7.3. European Initiatives

7.3.1. Collaborations with Major European Organizations

Systems biotechnology department at Technische Universität Münich (Germany), Andreas Kremling

Modeling of carbon metabolism in bacteria

Automatic control laboratory at ETH Zürich (Switzerland), John Lygeros, and Cell cycle laboratory, School of Medicine, University of Patras (Greece), Zoe Lygeros

Control theory and systems identification with applications to single-cell systems biology

LEMON Team

9. Partnerships and Cooperations

9.1. Regional Initiatives

Cart'Eaux project (European Regional Development Fund (ERDF)): in partnership with colleagues of LIRMM and HSM (Montpellier) and with Berger-Levrault company, Carole Delenne and Benjamin COMMANDRE are developing a methodology that will collect and merge multi-sources data in the aim of mapping urban drainage networks for hydraulic modeling purpose. This chain of treatment includes: i) detection of manhole covers from remote sensing data (aerial images, numerical elevation models...), 2) development of an algorithm to retrieve the network from the detected points and other information such as roads or topography, 3) data manning to extract useful characteristics for the hydraulic model, from various databases available or from documents automatically gathered from the web. A confidence index will be given to each characteristic assessed and a sensitivity analysis will enable the software to propose a hydraulic model together with an associated uncertainty.

The GeRIMU project (Gestion du Risque d'Inondation en Milieu Urbain) will be based on the SW2D computational code. The purpose is to optimize and implement the commercial version of the code into a complete software chain for the forecasting and scenario appraisal for rainfall-generated urban floods on the scale of the urban area. The test and application site is the entire urban area of Montpellier.

9.2. National Initiatives

Antoine Rousseau is member of the ANR project ANSWER (PI Céline Casenave), 2016-2019

Gwladys Toulemonde is head of a project (2016-2018) funded by INSU via the action MANU (MAthematical and NUmerical methods) of the LEFE program. This project, called Cerise, aims to propose methods for simulating scenarii integrating spatio-temporal extremes fields with eventual asymptotic independence for impact studies in environmental sciences. Fatima PALACIOS-RODRIGUEZ is also a member of this project.

9.3. International Initiatives

9.3.1. Inria International Labs

Antoine Rousseau collaborates with Inria Chile through the partnership with MERIC in Chile. Two visits every year.

9.3.1.1. Associated team NEMOLOCO

Title: NEw MOdeLing tOols for Coastal Oceanography

International Partner (Institution - Laboratory - Researcher):

Pontificia Universidad Católica de Chile (Chile) - CIGIDEN - Rodrigo Cienfuegos

Start year: 2017

See also: https://team.inria.fr/LEMON/en/

The NEMOLOCO project targets the improvement of models in the coastal zone. Expected contributions concern: - design and implementation of domain decomposition and coupling techniques for coastal modeling - high resolution ocean simulation (including nesting) thanks to the software ROMS-CROCO, applied to biological tracers tracking.

9.3.2. Inria International Partners

9.3.2.1. Declared Inria International Partners

In 2015, the *Marine Energies Research International Center* (MERIC) was launched in Chile by CORFO. Antoine Rousseau is the scientific coordinator for Inria, and several members of LEMON, CARDAMOM and TOSCA research teams will be involved in this 8 years project driven by DCNS. Antoine Rousseau is involved in the research line *advanced modeling for marine energy*.

9.3.2.2. Informal International Partners

Vincent Guinot collaborates with B.F. Sanders (University of California Irvine, USA)

Carole Delenne and Vincent Guinot collaborate with S. Soares-Frazao (Unité de Génie Civil, Université catholique de Louvain, Belgium)

Gwladys Toulemonde collaborates with C. Gaetan (Università Ca' Foscari - Venezia)

9.3.3. Participation in Other International Programs

Antoine Rousseauwas member of a successfull application to the REDES (Conicyt, Chile) program with H. Ramirez (CMM, Santiago) and P. Gajardo (UTFSM, Valparaiso).

9.4. International Research Visitors

Rodrigo Cienfuegos (PUC Santiago, Chile) visited Paris for two weeks in June (collaboration around TsunamiLab).

LIFEWARE Project-Team

8. Partnerships and Cooperations

8.1. National Initiatives

8.1.1. ANR Projects

- ANR-FWF CyberCircuits (2018-2022): "Cybergenetic circuits to test composability of gene networks", co-coordinated by C. Guet (IST Austria, Klosterneuburg, Austria) and J. Ruess (Inria EPI Lifeware);
- ANR-DFG SYMBIONT (2018-2021) on "Symbolic Methods for Biological Systems", coordinated by T. Sturm (CNRS, LORIA, Nancy, France) and A. Weber (Univ. Bonn, Germany) with F. Fages and F. Boulier (U. Lille), O. Radulescu (U. Montpellier), A. Schuppert (RWTH Aachen), S. Walcher (RWTH Aachen), W. Seiler (U. Kassel);
- ANR-MOST BIOPSY (2016-2020) on "Biochemical Programming System", coordinated by F. Molina (CNRS, Sys2diag, Montpellier) and J.H. Jiang (National Taiwan University), with F. Fages;
- ANR MEMIP (2016-2020) on "Mixed-Effects Models of Intracellular Processes", coordinated by G. Batt, with P. Hersen, (CNRS/Paris7), E. Cinquemani (Inria EPI IBIS) and M. Lavielle (Inria/CNRS/Polytechnique, EPI XPOP);
- ANR COGEX (2016-2019) on "Computer Aided Control of Gene Expression" coordinated by P. Hersen (MSC lab, CNRS/Paris7), with G. Batt and G. Truan (LISBP, CNRS/INSA);
- ANR Blanc HYCLOCK (2014-2018) on "Hybrid modeling of time for Circadian Clock Biology and Chronopharmacology", coordinated by F. Delaunay (CNRS, Nice), with F. Lévi (INSERM Paris-Sud), G. Bernot (CNRS I3S, Nice), O. Roux (Ecole Centrale Nantes), F. Fages and S. Soliman;
- ANR Blanc STOCH-MC (2014-2018) on "Stochastic Models: Scalable Model Checking", coordinated by Blaise Genest (Inria Rennes), with Grégory Batt, Wieslaw Zielonka (LIAFA), and Hugo Gimbert (LaBRI).

8.1.2. Inria Project Lab

- IPL COSY (2017-2021) "real-time control of synthetic microbial communities", coordinated by Eugenio Cinquemani (Ibis, Inria), with Jean-Luc Gouzé (Biocore, Inria), Gregory Batt, Frédéric Bonnans (Commands, Inria), Efimov Denis (Non-A, Inria), and Hans Geiselmann (BIOP, Université Grenoble-Alpes), Beatrice Laroche (Maiage, Inra Jouy-en-Josas).

8.2. European Initiatives

8.2.1. H2020 Projects

- H2020 FET-OPEN COSY-BIO (2017-2020), "Control Engineering of Biological Systems for Reliable Synthetic Biology Applications", coordinated by Diego di Bernardo (Tigem), with Filippo Menolascina (Edinburgh U), Mario di Bernardo (Naples U), Pascal Hersen (Paris7 U), Mustafa Khammash (ETHZ), Gregory Batt, Guy-Bart Stan (Imperial College), and Lucia Marucci (Bristol U).

8.3. International Research Visitors

8.3.1. Visits of International Scientists

The following researchers have been invited for short visits

- Carlo Spaccasassi, Microsoft Research Cambridge, UK
- Debdas Paul, Univ. Stuttgart, Germany

8.3.1.1. Internships

Lucia Nasti, PhD candidate at the Universita of Pisa, Italy, is visiting our group for 4 months.

8.3.2. Visits to International Teams

8.3.2.1. Research Stays Abroad

Jakob Ruess stayed at IST Austria twice a week in Feb and Nov 2018.

M3DISIM Project-Team

9. Partnerships and Cooperations

9.1. National Initiatives

9.1.1. Other funding

IPM-MS project (for Imagerie Polarimétrique de Mueller pour la réalisation d'un système original de caractérisation des propriétés mécaniques des Matériaux Structurés). 50k€ funded by the LABEX Lasips. This project, which involves the LPICM laboratory (Ecole Polytechnique, CNRS), the LMS (Ecole Polytechnique, CNRS, Mines ParisTech) and the Centre des Matériaux (Mines ParisTech), aims at developing an optical tool to study the link between the mechanical properties of a material and its hierarchical organization. Despite the development of new methods to observe the microstructure, one of the limitations is the number of observations that can be obtained on a given sample in a realistic experimental time. To overcome this difficulty, we are planning to use the Mueller polarimetry to obtain at a fast rate (a few frames per second, compared to a few frames per half-hour) relevant information on the local anisotropy of biological (heart, skin) and composite (short fibers composite) samples.

G. Bureau, software engineer in the team, was funded by an Inria Reo industrial contract with Kephalios, a startup working on innovative artificial valves devices.

9.2. European Initiatives

9.2.1. Collaborations with Major European Organizations

Partner 1: Division of Biomedical Engineering & Imaging Sciences (BMEIS), St Thomas' Hospital, King's College London, UK

clinical-modeling topics mostly encompassing congenital heart diseases (BMEIS acts as "Other participant" in the Inria Associate team ToFMOD, and R. Chabiniok additionally performs clinical MRI exams at St Thomas' hospital 0.5 days / week.

Partner 2: Department of Mathematics, Faculty of Nuclear Sciences and Physical Engineering, Czech Technical University in Prague, Czech Republic

model-constrained image registrations, trans-valvular flow in pathological valves.

Partner 3: Institute for Clinical and Experimental Medicine in Prague

Cardiovascular MRI

9.3. International Initiatives

9.3.1. Inria Associate Teams Not Involved in an Inria International Labs

9.3.1.1. ToFMod

Title: Cardiac Biomechanical Modeling of Chronic Right Ventricular Loading

International Partner (Institution - Laboratory - Researcher):

UT Southwestern Medical Center, Dallas,Texas (United States), Mohammad Tarique Hussain

Start year: 2018

See also: https://m3disim.saclay.inria.fr/associated-team/

This collaboration aims at addressing a crucial issue in cardiology of congenital heart diseases, namely, the optimal timing of pulmonary valve replacement (PVR) in patients with surgically repaired tetralogy of Fallot (ToF) prone to chronic pulmonary regurgitation or right ventricular outflow tract stenosis. Our strategy consists in exploiting the predictive power of biomechanical modeling to shed light in the decision process. We will start by a detailed proof-of-concept study, based on datasets that will be acquired in patients indicated for percutaneous PVR, prior to the procedure, and in the follow-up at 3- and 12-months post-PVR. These datasets will be first used to calibrate the Inria M3DISIM patient-specific heart model simulating a cardiac cycle (at each follow-up time point) to access the myocardial properties – namely, the active contractility and passive stiffness. The instantaneous tissue properties will be statistically analyzed and compared with the level of reverse remodeling – i.e. the positive outcome of PVR. Secondly, the data at each time point will be used to calibrate and further develop the models of long-term tissue remodeling created by the M3DISIM researchers. It is only by combining such invaluable longitudinal data with biomechanical modeling expertise that progress can be achieved in the above objective, indeed.

9.4. International Research Visitors

9.4.1. Invited researchers

- T. Hussain, A. Tandon (Senior researchers at UTSW Medical Center Dallas): joint work in the scope of the Inria Associate team ToFMOD
- F. Regazzoni (3rd year PhD student from MOX, Milan, Italy): From Sept 2018, joint work on model learning and data assimilation coupling.

9.4.2. Internships

- K. Solovska (Czech Technical University and IKEM Prague): 1-30 August 2018, collaborative work with M. Genet and R. Chabiniok in the scope of the Inria Associate team ToFMOD

MAGIQUE-3D Project-Team

8. Partnerships and Cooperations

8.1. Regional Initiatives

8.1.1. Partnership with I2M in Bordeaux supported by Conseil Régional d'Aquitaine

title: Imaging complex materials.
Coordinator: Hélène Barucq
Other partners: I2M CNRS Université Bordeaux I

The detection, localization and monitoring of the defect evolution in composite materials, concrete and more generally heterogeneous materials is a challenging problem for Aeronautics and energy production. It is already possible to localize defects in homogeneous materials by using methods based on ultrasonic inspection and sometimes, they are usable in particular heterogeneous materials, most of the time in 2D. Classical methods rely on the correspondence between the distance and the propagation time of the wave traveling between the defect and the receivers. In complex media, such a correspondence may be lapsed, for instance when the velocity depends on the frequency (dispersion) or of the propagation direction (anisotropy). The defect signature can also be embedded in the acoustic field sent by the structure (multiple reflections). The complexity of the propagation in heterogeneous materials makes then difficult the accurate localization of the defect, in particular in 3D.

Topological imaging techniques can be applied to heterogeneous media. They can find the positions of defects from two simulations performed in a safe experimental medium. They have been developed at I2M laboratory to carry on 2D single/multi mode inspection in isotropic and anisotropic waveguides. They have also been applied to a highly reflecting medium observed with a single sensor. The objective of this work is to extend the technique to 3D problems. In particular, we are going to handle detection in composite plates and in highly heterogeneous media including a collection of small scatterers.

This project is supported by the Conseil Régional d'Aquitaine, for a duration of 2 years.

8.2. National Initiatives

8.2.1. Depth Imaging Partnership

Magique-3D maintains active collaborations with Total. In the context of Depth Imaging, Magique-3D coordinates research activities dealing with the development of high-performance numerical methods for solving wave equations in complex media. This project has involved 2 other Inria Team-Projects (Hiepacs and Nachos) which have complementary skills in mathematics, computing and in geophysics. DIP is fully funded by Total by the way of an outline agreement with Inria.

In 2014, the second phase of DIP has begun. Lionel Boillot has been hired as engineer to work on the DIP platform. Six PhD students have defended their PhD since 2014 and they are now post-doctoral researchers or engineers in Europe. DIP is currently employing 2 PhD students and one post-doctoral researcher.

8.2.2. PRE Concert

Magique 3D is hosting an Inria "exploratory research project" (PRE) about modeling and designing wind musical instruments. This project is funding the post-doctoral position of Robin Tournemenne since July 2017.

8.2.3. ANR Num4Sun

The ANR has launched a specific program for supporting and promoting applications to European or more generally International projects. Magique-3D has been selected in 2016 after proposing a project to be applied as a FET project on the occasion of a call that will open in 2017 April. This project will gather researchers of the MPS (https://www.mps.mpg.de/en), of the BSC (https://www.bsc.es/), of the BCAM (http://www.bcamath.org/en/), of Heriot-Watt University (https://www.hw.ac.uk/) and Inria teams.

A kick-off meeting has been held in November 2016 in Strasbourg and a second one in Paris in July 2017. Thanks to this support, we have submitted a ETPHPC proposal in September 2017 The project is funded for 18 months starting from August 2016. The funding amounts 30000€.

8.2.4. ANR NonLocalDD

Magique 3-D is a partner of the ANR project entitled "Non Local Domain Decomposition Methods in Electromagnetics" that begins in october 2015. The aim of this project is to develop domain decomposition methods for the efficient solution of acoustics and Maxwell's equation either with boundary integral equations or finite element volume method. To obtain an exponential convergence of the iterative solution, non-local operators are studied and optimized to achieve a faster convergence. A post-doctoral student Marcella Bonazzoli has been hired by Magique 3-D in 2017 to study multi-domain integral equations for wave propagation. This student is supervised by Xavier Claeys, a partner of the NonLocalDD ANR project.

8.2.5. Grant from Fondation Blaise Pascal

The project Louis 14.0 has been selected by the Fondation Blaise Pascal as one of their supported projects for 2019. See more about the project at https://project.inria.fr/louis14point0/, in french.

8.3. European Initiatives

8.3.1. H2020 Projects

8.3.1.1. Mathrocks

Title: Multiscale Inversion of Porous Rock Physics using High-Performance Simulators: Bridging the Gap between Mathematics and Geophysics

Program: H2020

Duration: April 2018 - March 2022

Coordinator: Universidad Del Pais Vasco (EHU UPV)

Partners:

- Bcam - Basque Center for Applied Mathematics Asociacion (Spain)
- Barcelona Supercomputing Center - Centro Nacional de Supercomputacion (Spain)
- Universidad Del Pais Vasco Ehu Upv (Spain)
- Universitat Politecnica de Catalunya (Spain)
- REPSOL SA (Spain)
- Pontificia Universidad Catolica de Valparaiso (Chile)
- Curtin University of Technology (Australia)
- The University of Texas System (USA)
- University Nacional de Columbia (Colombia)
- Pontificia Universidad Catolica de Chile (Chile)
- Universidad Central de Venezuela (Venezuela)
- University de Buenos Aires (Argentina)
- Macquarie University (Australia)

Inria contact: Hélène BARUCQ

We will develop and exchange knowledge on applied mathematics, high-performance computing (HPC), and geophysics to better characterize the Earth´s subsurface. We aim to better understand porous rocks physics in the context of elasto-acoustic wave propagation phenomena. We will develop parallel high-continuity isogeometric analysis (IGA) simulators for geophysics. We will design and implement fast and robust parallel solvers for linear equations to model multi-physics electromagnetic and elasto-acoustic phenomena. We seek to develop a parallel joint inversion workflow for electromagnetic and seismic geophysical measurements. To verify and validate these tools and methods, we will apply the results to: characterise hydrocarbon reservoirs, determine optimal locations for geothermal energy production, analyze earthquake propagation, and jointly invert deep-azimuthal resistivity and elasto-acoustic borehole measurements. Our target computer architectures for the simulation and inversion software infrastructure consists of distributed-memory parallel machines that incorporate the latest Intel Xeon Phi processors. Thus, we will build a hybrid OpenMP and MPI software framework. We will widely disseminate our collaborative research results through publications, workshops, postgraduate courses to train new researchers, a dedicated webpage with regular updates, and visits to companies working in the area. Therefore, we will perform a significant role in technology transfer between the most advanced numerical methods and mathematics, the latest super-computer architectures, and the area of applied geophysics.

8.4. International Initiatives

8.4.1. Inria International Partners

8.4.1.1. Declared Inria International Partners

8.4.1.1.1. MAGIC2

Title: Advance Modeling in Geophysics

International Partner (Institution - Laboratory - Researcher):

California State University at Northridge (United States) - Department of Mathematics - Djellouli Rabia

The Associated Team MAGIC was created in January 2006 and renewed in January 2009. At the end of the program in December 2011, the two partners, MAGIQUE-3D and the California State University at Northridge (CSUN) decided to continue their collaboration and obtained the “Inria International Partner” label in 2013.

See also: https://project.inria.fr/magic/

The ultimate objective of this research collaboration is to develop efficient solution methodologies for solving inverse problems arising in various applications such as geophysical exploration, underwater acoustics, and electromagnetics. To this end, the research program will be based upon the following three pillars that are the key ingredients for successfully solving inverse obstacle problems. 1) The design of efficient methods for solving high-frequency wave problems. 2) The sensitivity analysis of the scattered field to the shape and parameters of heterogeneities/scatterers. 3) The construction of higher-order Absorbing Boundary Conditions.

In the framework of Magic2, Rabia Djellouli (CSUN) visited Magique 3D in February 2018

8.5. International Research Visitors

8.5.1. Visits of International Scientists

- José M. Carcione (Istituto Nazionale di Oceanografia e di Geofisica Sperimentale, OGS) visited Magique 3D in December 2018.
- Guy Chavent (Inria Rocquencourt, Emeritus professor) visited Magique 3D in December 2018.
- Barbara Romanowicz (Berkeley Seismological Laboratory, Collège de France) visited Magique 3D in November 2018

- Mounir Tlemcani (Université d'Oran, Algeria) visited Magique 3D in March 2018.
- Rabia Djellouli (CSUN) visited Magique 3D in February 2018.

8.5.2. Visits to International Teams

8.5.2.1. Research Stays Abroad

- Justine Labat visited Benjamin Stamm, RTWH Aachen University, Germany, in December 2018.
- In the framework of DIP, Pierre Jacquet visited Total Research Center at Houston, USA, in December 2018.

MAMBA Project-Team

9. Partnerships and Cooperations

9.1. National Initiatives

9.1.1. ANR

9.1.1.1. ANR Blanc 2014-2018 "Kibord"

This project gathers several members of the MAMBA team together with the ENS Cachan and Université Paris-Dauphine on the mathematical study of PDE models with application to biology.

9.1.1.2. ANR iLITE 2016 - 2020

Jean-Charles Duclos-Vallée, Paul Brousse Hospital, Villejuif. Partners are several departments in Paul Brousse Hospital, ENS Cachan, University of Compiègne and several companies all over France, and REO team, Inria Paris. The pursued objective is the bioengineering design of an artificial liver intended for liver replacement.

9.1.1.3. ANR InTelo 2017-2020

Telomere dynamics, headed by Teresa Teixeira (IBPC, Paris).

9.1.1.4. INCa/DGOS; PRT-K 2018-2021

Khê HOANG-XUAN, Hôpital Universitaire La Pitié Salpêtrière, Paris. Mathematical modeling at micro and macroscopic level of primary central nervous system lymphomas (PCNSL).

9.1.2. ITMO Cancer 2016 - 2020, HTE call (heterogeneity of tumours in their ecosystems)

9.1.2.1. ITMO Cancer EcoAML

Early leukaemogenesis in Acute Myelogenous Leukaemia (AML), 8 teams headed by François Delhommeau (CDR St Antoine, Paris).

9.1.2.2. ITMO Cancer MoGlImaging

Treatment-induced treatment resistance and heterogeneity in glioblastoma, 8 teams headed by Elizabeth Moyal (INSERM, Toulouse).

9.2. European Initiatives

9.2.1. Collaborations in European Programs, Except FP7 & H2020

Program: Celtic+

Project acronym: Sendate

Project title:Secure Networking for a Data Center Cloud in Europe

April 2016/May 2019

Coordinator: Nokia

Other partners: Siemens, IMT, ...

9.3. International Initiatives

9.3.1. Inria Associate Teams Not Involved in an Inria International Labs

9.3.1.1. MaMoCeMa

Title: Mathematical modeling of cell motility and of autophagy

International Partner (Institution - Laboratory - Researcher):

University of Vienna (Austria) - Wolfgang Pauli Institute - Christian Schmeiser

Start year: 2018

Numerous fruitful collaborations have been developed these last years between the WPI and the Inria team MAMBA. Diane Peurichard – newly recruited permanent member of the team MAMBA – worked two years (2016-2017) with Christian Schmeiser – member of the present project – through a post-doctoral contract at the university of Vienna. In collaboration with the biologists of IST, they developed mathematical tools to understand how cells move through adhesion-based and adhesion-free motion with applications in cancer development, prevalent theme of the team MAMBA. Collaborations WPI-MAMBA are presently maintained and ensured by the sabbatical of Marie Doumic – MAMBA team leader –, working at the university of Vienna with Christian Schmeiser and the PhD student Julia Delacour. They have initiated a collaboration on the mathematical modeling of autophagy, which requires both C. Schmeiser's expertise in biomechanics and M. Doumic's knowledge on aggregation processes. This team will also benefit of the strong links that C. Schmeiser has developed with the two biologists teams of S. Martens (on autophagy) and M. Sixt (on cell movement).

Of note, C. Schmeiser has been a laureate for the "Chaire d'excellence" program of the FSMP. As such, he is for six months in Paris, and delivered a course at IHP on entropy methods. Many of his students and collaborators visited him (D. Oelz, G. Jankowiak, L. Kanzler, G. Favre, L. Neumann...), and participated to a joint Mamba-MaMoCeMa meeting on December 6th, still strengthening our links.

9.3.2. Participation in Other International Programs

9.3.2.1. International Initiatives

ECOS Nord C17M01

Title: News methods for controle of dengue and arobivroses epidemics

International Partner (Institution - Laboratory - Researcher):

Universidad del Valle (Colombia) - Department of Mathematics - Olga Vasilieva

Duration: 2017 - 2019

Start year: 2017

The overall goal of the project is the development of mathematical models and theory-based control methods, contributing to the improvement of epidemiological surveillance and the control of dengue and other serious diseases transmitted by mosquitoes Aedes aegypti (chikungunya, yellow fever, zika fever). More specifically, it :

- Develops modeling framework for the biological control of mosquito populations (through the use of natural predators, Wolbachia bacteria etc.).
- Proposes and evaluates control strategies based on the use of biological agents and on their possible combinations with traditional control measures (such as removal of reproduction, spraying insecticides and / or larvicides, use of mosquito nets, repellents, etc.).
- Compares the results of biological control strategies (and their combinations) with those of traditional control using a cost / efficiency approach.
- Includes in the developments the spatial aspects of the questions above.

BMBF (Germany) / LiSym; 2016-2020 LiSym addresses liver diseases and regeneration, namely, steatosis, fibrosis and cirrhosis, and acute on chronic liver failure. Dirk Drasdo is co-coordinator of one sub-project, participant in one of the other ones, and member of the leadership board

BMBF (Germany) / MSDILI; 2016-2019 MS-DILI addresses multiscale modeling of drug-induced liver disease focusing on the role of APAP. Dirk Drasdo participates in this project.

9.4. International Research Visitors

9.4.1. Visits of International Scientists

- Prof. Olga Vasilieva (Universidade del Valle, Cali, Colombia) was invited during three weeks, together with Edwin Bairros, PhD student.
- Prof. Yukihiko Nakata (Shimane University, Matsue, Japan) was hosted during one week in the framework of the French program Exploration France.
- Prof. C. Schmeiser (university of Vienna, Austria) was visiting during four month, from september 2018, and should stay until february 2019.
- Prof. D. Oelz (university of Queensland, Australia) visited from Dec. 5th to Dec. 21st.
- Jieling Zhao, Postdoc from IfADo
- Paul van Liedekerke, Research engineer from IfADo

9.4.1.1. Internships

Ismael Gonzalez Valverde (University of Zaragoza) visited our team for 3 months working on implementation of the meshing of liver micro-structures in modeling of liver regeneration within TiSim.

9.4.2. Visits to International Teams

9.4.2.1. Sabbatical programme

Marie Doumic was in Vienna for a sabbatical stay until July 2018.

MATHNEURO Team

5. Partnerships and Cooperations

5.1. European Initiatives

5.1.1. FP7 Projects

5.1.1.1. HBP

Title: The Human Brain Project

Program: FP7

Duration: October 2013 - March 2016 (first part), then : April 2016 - March 2018 (second part) and then : April 2018 - March 2020 (third part)

Coordinator: EPFL

Partners:
see the webpage of the project.

Olivier Faugeras is leading the task T4.1.3 entitled “Meanfield and population models” of the Worpackage W4.1 “Bridging Scales”.

Inria contact: Olivier Faugeras (first part) and then : Romain Veltz (second and third part)

Understanding the human brain is one of the greatest challenges facing 21st century science. If we can rise to the challenge, we can gain profound insights into what makes us human, develop new treatments for brain diseases and build revolutionary new computing technologies. Today, for the first time, modern ICT has brought these goals within sight. The goal of the Human Brain Project, part of the FET Flagship Programme, is to translate this vision into reality, using ICT as a catalyst for a global collaborative effort to understand the human brain and its diseases and ultimately to emulate its computational capabilities. The Human Brain Project will last ten years and will consist of a ramp-up phase (from month 1 to month 36) and subsequent operational phases.
This Grant Agreement covers the ramp-up phase. During this phase the strategic goals of the project will be to design, develop and deploy the first versions of six ICT platforms dedicated to Neuroinformatics, Brain Simulation, High Performance Computing, Medical Informatics, Neuromorphic Computing and Neurorobotics, and create a user community of research groups from within and outside the HBP, set up a European Institute for Theoretical Neuroscience, complete a set of pilot projects providing a first demonstration of the scientific value of the platforms and the Institute, develop the scientific and technological capabilities required by future versions of the platforms, implement a policy of Responsible Innovation, and a programme of transdisciplinary education, and develop a framework for collaboration that links the partners under strong scientific leadership and professional project management, providing a coherent European approach and ensuring effective alignment of regional, national and European research and programmes. The project work plan is organized in the form of thirteen subprojects, each dedicated to a specific area of activity.
A significant part of the budget will be used for competitive calls to complement the collective skills of the Consortium with additional expertise.

5.2. International Research Visitors

5.2.1. Visits of International Scientists

Invitation of Andrey Shilnikov, Georgia State University (USA), January 2018

Invitation of Jean-Pierre Françoise, Sorbonne Université (Paris), April 2018

Invitation of Vivien Kirk, University of Auckland (New Zealand), May 2018

Invitation of Peter De Maesschalck, University of Hasselt (Belgium), June 2018

5.2.2. Visits to International Teams

Visit of Mathieu Desroches to Jean-Pierre Françoise (LJLL, Sorbonne Université, Paris) in October 2018

5.2.2.1. Research Stays Abroad

One-month research stay of Mathieu Desroches at BCAM (Bilbao, Spain) on an invited professor scholarship to work with Serafim Rodrigues, June 2018

MIMESIS Team

9. Partnerships and Cooperations

9.1. Regional Initiatives

At the regional level, the MIMESIS team collaborates with

9.1.1. ICube Automatique Vision et Robotique (AVR)

We have been collaborating with the medical robotics team on percutaneous procedures, in particular robotized needle insertion (with Prof. Bernard Bayle), and needle tracking in medical images (with Elodie Breton). We are also collaborating with Jonathan Vappou on elastography.

9.1.2. ICube Informatique Géométrique et Graphique (IGG)

MIMESIS joined the IGG team and develops collaboration in the domain of dynamic topologies, mainly through the use of the CGoGN framework. CGoGN is a C++ library for the manipulation of meshes. It implements combinatorial maps and their multiresolution extensions and has been used in various high level application like the simulation of crowds of autonomous agents and the simulation of cuts, tears and fractures in the context of surgical simulations.

9.1.3. Institute of Image-Guided Surgery (IHU) Strasbourg

We have several active projects and collaborations with IHU Strasbourg in order to collect and use medical images (such as MRI, CT, Fluoroscopy and Ultrasound) before, during and after minimally-invasive surgical procedures (percutaneous, endovascular and laparoscopic). Such images represent an essential support for the development of numerical simulations for intra-operative assistance through augmented and virtual reality. Eventually, simulations will be used for the diagnostic, treatment as well as for training and teaching in medical domain. Yet, before being used in current clinical routine, such simulations must be validated on animal models. Through our collaboration with IHU, we use CT and MRI images to retrieve the anatomical model of internal structures, whereas fluoroscopic and ultrasound images can be used to retrieve 2D images of the physiology and the navigation of surgical instruments within the anatomy. In-vivo procedures can also be performed under ethical approval of MSER (reference to ethic protocol *APAFIS #15433-2018060815283960*). We also collaborate with IHU-Strasbourg fellow surgeons, such as Pr. Mario GIMENEZ and Dr. Alain GARCIA, that provide medical and technical support for medical aspects (see Fig. 11).

- *Authors:* Raffaella Trivisonne, Stéphane Cotin

9.2. National Initiatives

9.2.1. ADT (Action de Développement Technologique)

Team MIMESIS received a support for the development of the project **LOSAR: Liver Open Surgery with Augmented Reality** that aims at developing tools for a per-operative usage of research algorithms developed in the team. Although the current trend is to move towards minimally invasive surgery, open-liver surgery remains the standard treatment for most patients. For Augmented reality purpose, open surgery raises specific constraints compared to celioscopic surgery, such as larger deformations of the liver and unavoidable occlusions of the organ. During the year 2017, the Mimesis team has developed an augmented reality prototype for open liver surgery. This prototype was developed as part of research projects and a collaboration between the team Mimesis and the CHB Paul Brousse (first service of hepatobiliary surgery in France).

Figure 11. Environmental Set-Up for Image Acquisition. IHU-Strasbourg Platform.

Our goal is to be able to repeatedly test our method for one or more important publications in medical conferences. This type of publication requires to methodically repeat our solution on several patients. However, the steps are still insufficiently automated and the algorithm needs to be improved for greater reliability. These essential elements lie outside traditional research missions and require significant development and engineering effort. Indeed, an effort of automation and ergonomics will have to be made to make the use of the software sufficiently simple to be used in the operating room. Furthermore, the accuracy of the deformed model (anatomical distances modeled versus actual anatomical relationships) must also be verified and validated through experimentation.

9.2.2. ANR (Agence Nationale de la Recherche)

MIMESIS coordinates the ANR project entitled **SPERRY: SuPervisEd Robotic suRgerY - application to needle insertion**. Percutaneous medical procedures (using surgical needles) are among the least invasive approaches to accessing deep internal structures of organs without damaging surrounding tissues. Today, many surgical procedures rely on the use of needles allowing for complex interventions such as curie-therapies or thermoablations of tumors (cryoablation, radio frequencies). Unlike traditional open surgery, these approaches only affect a localized area around the needle reducing this way trauma and risks of complications. These treatments also offer new solutions for tumors or for metastases for which traditional methods may be contraindicated due to the age of the patient and the extent or location of the disease. Although they provide very good results, these interventions significantly increase the level of expertise required for practitioners.

In this project, we want to develop new solutions for the control of medical robots interacting with soft tissues. This work is motivated by recent advances in the field of medical simulation achieving a sufficient level of realism to help surgeons during the operation. These simulations are now used for training of surgeons, and even for visual assistance during the operation thanks to augmented reality. The maturity of these techniques now suggests the ability to use a simulation intraoperatively to control the motion of a robotic system for needle insertion. This is really a challenge, because in general, very few information can be extracted in real time from images during an intervention. We believe that even minimal knowledge of the mechanical behavior of structures, associated with the use of images can make it possible and allow a robot to reach a pre-identified target during a planning stage, without human intervention.

9.2.3. Inria Collaborations

MIMESIS is closely connected to the SOFA Consortium, created by Inria in November 2015 with the objective to support the SOFA community and encourage contributions from new SOFA users. The Consortium should

also be a way to better answer to the needs of academic or industrial partners. MIMESIS actively participates at the development of SOFA and contributed to the evolution of the framework. Moreover, MIMESIS also participates in an initiative aiming at verification and validation of codes and algorithms of SOFA.

Further, MIMESIS actively collaborates with the following Inria teams:

MAGRIT: The team at Inria Grand Est focuses on research in computer vision and is also actively involved in computer-based solutions for the planning or the simulation of interventional radiology procedures, with a strong collaboration with the CHU in Nancy. We collaborate with MAGRIT in the area of interventional radiology and augmented reality. Currently, two PhD thesis are co-supervised by researcher from Magrit: the PhD thesis of Jaime Garcia Guevara and Raffaella Trivisonne.

DEFROST: The team conducts research in soft robotics. We continue mutual interaction with DEFROST mainly in the context of contact modeling.

9.2.4. National Collaborations

At the national level, the MIMESIS team collaborates with:

The TIMC laboratory*(Techniques de l'Ingénierie Médicale et de la Complexité)* in Grenoble: this large research group has a strong background in computer-aided surgery, medical imaging, registration, statistical and bio-mechanical modeling. We have regular interactions with various members of this group. We are collaborating with Yohan Payan (DR CNRS) on the modeling and simulation of the brain shift. A common PhD thesis started on that topic in late 2014. Other areas of interest are in the field of advanced soft tissue modeling and computer aided surgery.

The LML laboratory*(Laboratoire de Mécanique de Lille)*: a French research laboratory (UMR CNRS 8107) part of the Carnot institute ARTS. With more than two hundred researchers, LML focuses on the following research areas: mechanical reliability and Tribology, fluid mechanics, civil engineering and soil mechanics.

Hôpital Paul-Brousse a hospital in South Paris. We collaborate with *Centre Hépato-Biliaire* via the co-supervision of the Ph.D. thesis of Nicolas Golse, MD, who is a surgeon at the center.

9.3. European Initiatives

9.3.1. FP7 & H2020 Projects

- **HiPerNav** (https://hipernav.eu) is an Innovative Training Network (ITN) funded through a Marie Skłodowska-Curie grant. This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 722068. There is 14 fully funded and 2 partially funded PhD's working on the project. The project aims to improve soft tissue navigation through research and development, to improve several bottleneck areas:
  - Creating effective pre-operative model(s) and planning
  - Faster and more accurate intra-operative model updates
  - Faster and more accurate model-to-patient registration
  - More intuitive user-interaction and effective workflow
  - Usage of high performance computing (e.g. GPU)

  From these 14 PhD students, two of them are from the Mimesis team: **Jean-Nicolas Brunet** and **Sergei Nikolaev**.
- **Driven** ((https://driven.uni.lu/) The overall aim of the DRIVEN project is to boost the scientific excellence and innovation capacity in data-driven simulation of the University of Luxembourg (UL) and its high-quality Twinning partners: Institut National de Recherche en Informatique et en Automatique (Inria), University of Limerick (ULIM) and University of Texas at Austin (UT Austin). To achieve this aim, the 3 year project will build upon the existing strong research and innovation base of UL and its Twinning partners. The recently established Computational Sciences

interdisciplinary group is composed of members from different research units and disciplines as diverse as Earth Sciences, Life Sciences, Physics, Mathematics and Engineering, with the common goal to set up a network among application-driven scientists which can provide interdisciplinary expertise in the field and contribute to this platform of training and knowledge exchange. To boost their scientific excellence and technology transfer capacity in data-driven simulation, the partners will implement a research and innovation strategy focused on three sub-topics:

1. Mathematical foundations for data-driven simulations – UL with UT Austin,
2. Data-driven simulations for computer-assisted therapy – UL with Inria, and
3. Data-driven simulations for functional composite materials – UL with ULIM.

9.4. International Initiatives

9.4.1. Informal International Partners

- **CAMERA group, University of Bath, UK:** Collaboration on non-rigid registration using RGB-D sensors - Antoine Petit
- **PRISMA Lab, University of Naples, Italy:** Collaboration on soft object robotic manipulation, along with DEFROST team at Inria Lille, and collaboration on visual perception for robotic surgery - Antoine Petit.
- **University of Twente, Netherlands:** Thanks to our clinical partner IHU, we collaborate with Prof. Stefano Stramigioli, head of a group at Robotics and Mechatronics laboratory.
- **Faculty of Informatics, Masaryk University, Czech Republic:** We collaborate on simulation of living cells in fluorescent microscopy.
- **Team Legato, University of Luxembourg:** We have an active collaboration with Prof. Stéphane Bordas on error estimation in real-time simulations of deformable objects.
- **ARTORG Center for Biomedical Engineering Research, Bern, Switzerland:** Collaboration in the projects related to deep learning.

9.5. International Research Visitors

9.5.1. Internships

Domenico Idone (master student from Italy) did a six month internship in the team. The aim of the training period is to investigate a novel method to track catheter shape and location during vascular interventions. We have already experimented the use of a fiber optic, equipped with Fiber Bragg Grating sensors, embedded on a flexible plate, to determine its shape. This sensing system has allowed us to track the motion of the plate undergoing a two-dimensional deformation. The objective of this internship is to expand this work to the case of a three-dimensional deformation, which requires significant improvements over the previous approach.

Renée Geraats (Twente university) did a 2 months internship. She investigated different visualization solutions for augmented reality on fluoroscopic images of the liver and its vasculature, for the 2D3D Fusion project.

Daan Kuppens (Twente university) did a 2 months internship. He provided support on the acquisition of reliable porcine CT and X-ray fluoroscopic images fluoroscopic images, on CT segmentation of the liver and its vasculature and on clinical applications, for the 2D3D Fusion project.

Pim Hendricks (Twente university) did a 2 months internship. She provided support on the acquisition of reliable porcine CT and X-ray fluoroscopic images fluoroscopic images, and on clinical applications, for the 2D3D Fusion project.

MNEMOSYNE Project-Team

9. Partnerships and Cooperations

9.1. Regional Initiatives

9.1.1. PsyPhINe

Participant: Nicolas Rougier.

Project gathering researchers from: MSH Lorraine (USR3261), InterPsy (EA 4432), APEMAC, EPSaM (EA4360), Archives Henri-Poincaré (UMR7117), Loria (UMR7503) & Mnemosyne.

PsyPhiNe is a pluridisciplinary and exploratory project between philosophers, psychologists, neuroscientists and computer scientists. The goal of the project is to explore cognition and behavior from different perspectives. The project aims at exploring the idea of assignments of intelligence or intentionality, assuming that our intersubjectivity and our natural tendency to anthropomorphize play a central role: we project onto others parts of our own cognition. To test these hypotheses, we ran a series of experiments with human subject confronted to a motorized lamp that can or cannot interact with them while they're doing a specific task. We've organized our third national conference in Nancy gathering speakers from philosophy, robotics, art and psychology and closed a three years cycle. The group now aims at publishing a book gathering text from all the invited speakers.

9.2. National Initiatives

9.2.1. FUI Sumatra

Participants: Frédéric Alexandre, Thalita Firmo Drumond, Xavier Hinaut, Randa Kassab, Nicolas Rougier, Thierry Viéville.

This FUI project, supported by the Aerospace Valley Innovation Pole, gathers two industrial groups (Safran Helicopter and SPIE), three research labs and four SME. Its goal is to provide contextualized information to maintenance operators by the online analysis of the operating scene. We are concerned in this project with the analysis of visual scenes, in industrial contexts, and the extraction of visual primitives, categories and pertinent features, best decribing the scenes, with biologically inspired neuronal models.

Firstly, this is an opportunity for us to revisit the principles of deep network architectures by adapting principles that we will elaborate from the context of the hierarchical architecture of the temporal visual cortex. Secondly, we intend to exploit and adapt our model of hippocampus to extract more heterogenous features. This project is an excellent opportunity to associate and combine our models and also to evaluate the robustness of our models in real-world applications.

9.2.2. ANR SOMA (PRCI)

Participants: Nicolas Rougier, Remya Sankar.

This project is a convergence point between past research approaches toward new computational paradigms: adaptive reconfigurable architecture, cellular computing, computational neuroscience, and neuromorphic hardware:

1. SOMA is an adaptive reconfigurable architecture to the extent that it will dynamically re-organize both its computation and its communication by adapting itself to the data to process.
2. SOMA is based on cellular computing since it targets a massively parallel, distributed and decentralized neuromorphic architecture.
3. SOMA is based on computational neuroscience since its self-organization capabilities are inspired from neural mechanisms.
4. SOMA is a neuromorphic hardware system since its organization emerges from the interactions between neural maps transposed into hardware from brain observation.

This project represents a significant step toward the definition of a true fine-grained distributed, adaptive and decentralized neural computation framework. Using self-organized neural populations onto a cellular machine where local routing resources are not separated from computational resources, it will ensure natural scalability and adaptability as well as a better performance/power consumption tradeoff compared to other conventional embedded solutions.

9.2.3. ANR MACAQUE40

Participant: Nicolas Rougier.

Most of the theoretical models in economics proposed so far to describe money emergence are based on three intangible assumptions: the omniscience of economic agents, an infinite time and an extremely large number of agents (not bounded). The goal of this interdisciplinary study is to investigate the condition of apparition of a monetary economy in a more ecological framework provided with the assumption that the market is made up of a finite number of agents having a bounded rationality and facing a time constraint.

In this study, we propose a generic model and environment of monetary prospecting. Our first objective is to artificially identify structural (trading organisation, agents specialisation) and cognitive conditions (learning skills, memory and strategic anticipation abilities, tradeoff exploration/exploitation) that allowed money emergence. This will provide relevant environmental constraints that we will use during our manipulations in the laboratory. The agents that will be involved in these manipulations will be of two types: non-human primates (rhesus macaques) and humans.

9.2.4. Project Motus of the ANSES

Participant: André Garenne.

The MOTUS project (MOdulaTion dU Signal RF et effets sur le cerveau : approche in vivo et in vitro) is financed by the ANSES (the french national agency for health security). This 3 years project is studying the effects of GSM-RF on living matter and especially neuronal activity and development. Our main involvement concerns electrophysiological data and spike trains analysis as well as the development of pharmacological protocols to test GSM-RF effects hypotheses. Altogether, our experimental findings provide evidence for dose-dependent effects of RF signals on the bursting rate of neuronal cultures and suggest that part of the mechanism is nonthermal (publication in Journal of Neurophysiology). In an attempt to elucidate the depressing effect of GSM on in-vitro neuronal activity, pharmacological studies have also been realized on cortical cells.

9.3. International Initiatives

9.3.1. Participation in International Programs

9.3.1.1. Project LingoRob with Germany

LingoRob - Learning Language in Developmental Robots - is a project of the Programme Hubert Curien PHC Procope with Germany (University of Hamburg). The scientific objective of the collaboration is to better understand the mechanisms underlying language acquisition and enable more natural interaction between humans and robots in different languages, while modelling how the brain processes sentences and integrates semantic information of scenes. Models developed in both labs involve artificial neural networks, and in particular Echo State Networks (ESN), also known as pertaining to the Reservoir Computing framework. These neural models allow insights on high-level processes of the human brain, and at the same time are well suited as robot control platform, because they can be trained and executed online with low computational resources. The collaborators will also combine Deep Learning networks to the reservoir models already used in order to benefit from their very good feature extraction abilities.

MONC Project-Team

9. Partnerships and Cooperations

9.1. National Initiatives

9.1.1. Plan Cancer

9.1.1.1. NUMEP

Plan Cancer NUMEP: 2016–2019. Numerics for Clinical Electroporation Funding: 460 kE Partners: Inria Team MONC, Institut de Pharmacologie de Toulouse, CHU J. Verdier de Bondy Duration: Octobre 2016—Septembre 2019 Project leader: C. Poignard Co-PI: M-P. Rols (IPBS), O. Séror (CHU J. Verdier)

9.1.1.2. Dynamo

Plan Cancer DYNAMO: 2015–2018. Dynamical Models for Tissue Electroporation Funding: 370 kE Partners: Laboratoire Ampère, Lab. Vectorology and Anticancerous Therapies (IGR), Inria Team MONC Duration: Octobre 2015—Septembre 2018 Project leader: R. Scorretti (Laboratoire Ampère) Co-PI: L.M. Mir (IGR), C. Poignard (Inria Team MONC)

9.1.1.3. Moglimaging

- Project acronym - Moglimaging: Modeling of Glioblastoma treatment-induced resistance and heterogeneity by multi-modal imaging.
- Partners -
- Duration - from Nov. 2016 to Nov 2019.
- Coordinator - E. Cohen-Jonathan Moyal, Institut Universitaire du Cancer Toulouse / Local coordinator - O. Saut.
- Team participants - S. Benzekry, A. Collin, C. Poignard, O. Saut.

9.1.1.4. Systems Biology of Renal Carcinoma

- Title: Plan Cancer Systems Biology of Renal Carcinoma using a Mouse RCC model
- Partners : LAMC, INSERM-Univ. Bordeaux.
- Duration - June 2018 to June 2021
- Team participants: O. Saut, S. Benzekry (co-PI)
- 116.64k€

9.1.2. Transnation call: INCA/ARC

- Title: Minimally and non-invasive methods for early detection and/or progression of cancer
- Acronym: TRANSCAN
- Team participants: A. Collin, C. Poignard, O. Saut (local PI)
- Total funds: 1M150, Monc's share 275k€.

9.1.3. Competitivity Clusters

- Labex TRAIL (http://trail.labex.u-bordeaux.fr): MOD Project Consolidation. 1 2-years post-doc position (100k€), led by A. Collin, 1 PhD funding (100k€) led by O. Saut.

9.2. European Initiatives

MONC is partner of the European Lab EBAM devoted to electroporation. C.Poignard is member of the steering committee.

9.3. International Initiatives

9.3.1. Inria International Labs

Inria@SiliconValley

Associate Team involved in the International Lab:

9.3.1.1. Num4SEP

Title: Numerics for Spherical Electroporation

International Partner (Institution - Laboratory - Researcher):

University of California, Santa Barbara (United States) - Department of Mechanical Engineering - Frederic Gibou

Start year: 2017

See also: http://num4sep.bordeaux.inria.fr/

Electroporation-based therapies (EPTs) consist in applying high voltage short pulses to cells in order to create defects in the plasma membrane. They provide interesting alternatives to standard ablative techniques, for instance for deep seated badly located tumors. However their use is still limited due to a lack of knowledge of tissue electroporation. The goal of the associate team is to focus on the multiscale numerical modeling of spheroid electroporation, in order to provide new insights in electroporation at the mesoscopic scales (spheroids provide interesting tumor-like biological models). Benefiting from the expertise of F. Gibou's team in HPC for multiphysics, and the expertise of the team MONC in tumor growth and cell electroporation modeling, the goal of the associate team Num4SEP is to obtain accurate and efficient numerical tools for the quantitative evaluation of the EPTs at the mesoscopic scale.

9.3.2. Inria Associate Teams Not Involved in an Inria International Labs

9.3.2.1. METAMATS

Title: Modeling ExperimenTAl MetAsTasiS

International Partner (Institution - Laboratory - Researcher):

Roswell Park Cancer Institute (United States) - Department of Cancer Genetics Department of Medicine Department of Pharmacology and Therapeutics (Graduate Program) - John Ebos

Start year: 2017

See also: http://metamats.bordeaux.inria.fr/

The aim of the METAMATS associate team is to bring together a cancer biology experimental laboratory led by John ML Ebos (Roswell Park Cancer Institute) and the inria MONC team composed of applied mathematicians. The Ebos laboratory is specialized in the study of anti-cancer therapeutics (in particular, novel biologically targeted therapeutics such as anti-angiogenics and immunotherapies) on the development of metastases and produces unique, hard-to-obtain data sets on this process' dynamics. The MONC team is specialized in mathematical models in oncology, with a dedicated axis about modeling support and methodological development for analysis of data from preclinical studies. In particular, the work of S. Benzekry puts emphasis on proposing, studying and validating mathematical models of metastatic development under the action of various therapeutic modalities. Indeed, metastatic expansion remains the main challenge in the treatment of cancer and integrative studies combining experiments, mathematical models and clinical data have the potential to yield predictive computational tools of help to assist both the design of clinical trials and clinical oncologists in therapeutic decisions such as the control of the toxicity/efficacy balance or the optimal combination of treatment modalities.

9.3.3. Other international initiatives

MONC is partner of the European Lab EBAM devoted to electroporation. C.Poignard is member of the steering committee.

9.3.4. Informal International Partners

- Collaboration with Jonathan Mochel at the Department of Biomedical Sciences of Iowa State University (Ames, Iowa, USA). Development of mechanistic pharmacokinetics/pharmacodynamics models for comparative oncology (i.e. translational oncology across species integrating veterinary medicine). Sebastien Benzekry is Affiliate Assistant Professor at Iowa State University.
- Collaboration between Sebastien Benzekry and the laboratory of Yuval Shaked at the Rappaport Faculty of Medicine of the Technion (Israel Institute of Technology, Haifa, Israel). Our joint work deals with validating mathematical models of host-mediated resistance mechanisms to anti-cancer therapies.

9.4. International Research Visitors

9.4.1. Visits of International Scientists

June 2018: Visit of John Ebos (Roswell Park Cancer Institute, Buffalo, USA) in the context of the METAMATS Inria Associate team.

MORPHEME Project-Team

8. Partnerships and Cooperations

8.1. Regional Initiatives

8.1.1. Labex Signalife

The MORPHEME team is member of the SIGNALIFE Laboratory of Excellence.

Florence Besse and Xavier Descombes are members of the Scientific Committee.

8.1.2. Idex UCA Jedi

Florence Besse is a member of the scientific council of the IDEX JEDI Academy 2.

Laure Blanc-Féraud is chair of the scientific council of Academy 1 of Idex UCA JEDI.

A number of projects has been partially funded by the Idex.

- Artificial intelligence application to the identification of functional traits of zooplankton from high-resolution images (ARTIFACTZ) collaboration with Laval University, Québec / UCA Coll. with : F. Maps (ULaval), D. Laurandeau (ULaval),L. Guidi (LOV), S. Ayata (LOV), J.-O. Irisson (LOV) Participants : E. Debreuve
- Biological Image Super-resolution Enhanced with Tensor (Biset) supported by Académie 1 RISE Coll. with G. Favier (I3S), G. Sandoz (iBV) Participants : E. Debreuve, L. Blanc-Féraud, S. Schaub
- Quantitative analysis of exovesicle transport dynamics in the zebrafish Left/Right organizer. supported by Academy 2 "Complex Systems" Coll. with M. Furthauer (PI, iBV), T. Juan (iBV) Participants: R. Pages, X. Descombes
- Study of a complex biological system pf prostate organoid: applications in biomedical research. supported by Academy 2 "Complex Systems" Coll. with F. Bost (PI, C3M), S. Clavel (C3M), R.F. Roustan (C3M), S. Torrino (C3M). Participants: C. Girard-Riboulleau, X. Descombes
- Imaging analysis for mitochondrial network tracking and recgnition. supported by Academy 1 "Living Sciences" Coll. with M. Chami (IPMC), C. Badot (IPMC), F. Bost (C3M), S. Clavel (C3M), A. Charezac (C3M) Participants: G. Lavisse, X. Descombes.

8.1.3. 3AI Côte d'Azur

Laure Blanc-Féraud is a member of the scientific committee of the 3IA proposal of Nice.

8.2. National Initiatives

8.2.1. ANR RNAGRIMP

Participants: Florence Besse [PI], Fabienne de Graeve, Xavier Descombes, Eric Debreuve.

Here, we propose to study the molecular bases underlying the assembly and regulation of RNA granules, using the highly conserved IMP-containing granules as a paradigm. Specifically, we propose to perform an unbiased genome-wide RNAi screen on Drosophila cultured cells to identify mutant conditions in which the organization and/or distribution of IMP-containing granules is altered. To quantitatively and statistically analyze mutant conditions, and to define precise and coherent classes of mutants, we will combine high throughput microscopy with the development of a computational pipeline optimized for automatic analysis and classification of images. The function of positive hits isolated in the screen will then be validated in vivo in Drosophila neurons using fly genetics and imaging techniques, and characterized at the molecular and cellular levels using biochemical assays, in vitro phase transition experiments and live-imaging. Finally, the functional conservation of identified regulators will be tested in zebrafish embryos combining gene inactivation and live-imaging techniques. This integrative study will provide the first comprehensive analysis of the functional network that regulates the properties of the conserved IMP RNA granules. Our characterization of the identified regulators in vivo in neuronal cells will be of particular significance in the light of recent evidence linking the progression of several degenerative human diseases to the accumulation of non-functional RNA/protein aggregates.

This 4-years project started january, 2016 and is leaded by F. Besse (iBV, Nice). Participants are iBV, institut de biologie Paris Seine (IBPS, Paris), and Morpheme.

8.2.2. ANR HMOVE

Participants: Xavier Descombes, Eric Debreuve.

Among the signaling molecules involved in animal morphogenesis are the Hedgehog (Hh) family proteins which act at distance to direct cell fate decisions in invertebrate and vertebrate tissues. To study the underlying process we will develop accurate tracking algorithm to compare trajectories of different Hh pools transportation in live animals. This will allow us to analyze the contribution of the different carriers in the establishment of the Hh gradient. Moreover, we will develop new methods to modify the spatio-temporal and dynamical properties of the extra-cellular Hh gradient and separate the contribution of the apical versus basal Hh pools. We will complete this study with a genome-wide screen to identify genes and related cellular processes responsible for Hh release. The particular interest of this collaboration lies in the combination of development of tracking algorithm to analyze Hh distribution and trajectories with extremely powerful genetics, ease of in vivo manipulation and lack of genetic redundancy of Drosophila.

This 4-years project started january, 2016 and is leaded by P. Thérond (iBV, Nice). Participants are iBV and Morpheme.

8.2.3. ANR DIG-EM

Participants: Grégoire Malandain, Xavier Descombes, Gaël Michelin.

Morphogenesis controls the proper spatial organization of the various cell types. While the comparatively simple process of patterning and cell differentiation has received considerable attention, the genetic and evolutionary drivers of morphogenesis are much less understood. In particular, we very poorly understand why some morphogenetic processes evolve very rapidly, while others show remarkable evolutionary stability.

This research program aims at developing a high-throughput computational framework to analyze and formalize high-throughput 4D imaging data, in order to quantify and formally represent with cellular resolution the average development of an organism and its variations within and between species. In addition to its biological interest, a major output of the project will thus be the development of robust general computational methods for the analysis, visualization and representation of massive high-throughput light-sheet data sets.

This 4-years project started october the 1st, 2014 and is leaded by P. Lemaire (CRBM, Montpellier). Participants are the CRBM, and two Inria project-team, Morpheme and Virtual Plants.

8.2.4. ANR PhaseQuant

Participants: Grégoire Malandain, Eric Debreuve, Kevin Giulietti, Sarah Laroui.

The PhaseQuantHD project aims at developing a high-content imaging system using quadriwave lateral shearing interferometry as a quantitative phase imaging modality. Automated analysis methods will be developed and optimized for this modality. Finally an open biological study question will be treated with the system.

This 3-years project started october the 1st, 2014 and is leaded by B. Wattelier (Phasics, Palaiseau). Participants are Phasics, and three academic teams TIRO (UNS/CEA/CAL), Nice, Mediacoding (I3S, Sophia-Antipolis), and Morpheme.

8.2.5. Inria Large-scale initiative Naviscope

Participant: Grégoire Malandain.

This action gathers the expertise of seven Inria research teams (Aviz, Beagle, Hybrid, Morpheme, Parietal, Serpico and Mosaic) and other groups (MaIAGE, INRA, Jouy-en-Josas and UMR 144, Institut Curie Paris) and aimed at developing original and cutting-edge visualization and navigation methods to assist scientists, enabling semi-automatic analysis, manipulation, and investigation of temporal series of multi-valued volumetric images, with a strong focus on live cell imaging and microscopy application domains. More precisely, the three following challenges will be addressed:

- Novel machine learning methods able to detect the main regions of interest, and automatic quantification of sparse sets of molecular interactions and cell processes during navigation to save memory and computational resources.
- Novel visualization methods able to encode 3D motion/deformation vectors and dynamics features with color/texture-based and non-sub-resolved representations, abstractions, and discretization, as used to show 2D motion and deformation vectors and patterns.
- Effective machine learning-driven navigation and interaction techniques for complex functional 3D+Time data enabling the analysis of sparse sets of localized intra-cellular events and cell processes (migration, division, etc.).

8.2.6. Octopus Project

Participant: Eric Debreuve.

The Octopus project deals with automatic classification of images of zooplankton. It is conducted in collaboration with the Laboratoire d'Océanographie de Villefranche-sur-mer (LOV) et l'ENSTA Paris. The kickoff meeting took place in May 2015 and a 3-day *brainstorming* meeting on Deep Learning took place in December 2015. Participants are I3S (Frédéric Precioso and Mélanie Ducoffe), LOV (Marc Picheral and Jean-Olivier Irisson), and ENSTA Paris (Antoine Manzanera).

MOSAIC Team

8. Partnerships and Cooperations

8.1. Regional Initiatives

8.1.1. ENS de Lyon projets Emergents - Phyllo (2018 - 2019)

Participants: Christophe Godin, Bruno Leggio, Teva Vernoux [External Collaborator].

The aim in this project is to develop a model of phyllotaxis that would be compatible with the recent detailed and quantitative observations made by our group of the distribution of auxin in space and time at the SAM. In particular the work will seek at using the new quantitative data to estimate the parameters of the stochastic model previously developed of organ patterning.

8.1.2. IDEX Lyon Impulsion - MecaField (2019 - 2020

Participants: Christophe Godin, Teva Vernoux [External Collaborator].

In a previous work, we have shown that the coupling of mechanical and hydraulical descriptions in a 2D model of multicellular tissue growth induces the emergence of remarkable phenomena at tissue level. In particular, we have shown that the growth of an organ may induce a lateral inhibition surrounding the organ that prevents other organs to grow in its vicinity. The goal of this project is to estimate the hydraulic and mechanical parameters of such a model from confocal images of a growing SAM and to compare observations with the order of magnitude of the predicted inhibitory zones and of their amplitude at cellular resolution.

8.2. National Initiatives

8.2.1. Inria ADT - Gnomon

Participants: Olivier Ali, Romain Azaïs, Guillaume Cerutti, Florian Gacon, Christophe Godin, Jonathan Legrand, Grégoire Malandain [External Collaborator], Teva Vernoux [External Collaborator].

Gnomon is a user-friendly computer platform developed by the Mosaic team for seamless simulation of form development in silico. It is intended to be a major tool for the team members to develop, integrate and share their models, algorithms and tools. Flexible components (plugins) make it possible to up-load or to create such data-structures, to program their development, to analyze, visualize them and interact with them in 3D+time.

Based on the past experience of the team with the OpenAlea platform, the goal of this ADT is to develop a more scalable software engineering solution based on the dtk kernel developed by the group of software engineers (SED) from the Sophia-Antipolis Inria Center.

Partners:

- SED Sophia Antipolis Inria Research Centre
- Morpheme Inria projec-team, Sophia Antipolis, France

8.2.2. Inria IPL - Naviscope

Participants: Guillaume Cerutti, Emmanuel Faure [External Collaborator], Christophe Godin, Jonathan Legrand, Grégoire Malandain [External Collaborator].

In this project, we plan to develop original and cutting-edge visualization and navigation methods to assist scientists, enabling semi-automatic analysis, manipulation, and investigation of temporal series of multi-valued volumetric images, with a strong focus on live cell imaging and microscopy application domains. We will build Naviscope upon the strength of scientific visualization and machine learning methods in order to provide systems capable to assist the scientist to obtain a better understanding of massive amounts of information. Such systems will be able to recognize and highlight the most informative regions of the dataset by reducing the amount of information displayed and guiding the observer attention. Finally, we will overcome the technological challenge of gathering up the software developed in each team to provide a unique original tool for users in biological imaging, and potentially in medical imaging.

8.2.3. ANR - ReVeRIES

Participant: Guillaume Cerutti.

The aim of ReVeRIES (Reconnaissance de Végétaux Récréative, Interactive et Educative sur Smartphone) is to make use of mobile technologies to transmit general knowledge and identification skills on the plant world to an urban audience who has little to no botanical background. Following the work of the ReVeS project and the development of the Folia mobile application, a major objective is to recognize automatically the species of trees and shrubs encountered in France using photographs of their leaves, fruits, flowers and barks, while providing the user the botanical vocabulary and the keys to learn how to identify species.

Partners:

- EVS Laboratoire Environnement Ville et Société, Saint-Etienne
- IRHS Institut de Recherches en Horticulture et Semences, Angers
- LIRIS Laboratoire d'Informatique en Image et Système d'Information, Lyon
- LISTIC Laboratoire d'Informatique, Système, Traitement de l'Information et de la Connaissance, Annecy
- LIUM Laboratoire d'Informatique de l'Université du Maine, Le Mans

8.2.4. ANR - Imago (2016 - 2019)

Participants: Guillaume Cerutti, Christophe Godin, Jonathan Legrand.

The goal of this project is to investigate the role of ovule growth constraints on germ cell fate establishment. This project is motivated by recent findings from the partners' groups suggesting that disturbances in cell divisions and expansion in early (pre-meiotic) ovules are sufficient to induce ectopic germ cells. These observations suggest novel routes to engineer apomixis in plants but remains poorly understood. Recent developments in high-resolution 3D imaging, image processing, and modeling offer a powerful combination of approaches to investigate this question. IMAGO proposes to elucidate patterning rules governing ovule growth, and their contribution to female germ cell fate acquisition. We use a combination of high-resolution static and real-time 3D imaging, quantitative image processing, cell-based growth models and functional approaches to (1) define cellular growth patterns in the ovule primordium using quantitative imaging (2) test patterning rules in silico by cell-based growth models (3) validate patterning rules in vivo using genetic, pharmacological and mechanical perturbations.

Partners:

- UMR DIADE, IRD, Montpellier, France
- Department of Plant and Microbial Biology, Zurich, Swisszerland
- RDP, ENS de Lyon, France

8.2.5. ANR DigEM (2015 - 2019)

Participants: Christophe Godin, Bruno Leggio, Patrick Lemaire [External Collaborator], Grégoire Malandain [External Collaborator].

In this project, we will use advanced ligh-sheet imaging of live embryos to quantitatively describe embryonic morphogenesis in ascidians, a class of animals that undergo very rapid genomic divergence, yet show an extraordinary stasis of embryonic morphologies, based on invariant early cell lineages shared by all studied species. The global aims of the proposal, which will bridge micro- and macroevolutionary scales of analysis, are: i) to provide a global systems-level description at cellular resolution of an animal embryonic program; ii) to use this description to characterize intra-specific and inter-specific patterns of morphogenetic variations; iii) to analyze possible molecular mechanisms explaining the unusual robustness of this program to environmental and genetic perturbations. To achieve these aims, we will combine advanced live light-sheet microscopy, computational biology, functional gene assays and evolutionary approaches.

Partners:

- UMR CRBM, CNRS Montpellier, France
- Morpheme Inria projec-team, Sophia Antipolis, France

8.2.6. ERA-CAPS Genes2shape (2018 - 2021)

Participants: Olivier Ali, Guillaume Cerutti, Christophe Godin, Bruno Leggio, Jan Traas [External Collaborator].

This project is aimed at understanding how molecular regulation integrates with mechanics to control overall plant shape, an unresolved problem with wide implications for both fundamental and applied biology. We will address this issue in the Arabidopsis flower, which, besides their obvious importance as reproductive structures, are amongst the best characterised systems in plant developmental biology. From a mechanistic point of view, it is widely accepted that regulatory molecular networks interfere with the properties of the structural cellular elements (cell wall, cytoskeleton) to induce particular growth patterns. How this occurs and how this is coordinated in space is not known. To obtain a mechanistic understanding of such a complex process, information from multiple scales, from molecular networks to physical properties and geometry have to be combined into a single picture. An integrated tool to do so is currently not available. Building on our complementary experience in interdisciplinary research on plant development, we will therefore develop a tool, called the "Computable Flower" that permits (i) integration of data on geometry, gene expression and biomechanics and (ii) the user to explore, interpret and generate hypotheses based on data supported by mechanistic modelling approaches. The tool therefore provides an integrated description in the form of a 3D dynamic template of the growing flower bud.

Partners:

- University of Cambridge (Sainsbury Lab.)
- California Institute of Technology
- MaxPlanck Institutes of Molecular Plant Physiology

8.3. European Initiatives

8.3.1. FP7 & H2020 Projects

Program: H2020

Project acronym: ROMI

Project title: RObotics for MIcrofarms

Duration: November 2017 - October 2021

Coordinator: Sony

Other partners: Iaac, (Spain), FEI (France), Inria (France), CNRS (France), UBER (Germany), Chatelain (France)

Abstract: All over Europe, young farmers are starting small market farms and direct sales businesses. These farms can be found both in rural, peri-urban and urban areas. They grow a large variety of crops (up to 100 different varieties of vegetables per year) on small surfaces (0.01 to 5 ha) using organic farming practices. These farms have proven to be highly productive, sustainable and economically viable. However, a lot of work is done manually, resulting in physically challenging work conditions. ROMI will develop an open and lightweight robotics platform for these microfarms. We will assist these farms in weed reduction and crop monitoring. This will reduce manual labour and increase the productivity through advanced planning tools. Thanks to ROMI's weeding robot, farmers will save 25 percents of their time. This land robot will also acquire detailed information on sample plants and will be coupled with a drone that acquires more global information at crop level. Together, they will produce an integrated, multi-scale picture of the crop development that will help the farmer monitor the crops to increase efficient harvesting. For this, ROMI will have to adapt

and extend state-of-the-art land-based and air-borne monitoring tools to handle small fields with complex layouts and mixed crops. To achieve this, we will: (i) develop and bring to the market an affordable, multi-purpose, land-based robot, (ii) develop a weeding app for this robot that is adapted for organic microfarms, (iii) apply advanced 3D plant analysis and modelling techniques to in-field data acquisition, (iv) integrate these analysis techniques in the robot for detailed plant monitoring, (iv) integrate these techniques also in the aerial drone N-E-R-O for multi-scale crop monitoring, (v) extend the robot with novel, adaptive learning techniques to improve sensorimotor control of the plant monitoring app, and (vii) test the effectiveness of our solution in real-world field conditions.

8.3.2. Inria International Partners

8.3.2.1. Informal International Partners

8.3.2.1.1. Laboratoire International Associé (LIA): Computing Plant Morphogenesis

The focus of this LIA headed by Teva Vernoux (RDP) and Ottoline Leyser (SLCU) is on plant morphogenesis i.e. the mechanisms allowing the generation of plant shapes at different scales. Both the RDP and SLCU Laboratories are leaders of this field. The scenario for morphogenesis that has recently emerged is that chemical signals controlling cell identities lead to changes in mechanical properties of cells, triggering changes in shapes feeding back on the gene regulatory network. This in turn affects the distribution of chemical signals and mechanical forces, thus channeling morphogenesis. However, our understanding of the molecular and physical basis of morphogenesis in plants or in any other eukaryotic system is still in its infancy due to the complexity and non-linearity of processes involved in morphogenesis dynamics (or Morphodynamics). Understanding morphodynamics requires a modeling environment for the explicit representation of forms at multiple scales and for incorporating complex data from different origins and nature (chemical, mechanical, geometrical). In addition to creating a unique scientific environment, this LIA will gather the critical mass and interdisciplinary expertise required to create such a computational platform and to generate the data to produce an integrated vision of how chemical and mechanical signals interaction drive morphogenesis.

Partners:

- Sainsbury Lab. University of Cambridge (SLCU)

8.4. International Research Visitors

8.4.1. Visits of International Scientists

8.4.1.1. Internships

Farah Ben Naoum, associate professor at the University of Sidi Bel Abbes, paid a one-month visit (July 2018) in the Mosaic group to work with Romain Azaïs and Christophe Godin on algorithms to compute incrementally tree-edit distances based on their directed acyclic graph representation. This visit was funded by Inria and will be followed by another one month visit in March 2019 to complete the writing a related paper.

NEUROSYS Project-Team

8. Partnerships and Cooperations

8.1. Regional Initiatives

Within the *Contrat de Projet État Région (CPER) IT2MP* 2015-2020 on *Technological innovations, modeling and Personalized Medicine*, we are contributing on platform SCIARAT (*cognitive stimulation, Ambient Intelligence, Robotic assistance" and Telemedicine*) observing electroencephalographic activity of humans during motor tasks.

8.2. National Initiatives

8.2.1. Inria project-Lab BCI-LIFT 2015-2018 (Brain-Computer Interfaces: Learning, Interaction, Feedback, Training)

Project leader: Maureen Clerc
Partners: 7 Inria project-teams (Aramis, Athena, Demar, Hybrid, Mjolnir, Neurosys, Potioc), univ. Rouen, Dycog team at Centre de Recherche en Neurosciences de Lyon.

BCI-LIFT is a research initiative to reach a next generation of non-invasive Brain-Computer Interfaces (BCI), more specifically BCI that are easier to appropriate, more efficient, and suit a larger number of people. With this concern of usability as our driving objective, we build non-invasive systems that benefit from advanced signal processing and machine learning methods, from smart interface design, and where the user immediately receives supportive feedback. What drives this project is the concern that a substantial proportion of human participants is currently categorized “BCI-illiterate” because of their apparent inability to communicate through BCI. Through this project we aim at making it easier for people to learn to use BCI, by implementing appropriate machine learning methods and developing user training scenarios.

8.2.2. Projet CNRS PEPS S2IH INS2I 2018 : MoveYouMind (Design and evaluation of a visual neurofeedback based on specific corticomotor areas using source localization for enhancing motor imagery)

Project leader: Laurent Bougrain
Partners: Neurosys, Cognitive and Systems Neurosciences (univ. Lorraine/CRAN), Perseus (univ. Lorraine)
This project aims at improving the functional recovery protocols of hemiplegic stroke patients by increasing the precision of the identification of the brain areas involved in a kinesthetic motor task of the upper limbs. The brain areas engaged during this rehabilitation task will be detected by specific source localization methods based on the signals obtained by an electroencephalographic acquisition system with variable geometry, which will inform and therefore guide the patient (and the nursing staff) during the functional rehabilitation by indicating to her/him if the activity which she/he produces is in the right motor area. The project aims to design and evaluate a visual neurofeedback based on active cortical areas within an existing brain-computer interface.

8.2.3. Projet CNRS PEPS S2IH INS2I 2018 : HDCHS (From Human-Human Handshaking to Human-Robot Handshaking)

Project leader: Patrick Hénaff
Partners: Neurosys, Perseus (univ. Lorraine), Cerco

This project interfaces robotics, neuroscience and experimental psychology. It is part of on-going research initiated at LORIA on the understanding of physical and cognitive phenomena that appear while two persons handshake, in order to reproduce them with a humanoid robot naturally interacting with a human. This act is studied because is a multimodal physical and social interaction, socially common but complex from a neuroscience and robotics point of view, because it involves physical, psychological and sensorimotor couplings which differ, depending on the social context. This project proposes novel handshaking experiments aiming at understanding the physical and psychological synchronization phenomena (coupling, locking, rhythmicity), best known as the « Human Dynamic Clamp » (HDC) paradigm, in order to propose models in adequation with the bio-inspired controllers developed at LORIA for the control of humanoid robots.

8.3. International Initiatives

8.3.1. Informal International Partners

- We hosted Takeshi Nishida (Kuytech, Japan) for five months and Sozo Inoue (Kuytech, Japan) for one week to prepare a collaboration on neurosciences and robotics. Laurent Bougrain visited Takeshi Nishida, Kiyohisa Natsume and Toshimasa Yamazaki in Kyutech. Asako Watanabe, a master student from Kuytech, will come for 3 weeks in the team in January 2019 to work on EEG markers of a motor task.
- We collaborate with Anton Popov (Kiev Polytechnic Institute, Ukraine) on feature extraction of brain signal and deep learning (L. Bougrain). Oleksii Avilov is a Ph.D student under a joint supervision arrangement between Kiev Polytechnic Institute and university of Lorraine.
- We also collaborate with Emel Demircan (Univ South California) to use EMG-informed Computed Muscle Control for dynamic simulations of movement available in OpenSim [0]. She stayed 3 weeks in Neurosys this year.
- We also collaborate with LieJune Shiau (university of Houston, Texas, USA) on more theoretical approaches concerning the role of intrinsic neuronal dynamics in network synchronization and brain oscillations (L. Buhry).

8.4. International Research Visitors

8.4.1. Visits of International Scientists

- Takeshi Nishida, Ass. Prof, Kuytech, Japan, 5 weeks (Jun.-Jul. 2018)
- Emel Demircan, Ass. Prof, Univ South California, USA, 3 weeks (Jun.-Jul. 2018)
- Sozo Inoue, Full Prof, Kuytech, Japan, 1 week (dec. 2018)

8.4.1.1. Internships

- Sooraj Sivakumar, Student, IIT Madras, India (Jan-Mar 2018)

[0] https://opensim.stanford.edu/

NUMED Project-Team

5. Partnerships and Cooperations

5.1. National Initiatives

5.1.1. ANR

CNRS InFIniti, 2017-2018 (P. Vigneaux): 12ke in 2018

PARIETAL Project-Team

9. Partnerships and Cooperations

9.1. Regional Initiatives

9.1.1. Inserm-Inria project

This project is funded by the joint Inserm and Inria program 'médecine numérique' and is conducted in collaborations with our clinical partners from the Lariboisière hospital, Inserm uni U942 BioCANVAS (Biomarkers in Cardio-Neuro-VAScular diseases). It supports the PhD thesis of David Sabbagh.

Participants:

- Denis Engemann [coordinator, co-advisor]
- Alexandre Gramfort [thesis director, co-advisor]
- Etienne Gayat [clinical collaborator, co-advisor]
- Fabrice Vallée [clinical collaborator]
- David Sabbagh [PhD Student]

Post-operative delirium (POD) is a potential complication of anesthesia during surgery. It is often associated with adverse outcomes and is aggravated by aging. In elderly patients, post-operative complications have been estimated to incur tens of million US dollars of costs each year in the United States by prolonging hospitalization and potentially affecting health prognosis. Recent studies suggest that POD can already be prevented by improving electrophysiological monitoring of anesthesia depth and individual dosage of anesthetic agents. Doing so probably minimizes the time patients spend in a coma-like state that manifests itself in isoelectric burst suppression, an electroencephalogram (EEG) pattern characterized by alternation between quiescence and high-amplitude bursts, and causally linked to POD. However, such an enterprise, currently, depends on the trained clinical electrophysiologist and guidance by commercially provided EEG indices of states of consciousness. One such metric is the bispectral index (BIS), which, like other related metrics, does not explicitly take into account baseline changes related to normative aging and may therefore be biased when used naively.

While electrophysiological signatures of aging (e.g. drop in Alpha and Gamma band power), states of consciousness (e.g. drop in Theta band long-range connectivity) and drug response (e.g. anteriorization of alpha band power in propofol anesthesia) have been separately investigated in the past years, their common denominators are not known. It is therefore difficult to detect individual risk, choose the optimal dosage, and automate anesthesia monitoring readily for any patient in any hospital.

The goal of this research project is to build statistical models that enable prediction of burst suppression and subsequent POD by exploiting diverse EEG-signatures of states of consciousness in the context of aging. We approach this challenge by recasting it as a problem of learning brain-age from the point of view of electrophysiology of consciousness.

9.1.2. CoSmic project

Participants: Philippe Ciuciu [Correspondant], Carole Lazarus, Loubna El Gueddari.

This project is funded by CEA DRF-Impulsion.

This is a collaborative project with Jean-Luc Stark, (CEA) funded by the DRF-impulsion CEA program.

Compressed Sensing is a recent theory in maths that allows the perfect recovery of signals or images from compressive acquisition scenarios. This approach has been popularized in MRI over the last decade as well as in astrophysics (noticeably in radio-astronomy). So far, both of these fields have developed skills in CS separately. The aim of the COSMIC project is to foster collaborations between CEA experts in MRI (Parietal team within NeuroSpin) and in astrophysics (CosmoStat lab within the Astrophysics Department). These interactions will allow us to share different expertise in order to improve image quality, either in MRI or in radio-astronomy (thanks to the interferometry principle). In this field, given the data delivered by radio-telescopes, the goal consists in extracting high temporal resolution information in order to study fast transient events.

9.1.3. Metacog

Participants: Bertrand Thirion [Correspondant], Gaël Varoquaux, Jérome Dockès.

This project is funded by Digiteo.

This is a Digicosme project (2016-2019) and a collaboration with Fabian Suchanek (Telecom Paritech).

Understanding how cognition emerges from the billions of neurons that constitute the human brain is a major open problem in science that could bridge natural science –biology– to humanities –psychology. Psychology studies performed on humans with functional Magnetic Resonance Imaging (fMRI) can be used to probe the full repertoire of high-level cognitive functions. While analyzing the resulting image data for a given experiment is a relatively well-mastered process, the challenges in comparing data across multiple datasets poses serious limitation to the field. Indeed, such comparisons require to pool together brain images acquired under different settings and assess the effect of different *experimental conditions* that correspond to psychological effects studied by neuroscientists.

Such meta-analyses are now becoming possible thanks to the development of public data resources –OpenfMRI http://openfmri.org and NeuroVault http://neurovault.org. As many others, researchers of the Parietal team understand these data sources well and contribute to them. However, in such open-ended context, the description of experiments in terms of cognitive concepts is very difficult: there is no universal definition of cognitive terms that could be employed consistently by neuroscientists. Hence meta-analytic studies loose power and specificity. On the other hand, http://brainspell.org provide a set of curated annotation, albeit on much less data, that can serve as a seed or a ground truth to define a consensual ontology of cognitive concepts. Relating these terms to brain activity poses another challenge, of statistical nature, as brain patterns form high-dimensional data in perspective with the scarcity and the noise of the data.

The purpose of this project is to learn a semantic structure in cognitive terms from their occurrence in brain activation. This structure will simplify massive multi-label statistical-learning problems that arise in brain mapping by providing compact representations of cognitive concepts while capturing the imprecision on the definition these concepts.

9.1.4. HidimStat

Participants: Bertrand Thirion [Correspondant], Jerome-Alexis Chevalier, Joseph Salmon.

This project is funded by Digiteo.

This is a Digicosme project (2017-2020) and a collaboration with Joseph Salmon (Telecom Paritech).

The HiDimStat project aims at handling uncertainty in the challenging context of high dimensional regression problem. Though sparse models have been popularized in the last twenty years in contexts where many features can explain a phenomenon, it remains a burning issue to attribute confidence to the predictive models that they produce. Such a question is hard both from the statistical modeling point of view, and from a computation perspective. Indeed, in practical settings, the amount of features at stake (possibly up to several millions in high resolution brain imaging) limit the application of current methods and require new algorithms to achieve computational efficiency. We plan to leverage recent developments in sparse convex solvers as well as more efficient reformulations of testing and confidence interval estimates to provide several communities with practical software handling uncertainty quantification. Specific validation experiments will be performed in the field of brain imaging.

9.1.5. Template estimation for arbitrary alignments: application to brain imaging.

Participants: Bertrand Thirion [Correspondant], Thomas Bazeille.

This project is funded by Digiteo.

In the recent years, the nature of scientific inference has shifted quite substantially from model-based to predictive approaches, thanks to the generalization of powerful machine learning techniques. While this has certainly improved scientific standards, this has also obscured the objects and concepts on which inference is drawn. For instance, it is now possible –based on some initial data– to predict individual brain activity topographies, yet the very notion of a standard brain template has become increasingly elusive. Given the importance of establishing models for the progress of knowledge, we revisit the problem of model inference on data with high variance. Specifically, in a context where almost arbitrary transformation can successfully warp observations to each other with high accuracy, what is the common definition of a population model underlying all these observations? What is the working definition of a template ? We plan to leverage recent developments on optimal transport and multivariate analysis to build working definition of templates; we will use them in a brain imaging context to build a novel generation of brain templates.

9.1.6. AMPHI project

Participants: Bertrand Thirion [Correspondant], Joseph Salmon, Antonio Andre Monteiro Manoel.

This is a Digicosme project (2017-2020) and a collaboration with Joseph Salmon (Telecom Paritech) and Lenka Zdeborova (CEA, IPhT).

In many scientific fields, the data acquisition devices have benefited of hardware improvement to increase the resolution of the observed phenomena, leading to ever larger datasets. While the dimensionality has increased, the number of samples available is often limited, due to physical or financial limits. This is a problem when these data are processed with estimators that have a large sample complexity, such as multivariate statistical models. In that case it is very useful to rely on structured priors, so that the results reflect the state of knowledge on the phenomena of interest. The study of the human brain activity through neuroimaging belongs among these problems, with up to 10^6 features, yet a set of observations limited by cost and participant comfort. We are missing fast estimators for multivariate models with structured priors, that furthermore provide statistical control on the solution. Approximate message passing (AMP) methods are designed to work optimally with low- sample-complexity, they accommodate rather generic class of priors and come with an estimation of statistical significance. They are therefore well suited for our purposes. We want to join forces to design a new generation of inverse problem solvers that can take into account the complex structure of brain images and provide guarantees in the low-sample-complexity regime. To this end, we will first adapt AMP to the brain mapping setting, using first standard sparsity priors (e.g. Gauss-Bernoulli) on the model. We will then consider more complex structured priors that control the variation of the learned image patterns in space. Crucial gains are expected from the use of the EM algorithm for parameter setting, that comes naturally with AMP. We will also examine the estimators provided by AMP for statistical significance. AMPHI will design a reference inference toolbox released as a generic open source library. We expect a 3- to 10-fold improvement in CPU time, that will benefit to large-scale brain mapping investigations.

9.1.7. CDS2

Participants: Bertrand Thirion [Correspondant], Gaël Varoquaux, Guillaume Lemaitre, Joris Van Den Bossche.

CDS2 is an "Strategic research initiative" of the Paris Saclay University Idex http://datascience-paris-saclay.fr. Although it groups together many partners of the Paris Saclay ecosystem, Parietal has been deeply involved in the project. It currently funds a post-doc for Guillaume Lemaitre and an engineer positions for Joris van den Bossche. Alexandre Boucaud was funded till December as engineer.

9.2. National Initiatives

9.2.1. ANR

9.2.1.1. Neuroref: Mathematical Models of Anatomy / Neuroanatomy / Diffusion MRI

Participants: Demian Wassermann [Correspondant], Antonia Machlouzarides Shalit, Valentin Iovene.

While mild traumatic brain injury (mTBI) has become the focus of many neuroimaging studies, the understanding of mTBI, particularly in patients who evince no radiological evidence of injury and yet experience clinical and cognitive symptoms, has remained a complex challenge. Sophisticated imaging tools are needed to delineate the kind of subtle brain injury that is extant in these patients, as existing tools are often ill-suited for the diagnosis of mTBI. For example, conventional magnetic resonance imaging (MRI) studies have focused on seeking a spatially consistent pattern of abnormal signal using statistical analyses that compare average differences between groups, i.e., separating mTBI from healthy controls. While these methods are successful in many diseases, they are not as useful in mTBI, where brain injuries are spatially heterogeneous.

The goal of this proposal is to develop a robust framework to perform subject-specific neuroimaging analyses of Diffusion MRI (dMRI), as this modality has shown excellent sensitivity to brain injuries and can locate subtle brain abnormalities that are not detected using routine clinical neuroradiological readings. New algorithms will be developed to create Individualized Brain Abnormality (IBA) maps that will have a number of clinical and research applications. In this proposal, this technology will be used to analyze a previously acquired dataset from the INTRuST Clinical Consortium, a multi-center effort to study subjects with Post-Traumatic Stress Disorder (PTSD) and mTBI. Neuroimaging abnormality measures will be linked to clinical and neuropsychological assessments. This technique will allow us to tease apart neuroimaging differences between PTSD and mTBI and to establish baseline relationships between neuroimaging markers, and clinical and cognitive measures.

9.2.1.2. DirtyData: Data integration and cleaning for statistical analysis

Participants: Gaël Varoquaux [Correspondant], Patricio Cerda Reyes, Pierre Glaser.

Machine learning has inspired new markets and applications by extracting new insights from complex and noisy data. However, to perform such analyses, the most costly step is often to prepare the data. It entails correcting errors and inconsistencies as well as transforming the data into a single matrix-shaped table that comprises all interesting descriptors for all observations to study. Indeed, the data often results from merging multiple sources of informations with different conventions. Different data tables may come without names on the columns, with missing data, or with input errors such as typos. As a result, the data cannot be automatically shaped into a matrix for statistical analysis.

This proposal aims to drastically reduce the cost of data preparation by integrating it directly into the statistical analysis. Our key insight is that machine learning itself deals well with noise and errors. Hence, we aim to develop the methodology to do statistical analysis directly on the original dirty data. For this, the operations currently done to clean data before the analysis must be adapted to a statistical framework that captures errors and inconsistencies. Our research agenda is inspired from the data-integration state of the art in database research combined with statistical modeling and regularization from machine learning.

Data integrating and cleaning is traditionally performed in databases by finding fuzzy matches or overlaps and applying transformation rules and joins. To incorporate it in the statistical analysis, an thus propagate uncertainties, we want to revisit those logical and set operations with statistical-learning tools. A challenge is to turn the entities present in the data into representations well-suited for statistical learning that are robust to potential errors but do not wash out uncertainty.

Prior art developed in databases is mostly based on first-order logic and sets. Our project strives to capture errors in the input of the entries. Hence we formulate operations in terms of similarities. We address typing entries, deduplication -finding different forms of the same entity- building joins across dirty tables, and correcting errors and missing data.

Our goal is that these steps should be generic enough to digest directly dirty data without user-defined rules. Indeed, they never try to build a fully clean view of the data, which is something very hard, but rather include in the statistical analysis errors and ambiguities in the data.

The methods developed will be empirically evaluated on a variety of dataset, including the French public-data repository, data.gouv.fr. The consortium comprises a company specialized in data integration, Data Publica, that guides business strategies by cross-analyzing public data with market-specific data.

9.2.1.3. FastBig Project

Participants: Bertrand Thirion [Correspondant], Jerome-Alexis Chevalier, Tuan Binh Nguyen.

In many scientific applications, increasingly-large datasets are being acquired to describe more accurately biological or physical phenomena. While the dimensionality of the resulting measures has increased, the number of samples available is often limited, due to physical or financial limits. This results in impressive amounts of complex data observed in small batches of samples.

A question that arises is then : what features in the data are really informative about some outcome of interest ? This amounts to inferring the relationships between these variables and the outcome, conditionally to all other variables. Providing statistical guarantees on these associations is needed in many fields of data science, where competing models require rigorous statistical assessment. Yet reaching such guarantees is very hard.

FAST-BIG aims at developing theoretical results and practical estimation procedures that render statistical inference feasible in such hard cases. We will develop the corresponding software and assess novel inference schemes on two applications : genomics and brain imaging.

9.2.1.4. MultiFracs project

Participant: Philippe Ciuciu [Correspondant].

The scale-free concept formalizes the intuition that, in many systems, the analysis of temporal dynamics cannot be grounded on specific and characteristic time scales. The scale-free paradigm has permitted the relevant analysis of numerous applications, very different in nature, ranging from natural phenomena (hydrodynamic turbulence, geophysics, body rhythms, brain activity,...) to human activities (Internet traffic, population, finance, art,...).

Yet, most successes of scale-free analysis were obtained in contexts where data are univariate, homogeneous along time (a single stationary time series), and well-characterized by simple-shape local singularities. For such situations, scale-free dynamics translate into global or local power laws, which significantly eases practical analyses. Numerous recent real-world applications (macroscopic spontaneous brain dynamics, the central application in this project, being one paradigm example), however, naturally entail large multivariate data (many signals), whose properties vary along time (non-stationarity) and across components (non-homogeneity), with potentially complex temporal dynamics, thus intricate local singular behaviors.

These three issues call into question the intuitive and founding identification of scale-free to power laws, and thus make uneasy multivariate scale-free and multifractal analyses, precluding the use of univariate methodologies. This explains why the concept of scale-free dynamics is barely used and with limited successes in such settings and highlights the overriding need for a systematic methodological study of multivariate scale-free and multifractal dynamics. The Core Theme of MULTIFRACS consists in laying the theoretical foundations of a practical robust statistical signal processing framework for multivariate non homogeneous scale-free and multifractal analyses, suited to varied types of rich singularities, as well as in performing accurate analyses of scale-free dynamics in spontaneous and task-related macroscopic brain activity, to assess their natures, functional roles and relevance, and their relations to behavioral performance in a timing estimation task using multimodal functional imaging techniques.

This overarching objective is organized into 4 Challenges:

1. Multivariate scale-free and multifractal analysis,
2. Second generation of local singularity indices,
3. Scale-free dynamics, non-stationarity and non-homogeneity,
4. Multivariate scale-free temporal dynamics analysis in macroscopic brain activity.

9.3. European Initiatives

9.3.1. FP7 & H2020 Projects

9.3.1.1. Neurolang

Title: Accelerating Neuroscience Research by Unifying Knowledge Representation and Analysis Through a Domain Specific Language

Programm: ERC Starting researcher

Duration: 01/03/2018 - 28/02/2023

Coordinator: Demian Wassermann

Inria contact: Demian Wassermann

Summary:

Neuroscience is at an inflection point. The 150-year old cortical specialization paradigm, in which cortical brain areas have a distinct set of functions, is experiencing an unprecedented momentum with over 1000 articles being published every year. However, this paradigm is reaching its limits. Recent studies show that current approaches to atlas brain areas, like relative location, cellular population type, or connectivity, are not enough on their own to characterize a cortical area and its function unequivocally. This hinders the reproducibility and advancement of neuroscience.

Neuroscience is thus in dire need of a universal standard to specify neuroanatomy and function: a novel formal language allowing neuroscientists to simultaneously specify tissue characteristics, relative location, known function and connectional topology for the unequivocal identification of a given brain region.

The vision of NeuroLang is that a unified formal language for neuroanatomy will boost our understanding of the brain. By defining brain regions, networks, and cognitive tasks through a set of formal criteria, researchers will be able to synthesize and integrate data within and across diverse studies. NeuroLang will accelerate the development of neuroscience by providing a way to evaluate anatomical specificity, test current theories, and develop new hypotheses.

NeuroLang will lead to a new generation of computational tools for neuroscience research. In doing so, we will be shedding a novel light onto neurological research and possibly disease treatment and palliative care. Our project complements current developments in large multimodal studies across different databases. This project will bring the power of Domain Specific Languages to neuroscience research, driving the field towards a new paradigm articulating classical neuroanatomy with current statistical and machine learning-based approaches.

9.3.1.2. SLAB (698)

Title: Signal processing and Learning Applied to Brain data

Programm: ERC Starting researcher

Duration: 01/04/2017 - 31/08/2021

Coordinator: Alexandre Gramfort

Partner: LTCI , Telecom ParisTech (France)

Inria contact: Alexandre Gramfort

Summary:

Understanding how the brain works in healthy and pathological conditions is considered as one of the challenges for the 21st century. After the first electroencephalography (EEG) measurements in 1929, the 90's was the birth of modern functional brain imaging with the first functional MRI and full head magnetoencephalography (MEG) system. In the last twenty years, imaging has revolutionized clinical and cognitive neuroscience.

After pioneering works in physics and engineering, the field of neuroscience has to face two major challenges. The size of the datasets keeps growing. The answers to neuroscience questions are limited by the complexity of the signals observed: non-stationarity, high noise levels, heterogeneity of sensors, lack of accurate models. SLAB will provide the next generation of models and algorithms for mining electrophysiology signals which offer unique ways to image the brain at a millisecond time scale.

SLAB will develop dedicated machine learning and signal processing methods and favor the emergence of new challenges for these fields. SLAB focuses on five objectives: 1) source localization with M/EEG for brain imaging at high temporal resolution 2) representation learning to boost statistical power and reduce acquisition costs 3) fusion of heterogeneous sensors 4) modeling of non-stationary spectral interactions to identify functional coupling between neural ensembles 5) development of fast algorithms easy to use by non-experts.

SLAB aims to strengthen mathematical and computational foundations of brain data analysis. The methods developed will have applications across fields (computational biology, astronomy, econometrics). Yet, the primary impact of SLAB will be on neuroscience. The tools and high quality open software produced in SLAB will facilitate the analysis of electrophysiology data, offering new perspectives to understand how the brain works at a mesoscale, and for clinical applications (epilepsy, autism, tremor, sleep disorders).

9.3.1.3. Neuroimaging power (262)

Title: Neuroimaging power

Programm: Marie Curie Fellowhip

Duration: 01/11/2016 - 31/10/2019

Coordinator: Inria

Partner: BOARD OF TRUSTEES OF THE LELAND STANFORD JUNIOR UNIVERSITY (United States)

Inria contact: Bertrand Thirion

Summary:

There is an increasing concern about statistical power in neuroscience research. Critically, an underpowered study has poor predictive power. Findings from a low-power study are unlikely to be reproducible, and thus a power analysis is a critical component of any paper. This project aims to promote and facilitate the use of power analyses.

A key component of a power analysis is the specification of an effect size. However, in neuroimaging, there is no standardised way to communicate effect sizes, which makes the choice of an appropriate effect size a formidable task. The best way today to perform a power analysis is by collecting a pilot data set, a very expensive practice. To eliminate the need for pilot data, we will develop a standardised measure of effect size taking into account the spatial variance and the uncertainty of the measurements. Communicating effect sizes in new publications will facilitate the use of power analyses.

To further alleviate the need for pilot data, we will provide a library of effect sizes for different tasks and contrasts, using open data projects in neuroimaging. We will integrate our effect size estimator in open repositories NeuroVault and OpenfMRI. Consequently, these effect sizes can then serve as a proxy for a pilot study, and as such, a huge cost in the design of an experiment is eliminated.

A new experiment will not be identical to the open data and as such the hypothesised parameters might not be fully accurate. To address this issue, we present a flexible framework to analyse data mid-way without harming the control of the type I error rate. Such a procedure will allow re-evaluating halfway an experiment whether it is useful to continue a study, and how many more subjects are needed for statistically sound inferences. To make our methods maximally available, we will write a software suite including all these methods in different programming platforms and we will provide a GUI to further increase the use of power analyses.

9.3.1.4. HBP SGA1

Title: Human Brain Project Specific Grant Agreement 1

Programm: FET Flagship

Duration: 01/04/2016 - 31/02/2020

Coordinator: Katrin Amunts

Partners: 150 european labs, please see https://www.humanbrainproject.eu/en/open-ethical-engaged/contributors/partners

Inria contact: Bertrand Thirion

Summary

Understanding the human brain is one of the greatest scientific challenges of our time. Such an understanding can provide profound insights into our humanity, leading to fundamentally new computing technologies, and transforming the diagnosis and treatment of brain disorders. Modern ICT brings this prospect within reach. The HBP Flagship Initiative (HBP) thus proposes a unique strategy that uses ICT to integrate neuroscience data from around the world, to develop a unified multi-level understanding of the brain and diseases, and ultimately to emulate its computational capabilities. The goal is to catalyze a global collaborative effort. During the HBP's first Specific Grant Agreement (SGA1), the HBP Core Project will outline the basis for building and operating a tightly integrated Research Infrastructure, providing HBP researchers and the scientific Community with unique resources and capabilities. Partnering Projects will enable independent research groups to expand the capabilities of the HBP Platforms, in order to use them to address otherwise intractable problems in neuroscience, computing and medicine in the future. In addition, collaborations with other national, European and international initiatives will create synergies, maximizing returns on research investment. SGA1 covers the detailed steps that will be taken to move the HBP closer to achieving its ambitious Flagship Objectives.

9.3.1.5. HBP SGA2

Title: Interactive Computing E-Infrastructure for the Human Brain Project

Programm: FET Flagship

Duration: 01/04/2018 - 31/03/2020

Coordinator: Katrin Amunts

Partners: see https://www.humanbrainproject.eu/en/open-ethical-engaged/contributors/partners/

Inria contact: Bertrand Thirion

Summary:

The HBP Flagship was launched by the European Commission's Future and Emerging Technologies (FET) scheme in October 2013, and is scheduled to run for ten years. The Flagships, represent a new partnering model for visionary, long-term European cooperative research in the European Research Area, demonstrating the potential for common research efforts. The HBP has the following main objectives:

- Create and operate a European scientific Research Infrastructure for brain research, cognitive neuroscience, and other brain-inspired sciences
- Gather, organise and disseminate data describing the brain and its diseases
- Simulate the brain
- Build multi-scale scaffold theory and models for the brain
- Develop brain-inspired computing, data analytics and robotics
- Ensure that the HBP's work is undertaken responsibly and that it benefits society.

More information on the HBP's Flagship Objectives is available in the Framework Partnership Agreement.

The timeline of the Project is split into multiple phases, each of which will be covered by a separate funding agreement. The current phase is Specific Grant Agreement Two (SGA2), which spans the two-year period from April 2018–April 2020. The HBP is funded via several sources. Total funding is planned to be in the region of EUR 1 billion; around one half of which will be provided by the

European Union, and the other by Member States and private funding sources. The European Union contributed EUR 54 million to the Project in the Ramp-Up Phase (October 2013 to March 2016), EUR 89 million for the second phase (SGA1), and EUR 88 million for the current phase (SGA2). The FET Flagships Staff Working Document provides further information on how Flagships are funded.

9.4. International Initiatives

9.4.1. Inria International Labs

Inria@SiliconValley
Associate Team involved in the International Lab:

9.4.1.1. LargeBrainNets

Title: Characterizing Large-scale Brain Networks Using Novel Computational Methods for dMRI and fMRI-based Connectivity

International Partner (Institution - Laboratory - Researcher):

Stanford Cognitive & Systems Neuroscience Lab, Stanford Medical School, USA. Contact: Vinod Menon.

Start year: 2016

See also: http://www-sop.inria.fr/members/Demian.Wassermann/large-brain-nets.html

In the past two decades, brain imaging of neurotypical individuals and clinical populations has primarily focused on localization of function and structures in the brain, revealing activation in specific brain regions during performance of cognitive tasks through modalities such as functional MRI. In parallel, technologies to identify white matter structures have been developed using diffusion MRI. More recently, interest has shifted towards developing a deeper understanding of the brain's intrinsic architecture and its influence on cognitive and affective information processing. Using for this resting state fMRI and diffusion MRI to build the functional and structural networks of the human brain.

The human brain is a complex patchwork of interconnected regions, and graph-theoretical approaches have become increasingly useful for understanding how functionally connected systems engender, and constrain, cognitive functions. The functional nodes of the human brain and their structural inter-connectivity, collectively the "connectome", are, however, poorly understood. Critically, there is a dearth of computational methods for reliably identifying functional nodes of the brain and their structural inter-connectivity in vivo, despite an abundance of high-quality data from the Human Connectome Project (HCP). Devising and validating methods for investigating the human connectome has therefore taken added significance.

The first major goal of this project is to develop and validate appropriate sophisticated computational and mathematical tools for identifying functional nodes at the whole-brain level and measuring structural and functional connectivity between them, using state-of-the-art human brain imaging techniques and open-source HCP data. To this end, we will first develop and validate novel computational tools for (1) identifying stable functional nodes of the human brain using resting-state functional MRI and (2) measuring structural connectivity between functional nodes of the brain using multi-shell high-angular diffusion MRI. Due to the complementarity of the two imaging techniques fMRI and dMRI, our novel computational methods methods, the synergy between the two laboratories of this associate team will allow us to reveal in unprecedented detail the structural and functional connectivity of the human brain.

The second major goal of this project is to use our newly developed computational tools to characterize normal structural and functional brain networks in neurotypical adults.

Inria@SiliconValley

Associate Team involved in the International Lab:

9.4.1.2. Meta&Co

Title: Meta-Analysis of Neuro-Cognitive Associations

International Partner (Institution - Laboratory - Researcher):

Stanford (United States) - Psychology department. - Russel Poldrack

Start year: 2018

See also: http://team.inria.fr/parietal

Cognitive science and psychiatry describe mental operations: cognition, emotion, perception and their dysfunction. Cognitive neuroimaging bridge these mental concepts to their implementation in the brain, neural firing and wiring, by relying on functional brain imaging. Yet aggregating results from experiments probing brain activity into a consistent description faces the roadblock that cognitive concepts and brain pathologies are ill-defined. Separation between them is often blurry. In addition, these concepts and subdivisions may not correspond to actual brain structures or systems. To tackle this challenge, we propose to adapt data-mining techniques used to learn relationships in computational linguistics. Natural language processing uses distributional semantics to build semantic relationships and ontologies. New models are needed to learn relationships from heterogeneous signals: functional magnetic resonance images (fMRI), on the one hand, combined with related psychology and neuroimaging annotations or publications, on the other hand. Such a joint effort will rely on large publicly-available fMRI databases shared by Podrack Lab, as well as literature mining.

9.5. International Research Visitors

9.5.1. Visits of International Scientists

- June 2018: Prof. Lilianne Mujica-Parodi (Univ Stony-Brook, NY USA)
- April-June 2018: Dr Abderrahim Halimi (Edinburgh, UK)
- October 2018: Prof. Nikos Makris (Harvard Medical School)
- December 2018: Dr. Lang Chen (Stanford Medical University)

PLEIADE Team

8. Partnerships and Cooperations

8.1. Regional Initiatives

8.1.1. High-performance computing and metabarcoding

PLEIADE is member of two projects, one funded by the Région Nouvelle Aquitaine and one funded as Inria ADT Gordon, connecting Chameleon, StartPU and NewMadeleine, where the use case of metabarcoding (questions, data sets) hase been selected to link these layers together. This will permit us to address unsupervised clustering of one million reads next year. These projects are in collaboration with the HiePACS, TADAAM, and STORM project-teams.

8.1.2. COTE – Continental to Coastal Ecosystems

The Labex cluster of excellence COTE (Continental To coastal Ecosystems: evolution, adaptability and governance) develops tools to understand and predict ecosystem responses to human-induced changes as well as methods of adaptative management and governance to ensure their sustainability. The LabEx includes nine laboratories of the University of Bordeaux and major national research institutes involved in research on terrestrial and aquatic ecosystems (INRA, CNRS, IFREMER and IRSTEA). PLEIADE is a partner in two projects funded by COTE:

- *Malabar: Métabarcoding appliqué à la biodiversté des communauéts algales du Bassin d'Arcachon*
- *Aerobarcoding: détection de pollens allergenisants*. 2017-18.

8.2. National Initiatives

8.2.1. Biocontamination in aircraft reservoirs

ANTICOR is an industrial-academic research and development working group coordinated by Dassault Aviation, investigating the causes of microbial contamination in aircraft reservoirs and aimed at developing mitigating procedures and equipment. Previous results have shown that this contamination forms biofilms at the fuel-water interface and is comprised of complex communities of hundreds of bacterial and fungal species. PLEIADE is particularly interested in measuring and modeling these communities, especially as concerns understanding how they change based on environmental conditions and on reservoir geometry.

This working group continues work started in CAER – Alternative Fuels for Aeronautics, a 6 M-Euro contract with the Civil Aviation Directorate (Direction Générale de l'Aviation Civile, DGAC), coordinated by the French Petroleum Institute (Institut français de pétrole-énergies nouvelles, IFPEN) on behalf of a large consortium of industrial (EADS, Dassault, Snecma, Turbomeca, Airbus, Air France, Total) and academic (CNRS, INRA, Inria) partners to explore different technologies for alternative fuels for aviation.

8.2.2. Agence Française pour la Biodiversité

The AFB is a public law agency of the French Ministry of Ecology that supports public policy in the domains of knowledge, preservation, management, and restoration of biodiversity in terrestrial, aquatic, and marine environments. PLEIADE is a partner in two AFB projects developed with the former ONEMA:

- *Methods for metabarcoding*. 2017-18.
- *Molecular diagnosis of freshwater quality*. 2014-present.

8.2.3. Inria Projet Lab in silico Algae

In 2017 PLEIADE joined the IPL "In silico Algae" coordinated by Olivier Bernard. The IPL addresses challenges in modeling and optimizing microalgae growth for industrial applications. PLEIADE worked this year on comparative genomic analysis of genes implicated in lipid production by the picoalgae *Ostreococcus tauri*, in collaboration with Florence Corellou of the CNRS UMR 5200 (Laboratoire de Biogénèse Membranaire). The goal of this work is the production of long-chain polyunsaturated fatty acids, developed as nutritional additives. Mercia Ngoma Komb's two-month internship in PLEIADE contributed to this work.

8.3. European Initiatives

8.3.1. Collaborations in European Programs, Except FP7 & H2020

Alain Franc is co-chair of Working Group 4 (Data Analysis and Storage) of COST DNAqua.net [0], with the main task of developing contact with HPC and metabarcoding for serving the whole community. He chaired the meeting of this groups in Pécs in 2018. The goal of DNAqua-Net is to nucleate a group of researchers across disciplines with the task to identify gold-standard genomic tools and novel eco-genomic indices and metrics for routine application for biodiversity assessments and biomonitoring of European water bodies.

8.4. International Initiatives

8.4.1. Vitapalm – Food and nutrition security and sustainable agriculture in Africa

PLEIADE has joined the Vitapalm program financed by LEAP-Agri [0], the joint Europe Africa Research and Innovation (R&I) initiative related to Food and Nutrition Security and Sustainable Agriculture. Vitapalm will use genomics and selection to improve the nutritional quality and the stability of palm oil produced by Africa smallholdings for local consumption. Project partners are from Cameroon, France, Germany, and Ghana.

8.4.2. Simulation of metacommunities

In collaboration with the Pasteur Institute in Cayenne and the INRA MIA Research Team in Toulouse, PLEIADE is developing a stochastic model for simulation of metacommunities, in the framework of patch occupancy models. The objective is a better understanding of zoonose propagation, namely rabies through bat hosts in connection with disturbances of pristine forests in French Guiana, which have an impact on the exposure of human populations to wildlife that act as reservoirs of zoonoses.

8.4.3. CEBA – Center for the study of biodiversity in Amazonia

The Laboratoire of excellence CEBA promotes innovation in research on tropical biodiversity. It brings together a network of internationally-recognized French research teams, contributes to university education, and encourages scientific collaboration with South American countries. PLEIADE participates in three current international projects funded by CEBA:

- *MicroBIOMES: Microbial Biodiversities*. 2017-19.
- *Neutrophyl: Inferring the drivers of Neotropical diversification*. 2017-19.
- *Phyloguianas: Biogeography and pace of diversification in the Guiana Shield*. 2015-present

[0] http://dnaqua.net/
[0] http://www.leap-agri.com/

REO Project-Team

9. Partnerships and Cooperations

9.1. National Initiatives

9.1.1. ANR

9.1.1.1. ANR Project "IFSMACS"

Participants: Muriel Boulakia, Céline Grandmont [local coordinator].

Period: 2015-2019.
The objective of this project, coordinated by Takéo Takahashi (Inria Nancy Grand-Est), is the mathematical analysis of systems involving structures immersed in a fluid. This includes the asymptotic analysis, the study of the controllability and stabilization of fluid-structure interaction systems, the understanding of the motion of self-propelled structures and the analysis and development of numerical methods to simulate fluid-structure systems.

9.1.1.2. Participation to other ANR projects

- Laurent Boudin is a member of the ANR Blanc project Kibord on kinetic models in biology and related domains
- Laurent Boudin is a member of the ANR TecSan Oxhelease
- Céline Grandmont is a member of the ANR TecSan Oxhelease
- Irene Vignon Clementel is a member of the project iLite (09/16-), RHU-santé grant, a large French hospital-medical research consortium that aims at developing innovations for liver and tissue engineering (Inria PI: Dirk Drasdo).

9.2. European Initiatives

9.2.1. Collaborations in European Programs, Except FP7 & H2020

9.2.1.1. SimInhale COST

Participant: Irene Vignon Clementel.

Action MP1404, a pan-European network of experts in the field of inhaled medicine.

9.3. International Research Visitors

9.3.1. Visits of International Scientists

9.3.1.1. Internships

- Charu Mittal, Visiting PhD student, Indian Institute of Technology Bombay, March 2018–August 2018

SERENA Project-Team

9. Partnerships and Cooperations

9.1. Regional Initiatives

MILC (DMI RFSI, 2018–2019): "Mesure et Intégrale de Lebesgue en Coq", with LIPN (Université de Paris 13), and TOCCATA (Inria Saclay - Île-de-France). SERENA representants are François Clément and Vincent Martin (UTC).

GiS: scientific collaboration network between ten public institutions from the Paris (Ile-de-France) region, focused on natural resources and environment. The project-team SERENA is a member.

9.2. National Initiatives

9.2.1. ANR

ANR HHOMM: "Hybrid high-order methods on polyhedral meshes", Theoretical foundations and applications (up to software development) for the recently-devised Hybrid high-order methods. Coordinated by D. Di Pietro, University of Montpellier. SERENA representant is A. Ern, period 2015–2019.

ANR DEDALES: "Algebraic and geometric domain decomposition for subsurface flow". The project aims at developing high performance software for the simulation of two phase flow in porous media. It specifically targets parallel computers where each node is itself composed of a large number of processing cores, such as are found in new generation many-core architectures.

The partners are HIEPACS, Laboratoire Analyse, Géométrie et Application, University Paris 13, Maison de la Simulation, and ANDRA. SERENA representants are M. Kern (grant leader) and M. Vohralík, period 2014–2018. The project ended in October 2018.

9.3. European Initiatives

9.3.1. FP7 & H2020 Projects

- EoCoE: "Energy Oriented Center of Excellence" This project is coordinated by Maison de la Simulation and gathers 23 partners from 13 countries to use the tremendous potential offered by the ever-growing computing infrastructure to foster and accelerate the European transition to a reliable low carbon energy supply using HPC (High Performance Computing). SERENA representant M. Kern, period 2015–2018.
- ERC GATIPOR: "Guaranteed fully adaptive algorithms with tailored inexact solvers for complex porous media flows". The subject of this consolidator grant are new approaches to porous media multiphase flows: inexact Newton-multigrid solvers, local stopping criteria, adaptivity, and a posteriori error control. The goal is to guarantee the overall simulation error and to speed-up importantly the present-day simulations. SERENA representant is M. Vohralík (grant leader), period 2015–2020.
- PRACE: "Partnership for Advanced Computing in Europe" The mission of PRACE is to enable high-impact scientific discovery and engineering research and development across all disciplines to enhance European competitiveness for the benefit of society. PRACE has an extensive education and training effort for effective use of the Research Infrastructure. M. Kern is the French representative for training, and is in charge of the French node of the Prace training network, organizing 10-12 courses each year (period 2017-2019).

9.3.2. Collaborations in European Programs, Except FP7 & H2020

OPENCPS

Program: ITEA 3

Project acronym: OPENCPS

Project title: Open cyber-physical system model-driven certified development

Duration: Dec 2015–Dec 2018

Coordinator: Magnus Eek

Other partners: AB SKF, CEA, ELTE-Soft Kft., ESI Group, EDF, Wqua Simulation AB, Ericsson, IncQuery Labs Kft., KTH, Linköping University, RTE, SICS, SIREHNA, Saab AB, Sherpa Engineering, Siemens Industrial Torbumachinery AB, VTT Technical Research Center of Finland Ltd.

Abstract: Cyber-physical systems put increasing demands on reliability, usability, and flexibility while, at the same time, lead time and cost efficiency are essential for industry competitiveness. Tools and environments for model-based development of cyber-physical systems are becoming increasingly complex and critical for the industry: tool interoperability, vendor lock-ins, and tool life-cycle support are some of the challenges. The project focuses on interoperability between the standards Modelica/UML/FMI, improved execution speed of (co-)simulation, and certified code generation.

SERENA representants are Sébastien Furic and Pierre Weis.

9.4. International Initiatives

9.4.1. Inria International Partners

9.4.1.1. Informal International Partners

Erik Burman, Professor at University College London, UK, unfitted methods.

Jean-Luc Guermond, Professor at Texas A&M University, USA, finite element methods.

Ulrich Rüde, Professor at Friedrich-Alexander-Universität Erlangen-Nürnberg, Germany, multigrid methods.

Mary Wheeler, professor, University of Texas at Austin, USA, porous media applications.

Barbara Wohlmuth, Professor at Technical University of München, Germany, mixed finite element methods.

9.4.2. Participation in Other International Programs

Alexandre Ern participated for two weeks in Jul 2018 as an invited scientist in the ESI Program on Numerical Analysis on Complex PDE in the Sciences, Vienna, Austria (https://www.esi.ac.at/activities/events/2018/numerical-analysis-of-complex-pde-models-in-the-sciences).

9.5. International Research Visitors

9.5.1. Visits of International Scientists

Iain Smears, lecturer at University College London, March 26–30.

Thirupathi Gudi, Professor at Indian Institute of Science, Bangalore, India, January 15–February 28.

Jean-Luc Guermond, Professor at Texas A&M University, College Station, Texas, May 1–June 15.

Iain Smears, lecturer at University College London, June 18–27, and Christian Kreuzer, Professor at University Dortmund, June 18–29.

Carsten Carstensen, Professor at Humboldt University, Berlin, August 20–September 20.

Roland Becker, Professor at University of Pau, September 17–20.

Hend Ben Ameur, Professor at IPEST and member of ENIT-Lamsin, Tunis, Tunisia, November 19–30.

Théophile Chaumont-Frelet, junior researcher at Inria Sophia Antipolis, November 22–23.

9.5.1.1. Internships

Intissar Addali, 2nd year internship at ENSTA ParisTech, from May to Aug 2018, supervised by Karol Cascavita and Alexandre Ern.

9.5.2. Visits to International Teams

9.5.2.1. Research Stays Abroad

Alexandre Ern visited the research group of Prof. Victor Calo, Curtin University, Perth, Australia, in November 2018.

Martin Vohralík was invited for two weeks stay to Charles University, Prague for collaboration with J. Málek, April 2018.

SERPICO Project-Team

9. Partnerships and Cooperations

9.1. Regional Initiatives

Région Bretagne: Identification, localization and enumeration of ribosomes within a tomogram by combining state-of-the-art denoising methods and object descriptor-based recognition (CATLAS, see Section 8.2.1) (PhD thesis of Emmnuel Moebel); motion saliency in video sequences (PhD thesis of Léo Maczyta).

BioGenOuest: Collaboration with S. Prigent (engineer) in charge of the organization of image processing services for Biogenouest bio-imaging facilities.

IGDR: Collaboration with J. Pecreaux, Y. Le Cunff (co-supervision of PhD thesis of A. Caranfil).

9.2. National Initiatives

9.2.1. France-BioImaging project

Participants: Charles Kervrann, Patrick Bouthemy.

The goal of the France-BioImaging project (http://france-bioimaging.org/) is to build a distributed coordinated French infrastructure for photonic and electronic cellular bioimaging, dedicated to innovation, training and technology transfer. High-computing capacities are needed to exhaustively analyse image flows. Serpico is co-head of the IPDM (Image Processing and Data Management) node of the FBI network composed of 6 nodes. In this context, we address the following scientific problems: i/ exhaustive analysis of bioimaging data sets; ii/ deciphering of key steps of biological mechanisms at organ, tissular, cellular and molecular levels through the systematic use of time-lapse 3D microscopy and image processing methods; iii/ storage and indexing of extracted and associated data and metadata through an intelligent data management system. Serpico recruited R&D engineers (2011-2016) to disseminate image processing software, to build the Mobyle@Serpico web portal and to manage the IGRIDA-Serpico cluster (200 nodes; batch scheduler: OAR; File management: Puppet/Git/Capistrano; OS: Linux Debian 7; User connexion: public ssh key) opened for end-users and dedicated to large scale computing and data sets processing (storage: 200 TeraBytes).

- **Coordinator:** CNRS (Jean Salamero, UMR 144 CNRS-Institut Curie).
- **Partners:** University of Paris-Diderot-Paris 7, Aix-Marseille University, University of Bordeaux, University of Montpellier, Institut Pasteur, Institut Curie, Inria, ENS Ulm, University of Paris Descartes, UPMC, Ecole Polytechnique, Inserm.
- **Funding:** Investissement d'Avenir Infrastructures Nationales en Biologie et Santé, ANR INBS-PIA 2011.
- **Total amount:** 26 000 Keuros (Inria Serpico: 606 Keuros).

9.2.2. ANR DALLISH project (2016-2020): Data Assimilation and Lattice LIght SHeet imaging for endocytosis/exocytosis pathway modeling in the whole cell

Participants: Charles Kervrann, Ancageorgiana Caranfil, Antoine Salomon.

Cutting-edge LLS microscopy represents the novel generation of 3D fluorescence microscopes dedicated to single cell analysis, generating extraordinarily high resolved and sharp, but huge 3D images and videos. One single live cell experiment in one single biological condition can result into up to one terabyte of data.The goal of the project is to develop new paradigms and computational strategies for image reconstruction and 3D molecule tracking/motion estimation. Furthermore, establishing correspondences between image-based measurements and features, stochastic motion models, and underlying biological and biophysical information remains a challenging task. In a larger perspective, the quantitative description of image data corresponding to protein transport will be a prerequisite for understanding the functioning of a cell in normal and pathological situations including cancer, viral infection and neurodegenerative diseases.

- **Coordinator:** Inria (Charles Kervrann)
- **Partners:** Inria (Serpico, Beagle, Fluminance teams), INRA MaIAGE Unit Jouy-en-Josas, Institut Curie (UMR 144 CNRS & U1143 Inserm UMR 3666) Paris
- **Funding:** ANR (Agence Nationale de la Recherche) PRC (Collaborative Research Project)
- **Total amount:** 440 Keuros (Inria Serpico: 170 Keuros).

9.2.3. Inria Project Labs, Exploratory Research Actions and Technological Development Actions

Participants: Charles Kervrann, Patrick Bouthemy.

In the frame of the "Naviscope" IPL project, we plan to develop original and cutting-edge visualization and navigation methods to assist scientists, enabling semi-automatic analysis, manipulation, and investigation of temporal series of multi-valued volumetric images, with a strong focus on live cell imaging and microscopy application domains. We will build Naviscope upon the strength of scientific visualization and machine learning methods in order to provide systems capable to assist the scientist to obtain a better understanding of massive amounts of information. Such systems will be able to recognize and highlight the most informative regions of the dataset by reducing the amount of information displayed and guiding the observer attention. We will address the three following challenges and issues:

- Novel machine learning methods able to detect the main regions of interest, and automatic quantification of sparse sets of molecular interactions and cell processes during navigation to save memory and computational resources.
- Novel visualization methods able to encode 3D motion/deformation vectors and dynamics features with color/texture-based and non-sub-resolved representations, abstractions, and discretization, as used to show 2D motion and deformation vectors and patterns.
- Effective machine learning-driven navigation and interaction techniques for complex functional 3D+Time data enabling the analysis of sparse sets of localized intra-cellular events and cell processes (migration, division, etc.).

Finally, we will have also to overcome the technological challenge of gathering up the software developed in each team to provide a unique original tool for users in biological imaging, and potentially in medical imaging.

- **Coordinator:** Serpico Inria team (Charles Kervrann)
- **Partners:** Aviz Inria team (Saclay); Beagle Inria team (Lyon), Morpheme Inria team (Sophia-Antipolis); Parietal Inria team (Saclay); Mosaic Inria team (Lyon); MaIAGE INRA Unit (Jouy-en-Josas); Institut Curie CNRS-UMR 144 (Paris).
- **Funding:** Inria Project Lab (from 2018-2022)

9.3. European Initiatives

9.3.1. Major European Organizations with which the Team have followed Collaborations

ESFRI Euro-BioImaging initiative: SERPICO is involved in the ESFRI Euro-BioImaging project, one of the four new biomedical science projects in the roadmap of the European Strategic Forum on Research

Infrastructures (ESFRI). The mission of Euro-BioImaging is to provide access, service and training to state-of-the-art imaging technologies and foster the cooperation and networking at the national and European level including multidisciplinary scientists, industry, regional, national and European authorities. SERPICO also is involved in the French initiative, the so-called "France-BioImaging" (FBI) network which gathers several outstanding cellular imaging centers (microscopy, spectroscopy, probe engineering and signal processing) as described in Section 9.2.1 .

- **Coordinator:** EMBL (Jan Ellenberg, Heideldberg, Germany)
- **Partners:** 15 european countries in 2017
- **Funding:** Member states of the European Union

9.4. International Initiatives

9.4.1. Informal International Partners

Collaboration with Max-Planck Institute, Martinsried (Germany), Dr. Julio Ortiz and Antonio Martinez: Detection and segmentation of macromolecules in cryo-electron tomography (project in progress with Emmanuel Moebel and Charles Kervrann).

9.4.2. Inria Associate Teams Not Involved in an Inria International Labs

9.4.2.1. CytoDI Inria Associated-Team

Title: Quantitative Imaging of Cytoskeleton Dynamics in 3D

International Partner:

University of Texas, SouthWestern Medical Center, Dallas (United States) - Gaudenz Danuser

Start year: 2016

See also: http://serpico.rennes.inria.fr/doku.php?id=research:cytodi

Participants: Sandeep Manandhar, Patrick Bouthemy, Charles Kervrann.

The main scientific goal of the Associated-Team is the spatiotemporal characterization and comparison of cytoskeleton networks involved in cell migration and observed through live cell imaging in three dimensions (3D). Those networks include the cytoskeleton, i.e., microtubules (MT), intermediate filaments (IF), dynamically resolvable by Bessel Beam Light Sheet fluorescent microscopy. The goal will be achieved through the design of local and global descriptors of the spatial conformation and deformation of the cytoskeleton. Subsequently, general metrics to compare and classify the MT and IF networks will be investigated. This study will be carried out on oncogenically transformed lung cancer epithelial cells.

In 2018, the objective of the visit of Sandeep Manandhar (PhD student) at UTSW Dallas (March 1-31, 2018) was to i) get a deeper understanding of bioimaging capacities and limitations in the context of biological studies, 2) to refine the design and validation of his approaches in this context and 3) returning from his visit with a clear vision for biologically relevant tools. For the Danuser lab, the objective was 1) to evaluate the breakpoint of path-match-based approach toward heterogeneous motion 2) to fill the gap between object tracking and generic motion estimation for studies such as actin speckle or collagen.

9.5. International Research Visitors

9.5.1. Visits to International Teams

Leo Maczyta attended a summer school (one week): ICVSS 2018 (International Computer Vision Summer School), July, 8-14, Sicily, Italy.

SISTM Project-Team

9. Partnerships and Cooperations

9.1. Regional Initiatives

The team have strong links with :

- Research teams of the research center INSERM U1219 : "Injury Epidemiology, Transport, Occupation" (IETO), "Biostatistics", "Pharmacoepidemiology and population impact of drugs", "Multimorbidity and public health in patients with HIV or Hepatitis" (MORPH3Eus), "Computer research applied to health" (ERIAS) emerging research team.
- Bordeaux and Limoges CHU ("Centre Hospitalier Universitaire").
- Institut Bergonié, Univ Bordeaux through the Euclid platform
- Inria Project-team MONC, M3DISIM and CQFD

The project team members are involved in:

- EUCLID/F-CRIN clinical trials platform (Laura Richert)
- The research project “Self-management of injury risk and decision support systems based on predictive computer modelling. Development, implementation and evaluation in the MAVIE cohort study” funded by the Nouvelle-Aquitaine regional council (Marta Avalos).
- Phenotyping from Electronic Health Records pilot project in cooperation with with the ERIAS Inserm emerging team in Bordeaux and the Rheumatology service from the Bordeaux Hospital (Boris Hejblum)
- A cancer research project in collaboration with Inria MONC team on glioblastoma

9.2. National Initiatives

- Labex Vaccine Research Institute (VRI) There are strong collaborations with immunologists involved in the Labex Vaccine Research Institute (VRI) as Rodolphe Thiébaut is leading the Data science division (previously Biostatistics/Bioinformatics) http://vaccine-research-institute.fr.
- Collaboration with Inserm PRC (pôle Recherche clinique).
- Collaboration with Inserm Reacting (REsearch and ACTion targeting emerging infectious diseases) network

9.2.1. Expert Appraisals

- Rodolphe Thiébaut is a member of the CNU 46.04 (Biostatistiques, informatique médicale et technologies de communication).
- Rodolphe Thiébaut is a member of the Scientific Council of INSERM.
- Mélanie Prague is an expert for ANRS (France Recherche Nord&Sud Sida-HIV Hépatites) in the CSS 3 (Recherches cliniques et physiopathologiques dans l’infection à VIH) and AC 47 (Dynamique et contrôle des épidémies VIH et hépatites).
- Laura Richert is an expert for the PHRC (Programme hospitalier de recherche Clinique).
- Marta Avalos is an expert for the ANSM (Agence nationale de sécurité du médicament et des produits de santé)

9.2.2. Various Partnership

The project team members are involved in:

- DRUGS-SAFE platform funded by ANSM (Marta Avalos). Initiated in 2015-2018. Renewed for 2019.
- F-CRIN (French clinical research infrastructure network) was initiated in 2012 by ANR under two sources of founding "INBS/Infrastructures nationales en biologie et en santé" and "Programme des Investissements d'avenir". (Laura Richert)
- I-REIVAC is the French vaccine research network. This network is part of the "Consortium de Recherche en Vaccinologie (CoReVac)" created by the "Institut de Microbiologie et des Maladies Infectieuses (IMMI)". (Laura Richert)
- INCA (Institut National du Cancer) funded the project « Evaluation de l'efficacité d'un traitement sur l'évolution de la taille tumorale et autres critères de survie : développement de modèles conjoints. » (Principal PI Virginie Rondeau Inserm U1219, Mélanie Prague is responsible of Work package 4 mechanistic modeling of cancer: 5800 euros).
- Contrat Initiation ANRS MoDeL-CI: Modeling the HIV epidemic in Ivory Coast (Principal PI Eric Ouattara Inserm U1219 in collaboration with University College London, Mélanie Prague is listed as a collaborator).

9.3. European Initiatives

9.3.1. FP7 & H2020 Projects

The member of SISTM Team are involved in EHVA (European HIV Vaccine Alliance):

Program: Most information about this program can be found at http://www.ehv-a.eu.

Coordinator: Rodolphe Thiébaut is Work Package leader of the WP10 "Data Integration".

Other partners: The EHVA encompasses 39 partners, each with the expertise to promote a comprehensive approach to the development of an effective HIV vaccine. The international alliance, which includes academic and industrial research partners from all over Europe, as well as sub-Saharan Africa and North America, will work to discover and progress novel vaccine candidates through the clinic.

Abstract: With 37 million people living with HIV worldwide, and over 2 million new infections diagnosed each year, an effective vaccine is regarded as the most potent public health strategy for addressing the pandemic. Despite the many advances in the understanding, treatment and prevention of HIV made over the past 30 years, the development of broadly-effective HIV vaccine has remained unachievable. EHVA plans to develop and implement:

Discovery Platform with the goal of generating novel vaccine candidates inducing potent neutralizing and non-neutralizing antibody responses and T-cell responses

Immune Profiling Platform with the goal of ranking novel and existing (benchmark) vaccine candidates on the basis of the immune profile

Data Management/Integration/Down-Selection Platform, with the goal of providing statistical tools for the analysis and interpretation of complex data and algorithms for the efficient selection of vaccines

Clinical Trials Platform with the goal of accelerating the clinical development of novel vaccines and the early prediction of vaccine failure.

9.3.2. Collaborations in European Programs, Except FP7 & H2020

Program: The EBOVAC2 project is one of 8 projects funded under IMI Ebola+ programme that was launched in response to the Ebola virus disease outbreak. The project aims to assess the safety and efficacy of a novel prime boost preventive vaccine regimen against Ebola Virus Disease (EVD). Project acronym: EBOVAC2 Project title: EBOVAC2 Coordinator: Rodolphe Thiébaut Other partners: Inserm (France), Labex VRI (France), Janssen Pharmaceutical Companies of Johnson

& Johnson, London School of Hygiene & Tropical Medicine (United Kingdom), The Chancellor, Masters and Scholars of the University of Oxford (United Kingdom), Le Centre Muraz (Burknia Faso), Inserm Transfert (France) Given the urgent need for an preventive Ebola vaccine strategy in the context of the current epidemic, the clinical development plan follows an expedited scheme, aiming at starting a Phase 2B large scale safety and immunogenicity study as soon as possible while assuring the safety of the trial participants.

Phase 1 trials to assess the safety and immunogenicity data of the candidate prime-boost regimen in healthy volunteers are ongoing in the UK, the US and Kenya and Uganda. A further study site has been approved to start in Tanzania. Both prime-boost combinations (Ad26.ZEBOV prime + MVA-BN-Filo boost; and MVA-BN-Filo prime + Ad26.ZEBOV boost) administered at different intervals are being tested in these trials.

Phase 2 trials (this project) are planned to start as soon as the post-prime safety and immunogenicity data from the UK Phase I are available. Phase 2 trials will be conducted in healthy volunteers in Europe (France and UK) and non-epidemic African countries (to be determined). HIV positive adults will also be vaccinated in African countries. The rationale for inclusion of European volunteers in Phase 2, in addition to the trials in Africa, is to allow for higher sensitivity in safety signal detection in populations with low incidence of febrile illnesses, to generate negative control specimens for assay development, to allow for inclusion of health care workers or military personnel that may be deployed to Ebola-endemic regions.

EBOVAC3 As a follow-up project, the IMI-2 funded EBOVAC3 project, has started in 2018. In this project, the vaccine strategy will be further evaluated in specific populations in Africa (infants in Guinea and Sierra Leone; and front line workers in RDC). The project includes a work package on modelling, which is led by Rodolphe Thiebaut.

9.3.3. Collaborations with Major European Organizations

University of Oxford;

London School of Hygiene and Tropical Medicine;

University Hospital Hamburg;

Heinrich Pette Institute for Experimental Virology, Hambourg;

MRC, University College London;

MRC Biostatistics Unit, University of Cambridge.

9.4. International Initiatives

- Prevac-Up: this EDCTP-funded research program will collect and analyze important information on the effectiveness and maintainability of Ebola vaccination in sub-Saharan Africa.
- NIPAH program: a Franco-Chinese collaboration of 1 million euros per country over 5 years to develop a program to better understand Nipah Virus infection, its physiopathology and to develop new tools for diagnosis, treatment and prevention.

9.4.1. Inria International Labs

Inria@SiliconValley
Associate Team involved in the International Lab:

9.4.1.1. SWAGR

Title: Statistical Workforce for Advanced Genomics using RNAseq

International Partner (Institution - Laboratory - Researcher):

RAND Corporation (United States) - Statistics group - Denis Agniel

Start year: 2018

See also: https://team.inria.fr/swagr/

The SWAGR Associate Team aims at bringing together a statistical workforce for advanced genomics using RNAseq. SWAGR combines the biostatistics experience of the SISTM team from Inria BSO with the mathematical expertise of the statistics group at the RAND Corporation in an effort to improve RNAseq data analysis methods by developing a flexible, robust, and mathematically principled framework for detecting differential gene expression. Gene expression, measured through the RNAseq technology, has the potential of revealing deep and complex biological mechanisms underlying human health. However, there is currently a critical limitation in widely adopted approaches for the analysis of such data, as edgeR, DESeq2 and limma-voom can all be shown to fail to control the type-I error, leading to an inflation of false positives in analysis results. False positives are an important issue in all of science. In particular in biomedical research when costly studies are failing to reproduce earlier results, this is a pressing issue. SWAGR propose to develop a rigorous statistical framework modeling complex transcriptomic studies using RNAseq by leveraging the synergies between the works of B. Hejblum and D. Agniel. The new method will be implemented in open-source software as a Bioconductor R package, and a user friendly web-application will be made available to help dissemination. The new method will be applied to clinical studies to yield significant biological results, in particular in vaccine trials through existing SISTM partnerships. The developed method is anticipated to become a new standard for the analysis of RNAseq data, which are rapidly becoming common in biomedical studies, and has therefore the potential for a large impact.

9.4.2. Inria International Partners

Fred Hutchinson Cancer center, Seattle;

Baylor Institute for Immunology (Dallas);

Duke University -Duke Global Health Institute, Elizabeth Turner.

Harvard University - Department of Population Medicine - Rui Wang. M. Prague is a co-PI in an amfAR project for co-supervizion of a PhD student.

university of San Diego UCSD / Harvard School of public health - NIH program project grant "Revealing Reservoirs During Rebound", Harvard School of Public Health (HSPH) and the University of California, San Diego (P01AI131385, total budget $1.5M/yr for 5 years starting Oct 2017, both university manage the funding. Mélanie Prague is part of modelling unit of the "Quantitative Methods" research project (budget $220,000/yr). The principal investigator for this core is Victor de Grutolla (HSPH) The overall goal of this grant is to characterize viral rebound following antiretroviral therapy cessation in cohorts of patients who have started therapy early in infection, as well as in a cohort of terminally-ill patients who will interrupt therapy before death and subsequently donate their bodies to research.

Harvard University - program for evolutionary dynamics - Alison hill and Martin Nowak. Project submitted by M Prague for the Inria associated team with this laboratory.

Collaborations through clinical trials: NIH and University of Minnesota for the Prevac trial, NGO Alima for the Prevac trial, Several African clinical sites for Ebovac2 and Prevac trials;

Tianxi Cai from Harvard University on developing methods for the linkage and analysis of Electronic Health Records data (Boris Hejblum).

Katherine Liao from Harvard University on the analysis of Electronic Health Records data in the context of Rheumatoid Arthritis (Boris Hejblum).

Sylvia Richardson from MRC Biostatistics Unit Cambridge University on the scaling up of nonparametrics Bayesian appraches to Big data (Boris Hejblum).

Machine learning team Data61 at CSIRO, Australia (Marta Avalos)

9.5. International Research Visitors

9.5.1. Visits to International Teams

Marta Avalos visited Marcela Henríquez Henríquez 1 week in December 2018, Medical School, Pontifical Catholic University of Chile (Chile). Travel grant from the French Embassy in Chile and the French Institute of Chile

Boris Hejblum visited the RAND Corporation for a week in July 2018 for a research collaboration with Denis Agniel (Santa-Monica, USA).

Boris Hejblum visited the MRC BSU for 10 days in October 2018 for a research collaboration with Sylvia Richardson & Paul Kirk.

Chloé Pasin visited Harvard School of Public Health on May 9-11 2018 and Columbia University, Departement of Pathology and Cell Biology on May 14-17 2018.

Mélanie Prague got invited in University of Montreal (Canada) for a 3-days research trip in the pharmacy department on December 19-22 2018 to be member of the jury comittee of the PhD defense of Steven Sanche (Effet des antire´troviraux sur la pathoge´ne`se du VIH), as well as giving an invited talk.

Mélanie Prague spent 3 weeks in Boston as an invited researcher in Harvard School of Public Health & Department of evolutionary dynamics, Biostatistics department in January and february 2018.

9.5.1.1. Research Stays Abroad

- Laura Richert spent 6 months (March-August 2018) as a visting researcher at the Heinrich Pette Institut for Experimental Virology, Research Department Virus Immunology, Hamburg, Germany (head: Marcus Altfeld).

STEEP Project-Team

7. Partnerships and Cooperations

7.1. Regional Initiatives

7.1.1. QAMECS / MOBIL'AIR : ATMOSPHERIC POLLUTION: Characterization of novel exposure markers, of biological, health, economic and societal impacts and evaluation of public policies

Project funded by ADEME, Grenoble metropolis, IDEX Université Grenoble Alpes
Duration: 2016 – 2022
Project coordinator : Remy Slama (INSERM) and Sandrine Mathy (GAEL, CNRS). Inria Coordinator: Emmanuel Prados
Other partners: Air Rhône-Alpes, CNRS, Sciences Po Grenoble, Inserm, IAB, Université Grenoble-Alpes
Abstract: Urban atmospheric pollution is one of the main threats to human health that can be to some extent controlled by public action. In Europe, many cities have implemented various types of low emission zones (LEZ, focused on traffic and heating emissions), France being a notable exception. Although fine particulate matter (PM2.5) is usually assessed through its mass concentration, other metrics, such as PM chemical speciation as well as the so far little considered oxidative potential (OP) of PM, are worth considering, both in terms of associations with human health and in the context of monitoring of the efficiency of LEZ. QAMECS covers all dimensions from atmospheric emissions, impact of meteorological conditions on air pollution human behaviours related to transportation, environmental levels, health, associated economic costs and societal awareness. The project relies on environmental measurements, modelling, repeated observational (representative) population studies, an existing mother-child cohort, a controlled human experiment, health impact and related economic assessment. It is conducted by a consortium of specialists of chemistry and physics of air pollution, economics, sociology, epidemiology, geography, in relation with local authorities. It will bring results important for urban planning, public health, and more fundamental research on the measurement of PM and assessment of their biological and health impact.

7.2. National Initiatives

7.2.1. AF Filières : Analyse des Flux des Filières biomasse pour des stratégies régionales de bioéconomie

Project funded by ADEME
Duration: 2017-2019
Coordinator: Jean-Yves COURTONNE (Equipe STEEP, Inria) [Emmanuel Prados (STEEP/Inria) for Inria partner]
Other partners: Equipe STEEP, Inria, Grenoble Rhônalpénergie-Environnement (RAEE), Lyon Laboratoire d'Economie Forestière (LEF), INRA / AgroParisTech Nancy.
Keywords: Environmental assessment, Ecological accounting, Material Flow Analysis, Sustainable supply chains, Multicriteria analysis.
Abstract: Flow analyses of biomass supply chains for regional bioeconomy policies. The goals of the project are the following:

- Improve knowledge on the material flows of the forest-wood and agri-food supply chains in France at national and regional levels,
- Provide a holistic vision of the situation by associating environmental and socio-economic indicators to material flows,
- Provide a more precise assessments (quantitatively and qualitatively) in the case of the Auvergne-Rhône-Alpes region.

TONUS Team

9. Partnerships and Cooperations

9.1. Regional Initiatives

The thesis of Pierre Gerhard devoted to numerical simulation of room acoustics is supported by the Alsace region. It is a joint project with CEREMA (Centre d'études et d'expertise sur les risques, l'environnement, la mobilité et l'aménagement) in Strasbourg.

9.2. National Initiatives

9.2.1. Contracts with Industry

We are involved in a common project with the company AxesSim in Strasbourg. The objective is to help to the development of a commercial software for the numerical simulation of electromagnetic phenomena. The applications are directed towards antenna design and electromagnetic compatibility. This project was partly supported by DGA through "RAPID" funds. A CIFRE PhD has started in AxesSim on the same kinds of subjects in March 2015 (Bruno Weber). The new project is devoted to the use of runtime system in order to optimize DG solvers applied to electromagnetism [28]. The resulting software will be applied to the numerical simulation of connected devices for clothes or medicine. The project is supported by the "Banque Publique d'Investissement" (BPI) and coordinated by the Thales company.

9.2.2. National projects

- PEPS "initiative Jeunes" CNRS . E. Franck, F. Drui, C. Courtès, "Design and analysis of implicit kinetic schemes".

9.2.3. IPL FRATRES

The TONUS project belongs to the IPL FRATRES (models and numerical methods for Tokamak).
We detail the activity founded by the IPL FRATRES:

- Guillaume Morel was a post-doctoral fellow until October 2018, under the joint supervision of Nicolas Crouseilles (team IPSO, Inria Rennes) and Michel Mehrenmerger.
- Work session in Saint Etienne de Tinée with Inria CASTOR TEAM in July 2018.
- IPL Workshop in Alsace with Inria TEAM CASTOR AND MINGUS + exterior in November 2018.

9.2.4. HPC resources

- GENCI projet *Simulations 3D de plasmas deux espèces avec des méthodes particulaires et semi-lagrangiennes*: 400 000 scalar computing hours accepted in October 2017 on supercomputer OCCI-GEN. Coordinator: Sever Hirstoaga
  Participants: Yann Barsamian, Sever Hirstoaga, Michel Mehrenberger.
- PRACE project *SME HPC Adoption Programme in Europe: full simulation of an electromagnetic wave inside and outside a fully modelled human body*: 40 000 GPU computing hours accepted in October 2017 on supercomputer Piz Daint. Coordinator: Bruno Weber
  Participants: Philippe Helluy, Bruno Weber.

9.3. European Initiatives

9.3.1. FP7 & H2020 Projects

9.3.1.1. Eurofusion 2028

- Eurofusion Enabling Research Project ER15-IPP05 Extension (1/2018-12/2018): "Global non-linear MHD modelling in toroidal geometry of disruptions, edge localized modes, and techniques for their mitigation and suppression" (Principal Investigator: Matthias Hoelzl, Max-Planck Institute for Plasma Physics, Garching).
  Participant: Emmanuel Franck.
- EoCoE-II (2019-2022): the European center of excellence EoCoE-II brings together 20 partners from 7 European countries around exascale computing for energy-oriented numerical models. Eurofusion project MAGYK, Mathematics and Algorithms for GYrokinetic and Kinetic models (2019-2021), led by E. Sonnendrucker.
  Participant: Michel Mehrenberger.

9.4. International Initiatives

9.4.1. Participation in International Programs

- **Participants**: David Coulette, Emmanuel Franck, Philippe Helluy [local coordinator].
  ANR/SPPEXA "EXAMAG" is a joint French-German-Japanese project. Its goal is to develop efficient parallel MHD solvers for future exascale architectures. With our partners, we plan to apply highly parallelized and hybrid solvers for plasma physics. One of our objectives is to develop Lattice-Boltzmann MHD solvers based on high-order implicit Discontinous Galerkin methods, using SCHNAPS and runtime systems such as StarPU.

9.5. International Research Visitors

9.5.1. Visits of International Teams

9.5.1.1. Research Stays Abroad

- Lukas Tannhaüser from Würzburg University was invited in February 2018.

9.5.2. Visits to International Teams

9.5.2.1. Research Stays Abroad

- Philippe Helluy, Emmanuel Franck and Florence Drui visited Christian Klingenberg at Würzburg University.
- Philippe has been invited to a scientific stay at the University of Tokyo in February 2018. Collaboration about Vlasov-Poisson modeling with Naoki Yoshida.
- Emmanuel Franck visited Eric Sonnendruecker at IPP Gaching twice.

VISAGES Project-Team

9. Partnerships and Cooperations

9.1. Regional Initiatives

9.1.1. INCR: MUltiple Sclerosis Imaging Check-out (MUSIC)

Participants: Gilles Edan, Francesca Galassi, Olivier Commowick, Christian Barillot, Anne Kerbrat, Jean-Christophe Ferre.

The objective of this project is to investigate algorithms aimed at detecting, segmenting and following overtime the MS lesions, robustly enough to work on a multi-site clinical database. Methods are being evaluated on an amount of training and testing MS images with high quality segmentations from radiographers. The goal is to integrate the developed framework into a production workflow that will be employed by the clinical health network MUltiple Sclerosis Imaging Check-out (MUSIC), covering the western part of France.

9.1.2. ARED VARANASI

Participants: Christian Barillot, Camille Maumet, Xavier Rolland.

Thanks to the development of open science practices, more and more public datasets are available to the research community. In the field of brain imaging, these data, combined, bring a critical increase in sample size, necessary to build robust models of the typical and atypical brain. But, in order to build valid inferences on these data, we need to take into account their heterogeneity. Variability can arise due to multiple factors such as: differences in imaging instruments, in acquisitions protocols and even, in post-processing pipelines. In particular, the expansion of open source machine learning workflows creates a multitude of possible outputs out of the same dataset. The variations induced by this methodological plurality can be referred to as 'analytic variability' which will be the focus of the thesis funded in half by this ARED. The thesis will address two challenges: 1) How to combine neuroimaging data generated by different analysis pipelines? 2) How to publish neuroimages with an adequate level of metadata to enable their reuse? Methodological developments will combine machine learning techniques with methods from knowledge representation.

9.2. National Initiatives

9.2.1. Projet Fondation de France: PERINE

Participants: Élise Bannier, Isabelle Corouge, Julie Coloigner, Maia Proisy, Jean-Christophe Ferré, Christian Barillot.

This study evaluates the effect of prenatal exposure to neurotoxicants on the developing brain. Following previous studies in the PELAGIE cohort this MRI study involves ASL, Diffusion and working memory as well as motor inhibition BOLD fMRI together with neuropsychological tests in children. Inclusions have started in November 2014 and lasted for 2 years. The MRI acquisitions of the PERINE projects have all been performed with a total of 101 children participating to the project. A collaboration with an external PhD student started in January 2017 to process the functional MRI data of this project and Julie Coloigner was hired as a post-doc to work on the Diffusion and ASL data.

9.2.2. Projet Fondation de France: EPMR-MA

Participants: Pierre-Yves Jonin, Élise Bannier, Christian Barillot, Quentin Duché.

This project evaluates memory effects in healthy adults and in patients presenting cognitive impairments using BOLD fMRI and diffusion MRI. The inclusions of patients started in 2016 and all inclusions will be over by the end of 2017. Quentin Duché was hired to process the functional MRI and diffusion data end of 2016 and his contract was extended until May 2018.

9.2.3. Projet Fondation de France: Connectivity of the amygdala in depression

Participants: Christian Barillot, Jean-Marie Batail, Emmanuel Caruyer, Julie Coloigner, Gabriel Robert.

The onset of depression in teenagers and young adults increases the risk to develop a drug-resistant depression in the adulthood. This project aims at evaluating the role of early changes in the microstructure and connectivity of the amygdala. Using a cohort of drug-resistant patients (N=30), non drug-resistant patients (N=30) and controls (N=30), we will identify imaging biomarkers of the pathology. We will compute the same biomarkers in a group of young adults (N=180) and compare these with emotional and cognitive phenotypes in this population, searching for early differences in the development of the amygdala connectivity.

9.2.4. ANR "MAIA", 2015 generic projects program

Participants: Maia Proisy, Pierre Maurel, Antoine Legouhy, Olivier Commowick, Isabelle Corouge, Jean-Christophe Ferré, Christian Barillot.

Each year in France, 55 000 children are born prematurely, i.e., before the 37th week of gestation. Long-term studies of the outcome of prematurely born infants have clearly documented that the majority of such infants may have significant motor, cognitive, and behavioral deficits.

However, there is a limited understanding of the nature of the cerebral abnormality underlying these adverse neurologic outcomes. In this context, the emergence of new modalities of 3D functional MRI, e.g., Arterial Spin Labeling (ASL), or optical imaging technologies, e.g., Near InfraRed Spectroscopy (NIRS), brings new perspectives for extracting cognitive information, via metabolic activity measures. Other classical techniques devoted to cerebral signal measurement, such as ElectroEncephaloGraphy (EEG), provide cognitive information at the cortical level. Each of these various non-invasive imaging technologies brings substantial and specific information for the understanding of newborn brain development.

This project aims at developing innovative approaches for multi-image / multi-signal analysis, in order to improve neurodevelopment understanding methods. From a fundamental point of view, mathematics and computer science have to be considered in association with imaging physics and medicine, to deal with open issues of signal and image analysis from heterogeneous data (image, signal), considered in the multiphysics contexts related to data acquisition (magnetic, optic, electric signals) and biophysics modeling of the newborn brain. A sustained synergy between all these scientific domains is then necessary.

Finally, the sine qua non condition to reach a better understanding of the coupled morphological- cognitive development of premature newborns, is the development of effective software tools, and their distribution to the whole medical community. The very target of this project will be the design of such software tools for medical image / signal analysis, actually operational in clinical routine, and freely available. Academic researchers and industrial partners are working in close collaboration to reach that ambitious goal.

9.2.5. Fondation pour la recherche médicale (FRM) - Project "Hybrid EEG/IRM Neurofeedback for rehabilitation of brain pathologies

Participants: Élise Bannier, Jean-Marie Batail, Isabelle Bonan, Isabelle Corouge, Jean-Christophe Ferré, Jean-Yves Gauvrit, Pierre Maurel, Mathis Fleury, Giulia Lioi, Christian Barillot.

The goal of this project is to make full use of neurofeedback (NF) paradigm in the context of brain rehabilitation. The major breakthrough will come from the coupling associating functional and metabolic information from Magnetic Resonance Imaging (fMRI) to Electro-encephalography (EEG) to “optimize” the neurofeedback protocol. We propose to combine advanced instrumental devices (Hybrid EEG and MRI platforms), with new hybrid Brain computer interface (BCI) paradigms and new computational models to provide novel therapeutic and neuro-rehabilitation paradigms in some of the major mental and neurological disorders of the developmental and the aging brain (stroke, language disorders, Mood Depressive Disorder (MDD), ...). Though the concept of using neurofeedback paradigms for brain therapy has somehow been experimented recently (mostly through case studies), performing neurofeedback through simultaneous fMRI and EEG has almost never been done before so far (two teams in the world including us within the HEMISFER CominLabs project). This project will be conducted through a very complementary set of competences over

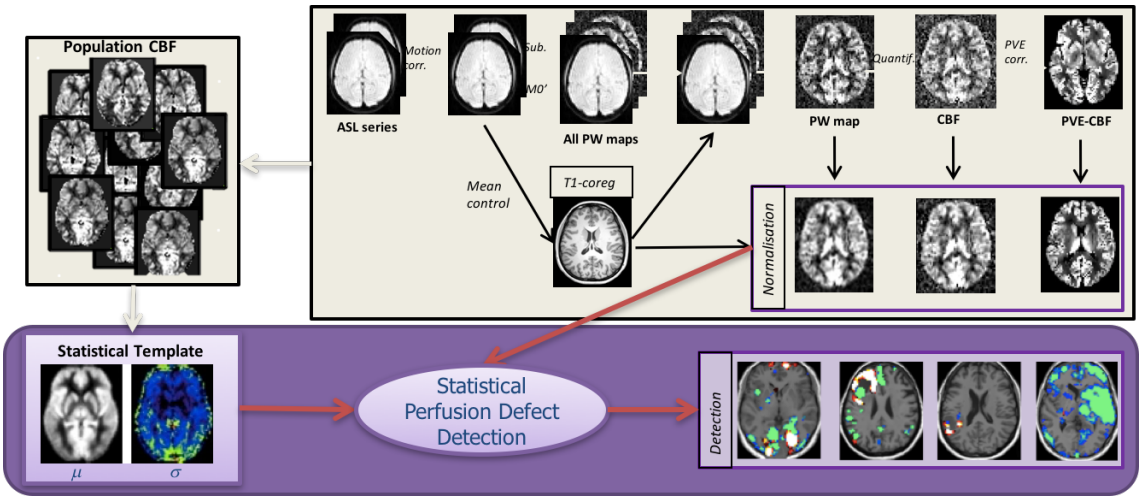

Figure 2. Processing workflow for quantification of Arterial Spin Labelling Cerebral Blood Flow with detection of abnormal perfusion

the different involved teams: VISAGES U1228, HYBRID and PANAMA Teams from Inria/Irisa Rennes and EA 4712 team from U. of Rennes I.

9.2.6. PHRC EMISEP: Evaluation of early spinal cord injury and late physical disability in Relapsing Remitting Multiple Sclerosis

Participants: Élise Bannier, Christian Barillot, Emmanuel Caruyer, Benoit Combès, Olivier Commowick, Gilles Edan, Jean-Christophe Ferré, Anne Kerbrat, Haykel Snoussi.

Multiple Sclerosis (MS) is the most frequent acquired neurological disease affecting young adults (1/1000 inhabitants in France) and leading to impairment. Early and well adapted treatment is essential in patients presenting aggressive forms of MS. This PHRC project focusses on physical impairment and especially on the ability to walk. Several studies, whether epidemiologic or based on brain MRI, have shown that several factors were likely to announce aggressive development of the disease, such as age, number of focal lesions on baseline MRI, clinical activity. However, these factors only partially explain physical impairment progression, preventing their use at the individual level. Spinal cord is often affected in MS, as demonstrated in postmortem or imaging studies. Yet, early radiological depiction of spinal cord lesions is not always correlated with clinical symptoms. Preliminary data, on reduced number of patients, and only investigating the cervical spinal cord have shown that diffuse spinal cord injury, observed via diffusion or magnetisation transfer imaging, would be correlated with physical impairment as evaluated by the EDSS score. Besides, the role of early spinal cord affection (first two years) in the evolution of physical impairment remains unknown.

In this project, we propose to address these different issues and perform a longitudinal study on Relapsing Remitting Multiple Sclerosis (RRMS) patients, recruited in the first year of the disease. Our goal is to show that diffuse and focal lesions detected spinal cord MRI in the first 2 years can be used to predict disease evolution and physical impairment at 5 years. Twelve centers are involved in the study to include 80 patients.

To date, all subjects have been included. H. Snoussi is working in the scope of his PhD thesis on diffusion imaging in the spinal cord starting with distortion correction.

B. Combès started as a post-doc in November 2016 to process the EMISEP imaging data, starting with morphological data processing (registration, segmentation) and magnetization transfer data processing.

9.2.7. Competitivity Clusters

9.2.7.1. The HEMISFER Project

Participants: Élise Bannier, Jean-Marie Batail, Isabelle Bonan, Isabelle Corouge, Claire Cury, Jean-Christophe Ferré, Jean-Yves Gauvrit, Pierre Maurel, Christian Barillot.

The HEMISFER project ("Hybrid Eeg-MrI and Simultaneous neuro-FEedback for brain Rehabilitation") will be conducted at Inria Rennes with the support of the Cluster of Excellence "CominLabs" [0]. The goal of HEMISFER is to make full use of the neurofeedback paradigm in the context of rehabilitation and psychiatric disorders. The major breakthrough will come from the use of a coupling model associating functional and metabolic information from Magnetic Resonance Imaging (fMRI) to Electro-encephalography (EEG) to "enhance" the neurofeedback protocol. We propose to combine advanced instrumental devices (Hybrid EEG and MRI platforms), with new man-machine interface paradigms (Brain computer interface and serious gaming) and new computational models (source separation, sparse representations and machine learning) to provide novel therapeutic and neuro-rehabilitation paradigms in some of the major neurological and psychiatric disorders of the developmental and the aging brain (stroke, attention-deficit disorder, language disorders, treatment-resistant mood disorders, etc.). This project will be conducted with the HYBRID and PANAMA Teams from Inria Rennes, the EA 4712 team from University of Rennes I and the ATHENA team from Inria Sophia-Antipolis. This work will benefit from the research 3T MRI and MRI-compatible EEG systems provided by the NeurInfo in-vivo neuroimaging platform on which these new research protocols will be set up. A budget of 500K€ provided by the CominLabs cluster to support this project (through experimental designs, PhDs, post-docs and expert engineers).

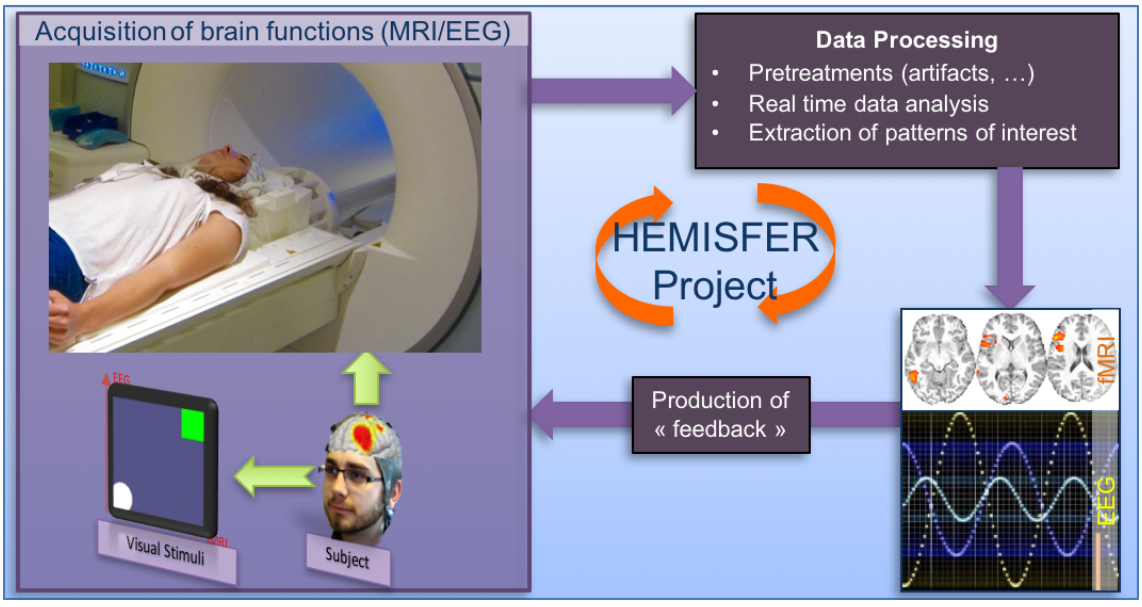

Figure 3. Principle of the Hemisfer project.

9.2.7.2. France Life Imaging (FLI)

Participants: Christian Barillot, Olivier Commowick, Michael Kain, Florent Leray, Julien Louis, Aneta Morawin, Mathieu Simon, Yao Chi.

[0] https://iww.inria.fr/cominlabs-newsletter/april-2013-four-projects-selected/#hemisfer

France Life Imaging (FLI) is a proposed large-scale research infrastructure project aimed at establishing a coordinated and harmonized network of biomedical imaging in France. This project was recently selected by the call "Investissements d'Avenir - Infrastructure en Biologie et Santé". One node of this project is the node Information Analysis and Management (IAM), a transversal node build by a consortium of teams that will contribute to the construction of a network for data storage and information processing. Instead of building yet other dedicated facilities, the IAM node will use already existing data storage and information processing facilities (LaTIM Brest; CREATIS Lyon; CIC-IT Nancy; VisAGeS U1228 Inria Rennes; CATI CEA Saclay; LSIIT/ICube Strasbourg) that will increase their capacities for the FLI infrastructure. Inter-connections and access to services will be achieved through a dedicated software platform that will be developed based on the expertise gained through successful existing developments. The IAM node has several goals. It aims first at building a versatile facility for data management that will inter-connect the data production sites and data processing for which state-of-the-art solutions, hardware and software, will be available to infrastructure users. Modular solutions are preferred to accommodate the large variety of modalities acquisitions, scientific problems, data size, and adapted for future challenges. Second, it aims at offering the latest development that will be made available to image processing research teams. The team VisAGeS fulfills multiple roles in this nation-wide project. Christian Barillot is the chair of the node IAM, Olivier Commowick is participating in the working group workflow and image processing and Michael Kain the technical manager. Apart from the team members, software solutions like MedInria and Shanoir will be part of the final software platform.

9.2.7.3. OFSEP

Participants: Élise Bannier, Christian Barillot, Olivier Commowick, Gilles Edan, Jean-Christophe Ferré, Michael Kain, Inès Fakhfakh.

The French Observatory of Multiple Sclerosis (OFSEP) is one of 10 projects selected in January 2011 in response to the call for proposal in the "Investissements d'Avenir - Cohorts 2010" program launched by the French Government. It allows support from the National Agency for Research (ANR) of approximately € 10 million for 10 years. It is coordinated by the Department of Neurology at the Neurological Hospital Pierre Wertheimer in Lyon (Professor Christian Confavreux), and it is supported by the EDMUS Foundation against multiple sclerosis, the University Claude Bernard Lyon 1 and the Hospices Civils de Lyon. OFSEP is based on a network of neurologists and radiologists distributed throughout the French territory and linked to 61 centers. OFSEP national cohort includes more than 50,000 people with Multiple Sclerosis, approximately half of the patients residing in France. The generalization of longitudinal monitoring and systematic association of clinical data and neuroimaging data is one of the objectives of OFSEP in order to improve the quality, efficiency and safety of care and promote clinical, basic and translational research in MS. For the concern of data management, the Shanoir platform of Inria has been retained to manage the imaging data of the National OFSEP cohort in multiple sclerosis.

9.3. European Initiatives

9.3.1. FP7 & H2020 Projects

9.3.1.1. OpenAire-Connect

Participants: Christian Barillot, Michael Kain, Camille Maumet, Xavier Rolland.

Project title: **OpenAire-Connect**

Partners: PI: CNR, Italy; Athena Research And Innovation Center In Information Communication & Knowledge Technologies, Greece; Uniwersytet Warszawski, Poland; JISC LBG, UK; Universitaet Bremen, Germany; Universidade Do Minho, Portugal; CNRS (Visages, Creatis), France; Universita Di Firenze, Italy; Institut De Recherche Pour Le Developpement (IRD), France; European Organization For Nuclear Research (CERN), Switzerland; International Center For Research On The Environment And The Economy, Greece

Budget: 2M € (120k€ for CNRS)

Abstract: The OpenAire-Connect H2020 project will introduce and implement the concept of Open Science as a Service (OSaaS) on top of the existing OpenAIRE infrastructure, delivering out-of-the-box, on-demand deployable tools. OpenAIRE-Connect will adopt an end-user driven approach (via the involvement of 5 prominent research communities), and enrich the portfolio of OpenAIRE infrastructure production services with a Research Community Dashboard Service and a Catch-All Notification Broker Service. The first will offer publishing, interlinking, packaging functionalities to enable them to share and re-use their research artifacts (introducing methods, e.g., data, software, protocols). This effort, supported by the harvesting and mining "intelligence" of the OpenAIRE infrastructure, will provide communities with the content and tools they need to effectively evaluate and reproduce science. OpenAIRE-Connect will combine dissemination and training with OpenAIRE's powerful NOAD network engaging research communities and content providers in adopting such services. These combined actions will bring immediate and long-term benefits to scholarly communication stakeholders by affecting the way research results are disseminated, exchanged, evaluated, and re-used. In this project VisAGeS is acting, through CNRS, as the French coordinator to develop the link with the Neuroimaging research community. This will be performed in the context of the FLI-IAM national infrastructure.

9.3.1.2. EIT-Health

Participants: Christian Barillot, Michael Kain.

Abstract: EIT Health aims to promote entrepreneurship and develop innovations in healthy living and active ageing, providing Europe with new opportunities and resources. EIT Health will enable citizens to lead healthier and more productive lives by delivering products, services and concepts that will improve quality of life and contribute to the sustainability of healthcare across Europe. EIT Health is a strong, diverse and balanced partnership of best-in-class organisations in education, research, technology, business creation and corporate and social innovation. EIT Health intends to foster cooperation and unlock Europe's innovation and growth potential – developing and retaining the best talents, creating high-quality jobs and boosting the global competitiveness of European industry. VisAGeS is involved in this project through the Inserm and Inria institutions. Christian Barillot is representing Inria as one expert in the dedicated WG "Healthy Brain". VisAGeS is also concerned by the WG "big data"..

9.4. International Initiatives

9.4.1. Inria International Partners

9.4.1.1. BARBANT

Title: Boston and Rennes, a Brain image Analysis Team

International Partner (Institution - Laboratory - Researcher):

Harvard University (United States) - Medical School - Simon K. Warfield

See also: https://team.inria.fr/barbant/

Between 2012 and 2017, BARBANT was an Inria associate team shared between Inria VisAGeS research team and the Computational Radiology Laboratory at the Boston Children's hospital (Harvard Medical School). The collaboration continued in 2018 aiming at better understanding the behavior of normal and pathological Central Nervous System (CNS) organs and systems. Pathologies of particular interest to us are multiple sclerosis, psychiatric, and pediatric diseases such as pediatric multiple sclerosis or tuberous sclerosis. A major challenge is to characterize the future course of the pathological processes in each patient as early as possible in order to predict the progression of the disease and/or adverse neurological outcomes, and to develop better techniques for both monitoring response to therapy and for altering therapy (duration, dose and nature) in response to patient-specific changes in imaging characteristics. At term, the goal is to introduce objective figures to correlate qualitative and quantitative phenotypic markers coming from the clinic and image analysis, mostly at the early stage of the pathologies. This will allow for the selection or adaptation of the treatment for patients at an early stage of the disease. Sudhanya Chatterjee's PhD was performed in 2018 under this collaboration.

9.4.1.2. Informal International Partners

- Collaboration with Neuropoly, Polytechnique Montreal: Haykel Snoussi visited the group of Julien Cohen-Adad and received an Inria-MITACS fellowship for a 3 months period (Nov. 2017-Jan. 2018). He worked on the processing of diffusion-weighted images of multiple sclerosis patients' spinal cord in the context of the EMISEP project. We also collaborate with Neuropoly, Polytechnique Montreal through the EMISEP project: Spinal cord data from the EMISEP study was shared with the group in Montreal for manual lesion segmentation and topological analysis of the presence of lesions, in the brain and spinal cord. This work resulted in a common publication [12].
- Camille Maumet collaborates with Prof. Thomas Nichols and his group, NISOx at the Oxford Big Data Institute and with international members of the INCF on neuroimaging data sharing.
- In the context of a project at Neurinfo, Elise Bannier and Jean-Christophe Ferré collaborated with Tobias Kober from Lausanne, to evaluate a sequence named FLAWS, allowing Fluid and White Matter supression for anterior thalamic nucleus visualization.

9.5. International Research Visitors

9.5.1. Visits of International Scientists

- Jean-Baptiste Poline, Associate Professor at McGill University, Montreal, Canada will visit the team on Dec 18-19 and give a talk on reproducibility in neuroimaging.
- Alice Bates, Postdoctoral research fellow at Australian National University, Canberra, visited the team from Oct 8 to Oct 26. She gave a talk on signal sampling and processing for spherical data, and collaborated with the team on a project related to multidimensional diffusion MRI.

9.5.2. Visits to International Teams

9.5.2.1. Research Stays Abroad

- Haykel Snoussi visited NeuroPoly, Polytechnique Montréal, Canada, from Oct 30th 2017 to Jan 26 2018; he was awarded a MITACS-Inria Globalink research award.

XPOP Project-Team

9. Partnerships and Cooperations

9.1. National Initiatives

9.1.1. ANR

Mixed-Effects Models of Intracellular Processes: Methods, Tools and Applications (MEMIP)

Coordinator: Gregory Batt (InBio Inria team)

Other partners: InBio and IBIS Inria teams, Laboratoire Matière et Systèmes Complexes (UMR 7057; CNRS and Paris Diderot Univ.)

9.1.2. Institut National du Cancer (INCa)

Targeting Rac-dependent actin polymerization in cutaneous melanoma - Institut National du Cancer

Coordinator: Alexis Gautreau (Ecole Polytechnique)

Other partners: Laboratoire de Biochimie (Polytechnique), Institut Curie, INSERM.

9.2. International Initiatives

9.2.1. International Initiatives

SaSMoTiDep

Title: Statistical and Stochastic modeling for time-dependent data

International Partners (Institution - Laboratory - Researcher):

Universidad de Valparaiso (Chile) - Centro de Investigación y Modelamiento de Fenómenos Aleatorios Valparaíso (CIMFAV) - Cristian Meza Becerra

Universidad Nacional de Colombia (Colombia) - Department of Statistics - Viswanathan Arunachalam

Duration: 01/01/2018 - 31/12/2019

Start year: 2018

See also: https://sasmotidep.uv.cl

In many applications, multiple measurements are made on one or several experimental units over a period of time. Such data could be called time-dependent data. From a statistical point of view, if we consider only one experimental unit, we can use a time series analysis. In the other hand, if we consider experimental designs (or observational studies) for several experimental units (or subjects) where each subject is measured at several points in time, we can use the term longitudinal data. In this project, we propose to study several statistical and stochastic models for repeated measures using parametric and non-parametric approaches. In particular, we will study the inference in complex mixed effects models, we will propose novel segmentation models for multiple series, non-parametric methods in dependent models and stochastic models. We will apply these methods to real data from several fields as biometrics, reliability, population dynamics and finance.

9.3. International Research Visitors

9.3.1. Visits of International Scientists

Ricardo Rios, Universidad Central de Venezuela, Caracas: September 2018.

AGORA Project-Team

9. Partnerships and Cooperations

9.1. Regional Initiatives

- FIL Grant, 2018
  Participants: Hervé Rivano
  The partners of this project, supported by the *Fédération d'Informatique de Lyon*, are: CITI, LIP.
  The goal is to use crow-sensing applications with data collection of Wi-Fi networks which are available in the neighborhood in order *i)* to build a map of the wireless network in terms of performance for the application and *ii)* to optimize the wireless network configuration.
- Labex IMU UrPolSens,10/2015-10/2018
  Participants: Walid Bechkit, Amjed Belkhiri, Ahmed Boubrima, Hervé Rivano
  The partners in this project are Ifsttar, LMFA, EVS, TUBA, and Air Rhone-Alpes, with Inria Agora leading the project.
  UrPolSens deals with the monitoring of air pollution using low-cost sensors interconnected by a wireless networks. Although they are less accurate than the high-end sensors used today, low-cost autonomous air quality sensors allow to achieve a denser spatial granularity and, hopefully, a better monitoring of air pollution. The main objectives of this project are to improve the modeling of air pollution dispersion; propose efficient models to optimize the deployment the sensors while considering the pollution dispersion and the impact of urban environment on communications; deploy a small-scale network for pollution monitoring as a proof of concept; compare the measured and estimated levels of exposure; study the spatial disparities in exposure between urban areas.
- Labex IMU 3M'Air 2018-2021
  Participants: Walid Beckhit, Ahmed Boubrima, Manoel Dahan, Mohamed Anis Fekih, Ichrak Mokhtari, Hervé Rivano.
  The partners in this project are: EVS, LMFA, Métropole de Lyon, Ville de Lyon , Atmo AURA, Météo France, Lyon Météo. Inria Agora is the leader of this project.
  The 3M'Air project explore the potential of participatory sensing to improve local knowledge of air quality and urban heat islands. The main aim of this project is therefore to equip citizens with low-cost mobile sensors and then ensure an efficient real-time data collection and analysis. This allows to obtain a finer spatiotemporal granularity of measurements with lighter installation and operational costs while involving citizens.
- ARC6 Robot fleet mobility under communication constraints, 10/2016-09/2019.
  Participant : Fabrice Valois.
  This work is a joint project with the Inria Chroma research group. Considering a fleet of drones moving in a 3D area, looking for a given target, we focus on how to maintain the wireless connectivity of the network of drones while the drones patrol autonomously. The other partners in this project are University of Grenoble and Viameca.
- Labex IMU Veleval, 10/2017-10/2019
  Participant: Hervé Rivano.
  The partners in this project are: EVS, LIRIS, LLSETI and CITI, with LAET leading the project.
  The goal of this pluridisciplinary project is to study, understand and model the behavior of cyclists in an urban environment with a methodology combining quantitative measurements of mobility traces and image analysis with qualitative informations from reactivation interviews. In particular the input of Agora is to provide crowdsourcing tools for gathering mobility data that are optimized for the practice of urban cycling.

9.2. National Initiatives

9.2.1. ANR

- ANR CANCAN 2019 - 2022 (accepted in 2018, kickoff in February 2019)
  Participants: Solohaja Rabenjamina, Razvan Stanica.
  The partners in this project are: CEDRIC, Inria, Orange Labs, with Thalès Communications & Security leading the project.
  The ANR CANCAN (Content and context based adaptation in mobile networks) targets the following objectives: *i)* collecting novel measurement datasets that describe mobile network data traffic at unprecedented spatial and temporal accuracy levels, and for different mobile services separately. The datasets will be gathered in an operational nationwide network, *ii)* evaluating existing analytics for classification, prediction and anomaly detection within real-world high-detail per-service mobile network data, and tailoring them to the specifications of the management of resources at different network levels, and *iii)* demonstrating the integration of data analytics within next-generation cognitive network architectures in several practical case studies.
- ANR MAESTRO 5G 2019 - 2022 (accepted in 2018, kickoff in February 2019)
  Participants: Hervé Rivano, Razvan Stanica.
  The partners in this project are: CEDRIC, Inria, L2S, LIA, Nokia Bell Labs, TSP, with Orange Labs leading the project.
  The ANR MAESTRO 5G (Management of slices int he radio access of 5G networks) is expected to provide: *i)* a resource allocation framework for slices, integrating heterogeneous QoS requirements and spanning on multiple resources including radio, backhauling/fronthauling and processing resources in the RAN, *ii)* acomplete slice management architecture including provisioning and reoptimization modules and their integration with NFV and SDN strata, *iii)* a business layer for slicing in 5G, *iv)* a demonstrator showing the practical feasibility as well as integration of the major functions and mechanisms proposed by the project, on a 5G Cloud RAN platform. The enhanced platform is expected to support the different 5G services.
- ANR CoWorkWorlds 01/2018 - 12/2020.
  Participants: Solohaja Rabenjamina, Razvan Stanica.
  The ANR CoWorkWorlds (Sustainability and spatiality in co-workers' mobility practices) project is lead by ENTPE. Its focus is on the study of co-working environments, and more precisely on the mobility behaviour of users of such spaces. Our role in the project is to collect and analyse mobility data from a set of users, using the PrivaMov smartphone application.

9.2.2. DGA

- DGA CLOTHO 10/2016-10/2018.
  Participants: Junaid Khan, Romain Pujol, Razvan Stanica, Fabrice Valois
  The partners in the DGA CLOTHO project are Traqueur and Sigfox. The objective of the project is to reduce the energy consumption of the device tracking functionality, by taking profit of short-range communications between the tracked objects.

9.2.3. PIA

- PIA ADAGE 07/2016-06/2018.
  Particpants: Elli Zavou, Razvan Stanica
  The partners in the PIA ADAGE project are Orange, LAAS-CNRS and Inria Privatics. The objective of the ADAGE project is to design and evaluate anonymization algorithms for the specific case of mobile traffic data. Our role in the project is focused on evaluating whether the anonymized data is still usable for adaptive networking mechanisms.

9.2.4. Pôle ResCom

- Ongoing participation (since 2006)
  Communication networks, working groups of GDR ASR/RSD, CNRS (http://rescom.inrialpes.fr). Hervé Rivano is member of the scientific committee of ResCom.

9.2.5. EquipEx

- SenseCity
  We have coordinated the participation of several Inria teams to the SenseCity EquipEx. Within the SenseCity project, several small reproduction of 1/3rd scale city surroundings will be built under a climatically controlled environment. Micro and nano sensors will be deployed to experiment on smart cities scenarios, with a particular focus on pollution detection and intelligent transport services. Agora will have the opportunity to tests some of its capillary networking solutions in a very realistic but controlled urban environment. A proof of concept test site has been built in 2015. We have deployed an experiment on low cost sensor network for vehicle detection and one on atmospheric pollution sensor calibration. The operational site is build, the information system is being finalized and the equipment will be inaugurated in April 2018.

9.2.6. Inria Project lab

- CityLab
  Agora is involved in the CityLab Inria Project Lab lead by Valérie Issarny. Within this project, Hervé Rivano co-advises, with Nathalie Mitton (FUN team, Inria Lille-Nord-Europe), the PhD thesis of Abdoul Aziz Mbacke on “Data gathering in sensor and passive RFID with energy harvesting for urban infrastructure monitoring”.

9.3. European Initiatives

9.3.1. Collaborations in European Programs, Except FP7 & H2020

Program: Interreg Med

Project acronym: ESMARTCITY

Project title: Enabling Smarter City in the MED Area through Networking

Duration: 02/2018 - 07/2020

Coordinator: Abruzzo Region, Italy

Other partners: ARIC and RWG (Greece), APEGR (Spain), RAIS (Bosnia and Herzegovina), ENA (Portugal), MCM and PoliMi (Italy), Capergies (France)

Abstract: The project has its primary objective in improving the innovation capacity of MED cities by creating innovation ecosystems, which involve actors of the quadruple helix (Citizens, Businesses Operators, Research, Universities and Public Authorities) , and in applying the Smart City concept, which utilizes digital and energy saving technologies to allow better services for the citizen with less impact on the environment, producing furthermore new employability and living scenarios. To achieve this goal, the project envisages the pilot testing of the Smart City concept to provide specific services to citizens in the field of intelligent urban districts, energy efficiency of buildings and smarter public lighting.

9.4. International Initiatives

9.4.1. Inria International Partners

9.4.1.1. Informal International Partners

- **University of Waterloo, ON, Canada**. Joint publications and visits to/from the group of Prof. Catherine Rosenberg.
- **Nimbus Centre, Cork, Ireland**. Collaboration around LoRa experiments with Dr. Ramona Marfievici.

- **CNR-IEIIT, Turin, Italy**. Joint publications and projects with Dr. Marco Fiore.
- **Trento University, Italy**. Collaboration around routing for IoT networks with the group of Prof. Gian Pietro Picco.
- **University of Edinburgh, UK**. Joint publications and visits to/from the group of Dr. Paul Patras.

9.4.2. Participation in Other International Programs

9.4.2.1. PHC Campus France

- **University of Cluj-Napoca, Romania**. PHC DRONEM (2017-2019) on Monitoring using connected fleet of drones, a collaboration with the group of Prof. Gabriela Czibula.

9.5. International Research Visitors

9.5.1. Visits of International Scientists

- Abdelmalik Bachir, Professor, Biskra University, Algeria: invited professor at INSA Lyon (July, 2018)
- Josep Paradells Aspas, Professor, Universitat Politecnica de Catalunya, Barcelona, Spain: invited professor at INSA Lyon (October 2018)
- Rui Li, PhD student, University of Edinburgh, Scotland, UK: visiting PhD student (March, 2018)

9.5.1.1. Research Stays Abroad

- Ahmed Boubrima visited the group of Prof. Azzedine Boukerche, University of Ottawa, Canada.
- Mihai Popescu visited the group of Prof. Gabriela Czibula, at University of Cluj-Napoca, Romania (3 periods of 1 month duration: April, June and November 2018).

ALPINES Project-Team

9. Partnerships and Cooperations

9.1. Regional Initiatives

GIS, Géosciences franciliennes: scientific collaboration network between ten public institutions from the Paris (Ile-de-France) region, focused on natural resources and environment. The project-team Alpines is a member.

9.2. National Initiatives

9.2.1. ANR

9.2.1.1. B3DCMB

ANR Decembre 2017 - Novembre 2021 This project is in the area of data analysis of cosmological data sets as collected by contemporary and forthcoming observatories. This is one of the most dynamic areas of modern cosmology. Our special target are data sets of Cosmic Microwave Background (CMB) anisotropies, measurements of which have been one of the most fruitful of cosmological probes. CMB photons are remnants of the very early evolution of the Universe and carry information about its physical state at the time when the Universe was much younger, hotter and denser, and simpler to model mathematically. The CMB has been, and continue to be, a unique source of information for modern cosmology and fundamental physics. The main objective of this project is to empower the CMB data analysis with novel high performance tools and algorithms superior to those available today and which are capable of overcoming the existing performance gap. Partners: AstroParticules et Cosmologie Paris 7 (PI R. Stompor), ENSAE Paris Saclay.

9.2.1.2. ANR Cine-Para

October 2015 - September 2019, Laura Grigori is Principal Coordinator for Inria Paris. Funding for Inria Paris is 145 Keuros. The funding for Inria is to combine Krylov subspace methods with parallel in time methods. Partners: University Pierre and Marie Curie, J. L. Lions Laboratory (PI Y. Maday), CEA, Paris Dauphine University, Paris 13 University.

9.2.1.3. Non-local DD

ANR appel à projet générique October 2015 - September 2020

This project in scientific computing aims at developing new domain decomposition methods for massively parallel simulation of electromagnetic waves in harmonic regime. The specificity of the approach that we propose lies in the use of integral operators not only for solutions local to each subdomain, but for coupling subdomains as well. The novelty of this project consists, on the one hand, in exploiting multi-trace formalism for domain decomposition and, on the other hand, considering optimized Schwarz methods relying on Robin type transmission conditions involving quasi-local integral operators.

9.2.1.4. Soilμ-3D

ANR appel à projet générique October 2015 - September 2020

In spite of decades of work on the modeling of greenhouse gas emission such as CO2 and N2O and on the feedback effects of temperature and water content on soil carbon and nitrogen transformations, there is no agreement on how these processes should be described, and models are widely conflicting in their predictions. Models need improvements to obtain more accurate and robust predictions, especially in the context of climate change, which will affect soil moisture regime.

The goal of this new project is now to go further using the models developed in MEPSOM to upscale heterogeneities identified at the scale of microbial habitats and to produce macroscopic factors for biogeochemical models running at the field scale.

To achieve this aim, it will be necessary to work at different scales: the micro-scale of pores (μm) where the microbial habitats are localized, the meso-scale of cores at which laboratory measurements on CO2 and N2O fluxes can be performed, and the macro-scale of the soil profile at which outputs are expected to predict greenhouse gas emission. The aims of the project are to (i) develop new descriptors of the micro-scale 3D soil architecture that explain the fluxes measured at the macro-scale, (ii) Improve the performance of our 3D pore scale models to simulate both micro-and meso- scales at the same time. Upscaling methods like "homogeneization" would help to simulate centimeter samples which cannot be achieved now. The reduction of the computational time used to solve the diffusion equations and increase the number of computational units, (iii) develop new macro-functions describing the soil micro-heterogeneity and integrate these features into the field scale models.

9.3. European Initiatives

9.3.1. FP7 & H2020 Projects

9.3.1.1. NLAFET (197)

Title: Parallel Numerical Linear Algebra for Future Extreme-Scale Systems

Programm: H2020

Duration: November 2015 - April 2019

Coordinator: UMEÅ Universitet

Partners:

Science and Technology Facilities Council (United Kingdom)

Computer Science Department, UmeåUniversitet (Sweden)

Mathematics Department, The University of Manchester (United Kingdom)

Inria, Alpines group

Inria contact: Laura Grigori

The NLAFET proposal is a direct response to the demands for new mathematical and algorithmic approaches for applications on extreme scale systems, as identified in the FETHPC work programme and call. This project will enable a radical improvement in the performance and scalability of a wide range of real-world applications relying on linear algebra software, by developing novel architecture-aware algorithms and software libraries, and the supporting runtime capabilities to achieve scalable performance and resilience on heterogeneous architectures. The focus is on a critical set of fundamental linear algebra operations including direct and iterative solvers for dense and sparse linear systems of equations and eigenvalue problems. Achieving this requires a co-design effort due to the characteristics and overwhelming complexity and immense scale of such systems. Recognized experts in algorithm design and theory, parallelism, and auto-tuning will work together to explore and negotiate the necessary tradeoffs. The main research objectives are: (i) development of novel algorithms that expose as much parallelism as possible, exploit heterogeneity, avoid communication bottlenecks, respond to escalating fault rates, and help meet emerging power constraints; (ii) exploration of advanced scheduling strategies and runtime systems focusing on the extreme scale and strong scalability in multi/many-core and hybrid environments; (iii) design and evaluation of novel strategies and software support for both offline and online auto-tuning. The validation and dissemination of results will be done by integrating new software solutions into challenging scientific applications in materials science, power systems, study of energy solutions, and data analysis in astrophysics. The deliverables also include a sustainable set of methods and tools for cross-cutting issues such as scheduling, auto-tuning, and algorithm-based fault tolerance packaged into open-source library modules.

9.4. International Initiatives

9.4.1. Inria International Partners

9.4.1.1. Informal International Partners

- J. Demmel, UC Berkeley, USA
- R. Hipmair, ETH Zurich
- M. Grote, Université de Bâle, Suisse
- F. Assous, Israel

9.5. International Research Visitors

9.5.1. Visits of International Scientists

- Visit to Xavier Claeys of Jan Zapletal from IT4Innovation of University of Ostrava, Czech Republic from 4th to 30th of March 2018. The main topic of the visit was discussions around HPC implementation of multi-trace formulations in the BEM code of IT4Innovation.
- Visit to Laura Grigori of Agnieszka Miedlar, University of Kansas, from Jun 2018 until Jul 2018.
- Visit to Laura Grigori of Qiang Niu, Xi'an Jiaotong Liverpool University, from May 2018 until Jul 2018.
- Visit to Frédéric Nataf of Lawrence Mitchell from University of Durham (UK) from December 17th to 22nd. The main topic of the visit was to finalize the interface of the finite element software Firedrake to our library geneo4PETSc.
- Visit to Frédéric Hecht of T. Chacon of Differential equations and numerical analysis at University of Seville Rectorate form April 23th to May 4th.
- Visit to Frédéric Hecht of P. Degond of Department of Mathematics at Imperial College London form Juin 6th to 10th.

9.5.1.1. Internships

- Visit to Xavier Claeys of Michal Kravchenko from IT4Innovation of University of Ostrava, Czech Republic from 1st of October to 28th of December 2018. The main subject of the visit was effective implementation of multi-trace formulations in the BEM code of IT4Innovation.

9.5.2. Visits to International Teams

9.5.2.1. Research Stays Abroad

- Visit of Xavier Claeys to Ralf Hiptmair at ETH Zuerich from the 19th of August to 25th of August 2018. The main subject of the visit was discussion on boundary integral equations adapted to low frequency electromagnetics.
- Visit of Xavier Claeys to Paul Escapil-Inchauspe at Pontificia Universidad Catholica at Santiago Chile for further collaboration around analysis of local multi-trace formulation for electromagnetics.
- Visit of Laura Grigori to the group of Professor J. Demmel, UC Berkeley, for 6 weeks in July and August 2018.

AVALON Project-Team

9. Partnerships and Cooperations

9.1. Regional Initiatives

9.1.1. CPER

Participants: Thierry Gautier, Laurent Lefèvre, Christian Perez.

The LECO experimental platform is a new medium size scientific instrument deployed in Grenoble in 2018. It was funded by the CPER 2015-2020 LECO++ to investigate research related to BigData and HPC.

9.2. National Initiatives

9.2.1. PIA

9.2.1.1. PIA ELCI, Environnement Logiciel pour le Calcul Intensif, 2014-2018

Participants: Mathilde Boutigny, Thierry Gautier, Laurent Lefèvre, Christian Perez, Issam Raïs, Jérôme Richard, Philippe Virouleau.

The ELCI PIA project is coordinated by BULL with several partners: CEA, Inria, SAFRAB, UVSQ.

This project aims to improve the support for numerical simulations and High Performance Computing (HPC) by providing a new generation software stack to control supercomputers, to improve numerical solvers, and pre- and post computing software, as well as programming and execution environment. It also aims to validate the relevance of these developments by demonstrating their capacity to deliver better scalability, resilience, modularity, abstraction, and interaction on some application use-cases. AVALON is involved in WP1 and WP3 ELCI Work Packages through the PhD of Issam Raïs and the postdoc of Hélène Coullon. Laurent Lefèvre is the Inria representative in the ELCI technical committee.

9.2.2. MRSEI

9.2.2.1. Fennec, FastEr NaNo-Characterisation, 24 months, 2018-2021

Participants: Eddy Caron, Christian Perez.

The goal of the ANR-MRSEI FENNEC project is to support the submission of a project to the European call DT-NMBP-08-2019 entitled “Real-time nano-characterisation technologies (RIA)”.

9.2.3. Inria Large Scale Initiative

9.2.3.1. DISCOVERY, DIStributed and COoperative management of Virtual EnviRonments autonomouslY, 4 years, 2015-2019

Participants: Maverick Chardet, Jad Darrous, Christian Perez.

To accommodate the ever-increasing demand for Utility Computing (UC) resources, while taking into account both energy and economical issues, the current trend consists in building larger and larger Data Centers in a few strategic locations. Although such an approach enables UC providers to cope with the actual demand while continuing to operate UC resources through centralized software system, it is far from delivering sustainable and efficient UC infrastructures for future needs.

The DISCOVERY initiative aims at exploring a new way of operating Utility Computing (UC) resources by leveraging any facilities available through the Internet in order to deliver widely distributed platforms that can better match the geographical dispersal of users as well as the ever increasing demand. Critical to the emergence of such locality-based UC (LUC) platforms is the availability of appropriate operating mechanisms. The main objective of DISCOVERY is to design, implement, demonstrate and promote the LUC Operating System (OS), a unified system in charge of turning a complex, extremely large-scale and widely distributed infrastructure into a collection of abstracted computing resources which is efficient, reliable, secure and at the same time friendly to operate and use.

To achieve this, the consortium is composed of experts in research areas such as large-scale infrastructure management systems, network and P2P algorithms. Moreover two key network operators, namely Orange and RENATER, are involved in the project.

By deploying and using such a LUC Operating System on backbones, our ultimate vision is to make possible to host/operate a large part of the Internet by its internal structure itself: A scalable set of resources delivered by any computing facilities forming the Internet, starting from the larger hubs operated by ISPs, government and academic institutions, to any idle resources that may be provided by end-users.

9.2.3.2. HAC SPECIS, High-performance Application and Computers, Studying PErformance and Correctness In Simulation, 4 years, 2016-2020

Participants: Dorra Boughzala, Idriss Daoudi, Thierry Gautier, Laurent Lefèvre, Frédéric Suter.

Over the last decades, both hardware and software of modern computers have become increasingly complex. Multi-core architectures comprising several accelerators (GPUs or the Intel Xeon Phi) and interconnected by high-speed networks have become mainstream in HPC. Obtaining the maximum performance of such heterogeneous machines requires to break the traditional uniform programming paradigm. To scale, application developers have to make their code as adaptive as possible and to release synchronizations as much as possible. They also have to resort to sophisticated and dynamic data management, load balancing, and scheduling strategies. This evolution has several consequences:

First, this increasing complexity and the release of synchronizations are even more error-prone than before. The resulting bugs may almost never occur at small scale but systematically occur at large scale and in a non deterministic way, which makes them particularly difficult to identify and eliminate.

Second, the dozen of software stacks and their interactions have become so complex that predicting the performance (in terms of time, resource usage, and energy) of the system as a whole is extremely difficult. Understanding and configuring such systems therefore becomes a key challenge.

These two challenges related to correctness and performance can be answered by gathering the skills from experts of formal verification, performance evaluation and high performance computing. The goal of the HAC SPECIS Inria Project Laboratory is to answer the methodological needs raised by the recent evolution of HPC architectures by allowing application and runtime developers to study such systems both from the correctness and performance point of view.

9.3. European Initiatives

9.3.1. FP7 & H2020 Projects

9.3.1.1. POP

Participant: Frédéric Suter.

Program: H2020 Center of Excellence

Project acronym: POP

Project title: Performance Optimisation and Productivity

Duration: 2015-2018

Coordinator: Barcelona Supercomputing Centre (BSC)

Other partners: High Performance Computing Center Stuttgart of the University of Stuttgart (HLRS), Jülich Supercomputing Centre (JSC), Numerical Algorithm Group (NAG), Rheinisch-Westfälische Technische Hochschule Aachen (RWTH), TERATEC (TERATEC).

Abstract: The Center of Excellence for Performance Optimisation and Productivity provides performance optimisation and productivity services for academic and industrial codes. European's leading experts from the High Performance Computing field will help application developers getting a precise understanding of application and system behaviour. This project is supported by the European Commission under H2020 Grant Agreement No. 676553.

Established codes, but especially codes never undergone any analysis or performance tuning, may profit from the expertise of the POP services which use latest state-of-the-art tools to detect and locate bottlenecks in applications, suggest possible code improvements, and may even help by Proof-of-Concept experiments and mock-up test for customer codes on their own platforms.

9.3.2. Collaborations in European Programs, Except FP7 & H2020

9.3.2.1. COST IC1305 : Nesus

Participants: Marcos Dias de Assunção, Laurent Lefèvre.

Program: COST

Project acronym: IC1305

Project title: Network for Sustainable Ultrascale Computing (NESUS)

Duration: 2014-2018

Coordinator: Jesus Carretero (Univ. Madrid)

Abstract: Ultrascale systems are envisioned as large-scale complex systems joining parallel and distributed computing systems that will be two to three orders of magnitude larger that today's systems. The EU is already funding large scale computing systems research, but it is not coordinated across researchers, leading to duplications and inefficiencies. The goal of the NESUS Action is to establish an open European research network targeting sustainable solutions for ultrascale computing aiming at cross fertilization among HPC, large scale distributed systems, and big data management. The network will contribute to glue disparate researchers working across different areas and provide a meeting ground for researchers in these separate areas to exchange ideas, to identify synergies, and to pursue common activities in research topics such as sustainable software solutions (applications and system software stack), data management, energy efficiency, and resilience. In Nesus, Laurent Lefèvre is co-chairing the Working on Energy Efficiency (WG5).

9.4. International Initiatives

9.4.1. Inria International Labs

9.4.1.1. Joint Laboratory for Extreme Scale Computing (JLESC) (2014-2018)

Participants: Thierry Gautier, Christian Perez, Jérôme Richard.

Partners: NCSA (US), ANL (US), Inria (FR), Jülich Supercomputing Centre (DE), BSC (SP), Riken (JP).
The purpose of the Joint Laboratory for Extreme Scale Computing (JLESC) is to be an international, virtual organization whose goal is to enhance the ability of member organizations and investigators to make the bridge between Petascale and Extreme computing. The founding partners of the JLESC are Inria and UIUC. Further members are ANL, BSC, JSC and RIKEN-AICS.

JLESC involves computer scientists, engineers and scientists from other disciplines as well as from industry, to ensure that the research facilitated by the Laboratory addresses science and engineering's most critical needs and takes advantage of the continuing evolution of computing technologies.

9.4.1.2. Associate Team DALHIS – Data Analysis on Large-scale Heterogeneous Infrastructures for Science (2013-2018)

Participant: Frédéric Suter.

Partners: EPC Myriads (Rennes, Bretagne Atlantique), AVALON (Grenoble, Rhône-Alpes), Data Science and Technology Department (LBNL,USA).

The goal of the Inria-LBL collaboration is to create a collaborative distributed software ecosystem to manage data lifecycle and enable data analytics on distributed data sets and resources. Specifically, our goal is to build a dynamic software stack that is user-friendly, scalable, energy-efficient and fault tolerant. We plan to approach the problem from two dimensions: (i) Research to determine appropriate execution environments that allow users to seamlessly execute their end-to-end dynamic data analysis workflows in various resource environments and scales while meeting energy-efficiency, performance and fault tolerance goals; (ii) Engagement in deep partnerships with scientific teams and use a mix of user research with system software R&D to address specific challenges that these communities face, and inform future research directions from acquired experience.

9.4.2. Inria Associate Teams Not Involved in an Inria International Labs

9.4.2.1. Associate Team SUSTAM – Sustainable Ultra Scale compuTing, dAta and energy Management (2017-2020)

Participants: Eddy Caron, Hadrien Croubois, Marcos Dias de Assunção, Alexandre Da Silva Veith, Jean-Patrick Gelas, Olivier Glück, Laurent Lefèvre, Valentin Lorentz, Christian Perez, Issam Raïs.

International Partners: Rutgers University (United States) - RDI2 - Manish Parashar

The SUSTAM associate team will focus on the joint design of a multi-criteria orchestration framework dealing with resources, data and energy management in an sustainable way. The SUSTAM associated team will enable a long-term collaboration between the Inria AVALON team and the Rutgers Discovery Informatics Institute (RDI2) from Rutgers University (USA). The SUSTAM associated team is leaded by Laurent Lefèvre.

9.4.3. Participation in Other International Programs

9.4.3.1. Joint Project CNRS/University of Melbourne – Algorithms for Placement and Reconfiguration of Data Stream Processing Applications (2017-2018)

Participants: Marcos Dias de Assunção, Alexandre Da Silva Veith, Laurent Lefèvre.

Partner: Clouds Lab (The University of Melbourne, Australia).

Much of the "big data" produced today is created as continuous data streams that are most valuable when processed quickly. Several data stream processing frameworks have been designed for running on clusters of homogeneous computers. Under most frameworks, an application is a Direct Acyclic Graph (DAG) whose vertices are operators that execute transformations over the incoming data and edges that define how the data flows between operators. While cloud computing is a key infrastructure for deploying such frameworks, more modern solutions leverage the edges of the Internet (e.g. edge computing) to offload some of the processing from the cloud and hence reduce the end-to-end latency. The placement and reconfiguration of stream processing DAGs onto highly distributed and heterogeneous infrastructure are, however, challenging endeavours. This project aims to investigate algorithms for the placement and dynamic reconfiguration of stream processing components considering multiple criteria.

9.5. International Research Visitors

9.5.1. Research Stays Abroad

Participant: Olivier Glück.

Olivier Glück has been invited professor by Concordia University (Faculty of Engineering & Computer Science, Department of Computer Science & Software Engineering). He has conducted researches with Dr. Brigitte Jaumard, Professor & Research Chair, Tier 1, on the Optimization of Communication Networks. He has worked on the following Virtual Machine (VM) migration optimization problem: find a scheduling of VM migration that minimizes the makespan *i.e.,* total duration of the migration assuming that the current VM placement and the target one are given. He has proposed a new sequence-based optimization model with a Mixed Integer Linear Program (MILP), which not only guarantees the finding of the best VM migration scheduling but also the migration of the largest possible number of VMs in the case of deadlocks. He also worked on the design of heuristic algorithms for VM migration and a generator of real VM migration instances to evaluate the models and heuristics proposed. He has also worked on the task offloading problem in edge computing.

Coast Project-Team

8. Partnerships and Cooperations

8.1. Regional Initiatives

8.1.1. Region Grand Est TV Paint (2017–2019)

Participants: Claudia-Lavinia Ignat, Gérald Oster, Cédric Enclos.

Partners: TVPaint Development, Inria Coast project-team

Website: https://www.tvpaint.com/

This is a project in collaboration with TVPaint Development financed by Region Grand Est. It is a follow-up of a project in collaboration with TVPaint Development financed by Region Lorraine from 2016 to 2017. The goal is to contribute to the creation of a collaborative system dedicated to manage the production of animated movies. This system has to manipulate a large amount of data in a safe and secure manner. Based on the previously proposed architecture and prototype, this project intends to design and implement a commercial product. In the framework of this project, we bring our expertise in data management, business process management, distributed systems and collaborative systems.

8.2. National Initiatives

8.2.1. OpenPaas NG (2015–2019)

Participants: Claudia-Lavinia Ignat, François Charoy [contact], Gérald Oster, Olivier Perrin, Jean-Philippe Eisenbarth, Phillippe Kalitine, Matthieu Nicolas, Mohammed Riyadh Abdmeziem, Victorien Elvinger, Quentin Laporte Chabasse, Hoai Le Nguyen, Hoang Long Nguyen.

Partners: Linagora, XWiki SAS, Nexedi, Coast project-team (Université de Lorraine, LORIA), DaScim team (LIX).

Website: http://www.open-paas.org/

This project is financed by BpiFrance and involves French industrial leaders in open-source software development (Linagora, Nexedi, XWiki) and academic partners in collaborative work (Coast team) and recommender systems (DaScim team, LIX). The goal of the project is to develop next generation of cloud enabled virtual desktop based on an Enterprise Social Network to provide advanced collaborative and recommendation services. Coast team is responsible of the work package dedicated to the design of the peer-to-peer collaborative middleware. In this context, we bring our expertise on data replication for collaborative data in peer-to-peer environments and on trust and access control and identity management in distributed collaborative information systems.

8.3. International Initiatives

8.3.1. Inria Associate Teams Not Involved in an Inria International Labs

8.3.1.1. USCoast2

Title: User Studies on Trustworthy Collaborative Systems

International Partner (Institution - Laboratory - Researcher):

Wright State University (United States) - Department of Psychology, Knoesis - Valerie Shalin

Start year: 2016

See also: http://usCoast.loria.fr

The proposed project addresses the perception of trust by users, the appropriateness of a trust-based security approach and the role of trust metrics in the management of distributed work. The main challenge of this project is how to measure trust based on user behaviour and to verify by means of experimental studies with users that the trust-based mechanism is acceptable by users. We plan to apply this trust-based mechanism for two types of applications. The first one is collaborative editing where user trust will be computed based on the quality of user contributions for a document or project. The second type of application is in the management of work over a large group of people in order to conduct efficient, high-yield, high-density real time crowdsourcing activities. Partners of USCoast2 project have complementary expertise. Coast provides expertise in collaborative methods, systems and related technologies. Coast will propose algorithms that track and manipulate trust metrics.Knoesis provides expertise on the analysis of human work-related behaviour, including methods of data collection and data analysis, as well as a theoretical foundation for the evaluation of human performance. Knoesis will analyse trust from a psychological phenomenon point of view.

8.3.2. Inria International Partners

8.3.2.1. Informal International Partners

As part of our work on elastic business processes execution, we started a collaboration with Professor Cesare Pautasso from the University of Lugano. We developed a benchmarking framework for business process execution in the cloud, including hot migration of process engine in a multi-tenant setting. This collaboration resulted in a framework that allows repeatable evaluation of process execution.

8.4. International Research Visitors

8.4.1. Visits of International Scientists

Weihai Yu, The Arctic University of Norway, is doing his sabbatical year in the period September 1, 2018 - August 31, 2019 in the Coast team. He is working on the formalisation of undo with CRDTs.

8.4.2. Visits to International Teams

8.4.2.1. Research Stays Abroad

- François Charoy visited Knoesis team at Wright State University, OH from the 15th of June to the 23rd of July (USCoast2). He worked with Valerie Shalin on trust in sharing data during crisis amng different organisations.
- François Charoy visited the SOC Team of Boualem Benatallah at UNSW, Sydney, Australia from the 26 of August to the 14th of September. He collaborated with Boualem Benatallah on a new project on Composition of cognitive services at a large scale.

COATI Project-Team

8. Partnerships and Cooperations

8.1. Regional Initiatives

8.1.1. COSIT, 2018-2019

Participants: Mohammed Amine Ait Ouahmed, Ali Al Zoobi, David Coudert, Nicolas Nisse.

Program: Innovation project, Centre de reference "Smart City" of IDEX UCA[JEDI].

Project acronym: COSIT

Project title: Convergent Service for Intermodal Transportation

Duration: February 2018 - January 2019

Coordinator: David Coudert

Other partners: UMR ESPACE (France) and SME Instant-System

Abstract: On-demand transportation is a highly flexible mode of transportation that aims at optimizing transit operator service by reducing operational cost while increasing the number of passengers per vehicles, and to increase customer satisfaction. We are considering a service where a fleet of vehicles (minibuses with a limited number of seats) is used to answer user requests. Vehicle trajectories need to be recalculated dynamically as new queries arrive. It is a complementary offer to existing public transport services (bus, tram, metro, etc.) and intermediate in terms of cost and quality of service between public transport and individual transport (taxi, VTC).

In the COSIT project, we studied different aspects of the problem including static and dynamic algorithms for the assignment of users to vehicles, the study of user flows in the city, and the prediction of users queries. We will developed a graphical interface to visualize the evolution of vehicle itineraries as the demands of users arrive.

8.1.2. SNIF, 2018-2021

Participants: David Coudert, Frédéric Giroire, Nicolas Nisse, Stéphane Pérennes.

Program: Innovation project of IDEX UCA[JEDI].

Project acronym: SNIF

Project title: Scientific Networks and IDEX Funding

Duration: September 2018 - August 2021

Coordinator: Patrick Musso

Other partners: GREDEG, SKEMA, I3S (SigNet) and Inria (COATI), all from UCA.

Abstract: Scientific collaboration networks play a crucial role in modern science. This simple idea underlies a variety of initiatives aiming to promote scientific collaborations between different research teams, universities, countries and disciplines. The recent French IDEX experience is one of them. By fostering competition between universities and granting few of them with a relatively small amount of additional resources (as compare to their global budget), public authorities aim to encourage them to deeply reshape the way academic activities are organized in order to significantly increase the quality of their research, educational programs and innovative activities. The development of new collaboration networks is one of the factors at the heart of this global reorganization. Promoting new international and/or interdisciplinary collaborations is supposed to increase researchers' productivity and industry partnerships. This project aims to question the validity of this line of thought.

8.2. National Initiatives

8.2.1. ANR-17-CE22-0016 MultiMod, 2018-2021

Participants: Mohammed Amine Ait Ouahmed, Ali Al Zoobi, David Coudert, Nicolas Nisse, Michel Syska.

Program: ANR

Project acronym: MultiMod

Project title: Scalable routing in Multi Modal transportation networks

Duration: January 2018 - December 2021

Coordinator: David Coudert

Other partners: Inria Paris, EP GANG; team CeP, I3S laboratory; SME Instant-System; SME Benomad

Abstract: The MultiMod project addresses key algorithmic challenges to enable the fast computation of personalized itineraries in large-scale multi-modal public transportation (PT) networks (bus, tram, metro, bicycle, etc.) combined with dynamic car-pooling. We will use real-time data to propose itineraries with close to real travel-time, and handle user-constraints to propose personalized itineraries. Our main challenge is to overcome the scalability of existing solutions in terms of query processing time and data-structures space requirements, while including unplanned transportation means (car-pooling), real-time data, and personalized user constraints. The combination of car-pooling and PT network will open-up areas with low PT coverage enable faster itineraries and so foster the adoption of car-pooling. We envision that the outcome of this project will dramatically enhanced the mobility and daily life of citizens in urban areas.

Web: https://project.inria.fr/multimod/

8.2.2. PEPS POCODIS

Program PEPS

Project Acronym: POCODIS

Project Title: POndérations et COlorations DIStinguantes de graphes

Duration: Février-Décembre 2018

Coordinator: Julien Bensmail

Others Partners: None

Abstract: This project is about two conjectures on *proper* weightings of a graph, namely the 1-2-3 conjecture and a conjecture about localy irregular decompositions. A weighting is proper whenever the coloring obtained by taking as color for a vertex v the sum of the weight in the neighbourhood of v is a proper coloring, more concisely adjacent vertices have different sums. The main objective of the project is to address several open questions around (i.e. motivated by) these conjectures since we believe that this could lead to significant progress toward the solution of the two main conjectures. To that aim we will make use of several recent and innovative tools and technique in the field, such as the probabilistic method and the polynomial method. In order to use and understand these techniques to their best we shall strengthen several international collaborations with experts from the field.

8.2.3. PICS DISCO

Program: PICS

Project acronym: DISCO

Project title: DIsjoint Structures and Coverings in Oriented graphs

Duration: January 2018 -December 2020.

Coordinator: Stéphane Bessy (LIRMM)

Other partners: organisme, labo (pays) CNRS LIRMM (Montpellier), Syddansk universitet (Odense, Danemark)

Abstract: Directed graphs (digraphs) are much less understood than undirected graphs. Many, seemingly very simple questions remain unsolved for digraphs while the analogous problem for undirected graphs is trivial. At the same time digraphs is a very important modelling tool for practical applications and so a better undestanding of their structure is important. The purpose of DISCO is to advance knowledge on fundamental problems on digraphs, including splitting a digraph into smaller pieces with given properties, problems regarding disjoint paths and trees, finding small certificates for given properties, such as strong spanning subdigraphs with few arcs. The later is important for speeding up certain algorithms.

Through a concerted effort we expect to obtain important results which will lead to a better undestanding of fundamental questions about the structure of digraphs. The participants will meet regularly both in France and in Denmark to work on carefully selected problems.

8.2.4. GDR Actions

8.2.4.1. GDR RSD, ongoing (since 2006)

Members of COATI are involved in the working group RESCOM (*Réseaux de communications*) of GDR RSD, CNRS (http://rescom.asr.cnrs.fr/). In particular, David Coudert is co-chair of this working group since 2017 and has organized its annual summer school, RESCOM'18. Christelle Caillouet was co-chair of the programme committee of the annual conference AlgoTel'18.

We are also involved in the working group "Energy" of GDR RSD. In particular, Frédéric Giroire is co-hair of this working group.

8.2.4.2. GDR IM, ongoing (since 2006)

Members of COATI are involved in the working group "Graphes" of GDR IM, CNRS. (http://gtgraphes.labri.fr/). In particular, Frédéric Havet is member of the steering committee.

8.2.4.3. GDR MADICS, ongoing (since 2017)

Members of COATI are involed in the working group GRAMINEES (GRaph data Mining in Natural, Ecological and Environnemental Sciences) of GDR MADICS (Masses de Données, Informations et Connaissances en Sciences). (http://www.madics.fr/actions/actions-en-cours/graminees/).

The annual summer school RESCOM'18 of GDR RSD has been co-organized with GDR MADICS.

8.3. International Initiatives

8.3.1. IFCAM Program, Applications of Graph homomorphisms

Program: IFCAM 2018-2020 (http://math.iisc.ac.in/~ifcam/)

Project acronym: –

Project title: Applications of graph homomorphisms on graph database

Duration: Janvier 2018 - Décembre 2020

Coordinator: Reza Naserasr (for France) - Sagnik Sen (for India)

Other partners: complete list of participants on the project website.

Abstract: In this project, we are going to study the graph homomorphism problems from a very general point of view. Apart from studying the usual graph homomorphism on undirected graphs, we will study it for different types of graphs such as, signed graphs, oriented graphs, edge-colored graphs, colored mixed graphs etc. We will apply the theories and techniques associated with graph homomorphism to solve practical problems. Our main application oriented work is studying graph homomorphism in the context of graph database, a type of database now a days used even by popular social medias. Graph homomorphism is equivalent to the query evaluation problem in graph

database, and thus have exciting intersection with the theory. In our group we have experts of graph homomorphisms as well as graph database making this project a potential case for Indo-French interdisciplinary collaboration. We want to organize a workshop by the end of this project. We also consider a few other application oriented topics as auxiliary research tracks inside this project.

8.3.2. Inria International Labs

Inria Chile

Associate Team involved in the International Lab:

8.3.2.1. ALDYNET

Title: distributed ALgorithms for DYnamic NETworks

International Partner (Institution - Laboratory - Researcher):

Universidad Adolfo Ibañez (Chile) - Facultad de Ingeniería y Ciencias - Karol SUCHAN

Start year: 2016

See also: https://team.inria.fr/coati/projects/aldynet/

This associated team would be the natural continuation of the fruitful EA AlDyNet (2013-2015, https://team.inria.fr/coati/projects/aldynet/)

The main goal of this Associate Team is to design and implement practical algorithms for computing graph structural properties. We will then use these algorithms on a concrete case of study which concerns the transportation network of the Santiago agglomeration. We are both interested in theoretical results concerning the feasibility of computing graph properties, and by their practical implementation (using Sagemath) for our application and their diffusion in the scientific community. There are three main objectives:

1) Design efficient algorithms to compute important graph properties (hyperbolicity, treelength, centrality, treewidth...) in real networks. We are not only interested by the worst-case time-complexity of these algorithms but by their performance in practice.

2) Implement and document our algorithms using the open-source framework SageMath. One advantage of using SageMath is that it has interfaces with other graph libraries (igraph, Boost...) and with Linear Programming solver (GLPK, Cplex...). Moreover, the success of SageMath (which has accumulated thousands of users over the last 10 years) will participate to the diffusion of our algorithms.

3) Apply our algorithms on the Santiago transportation network that have been collected by our Chilean partner during the last year of AlDyNet (2013-2015). Based on the results, propose tools for decision support in designing bus routes, timetables, etc. More precisely, we have collected information about the use of public transport (data of smart cards for automatic fare collection - BIP-, bus routes and bus schedules, etc.), urban infrastructure information, schools' addresses, and approximate locations where students live. We have started to clean and consolidate these data. We will then develop decision support tools, for example, for improving quality education accessibility.

8.3.3. Inria International Partners

8.3.3.1. Informal International Partners

Apart from formal collaboration COATI members maintain strong connections with the following international teams, with regular visits of both sides.

Universidade Federal do Ceará (Fortaleza, Brazil), ParGO team;

Universidade Estadual do Ceará (Fortaleza, Brazil), Prof. Leonardo Sampaio;

Univ. of Southern Denmark (Odense, Denmark), Prof. Jørgen Bang-Jensen;

RWTH Aachen Univ., Lehrstuhl II für Mathematik (Aachen, Germany), Prof. Arie M.C.A. Koster;

Concordia Univ. (Montréal, Québec, Canada), Prof. Brigitte Jaumard.

8.4. International Research Visitors

8.4.1. Visits of International Scientists

- Jørgen Bang-Jensen

  University of Southern Denmark, Odense, Denmark. June 2018.
- Romuald Elie

  Paris-Est University. February 3 - March 2 2018.
- Gwenael Joret

  Université Libre de Bruxelles, Belgique. March 2018.
- Takako Kodate

  Tokyo's Woman's Christian University. December 15 2017 till March 31 2018.
- Kasper Szabo Lyngsie

  Technical University of Denmark, Lyngby, Denmark. June 27 - July 8.
- Joseph Peters

  Simon Fraser University, Vancouver, BC, Canada. October 1 2017 till March 31 2018.
- Tahiry Razafindralambo

  Université de la Réunion. July 8-28 2018.
- Leonardo Sampaio Rocha

  University Federal de Ceara, Fortaleza, Brazil. July 1 2018 till June 30 2019.
- Karol Suchan

  Universidad Adolfo Ibañez, Santiago, Chile. September 9-23 2018.
- Robert E. Tarjan

  Princetown University, Princetown, NJ, USA. July 2018.
- Min-Li (Joseph) Yu

  University of the Fraser Valley, Abbotsford, BC, Canada. March 1 till April 15 2018.

8.4.2. Visits to International Teams

8.4.2.1. Research Stays Abroad

- Julien Bensmail :

  Northwestern Polytechnical University, Xi'an, China. 22 Avril-13 Mai.

  LaBRI, Bordeaux, France. 23 Mai-12 Juin.

  Technical University of Denmark, Lyngby, Denmark. 22 Août-2 Septembre.

  AGH University, Krakow, Poland. 24 Novembre-2 Décembre.
- David Coudert :

  Universidad Adolfo Ibañez, Santiago, Chile, December 1-14, 2018.
- Frédéric Havet :

  University of Southern Denmark, Odense, Denmark. April 2018.

  Ecole Normale Supérieure de Lyon, France, January and September 2018.
- Nicolas Nisse :

  Xidian University, Xi'an, China, September 1-15, 2018

  Univ. Adolfo Ibañez, Santiago, Chile, December 1-15, 2018

CTRL-A Project-Team

8. Partnerships and Cooperations

8.1. Regional Initiatives

8.1.1. Grenoble Alpes Cybersecurity Institute Cross-Disciplinary Project of the Idex

The Grenoble Alpes Cybersecurity Institute aims at undertaking ground-breaking interdisciplinary research in order to address cybersecurity and privacy challenges. Our main technical focus is on low-cost secure elements, critical infrastructures, vulnerability analysis and validation of large systems, including practical resilience across the industry and the society.

In Ctrl-A, it is funding an internship position followed by a PhD position to be provided in September 2019 and supervised by Stephane Mocanu.

8.2. National Initiatives

8.2.1. ANR HPeC

HPeC is an ANR project on Self-Adaptive, Energy Efficient High Performance Embedded Computing, with a UAV case study (http://hpec.fr/). The Coordinator is Lab-STICC / MOCS (Lorient / Brest), and the duration: 42 month from october 2015. Others Partners are: UBO, U. Clermont-Ferrand, InPixal.

In Ctrl-A, it is funding a post-doc position, hired in Grenoble and co-advised with Lorient : Soguy Gueye. The work will be continued with a post-doc hired in Lorient : Erwan Moreac. A PhD based in Brest, Chabha Hireche, is co-advised by Stéphane Mocanu.

8.2.2. ANR Sacade

The ANR ASTRID Sacade project is funded by DGA. Stéphane Mocanu is in charge of several workpackages including a demonstrator. An expert engineer position is funded for the implementation of attack/defense scenarios in SCADA.

8.2.3. Informal National Partners

We have contacts with colleagues in France, in addition to the cooperation mentioned before, and with whom we are submitting collaboration projects, co-organizing events and workshops, etc. They feature : Avalon Inria team in Lyon (Ch. Perez, L. Lefevre, E. Caron), LIP6 (J. Malenfant), Scales Inria team in Sophia-Antipolis (L. Henrio), LIRRM in Montpellier (A. Gamatié, K. Godary, D. Simon), IRISA/Inria Rennes (J. Buisson, J.L. Pazat, ...), Telecom Paris-Tech (A. Diaconescu, E. Najm), LAAS (Thierry Monteil), LURPA ENS Cachan (J.M. Faure, J.J. Lesage).

8.2.4. Informal National Industrial Partners

We have ongoing discussions with several industrial actors in our application domains, some of them in the framework of cooperation contracts, other more informal: Eolas/Business decision (G. Dulac, I. Saffiedine), ST Microelectronics (V. Bertin), Schneider Electric (C. El-Kaed, P. Nappey, M. Pitel).

8.3. International Initiatives

8.3.1. Inria International Labs

We participate in the jLESC, Joint Laboratory for Extreme Scale Computing, with partners Inria, the University of Illinois, Argonne National Laboratory, Barcelona Supercomputing Center, Jülich Supercomputing Centre and RIKEN AICS.

We participated to the 7th Workshop of the JLESC at Urbana-Champain in July 2017.

We started a cooperation with Argonne National Labs, on Improving the performance and energy efficiency of HPC applications using autonomic computing techniques.

https://jlesc.github.io/projects/energy_autonomic/

We are also exploring possibilities on the topic of integrating FPGAs in HPC grids, with a participation in a workshop at FPT 18.

https://collab.cels.anl.gov/display/HPCFPGA/HPC-FPGA

8.3.2. Inria International Partners

8.3.2.1. Informal International Partners

We have ongoing relations with international colleagues in the emerging community on our topic of control for computing e.g., in Sweden at Lund (K.E. Arzen, M. Maggio), Mälardalen (A. Papadopoulos) and Linnaeus Universities (D. Weyns, N. Khakpour), in the Netherlands at CWI/leiden University (F. Arbab), in the U.K. at Liverpool U. (N. Berthier), in China at Heifei University (Xin An), in Italy at University Milano (C. Ghezzi, A. Leva), in the USA at Ann Arbor University (S. Lafortune) and UMass (P. Shenoy, E. Cecchet).

DANTE Project-Team

9. Partnerships and Cooperations

9.1. Regional Initiatives

9.1.1. Idex Lyon ACADEMICS

Participants: Paulo Gonçalves, Dominique Barbe, Gaetan Frusque.

See Section 5.1.1 for an executive summary of this project. The project brings together a **consortium of 4 teams from Laboratories of Université de Lyon** (UdL) and will form a working group with complementary expertise in machine learning (deep learning, statistical learning, data mining), in data science (complex data analysis, adaptive and/or data-driven methods, network science) and in the studies of climate modeling and of computational social science. It comprises:

- Laboratoire Informatique du Parallélisme (LIP): P. Gonçalves (PI), M. Karsai (PI for Comp. Social Sc.)
- Laboratoire de Physique (LP): P. Borgnat (Coordinator), F. Bouchet (PI for Climate)
- Laboratoire Hubert Curien (LabHC), Université Jean Monnet: M. Sebban (PI)
- Laboratoire d'InfoRmatique en Images et Systèmes d'information (LIRIS): C. Robardet (PI)

The **impacts** of the project will stem from the efficiency of our proposed methods to learn from complex and dynamic data, and if so, **future applications** will naturally follow in many areas: social science and study of social interactions, climate and environmental science but also in technological networks, neuroscience with the study of brain networks and more generally in any domain where effective dynamical models of complex situations are to be learned from data. All these situations go beyond the current classical applicative frameworks of ML (time measurements, 2D images, or texts) and compel us to work out a major scientific breakthrough.

9.1.2. ISI Torino / Dante

Participant: Márton Karsai [correspondant].

Duration of the project: **October 2016 - October 2020**.

This project involves M. Karsai and L. Gauvin (ISI Torino) and funded by the IXXI Complex System Institute. The purpose of this project is to investigate the presence and the importance of higher-order correlations in dynamical networks. As the first attempt to address this problem we applied autoencoder, a recent representation using deep neural networks, on modelled and small-scale real temporal networks. However, since the results were trivial on the modelled network and not convincing on the real one we decided to take a different approach during the second phase of the project. We involved an ISI PhD student Maddalena Toricelli, to work out a method for temporal network embedding. Our idea is to extend the node2vec representation of static networks for time-varying structures, by using a local random walk to explore the structural-temporal neighbourhood of a node. Based on such local information we can effectively propose an embedding, which captures the temporal and structural properties of nodes in a temporal network.

9.2. National Initiatives

9.2.1. Equipex FIT (Futur Internet of Things)

Participant: Éric Fleury [correspondant].

FIT was one of 52 winning projects in the Equipex research grant program. It will set up a competitive and innovative experimental facility that brings France to the forefront of Future Internet research. FIT benefits from 5.8 million euro grant from the French government Running from 22.02.11 – 31.12.2019. The main ambition is to create a first-class facility to promote experimentally driven research and to facilitate the emergence of the Internet of the future.

9.2.2. ANR GRAPHSIP (Graph Signal Processing)

Participants: Paulo Gonçalves [correspondant], Éric Fleury, Thomas Begin, Mikhail Tsitsvero.

Duration of the project: **October 2014 - October 2018**.

An increasing number of application areas require the processing of massive datasets. These data can often be represented by graphs in order to encode complex interactions. When data vectors are associated with graph vertices, a so-called graph signal is obtained. The processing of such graph signals includes several open challenges because of the nature of the involved information. Indeed graph theory and signal and image processing methodologies do not combine readily. In particular, such a combination requires new developments, allowing classical signal processing methods to work on irregular grids and non Euclidean spaces. Considering the significant success of classical signal processing tools, it appears essential to generalise their use to graph signals. The GRAPHSIP project aims at developing a set of advanced methods and algorithms for the processing of graph signals: multi-scale transforms and solutions of variational problems on graphs. The major outcomes of this project are expected to lead to significant breakthroughs for graph data processing. The project will also focus on two novel applications on instances of graph signals: brain networks and 3D colour point clouds. They will exemplify and illustrate the proposed methodological advances on emerging applications.

9.2.3. ANR SoSweet

Participants: Jean Pierre Chevrot, Éric Fleury, Márton Karsai [correspondant], Jean-Philippe Magué [PI].

Duration of the project: **November 2015 - November 2019**.

The SoSweet project focuses on the synchronic variation and the diachronic evolution of the variety of French used on Twitter. The recent rise of novel digital services opens up new areas of expression which support new linguistic behaviours. In particular, social medias such as Twitter provide channels of communication through which speakers/writers use their language in ways that differ from standard written and oral forms. The result is the emergence of new varieties of languages. The main goal of SoSweet is to provide a detailed account of the links between linguistic variation and social structure in Twitter, both synchronically and diachronically. Through this specific example, and aware of its bias, we aim at providing a more detailed understanding of the dynamic links between individuals, social structure and language variation and change.

9.2.4. ANR DylNet

Participants: Márton Karsai [correspondant], Jean Pierre Chevrot, Jean-Philippe Magué, Éric Fleury.

Duration of the project: **September 2016 - September 2020**.

The DylNet project aims to observe and to characterise the relationships between childhood sociability and oral-language learning at kindergarten. With a view to this, it takes an multidisciplinary approach combining work on language acquisition, sociolinguistics, and network science. It will be implemented by following all the children (≈ 220) and teaching staff in one kindergarten over a 3-year period. The use of wireless proximity sensors will enable collection of social contacts throughout the study. The data on sociability will be linked to the results of language tests and recordings of verbal interactions used to follow the children's progress on both a psycholinguistic level (lexicon, syntax, pragmatics) and a sociolinguistic level (features showing belonging to a social group). The aim is to better understand the mechanisms of adaptation and integration at work when young children first come into contact with the school context.

9.2.5. Inria PRE LIAISON

Participants: Márton Karsai [correspondant], Éric Fleury.

Duration of the project: **November 2017 - December 2019**.

This project implements unsupervised deep learning approaches to infer correlations/patterns that exist between dynamic linguistic variables, the mesoscopic and dynamic structure of the social network, and their socio-economic attributes. This interdisciplinary project is positioned at the crossroads of Natural Language Processing (NLP), Network Science, Data Science and Machine Learning.

More precisely, we develop a joint feature-network embedding, named AN2VEC (Attributed Network to Vector), which ultimately aims at disentangling the information shared by the structure of a network and the features of its nodes. Building on the recent developments of Graph Convolutional Networks (GCN), we use a multitask GCN Variational Autoencoder where different dimensions of the generated embeddings can be dedicated to encoding feature information, network structure, or shared feature-network information separately. This method thus defines a range of models whose performance in embedding a given data set varies depending with the allocation of dimensions. By exploring the behaviour of these models on synthetic data sets having different levels of feature-network correlation, we show (i) that embeddings relying on shared information perform better than the corresponding reference with unshared information, and (ii) that this performance gap increases with the correlation between network and feature structure, thus confirming that our embedding is able to capture joint information of structure and features.

9.2.6. Inria & HCERES

Participants: Éric Guichard [correspondant], Éric Fleury.

Bilateral project on the evolution of the Multi/inter-disciplinary of SHS.

An increasing number of researchers in SHS has the desire to develop new researches with computer scientists or mathematicians because they want to apply new methodologies (according to various or numerous data) or to develop older ones, which can now be easily implemented online. Some also develop a reflexion on their discipline, with the idea that epistemological questions are revitalized by the internet. This reality invite them to discuss with philosophers or with other SHS scientists who have the same intuition (eg: cartography, visualisation).

The project is hence to measure these new forms or inter-multi-disciplinarity. The main source will be the publications of all academics of French SHS laboratories, to find out who writes a paper with somebody of a different discipline and/or laboratories. All data are anonymized,

9.2.7. Inria IPL BetterNet

Participant: Éric Guichard.

An Observatory to Measure and Improve Internet Service Access from User Experience [0].

BetterNet aims at building and delivering a scientific and technical collaborative observatory to measure and improve the Internet service access as perceived by users. In this Inria Project Lab, we will propose new original user-centered measurement methods, which will associate social sciences to better understand Internet usage and the quality of services and networks with a particular focus on geography and cartography.

9.3. European Initiatives

9.3.1. FP7 & H2020 Projects

9.3.1.1. EMBERS

- Title: Enabling a Mobility Back-End as a Robust Service
- Programm: H2020
- Duration: December 2015 - November 2018
- Coordinator: UPMC

[0] https://www.inria.fr/en/research/research-teams/inria-project-labs

- Partners:
  - Fraunhofer Gesellschaft Zur Forderung Der Angewandten Forschung Ev (Germany)
  - Technische Universitat Berlin (Germany)
  - Universite Pierre et Marie Curie - Paris 6 (France)
  - Ubiwhere Lda (Portugal)
- Inria contact: Eric Fleury
- EMBERS will bring to market a back-end for smart city mobility that is developed by a European small enterprise based upon its smart parking and smart traffic management products that two municipalities in Portugal currently deploy. The Mobility Back-end as a Service (MBaaS) replaces such all-in-one systems, in which a municipality purchases the full set of components from a single vendor. Instead, the city manager can purchase best-of-breed devices and apps developed by third parties, with the only constraint being that they interoperate with the back-end via a free, open, smart city mobility API. This domain-specific API lowers barriers to entry for app and device developers, making it easier for innovative SMEs to enter the market. Furthermore, the API is offered via a variety of generic interfaces, including oneM2M, ETSI M2M, OMA LWM2M, and FIWARE NGSI. EMBERS thus clears the way for developers and to municipalities that have adopted any one of these potential emerging machine-to-machine (M2M) communication standards. Beyond its primary goal of bringing the MBaaS to market, EMBERS will stimulate development of an entire ecosystem around the MBaaS smart city mobility API. Separating out the back-end from the other components will, however, require rigorous testing. EMBERS will experiment with the system on two testbeds that are part of the FIRE OneLab facility: the FUSECO Playground, for M2M communications, and FIT IoT-LAB, for wireless sensor devices. EMBERS will host a hackathon and an app challenge to bring in third party developers. The project will also include three demonstrators by third parties via an open call. These activities will contribute back to FIRE by demonstrating successful experimentation by SMEs developing close-to-market products. The project will also conduct real world pilots in two or more cities as a final step in bringing the MBaaS to market.

9.3.1.2. ARMOUR

Title: Large-Scale Experiments of IoT Security & Trust (Project nÂ°688237)

Programm: H2020

Duration: 2015 Dec to 2018

Coordinator: UPMC

Partners:

Synelixis Lyseis Pliroforikis Automatismou & Tilepikoinonion Monoprosopi EPE (Greece)

Smartesting Solutions & Services (France)

Unparallel Innovation, Lda (Portugal)

Easy Global Market (France)

ODIN Solutions (Spain)

Universite Pierre et Marie Curie - Paris 6 (France)

Inria contact: Eric Fleury

ARMOUR will provide duly tested, benchmarked and certified Security & Trust solutions for large-scale IoT using upgraded FIRE large-scale IoT/Cloud testbeds properly-equipped for Security & Trust experimentations. ARMOUR takes the top large-scale FIT IoT-LAB testbed a FIRE OpenLAB / FIT IoT LAB facility â and enhances it as to enable experimentally-driven research on a key research dimension: large-scale IoT Security & Trust. Presently, no proper installations exist to experiment IoT Security & Trust on large-scale conditions; ARMOUR will develop and install such capability.

9.4. International Initiatives

9.4.1. Participation in International Programs

9.4.1.1. PHC Peridot

Participants: Mohammed Amer, Thomas Begin, Anthony Busson, Isabelle Guérin Lassous.

Framework for Control and Monitoring of Wireless Mesh Networks (WMN) using Software-Defined Networking (SDN). The main objective of this project is propose mechanisms and modifications in the SDN architecture, specifically in the OpenFlow, which allow SDN mechanisms to operate over WMN considering the dynamic network topology that WMN may experience and some other relevant characteristics. The project will involve devising mechanisms for controlling mesh switches through controllers in a wireless environment, which will require developing novel and WMN-specific rules, actions and commands. The project will involve proposing mechanism that consider dynamic environment of WMN along with providing redundancy in the network. Besides, there is a requirement to have an adaptive measurement API for WMN. This is the second objective of our research project. The proposed measurement API will enable the network operators to monitor network traffic over WMN which may be content-specific or host-specific. This is a joint project between DANTE and M. A. Jinnah University, Islamabad. It started in June 2015 and will end in June 2018.

9.4.2. International Initiatives

9.4.2.1. MOTif - Mobile phone sensing of human dynamics in techno-social environment

- Program: Stic AmSud
- Duration: January 2018 - December 2019
- Coordinator: Inria DANTE (Márton Karsai)
- Partners:
  - Universidad de Buenos Aires (Argentina)
  - Grandata (USA-Argentina)
  - Universidade Federal de Minas Gerais (Brazil)
  - LNCC (Brazil)

This project brings together two Inria teams - INFINE (Saclay) - DANTE (Lyon) and multiple Latin-American partners to work together with the IT company Grandata.

Scope of the project: Information and Communication Technology (ICT) is becoming increasingly social, as demonstrated by the multitude of emerging technologies and technology platforms that facilitate social interactions, taking place as communication via telephone, text message, email, online social networks etc. At the same time, our social activities are increasingly embedded in the ICT environments that enable and enhance our ability to transact, share experiences, and maintain social relationships. One of the best ways to explore these developments is through the mining and analysis of data, which are collected through mobile phones and allow us to investigate how individuals act when embedded in a technology-enabled environment. Unlimited access to a wide range of mobile applications and services may change our way to gain information, to communicate, or even to behave in different contextual places like home, work, or anywhere else. Thus understanding individual activity patterns and the source of decisions behind them is moreover important for the design of future services and to estimate the demand on the infrastructure. The MOTIf project builds on the analysis and modeling of geo-localized temporally detailed but fully anonymised mobile phone call networks. These datasets allow us to address the two scientific objectives about spatiotemporal patterns of service usage of anonymised individuals to learn when, where, and what people are doing; and about the fine-grained sociodemographic structure of society and its effect on the the individual social behaviour. In other words our goal in general is to understand how individuals behave in a dynamic techno-social environment.

9.5. International Research Visitors

9.5.1. Visits of International Scientists

- Don Towsley, University of Massachusetts, Amherst, USA (march 15 - june 15, 2018).
- Alexandre Brandwajn, University of California Santa Cruz, USA (march 2018)

9.5.2. Visits to International Teams

9.5.2.1. Research Stays Abroad

- Philippe Nain visited the University of Massachusetts at Amherst (Sep. 1, 2018 - Jan. 31, 2019). He taught a graduate course on Performance Evaluation of Computer and Communication Systems and collaborated with Prof. D. Towsley and some of his students/collaborators on several research projects.
- Christophe Crespelle is on leave with a Marie Sklodowska-Curie Grant from EU. He is currently at the University of Bergen (Norway) until the beginning of 2020.
- Christophe Crespelle visited the Institute of Mathematics of the Vietnam Academy of Science and Technology, Hanoi, Vietnam (Nov. 6 - Dec. 6, 2018).

DATAMOVE Project-Team

8. Partnerships and Cooperations

8.1. National Initiatives

8.1.1. ANR

- **ANR grant GRECO (2017-2020).** Resource manager for cloud of things. Coordinator: Quarnot Computing. Partners: Quarnot Computing, Grenoble-INP, Inria.
- **ANR grant Energumen (2018-2022).** Resource management: malleable jobs for a better use of the resources along with energy optimization. Coordinator: Denis Trystram. Partners: Grenoble-INP, IRIT, Sorbonne Université.

8.1.2. Competitivity Clusters

- **PIA Avido (2015-2018)**. In situ analysis and visualization for large scale numerical simulation. Coordinator: EDF SA. Partners: EDF R&D, Total SA, Kitware SAS , Université Pierre et Marie CURIE, Inria (DataMove).
- **FUI OverMind (2015-2018)**. Task planification and asset management for the cartoon productions. Coordinator: Teamto Studio. Partners: Teamto Studio, Folimage Studio, Ecole de Gobelins, Inria (DataMove).
- **FUI IDIOM (2018-2020)**. Monitoring and optimization of I/Os. Coordinator DDN Storage. Partners: DDN Storage, Criteo, Quarnot, QuasarDB, CEA, Université de Bretagne Occidentale, Telecom SudParis, Inria (DataMove).

8.1.3. Inria

- Inria PRE COSMIC (exploratory research project), 2017-2019. Photovoltaic Energy Management for Distributed Cloud Platforms. Myriads, DataMove.
- Inria IPL HPC-BigData, 2018-2021). Convergence between HPC, Big Data and AI. Coordinator: Bruno Raffin. Partners: the Inria teams Zenith, Kerdata, Datamove, Tadaam, SequeL, Parietal, Tau, and the external partners ATOS, ANL, IBPC, ESI-Group. See https://project.inria.fr/hpcbigdata/

8.2. European Initiatives

8.2.1. Collaborations in European Programs, Except FP7 & H2020

Program: SKŁODOWSKA-CURIE ACTIONS - Individual Fellowship

Project acronym: DAMA

Project title: Extreme-Scale Data Management

Duration: November 2018 - October 2020

Coordinator: Bruno Raffin

Followship Recipient: Francieli Zanon Boito.

Abstract: This project is concerned with the I/O challenges that arise from the convergence between these two different paradigms. It is clear data analytics tools cannot simply replace their typical storage solutions for the HPC I/O stack, centered on the abstraction of files and powered by a parallel file system, because their workload is not well suited for that and would observe poor performance. Moreover, the separated storage infrastructure breaks the data affinity idea in which they are built upon. Finally, even among traditional HPC applications there is a need to minimize data movement, as it imposes high latency and increases energy consumption.

8.3. International Initiatives

8.3.1. Inria International Labs

8.3.1.1. JLESC

Title: Joint Laboratory for Extreme-Scale-Computing.

International Partners:

University of Illinois at Urbana Champaign (USA)

Argonne National Laboratory (USA),

Barcelona Supercomputing Center (Spain),

Jülich Supercomputing Centre (Germany)

Riken Advanced Institute for Computational Science (Japan)

Start year: 2009

See also: https://jlesc.github.io/

The purpose of the Joint Laboratory for Extreme Scale Computing is to be an international, virtual organization whose goal is to enhance the ability of member organizations and investigators to make the bridge between Petascale and Extreme computing. The JLESC organizes a workshop every 6 months DataMove participates to. DataMove developed several collaborations related to in situ processing with Tom Peterka group (ANL) , the Argo exascale operating system with Swann Perarnau (ANL).

8.3.2. Participation in Other International Programs

8.3.2.1. LICIA

Title: International Laboratory in High Performance and Ubiquitous Computing

International Partner (Institution - Laboratory - Researcher):

UFRGS (Brazil)

Duration: 2011 - 2018

See also: http://licia-lab.org/

The LICIA is an Internacional Laboratory and High Performance and Ubiquitous Computing born in 2011 from the common desire of members of Informatics Institute of the Federal University of Rio Grande do Sul and of Laboratoire d'Informatique de Grenoble to enhance and develop their scientific parternship that started by the end of the 1970. LICIA is an Internacional Associated Lab of the CNRS, a public french research institution. It has support from several brazilian and french research funding agencies, such as CNRS, Inria, ANR, European Union (from the french side) and CAPES, CNPq, FAPERGS (from the Brazilian side). DataMove is deeply involved in the animation of LICIA. Bruno Raffin is LICIA associate director.

8.4. International Research Visitors

8.4.1. Visits of International Scientists

Professor visit: Alba Cristina Magalhaes Alves De Melo, Professor at University of Brasilia, visited the Datamove for one month in 2018.

PhD in progress: Danilo Carastan Dos Santos, Dynamic Scheduling of Tasks in High Performance Platforms with Machine Learning (Sao Paulo, Brasil). 1 year "sandwich" visit. Local adviser: Denis Trystram

DELYS Team

7. Partnerships and Cooperations

7.1. National Initiatives

7.1.1. ANR

7.1.1.1. ESTATE - (2016–2020)

Members: LIP6 (DELYS, project leader), LaBRI (Univ. de Bordeaux); Verimag (Univ. de Grenoble).

Funding: ESTATE is funded by ANR (PRC) for a total of about 544 000 euros, of which 233 376 euros for DELYS.

Objectives: The core of ESTATE consists in laying the foundations of a new algorithmic framework for enabling Autonomic Computing in distributed and highly dynamic systems and networks. We plan to design a model that includes the minimal algorithmic basis allowing the emergence of dynamic distributed systems with self-* capabilities, *e.g.*, self-organization, self-healing, self-configuration, self-management, self-optimization, self-adaptiveness, or self-repair. In order to do this, we consider three main research streams:

(i) building the theoretical foundations of autonomic computing in dynamic systems, (ii) enhancing the safety in some cases by establishing the minimum requirements in terms of amount or type of dynamics to allow some strong safety guarantees, (iii) providing additional formal guarantees by proposing a general framework based on the Coq proof assistant to (semi-)automatically construct certified proofs.

The coordinator of ESTATE is Franck Petit.

7.1.1.2. RainbowFS - (2016–2020)

Members: LIP6 (DELYS, project leader), Scality SA, CNRS-LIG, Télécom Sud-Paris, Université Savoie-Mont-Blanc.

Funding: is funded by ANR (PRC) for a total of 919 534 euros, of which 359 554 euros for DELYS.

Objectives: RainbowFS proposes a "just-right" approach to storage and consistency, for developing distributed, cloud-scale applications. Existing approaches shoehorn the application design to some predefined consistency model, but no single model is appropriate for all uses. Instead, we propose tools to co-design the application and its consistency protocol. Our approach reconciles the conflicting requirements of availability and performance vs. safety: common-case operations are designed to be asynchronous; synchronisation is used only when strictly necessary to satisfy the application's integrity invariants. Furthermore, we deconstruct classical consistency models into orthogonal primitives that the developer can compose efficiently, and provide a number of tools for quick, efficient and correct cloud-scale deployment and execution. Using this methodology, we will develop an entreprise-grade, highly-scalable file system, exploring the rainbow of possible semantics, and we demonstrate it in a massive experiment.

The coordinator of RainbowFS is Marc Shapiro.

7.1.2. LABEX

7.1.2.1. SMART - (2012–2019)

Members: ISIR (Sorbonne Univ./CNRS), LIP6 (Sorbonne Univ./CNRS), LIB (Sorbonne Univ./INSERM), LJLL (Sorbonne Univ./CNRS), LTCI (Institut Mines-Télécom/CNRS), CHArt-LUTIN (Univ. Paris 8/EPHE), L2E (Sorbonne Univ.), STMS (IRCAM/CNRS).

Funding: Sorbonne Universités, ANR.

Description: The SMART Labex project aims globally to enhancing the quality of life in our digital societies by building the foundational bases for facilitating the inclusion of intelligent artifacts in our daily life for service and assistance. The project addresses underlying scientific questions raised by the development of Human-centered digital systems and artifacts in a comprehensive way. The research program is organized along five axes and DELYS is responsible of the axe "Autonomic Distributed Environments for Mobility."

The project involves a PhD grant of 100 000 euros over 3 years.

7.2. European Initiatives

7.2.1. FP7 & H2020 Projects

7.2.1.1. LightKone

Title: Lightweight Computation for Networks at the Edge

Programm: H2020-ICT-2016-2017

Duration: January 2017 - December 2019

Coordinator: Université Catholique de Louvain

Partners:

Université Catholique de Louvain (Belgium)

Technische Universitaet Kaiserslautern (Germany)

INESC TEC - Instituto de Engenharia de Sistemas e Computadores, Tecnologia e Ciencia (Portugal)

Faculdade de Ciencias E Tecnologiada Universidade Nova de Lisboa (Portugal)

Universitat Politecnica De Catalunya (Spain)

Scality (France)

Gluk Advice B.V. (Netherlands)

Inria contact: Marc Shapiro

The goal of LightKone is to develop a scientifically sound and industrially validated model for doing general-purpose computation on edge networks. An edge network consists of a large set of heterogeneous, loosely coupled computing nodes situated at the logical extreme of a network. Common examples are networks of Internet of Things, mobile devices, personal computers, and points of presence including Mobile Edge Computing. Internet applications are increasingly running on edge networks, to reduce latency, increase scalability, resilience, and security, and permit local decision making. However, today's state of the art, the gossip and peer-to-peer models, give no solution for defining general-purpose computations on edge networks, i.e., computation with shared mutable state. LightKone will solve this problem by combining two recent advances in distributed computing, namely synchronisation-free programming and hybrid gossip algorithms, both of which are successfully used separately in industry. Together, they are a natural combination for edge computing. We will cover edge networks both with and without data center nodes, and applications focused on collaboration, computation, and both. Project results will be new programming models and algorithms that advance scientific understanding, implemented in new industrial applications and a startup company, and evaluated in large-scale realistic settings.

7.3. International Initiatives

7.3.1. Participation in Other International Programs

7.3.1.1. STIC Amsud

Title: PaDMetBio - Parallel and Distributed Metaheuristics for Structural Bioinformatics

International Partners (Institution - Laboratory - Researcher):

Universidade Federal do Rio Grande do Sul (Brazil)- Mãrcio Dorn

Universidad Nacional de San Luis (Argentina) - Verõnica Gil-Costa

Universidad de Santiago de Chile (Chile) - Mario Inostroza-Ponta

Duration: 2017 - 2018

Start year: 2017

Structural bioinformatics deals with problems where the rules that govern the biochemical processes and relations are partially known which makes hard to design efficient computational strategies for these problems. There is a wide range of unanswered questions, which cannot be answered neither by experiments nor by classical modeling and simulation approaches. Specifically, there are several problems that still do not have a computational method that can guarantee a minimum quality of solution. Two of the main challenging problems in Structural Bioinformatics are (1) the three-dimensional (3D) protein structure prediction problem (PSP) and (2) the molecular docking problem for drug design. Predicting the folded structure of a protein only from its amino acid sequence is a challenging problem in mathematical optimization. The challenge arises due to the combinatorial explosion of plausible shapes, where a long amino acid chain ends up in one out of a vast number of 3D conformations. The problem becomes harder when we have proteins with complex topologies, in this case, their predictions may be only possible with significant increases in high-performance computing power. In the case of the molecular docking problem for drug design, we need to predict the preferred orientation of a small drug candidate against a protein molecule. With the increasing availability of molecular biological structures, smarter docking approaches have become necessary. These two problems are classified as NP-Complete or NP-Hard, so there is no current computational approach that can guarantee the best solution for them in a polynomial time. Because of the above, there is the need to build smarter approaches that can deliver good solutions to the problem. In this project, we plan to explore a collaborative work for the design and implementation of population based metaheuristics, like genetic and memetic algorithms. Metaheuristics are one of the most common and powerful techniques used in this case. The main goal of this project is to gather the expertise and current work of researchers in the areas of structural bioinformatics, metaheuristics and parallel and distributed computing, in order to build novel and high quality solutions for these hot research area.

7.3.1.2. Capes-Cofecub

Title: CHOOSING - Cooperation on Hybrid cOmputing clOuds for energy SavING

French Partners: Paris XI (LRI), Regal, LIG, SUPELEC

International Partners (Institution - Laboratory - Researcher):

Universidade de São Paulo - Instituto de Matemática e Estatística - Brazil, Unicamp - Instituto de Computação - Brazil

Duration: 2014–2018

The cloud computing is an important factor for environmentally sustainable development. If, in the one hand, the increasing demand of users drive the creation of large datacenters, in the other hand, cloud computing's "multitenancy" trait allows the reduction of physical hardware and, therefore, the saving of energy. Thus, it is imperative to optimize the energy consumption corresponding to the datacenter's activities. Three elements are crucial on energy consumption of a cloud platform: computation (processing), storage and network infrastructure. Therefore, the aim of this project is to provide different techniques to reduce energy consumption regarding these three elements. Our work mainly focuses on energy saving aspects based on virtualization, i.e., pursuing the idea of the intensive migration of classical storage/processing systems to virtual ones. We will study how different organizations (whose resources are combined as hybrid clouds) can cooperate with each other in order to minimize the energy consumption without the detriment of client requirements or quality of service. Then, we intend to propose efficient algorithmic solutions and design new coordination mechanisms that incentive cloud providers to collaborate.

7.3.1.3. Spanish research ministry project

Title: BFT-DYNASTIE - Byzantine Fault Tolerance: Dynamic Adaptive Services for Partitionable Systems

French Partners: Labri, Irisa, LIP6

International Partners (Institution - Laboratory - Researcher):

University of the Basque Country UPV - Spain, EPFL - LSD - Switzerland, Friedrich-Alexander-Universitat Erlangen-Nurenberg - Deutschland, University of Sydney - Australia

Duration: 2017–2019

The project BFT-DYNASTIE is aimed at extending the model based on the alternation of periods of stable and unstable behavior to all aspects of fault-tolerant distributed systems, including synchrony models, process and communication channel failure models, system membership, node mobility, and network partitioning. The two main and new challenges of this project are: the consideration of the most general and complex to address failure model, known as Byzantine, arbitrary or malicious, which requires qualified majorities and the use of techniques form the security area; and the operation of the system in partitioned mode, which requires adequate reconciliation mechanisms when two partitions merge.

DIANA Project-Team

8. Partnerships and Cooperations

8.1. Inria internal funding

8.1.1. ADT ACQUA

Participants: Chadi Barakat.

In the context of the Inria ADT call, we have a funding for a two year engineering position on the ACQUA project for the 2015-2017 period. Thierry Spetebroot is hired on this position. In 2017, this ADT got extended by six months beyond the two years period to therefore end on March 2018.

8.1.2. IPL BetterNet

Participants: Chadi Barakat.

The DIANA team is part of the Inria Project Lab BetterNet (http://project.inria.fr/betternet/). Within this lab, Inria has funded two PhD students in 2017 co-supervised by Chadi Barakat from the DIANA project-team. The first PhD student is Thibaut Ehlinger hosted within the DIANA team and co-supervised by Vassilis Christophides from the MiMove team in Paris. The second PhD student is Imane Taibi hosted by the Dionysos team in Rennes and co-supervied by Gerardo Rubino and Yassine Hadjadj-Aoul. Both PhDs started on the 1st of November 2017. Further in 2018, Inria funded a PostDoc position to supervise the experiments planned within the IPL and develop the data analysis part. This PostDoc position is occupied by Giulio Grassi who is co-supervised by Chadi Barakat from the DIANA project-team and Renata Teixeira from the MiMove project-team. Giulio Grassi started on October 1st, 2018 and is currently located in Paris.

8.2. Regional Initiatives

8.2.1. ElectroSmart

Participants: Arnaud Legout, Mondi Ravi, David Migliacci, Abdelhakim Akodadi, Yanis Boussad.

The ElectroSmart project benefits form the following fundings:

- a 39 months engineering position from the UCN@Sophia Labex for the 2016-2019 period (Ravi Mondi is hired on this position)
- 30KEuros from Academy 1 of UCAJedi
- a two years engineering position from an Inria ADT for 2017/2019 (Abdelhakim Akodadi)
- a 18 months business developer from Inria ATT for june 2017-june 2019 (David Migliacci)
- a 3 years 2017/2020 Ph.D. thesis from Academy 1 of UCAJedi (Yanis Boussad)

8.2.2. D2D Indoor

Participants: Chadi Barakat, Zeineb Guizani.

This project is joint with the NFCOM startup in Nice, specialized in the development of new services for mobile phones. The project aims at leveraging mobile to mobile communications for offloading the cellular infrastructure, and will target a solution based on algorithms previously developed in the DIANA project-team (BitHoc and HBSD). The project got a funding for one year engineer from the Labex. Zeineb Guizani has been working on this project since July 2018.

8.3. National Initiatives

8.3.1. ANR

- **ANR JCJC DET4ALL** (2019-2021): Modern factories and industrial system massively rely on cyber physical systems with digital communications (e.g., to allow collaborative robots, for data analytics...). However, industrial networks are still mostly managed and conceived as collections of independent communicating units instead of one unified piece of software.

  The reason why the shift of paradigm did not occur yet to industrial digital communication networks is because industrial processes generally impose strong determinism and real-time constraints. As a result, industrial networks have a propensity of being physically segregated to contain potential malfunctions and simplify conception.

  With the DET4ALL project, we will apply the concept of network programmability to the world of industrial communicating systems. To that aim, we will construct and prove the essential building blocks that will allow to virtualise industrial networks:

  – algorithms to automatically provision the various components constituting industrial networks;

  – Domain Specific Languages (DSLs) to specify real-time communication schemes;

  – mechanisms to update on-the-fly the production infrastructures without service degradation.

  The impact of the DET4ALL project goes beyond technological advances; it will also bring a new vision on what production tools can become, namely agile systems in perpetual evolution.
- **ANR FIT** (2011-2019): FIT (Future Internet of Things) aims at developing an experimental facility, a federated and competitive infrastructure with international visibility and a broad panel of customers. It will provide this facility with a set of complementary components that enable experimentation on innovative services for academic and industrial users. The project will give French Internet stakeholders a means to experiment on mobile wireless communications at the network and application layers thereby accelerating the design of advanced networking technologies for the Future Internet. FIT is one of 52 winning projects from the first wave of the French Ministry of Higher Education and Research's Equipements of Excellence (Equipex) research grant programme. The project will benefit from a 5.8 million euro grant from the French government. Other partners are UPMC, IT, Strasbourg University and CNRS. The project was extended for one year and will end in december 2019. See also http://fit-equipex.fr/.
- **ANR BottleNet** (2016-2019): BottleNet aims to deliver methods, algorithms, and software systems to measure Internet Quality of Experience (QoE) and diagnose the root cause of poor Internet QoE. This goal calls for tools that run directly at users' devices. The plan is to collect network and application performance metrics directly at users' devices and correlate it with user perception to model Internet QoE, and to correlate measurements across users and devices to diagnose poor Internet QoE. This data-driven approach is essential to address the challenging problem of modeling user perception and of diagnosing sources of bottlenecks in complex Internet services. ANR BottleNet will lead to new solutions to assist users, network and service operators as well as regulators in understanding Internet QoE and the sources of performance bottleneck.

8.4. European Initiatives

8.4.1. FP7 & H2020 Projects

- Program: FP7 FIRE programme
- Project acronym: Fed4Fire+
- Project title: Federation for FIRE Plus

- Duration: January 2017 - December 2021
- Coordinator: iMinds (Belgium)
- Other partners: 20 european partners including IMEC (Belgium), UPMC (Fr), Fraunhofer (Germany), TUB (Germany), etc.
- Web site: http://www.fed4fire.eu/
- Abstract: The Fed4FIRE+ project has the objective to run and further improve Fed4FIRE as best-in-town federation of experimentation facilities for the Future Internet Research and Experimentation initiative. Federating a heterogeneous set of facilities covering technologies ranging from wireless, wired, cloud services and open flow, and making them accessible through common frameworks and tools suddenly opens new possibilities, supporting a broad range of experimenter communities covering a wide variety of Internet infrastructures, services and applications. Fed4FIRE+ will continuously upgrade and improve the facilities and include technical innovations, focused towards increased user satisfaction (user-friendly tools, privacy-oriented data management, testbed SLA and reputation, experiment reproducibility, service-level experiment orchestration, federation ontologies, etc.). It will open this federation to the whole FIRE community and beyond, for experimentation by industry and research organisations, through the organization of Open Calls and Open Access mechanisms. The project will also establish a flexible, demand-driven framework which allows test facilities to join during the course of its lifetime by defining a set of entry requirements for new facilities to join and to comply with the federation. FIRE Experimental Facilities generate an ever increasing amount of research data that provides the foundation for new knowledge and insight into the behaviour of FI systems. Fed4FIRE+ will participate in the Pilot on Open Research Data in Horizon 2020 to offer open access to its scientific results, to the relevant scientific data and to data generated throughout the project's lifetime. Fed4FIRE+ will finally build on the existing community of experimenters, testbeds and tool developers and bring them together regularly (two times a year) in engineering conferences to have maximal interaction between the different stakeholders involved.

8.5. International Initiatives

8.5.1. Inria Associate Teams Involved in an Inria International Lab

8.5.1.1. DrIVE

Title: DrIVE: Distributed Intelligent Vehicular Environment - Enabling ITS through programmable networks

Inria International Lab: **Inria@SiliconValley**

International Partner (Institution - Laboratory - Researcher):

Ericsson Research, Indaiatuba-SP, BRAZIL (Brazil) Mateus Augusto Silva Santos

Start year: 2018

See also: https://team.inria.fr/diana/drive-associated-team/

Abstract: Transportation systems are part of our society's critical infrastructure and are expected to experience transformative changes as the Internet revolution unfolds. The automotive industry is a notable example: it has been undergoing disruptive transformations as vehicles transition from traditional unassisted driving to fully automated driving, and eventually to the self-driving model. Communication technology advancements such as support for vehicle-to-infrastructure (V2I) and vehicle-to-vehicle (V2V) communication have been one of the key enablers of next generation transportation services, also known as Intelligent Transport Systems (ITS). However, ITS services and applications pose significant challenges to the underlying communication and network infrastructure due to their stringent low latency, reliability, scalability, and geographic decentralization requirements. The DrIVE associated team proposal aims at addressing such challenges by: (1) developing a programmable network control plane that will dynamically adjust to current environment conditions and network characteristics to support ITS' scalability, quality of service (QoS), and decentralization requirements, and (2) applying the proposed distributed network control plane framework to ITS applications, such as road hazard warning, autonomous- and self-driving vehicles, and passenger-centric services (e.g., infotainment and video streaming).

8.5.2. Inria Associate Teams Not Involved in an Inria International Labs

8.5.2.1. UHD-on-5G

Title: Ultra High Definition video streaming on future 5G networks

International Partner (Institution - Laboratory - Researcher):

National Institute of Information and Communications Technology (NICT) (Japan) - Hitoshi Asaeda

Start year: 2016

See also: https://team.inria.fr/diana/uhd-on-5g/

The aim of this collaboration is to design and develop efficient mechanisms for streaming UHD video on 5G networks and to evaluate them in a realistic and reproducible way by using novel experimental testbeds.

Our approach leverages and extends when necessary ICN and SDN technologies to allow very high quality video streaming at large scale. We also plan to use Virtual Network Functions (VNF) in order to place easily and dynamically different functions (e.g. transcoding, caching) at strategic locations within the network. Specifically, the placement of these functions will be decided by SDN controllers to optimize the quality of experience (QoE) of users. Moreover, we plan to integrate ICN functionalities (e.g., name-based forwarding and multipath transport using in-network caching) with SDN/NFV to provide better QoE and mobility services support to users than traditional IP architectures. Monitoring mechanisms such as the Contrace tool we developed in the SIMULBED associated team will be helpful to provide an accurate view of the network at the SDN controllers side. In addition, we will build a large-scale testbed to evaluate our solutions through reproducible experimentations based on two testbeds: the ICN wired CUTEi tesbed developed by NICT and the wireless R2lab testbed developed by Inria.

8.6. International Research Visitors

8.6.1. Visits of International Scientists

Katia Obraczka is Professor of Computer Engineering and Graduate Director at Department of Computer Engineering, UC Santa Cruz where she leads the Internetworking Research Group (i-NRG). She has visited us for four weeks in July 2018. The Labex UCN@Sophia has supported two one-month visits at the DIANA project-team, in July 2017 and during summer 2018 to work in particular on the decentralization of the SDN control plane applied to Intelligent Transport Systems (ITS). These two visits were very fruitful as they resulted in common publications [18], [17] and contributed to the start of the DrIVE Associated team.

8.6.2. Internships

Yevhenii Semenko and Alberto Zirondelli

Date: from from Apr 2018 until Sep 2018

Institution: Ubinet Master intern, University of Nice Sophia Antipolis

Supervisor: Damien Saucez

Subject: Privacy preserving taxi service with blockain

Laila Daanoun

Date: from Apr 2018 until Aug 2018

Institution: Ubinet Master intern, University of Nice Sophia Antipolis

Supervisor: Damien Saucez

Subject: The Network of the Future in Industry 4.0: Solving the Reachability problem

Gayatri Sivadoss

Date: from Apr 2018 until Aug 2018

Institution: Ubinet Master intern, University of Nice Sophia Antipolis

Supervisor: Mohamed Naoufal Mahfoudi, Thierry Turletti and Walid Dabbous

Subject: LoRa: Characterization and Range Extension in campus environment

Ohtmane Bensouda Korachi

Date: from Apr 2018 until Aug 2018

Institution: Ubinet Master intern, University of Nice Sophia Antipolis

Supervisor: Mohamed Naoufal Mahfoudi, Thierry Turletti and Walid Dabbous

Subject: Geolocation for LoRa Low Power Wide Area Network

Othmane Belmoukadam

Date: from Mar 2018 until Aug 2018

Institution: Ubinet Master intern, University of Nice Sophia Antipolis

Supervisor: Chadi Barakat

Subject: ACQUA - A data-driven approach for network and Quality of Experience monitoring

Yonathan Bleyfuesz

Date: from Feb 2018 to Aug 2018

Institution: International Master programme M1, University of Nice Sophia Antipolis

Supervisor: Thierry Parmentelat

Subject: Using `nepi-ng` to evaluate MANET routing protocols.

Indukala Naladala

Date: from May 2018 until Jul 2018

Institution: National Institute of Technology Karnataka, Surathkal, India

Supervisor: Thierry Turletti and Walid Dabbous

Subject: Integration of R2LAB with ns-3

Janati Idrissi

Date: from Mar 2018 until Aug 2018

Institution: Ubinet Master intern, University of Nice Sophia Antipolis

Supervisor: Arnaud Legout

Subject: Étude de la précision de la localisation dans ElectroSmart sous Android.

8.6.3. Visits to International Teams

Thierry Turletti visited NICT in Tokyo Japan in the context of the UHD-on-5G associated team in october 2018.

Thierry Turletti also visited UNICAMP in Campinas Bresil in the context of the UHD-on-5G associated team in october 2018.

DIONYSOS Project-Team

9. Partnerships and Cooperations

9.1. Regional Initiatives

- Yann Busnel is a member of the ONCOSHARe project (ONCOlogy bigdata SHARing for Research) funded by Brittany and Pays de la Loire regions, with 280.000 k€ for 24 months.
- Bruno Sericola continues to work on the analysis of fluid queues with Fabrice Guillemin from Orange Labs in Lannion, France.

9.2. National Initiatives

ANR

- Yassine Hadjadj-Aoul is participating at 20% of his time to the IRT BCOM granted by the ANR.
- Sofiène Jelassi is participating at 20% of his time to the IRT BCOM granted by the ANR.
- Yann Busnel is a member of the three following projects: SocioPlug granted by the ANR (ANR-13-INFR-0003), INSHARE granted by the ANR (ANR-15-CE19-0024) and BigClin granted by the LabEx CominLabs (ANR-10-LABX-07-01).

IPL (Inria Project Lab) BetterNet

Yassine Hadjadj-Aoul, Gerardo Rubino and Bruno Tuffin are members of the IPL (Inria Project Lab) BetterNet: An Observatory to Measure and Improve Internet Service Access from User Experience, 2016-2020.

BetterNet aims at building and delivering a scientific and technical collaborative observatory to measure and improve the Internet service access as perceived by users. In this Inria Project Lab, we will propose new original user-centered measurement methods, which will associate social sciences to better understand Internet usage and the quality of services and networks. Our observatory can be defined as a vantage point, where: 1) tools, models and algorithms/heuristics will be provided to collect data, 2) acquired data will be analyzed, and shared appropriately with scientists, stakeholders and civil society, and 3) new value-added services will be proposed to end-users.

9.3. European Initiatives

- Bruno Sericola continues to work on the analysis of fluid queues with Marie-Ange Remiche from the university of Namur in Belgium.

9.3.1. FP7 & H2020 Projects

9.3.1.1. FINTEROP

Program: H2020-ICT-12-2015

Project acronym: F-Interop

Project title: FIRE+ online interoperability and performance test tools to support emerging technologies from research to standardization and market launch

Duration: November 2015 – October 2018

Coordinator: UPMC-LIP6

Other partners: 9 partners including F. Sismondi and C. Viho (Dionysos), and T. Watteyne (Eva)

Abstract: The goal of F-Interop is to extend FIRE+ with online interoperability and performance test tools supporting emerging IoT-related technologies from research to standardization and to market launch for the benefit of researchers, product development by SME, and standardization processes.

9.4. International Initiatives

9.4.1. Inria International Partners

9.4.1.1. Informal International Partners

We maintain a strong line of collaborations with the Technical University Federico Santa María (UTFSM), Valparaíso, Chile. Over the years, this has taken different forms (associated team Manap, Stic AmSud project "AMMA", Stic AmSud project "DAT"). In 2018, we finished a joint PhD work (co-tutelle PhD of Nicolás Jara), and a new joint PhD will start in 2019 (PhD of Jonathan Olavarría). The first one was on optical network analysis and design; the second one's topic is on modeling evaluation techniques, with focus on Stochastic Activity Networks.

9.4.2. Participation in Other International Programs

ECOS-Sud project MASC: Mathematical Algorithms for Semantic Cognition. MASC is a three-year project (code U17E03) with the Faculty of Sciences of the university of the Republic, in Uruguay, on the application of mathematical modeling tools to a better understanding of a cognitive disease called semantic dementia. This involves Prof. Eduardo Mizraji and Jorge Graneri, a PhD student whose co-advisors are Prof. Mizraji and G. Rubino from Dionysos, plus Pablo Rodríguez Bocca, from the Engineering Faculty of the university of the Republic. Our contribution to this project is around the use of mathematical models of neural structures.

9.5. International Research Visitors

- Pierre L'Ecuyer holds an Inria International Chair, Nov. 2013- Oct. 2018.
- Three colleagues from the University of the Republic, Uruguay, visited us in 2018. First, Jorge Graneri, in the context of the starting ECOS project MASC (July–August), then Professor Gustavo Guerberoff to work on mathematical problems related to reliability network models (October–November), and then Professor Pablo Rodríguez Bocca, to work also on the previously entioned ECOS project.

9.5.1. Visits to International Teams

9.5.1.1. Research Stays Abroad

- Yassine Hadjadj-Aoul was able to benefit from a one-month scientific stay at the Metropolitan University of Manchester (MMU), in June 2018. This stay was part of the "Research and knowledge Exchange Funding" program run by the MMU.

DIVERSE Project-Team

8. Partnerships and Cooperations

8.1. Regional Initiatives

8.1.1. PEC – Pôle d'Excellence Cyber

- Coordinator: Université de Rennes 1
- Dates: 2016-2019
- Abstract: Formal and Executable Specification of domain-specific language families

8.2. National Initiatives

8.2.1. ANR

8.2.1.1. SOPRANO

- Coordinator: CEA
- CEA, University of Paris-Sud, Inria Rennes, OcamlPro, Adacore
- Dates: 2014-2018
- Abstract: Today most major verification approaches rely on automatic external solvers. However these solvers do not fill the current and future needs for verification: lack of satisfying model generation, lack of reasoning on difficult theories (e.g. floating-point arithmetic), lack of extensibility for specific or new needs. The SOPRANO project aims at solving these problems and prepare the next generation of verification-oriented solvers by gathering experts from academia and industry. We will design a new framework for the cooperation of solvers, focused on model generation and borrowing principles from SMT (current standard) and CP (well-known in optimisation). These ideas will be implemented in an open-source platform, with regular evaluations from the industrial partners.

8.2.1.2. VaryVary ANR JCJC

- Coordinator: Mathieu Acher
- DiverSE, Inria/IRISA Rennes
- Dates: 2017-2021
- Abstract: Most modern software systems (operating systems like Linux, Web browsers like Firefox or Chrome, video encoders like x264 or ffmpeg, servers, mobile applications, etc.) are subject to variation or come in many variants. Hundreds of configuration options, features, or plugins can be combined, each potentially with distinct functionality and effects on execution time, memory footprint, etc. Among configurations, some of them are chosen and do not compile, crash at runtime, do not pass a test suite, or do not reach a certain performance quality (e.g., energy consumption, security). In this JCJC ANR project, we follow a thought-provocative and unexplored direction: We consider that the variability boundary of a software system can be specialized and should vary when needs be. The goal of this project is to provide theories, methods and techniques to make vary variability. Specifically, we consider machine learning and software engineering techniques for narrowing the space of possible configurations to a good approximation of those satisfying the needs of users. Based on an oracle (e.g., a runtime test) that tells us whether a given configuration meets the requirements (e.g. speed or memory footprint), we leverage machine learning to retrofit the acquired constraints into a variability that can be used to automatically specialize the configurable system. Based on a relative small number of configuration samples, we expect to reach high accuracy for many different kinds of oracles and subject systems. Our preliminary experiments suggest that

varying variability can be practically useful and effective. However, much more work is needed to investigate sampling, testing, and learning techniques within a variety of cases and application scenarios. We plan to further collect large experimental data and apply our techniques on popular, open-source, configurable software (like Linux, Firefox, ffmpeg, VLC, Apache or JHipster) and generators for media content (like videos, models for 3D printing, or technical papers written in LaTeX).

8.2.2. Competitivity Clusters

8.2.2.1. Occiware

- Coordinator: Open Wide
- Open Wide, ActiveEon SA, CSRT - Cloud Systèmes Réseaux et Télécoms, Institut Mines-Télécom/Télécom SudParis, Inria, Linagora, Obeo, OW2 Consortium, Pôle Numérique, Université Joseph Fourier,
- Dates: 2014-2018
- Abstract: The Occiware project aims to establish a formal and equipped framework for the management of all cloud resource based on the OCCI standard.

8.2.3. Cominlabs

8.2.3.1. PROFILE

- Coordinator: Université de Rennes 1
- Partners: Inria, Université de Rennes 2
- Dates: 2016-2019
- Abstract: The PROFILE project brings together experts from law, computer science and sociology to address the challenges raised by online profiling, following a multidisciplinary approach. More precisely, the project will pursue two complementary and mutually informed lines of research: (i) Investigate, design, and introduce a new right of opposition into the legal framework of data protection to better regulate profiling and to modify the behavior of commercial companies towards being more respectful of the privacy of their users; (ii) Provide users with the technical means they need to detect stealthy profiling techniques as well as to control the extent of the digital traces they routinely produce. As a case study, we focus on browser fingerprinting, a new profiling technique for targeted advertisement. The project will develop a generic framework to reason on the data collected by profiling algorithms, to uncover their inner workings, and make them more accountable to users. PROFILE will also propose an innovative protection to mitigate browser fingerprinting, based on the collaborative reconfiguration of browsers.

8.3. European Initiatives

8.3.1. FP7 & H2020 Projects

8.3.1.1. H2020 ICT-10-2016 STAMP

- Coordinator: Inria Rennes
- Other partners: ATOS, ActiveEon, OW2, TellU, Engineering, XWiki, TU Delft, SINTEF
- Dates: 2016-2019
- Abstract: Leveraging advanced research in automatic test generation, STAMP aims at pushing automation in DevOps one step further through innovative methods of test amplification. It will reuse existing assets (test cases, API descriptions, dependency models), in order to generate more test cases and test configurations each time the application is updated. Acting at all steps of development cycle, STAMP techniques aim at reducing the number and cost of regression bugs at unit level, configuration level and production stage.

STAMP will raise confidence and foster adoption of DevOps by the European IT industry. The project gathers three academic partners with strong software testing expertise, five software companies (in: e-Health, Content Management, Smart Cities and Public Administration), and an open source consortium. This industry-near research addresses concrete, business-oriented objectives. All solutions are open source and developed as microservices to facilitate exploitation, with a target at TRL 6.

8.3.2. Collaborations in European Programs, Except FP7 & H2020

- Coordinator: UR1
- Other partners: Airbreizh - Surveillance of Brittany air quality association, branch of the French national air surveillance network, AmpliSIM - SME specialized in pollution numerical simulation, CNRS / IDRIS - Institute for Development and Resources in Intensive Scientific Computing, GENCI - Supercomputing centres association, Keolis - Public transport operator for Rennes Metropole, Neovia – SME specialized in HPC and project management, Rennes Métropole – Local authority in charge of the Service Public Métropolitain de la Donnée (SPMD), Ryax Technologies – SME providing Data Analytics workflows' automation and seamless orchestration on hybrid distributed infrastructures UCit – SME providing HPC as a Service
- Dates: 2018-2020
- Abstract: The AQMO project is co-financed by the European Union through its CEF programme. It addresses the air quality challenge, thanks to the development of a smart city pilot in the area of Rennes Metropole. The project will provide an end-to-end urban platform that extends current practices in air quality measurements. The AQMO platform will provide citizens, local authorities, scientific organizations and private companies with new data and innovative services based on computing simulation.
- Program: EIT Digital
- Project acronym: UAV-Retina
- Project title: Unmanned Aerial Vehicles - Retina
- Duration: from 2018-10 to 2019-12
- Coordinator: UR1
- Other partners: Bright Cape (company from the Netherlands), FBK (Trento University, Italy), JCP Connect (company from France), Tellus Environment (company from France), Fire Department of Ille et Vilaine (France), Fire Department of Trento (Italy)
- Abstract: The UAV-Retina objectives aims at the creation of s startup company for a flexible autonomous drone platform for search and rescue, using advanced unmanned vehicles and data analytics. The markets for the company will be Improved Explosive Devices detection, support for firefighting operations, and support for avalanche search and rescue operations.

8.3.3. Collaborations with Major European Organizations

- SINTEF, ICT (Norway): Model-driven systems development for the construction of distributed, heterogeneous applications. We collaborate since 2008 and are currently in two FP7 projects together.
- Université du Luxembourg, (Luxembourg): Models runtime for dynamic adaptation and multi-objective elasticity in cloud management; model-driven development.
- KTH, the Royal Institute of Technology (Sweden): continuous software testing, perturbation and diversification.

8.4. International Initiatives

8.4.1. Inria International Labs

IIL CWI-Inria

Associate Team involved in the International Lab:

8.4.1.1. ALE

- Title: Agile Language Engineering
- International Partner (Institution - Laboratory - Researcher):
  - CWI (Netherlands) Tijs van der Storm
- Start year: 2017
- See also: http://gemoc.org/ale/
- Software engineering faces new challenges with the advent of modern software-intensive systems such as complex critical embedded systems, cyber-physical systems and the Internet of things. Application domains range from robotics, transportation systems, defense to home automation, smart cities, and energy management, among others. Software is more and more pervasive, integrated into large and distributed systems, and dynamically adaptable in response to a complex and open environment. As a major consequence, the engineering of such systems involves multiple stakeholders, each with some form of domain-specific knowledge, and with an increasingly use of software as an integration layer.

  Hence more and more organizations are adopting Domain Specific Languages (DSLs) to allow domain experts to express solutions directly in terms of relevant domain concepts. This new trend raises new challenges about designing DSLs, evolving a set of DSLs and coordinating the use of multiple DSLs for both DSL designers and DSL users.

  ALE will contribute to the field of Software Language Engineering, aiming to provide more agility to both language designers and language users. The main objective is twofold. First, we aim to help language designers to leverage previous DSL implementation efforts by reusing and combining existing language modules. Second, we aim to provide more flexibility to language users by ensuring interoperability between different DSLs and offering live feedback about how the model or program behaves while it is being edited (aka. live programming/modeling).

8.4.2. Inria International Partners

8.4.2.1. Informal International Partners

- Université de Montréal (Canada)
- McGill University (Canada)
- University of Alabama (USA)
- TU Wien (Austria)
- Michigan State University (MSU)
- Aachen University (Germany)
- KTH (Sweden)

8.4.3. Participation in Other International Programs

The GEMOC studio has been sustained through the creation of a Research Consortium at the Eclipse Foundation.

8.4.3.1. International initiative GEMOC

The GEMOC initiative (cf. http://www.gemoc.org) is an open and international initiative launched in 2013 that coordinates research partners worldwide to develop breakthrough software language engineering (SLE) approaches for global software engineering through the use of multiple domain-specific languages. GEMOC members aim to provide effective SLE solutions to problems associated with the design and implementation of collaborative, interoperable and composable modeling languages.

The GEMOC initiative aims to provide a framework that facilitates collaborative work on the challenges of using of multiple domain-specific languages in software development projects. The framework consists of mechanisms for coordinating the work of members, and for disseminating research results and other related information on GEMOC activities. The framework also provides the required infrastructure for sharing artifacts produced by members, including publications, case studies, and tools.

The governance of the GEMOC initiative is ensured by the Advisory Board. The role of the Advisory Board is to coordinate the GEMOC work and to ensure proper dissemination of work products and information about GEMOC events (e.g., meetings, workshops).

Benoit Combemale is the co-founder and currently acts as principal coordinator of the GEMOC initiative. Benoit Combemale and Jean-Marc Jézéquel are part of the Advisory Board, and 9 DIVERSE members are part of the GEMOC initiative.

8.5. International Research Visitors

8.5.1. Visits of International Scientists

- Yves Le Traon, Professor at the University of Luxembourg, visited the team in June and July 2018.
- François Fouquet, Junior Researcher at the SnT (Lux), visited the team in March 2018.
- Jordi Cabot, Research Professor at Internet Interdisciplinary Institute, the Research center of the Open University of Catalonia (UOC), SOM Research Lab leader, visited the team in December 2018.
- Erwan Bousse, postdoctoral researcher at TU Wien, Austria, visited the team from January until Aug 2018
- Marcel Heinz, research assistant and PhD student at University of Koblenz-Landau visited the team in Jul 2018

8.5.1.1. Internships

- Enzo Menegaldo, from Jun 2018 until Sep 2018
- Yannick Namour from Apr 2018 until Aug 2018
- Koko Armando Nguepi Kenfack Until Jan 2018
- Anthony Orain from Jun 2018 until Jul 2018
- Max Aguirre, from Jun 2018 until Jul 2018
- Gwendal Didot, from May 2018 until Aug 2018
- Arnaud Gohier, from Apr 2018 until Aug 2018
- Alexis Lemasle, from May 2018 until Aug 2018
- Hugo Martin, from Feb 2018 until Aug 2018

8.5.2. Visits to International Teams

- Fabien Coulon visited CWI for 1 week in June 2018 in the context of the Associated Team ALE.
- Manuel Leduc visited CWI for 1 week in December 2018 in the context of the Associated Team ALE.
- Benoit Combemale made several short visits at CWI in the context of the Associated Team ALE, and visited TU Eindhoven in November 2018.
- Olivier Barais and Amine Benelallam made several short visits at KTH in the context of a collaboration with Prof Monperrus and Prof Baudry.

DYOGENE Project-Team

8. Partnerships and Cooperations

8.1. Regional Initiatives

8.1.1. Laboratory of Information, Networking and Communication Sciences (LINCS)

Dyogene participates in LINCS https://www.lincs.fr/, a research centre co-founded by Inria, Institut Mines-Télécom, UPMC and Alcatel-Lucent Bell Labs (currently Nokia Bell Labs) dedicated to research and innovation in the domains of future information and communication networks, systems and services. S. Meyn [Unversity of Florida] was invited professor by LINCS and ENS from July to December 2018.

8.1.2. PGMO

Dyogene participates to the PGMO (Gaspard Monge Program for Optimization, operations research, and their interactions with data science) via the project a 2 year project "Distributed control of flexible loads" funded through the ICODE/IROE call. This is a collaborative project between University Paris-Sud (PI: Gilles Stoltz) and Inria (PI: Ana Busic). Post-doc Cheng Wan was financed by this project from Feb-Nov 2018.

8.2. National Initiatives

8.2.1. GdR GeoSto

Members of Dyogene participate in Research Group GeoSto (Groupement de recherche, GdR 3477) http://gdr-geostoch.math.cnrs.fr/ on Stochastic Geometry led by and David Coupier [Université de Valenciennes].

This is a collaboration framework for all French research teams working in the domain of spatial stochastic modeling, both on theory development and in applications. This year DYOGENE has co-organized yearly conference of the GdR *Stochastic Geometry Days 2018* 14–18 mai 2018 Paris (France); https://geosto-2018.sciencesconf.org/.

8.2.2. GdR RO

Members of Dyogene participate in GdR-RO (Recherche Opérationelle; GdR CNRS 3002), http://gdrro.lip6.fr/, working group COSMOS (Stochastic optimization and control, modeling and simulation), lead by A. Busic and E. Hyon (LIP 6); http://gdrro.lip6.fr/?q=node/78

8.2.3. ANR JCJC PARI

Probabilistic Approach for Renewable Energy Integration: Virtual Storage from Flexible Loads. The project started in January 2017. PI — A. Bušić. This project is motivated by current and projected needs of a power grid with significant renewable energy integration. Renewable energy sources such as wind and solar have a high degree of unpredictability and time variation, which makes balancing demand and supply challenging. There is an increased need for ancillary services to smooth the volatility of renewable power. In the absence of large, expensive batteries, we may have to increase our inventory of responsive fossil-fuel generators, negating the environmental benefits of renewable energy. The proposed approach addresses this challenge by harnessing the inherent flexibility in demand of many types of loads. The objective of the project is to develop decentralized control for automated demand dispatch, that can be used by grid operators as ancillary service to regulate demand-supply balance at low cost. We call the resource obtained from these techniques virtual energy storage (VES). Our goal is to create the necessary ancillary services for the grid that are environmentally friendly, that have low cost and that do not impact the quality of service (QoS) for the consumers. Besides respecting the needs of the loads, the aim of the project is to design local control solutions that require minimal communications from the loads to the centralized entity. This is possible through a systems architecture that includes the following elements: i) local control at each load based on local measurements combined with a grid-level signal; ii) frequency decomposition of the regulation signal based on QoS and physical constraints for each class of loads.

8.3. International Initiatives

8.3.1. Inria International Partners

8.3.1.1. IFCAM Project "Geometric statistics of stationary point processes"

B. Błaszczyszyn and Yogeshwaran D. from Indian Statistical Institute (ISI), Bangalore, have got in 2018 the approval from Indo-French Centre for Applied Mathematics (IFCAM), for their joint project on "Geometric statistics of stationary point processes" for the period 2018–2021. B. Błaszczyszyn was visiting ISI Bangalore for two weeks in November–December 2018.

8.3.1.2. Informal International Partners

- University of Florida: collaborations with Prof Sean Meyn (ECE), Associate Prof Prabir Barooah (MAE), and the PhD students: A. Devraj (ECE), A. Coffman (MAE), N. Cammardella (ECE), J. Mathias (ECE).

8.4. International Research Visitors

8.4.1. Visits of International Scientists

- D. Yogeshwaran [Indian Statistical Institute, Bangalore, India]
- S. Meyn [University of Florida, USA] was invited Prof at ENS and LINCS, July - December 2018

8.4.1.1. Internships

- Master Probabilités et Modèles aléatoires UPMC, Walid Ghanem, *Hydrodynamic limit of a network with moving servers*, 04-07/2018, encadrant Christine Fricker.
- Master MASH (Mathématiques appliquées aux sciences humaines) ENS-Paris Dauphine University, *Using customer oriented policies based on probabilistic methods to enhance the Bike Sharing System Velib'*, 08-011/2018, encadrants Christine Fricker et Laurent Massoulié.
- Akshay Goel [Kyushu University, Fukuoka, Japan] Mars 2018,
- Tokuyama Kiichi [Tokyo Tech, Tokyo, Japan], April 2018,

8.4.2. Visits to International Teams

8.4.2.1. Research Stays Abroad

- B. Błaszczyszyn was visiting Yogeshwaran D. at the Indian Statistical Institute Bangalore for two weeks in November–December 2018 (IFCAM project).
- A. Busic was a long-term participant (March-Mai 2018) of the Real-Time Decision Making program, Simons Institute, UC Berkeley, USA; https://simons.berkeley.edu/programs/realtime2018

EASE Team

8. Partnerships and Cooperations

8.1. National Initiatives

8.1.1. Collaborations

We have a long-term collaboration with the CAOR lab at Mines ParisTech. We developed an open source IPv6 communication stack for ITS applications. We also participate together in standardisation at IETF, ETSI ITS and ISO TC204 to develop a comprehensive set of standards. A start-up named YoGoKo has been launched in June 2014 to exploit the outcomes of this collaboration.

8.2. European Initiatives

8.2.1. Collaborations in European Programs, Except FP7 & H2020

Project: SCOOP@F part 2

Partners: MEDE, Renault, PSA, IMT Atlantique

Starting: Jan 2016; Ending : Dec 2019

Coordinator: JM. Bonnin

Abstract: SCOOP@F is a Cooperative ITS pilot deployment project that intends to connect approximately 3000 vehicles with 2000 kilometers of roads. It consists of 5 specific sites with different types of roads: Ile-de-France, "East Corridor" between Paris and Strasbourg, Brittany, Bordeaux and Isère. SCOOP@F is composed of SCOOP@F Part 1 from 2014 to 2015 and SCOOP@F Part 2 from 2016 to 2019. Its main objective is to improve the safety of road transport and of road operating staff during road works or maintenance. The project includes the validations of Cooperative ITS services in open roads, cross border tests with other EU Member States (Spain, Portugal and Austria) and development of a hybrid communication solution (3G-4G/ITS G5). We are involved in the project to study the security and privacy properties of the hybrid architecture that allow to use non dedicated communication networks (WiFi, 5G) as well as the vehicular dedicated communication technologies (G5). The second phase of SCOOP will end up in 2019. As a partner of the InDiD consortium, we proposed a follow up for this project to the EC for the period 2020-2023.

Project: SCHIEF

Partners: TUM (Technical University of Munchen), IMT Atlantique, Eurecom

Starting: Sept 2016; Ending : Dec 2018

Coordinator: JM. Bonnin

Abstract: In SCHEIF, we create a pilot for an enabler platform for the industrial Internet of Things. We envision a three-layered architecture with Sensors and actuators on the lowest layer. This layer includes industrial robots. On top of this hardware layer we envision site-local processing of data. Such a processing is beneficial since it allows keeping latency boundaries on the one hand and being in full control of all data on the other hand. The latency is relevant for enabling diverse time-critical operations as they often happen in industrial production environments. The local processing is relevant for protecting data. A privacy-conform processing is required to protect company secrets and to protect the privacy of workers. The third layer comprises data processing in the cloud. We envision mostly local data processing. However, offloading computing tasks to public or private clouds will be relevant for compute-intense tasks and those tasks that require coordination between production sites. The main scenario of SCHEIF is an industrial production site where mobile robots and human workers coexist. The focus is providing the data required to manage and optimize the production process always at the most suitable quality. The suitability of data relies on the requirements of the data producers and consumers. A planned demo scenario is a provoked system crash that leads to reprioritization of data streams to mitigate from the failure.

8.3. International Initiatives

8.3.1. Informal International Partners

Two years ago we initiate a collaboration with Valerie Gay and Christopher Lawrence (UTS / Australia) on adapting smart spaces for eHealth applications. We continue the collaboration and Jean-Marie Bonnin visited UTS last August. As a result a first position paper has been published in OZCHI 2017, the 29th Australian Conference on Human-Computer Interaction held in Brisbane 28th November -1st December, and a second paper this year at ICOST 2018 (July 2018, Singapore) [4]. Christopher Lawrence visited us in April 2018 and gave an invited talk. Jean-Marie Bonnin visited UTS last August and participated in the deployment of the MyMob Mobile App in several indigenous communities.

8.4. International Research Visitors

8.4.1. Visits of International Scientists

- Christopher Lawrence, Associate Professor, University of Technology Sydney, visited the team in April 2018
- Marc-Oliver Pahl, Research Associate, Technischen Universitat Munchen (TUM), visited the team in July 2018

EVA Project-Team

9. Partnerships and Cooperations

9.1. National Initiatives

9.1.1. ANR

- The GeoBot FUI project (https://geobot.fr/) is one of the most innovative, challenging and fun projects around wireless localization in the world today. It applies true innovation to a real-world problem, with a clear target application (and customer) in mind. The GeoBot partners are building a small robot (think of a matchbox-sized RC car) that will be inserted into a gas pipe, and move around it to map the location of the different underground pipes. Such mapping is necessary to prevent gas-related accidents, for example during construction. At the end of the project, this solution will be commercialized and used to map the network of gas pipe in France, before being used in worldwide. Each partner is in charge of a different aspect of the problem: robotics, analysis of the inertial data, visualization, etc. Inria is in charge of the wireless part. We will be equipping the robot with a wireless chip(set) in order to (1) communicate with the robot as it moves about in the pipes while standing on the surface, and (2) discover the relative location of the robot w.r.t. a person on the surface. Inria is evaluating different wireless technologies, benchmarking around ranging accuracy and capabilities to communicate. We start from off-the-shelf kits from different vendors and build a custom board, benchmark it, and integrate it with the other partners of the project.

9.1.2. Other collaborations

- EVA has a collaboration with Orange Labs. **Thomas Watteyne** supervises the PhD of Mina Rady, which happens under a CIFRE agreement with Orange Labs.
- EVA has a collaboration with Vedecom. **Paul Muhlethaler** supervises Fouzi Boukhalfa's PhD funded by Vedecom. This PhD aims at studying low latency and high reliability vehicle-to-vehicle communication to improve roads safety.
- EVA has an ongoing collaboration with SODEAL company, which exploits the Cap d'Agde marina, as part of the SmartMarina project.

9.2. European Initiatives

9.2.1. FP7 & H2020 Projects

The H2020 following projects are ongoing:

- H2020 SPARTA, Jan 2019 – December 2020.
- H2020 F-Interop, http://f-interop.eu/, Nov 2015 – Oct 2018.
- H2020 ARMOUR, https://www.armour-project.eu/, Feb 2016 – Jan 2018.

9.2.2. Collaborations with Major European Organizations

Inria-EVA has collaboration in 2018 with ETSI (the European Telecommunications Standards Institute) to organize the F-Interop 6TiSCH 2 Interop Event on 2-4 February 2018 in Paris.

9.3. International Initiatives

9.3.1. Inria Associate Teams Not Involved in an Inria International Labs

9.3.1.1. REALMS

- Title: Real-Time Real-World Monitoring Systems
- International Partner (Institution - Laboratory - Researcher):
  - University of California Berkeley (United States) - Civil and Environmental Engineering - Steven Glaser
  - University of Michigan (United States) - Civil and Environmental Engineering - Branko Kerkez
- Start year: 2015
- See also: http://glaser.berkeley.edu et http://www-personal.umich.edu/~bkerkez/
- The Internet of Things revolution prompted the development of new products and standards; The IEEE 802.15.4e (2012) standard introduced the Time Synchronized Channel Hoping (TSCH) which can provide end-to-end reliability of 99.999 % and an energy autonomy of many years. This exceptional performance prompted the IETF to create the 6TISCH working group to standardize the integration of TSCH networks in the Internet. While the first experimental data have highlighted the great robustness of these networks, there is no data of a real network, accessible in real time, on a large scale and over a long period. Such data is needed to better model network performance and produce better products and standards. Teams of Professors Glaser and Kerkez are successfully deploying such networks to study mountain hydrology, monitor water quality and manage rainwater in urban environments. A model is missing to assist in the deployment and operation of these networks, as well as to monitor an operational network.

9.3.1.2. DIVERSITY

- Title: Measuring and Exploiting Diversity in Low-Power Wireless Networks
- International Partner (Institution - Laboratory - Researcher):
  - University of Southern California (United States) - Autonomous Networks Research Group (ANRG) - Bhaskar Krishnamachari
- Start year: 2016
- The goal of the DIVERSITY associate team is to develop the networking technology for tomorrow's Smart Factory. The two teams comes with a perfectly complementary background on standardization and experimentation (Inria-EVA) and scheduling techniques (USC-ANRG). The key topic addressed by the joint team will be networking solutions for the Industrial Internet of Things (IIoT), with a particular focus on reliability and determinism.

9.3.2. Inria International Partners

9.3.2.1. Declared Inria International Partners

Inria-EVA has a long-standing Memorandum of Understanding with the OpenMote company (http://www.openmote.com/), which runs until 2020. OpenMote emerged as a spin-off of the OpenWSN project, co-lead by **Thomas Watteyne** and Prof. Xavier Vilajosana, Professor at the Open University of Catalonia and Chief Technical Officer at OpenMote.

The collaboration has been ongoing since 2012 and at the time of writing has resulted in:

- Joint academic publications, including 7 journal articles, 1 letter, 1 book chapter, 5 conference papers, 2 tutorials and invited talks.
- Joint standardization activities, in particular in the IETF 6TiSCH working group, co-chaired by **Thomas Watteyne** and for which Prof. Xavier Vilajosana is a key contributor. This activity has resulted in the joint participation in 12 IETF face-to-face meetings, joint participation in over 100 audioconferences, co-authorship of 3 Internet-Drafts and joint organization of 2 interop events.
- Joint software development, as both institutions closely collaborate in the maintenance, development, promotion and research along the OpenWSN project, including the development of the protocol stack, the integration of novel hardware technologies, the support to the community and the participation in standardization activities and interoperability events.

This MOU is NOT a commitment of funds by any part.

9.3.2.2. Informal International Partners

The Inria-EVA collaborates extensively with Prof. Pister's group at UC Berkeley on the OpenWSN and Smart Dust projects. This activity translated into several members of the Pister team visiting Inria-EVA and vice-versa in 2018.

9.3.2.3. International Initiatives

Inria-EVA participates in the IoT Benchmarks Initiative (https://www.iotbench.ethz.ch/)

Inria-EVA will be participating in 2019 in the WirelessWine SticAm-Sud project.

9.4. International Research Visitors

9.4.1. Visits of International Scientists

1. **Prof. Xavi Vilajosana (UOC/OpenMote)** (26-30 November 2018) working on OpenMote B bring-up with Tengfei Chang and **Thomas Watteyne**
2. **Brian Gregory Kilberg (UC Berkeley)** (11-18 September 2018) working on OpenWSN/ROS integration with **Thomas Watteyne** and Tengfei Chang
3. **Prof. Xavi Vilajosana (UOC/OpenMote)** (24-28 June 2018) working on F-Interop 6TiSCH with **Thomas Watteyne** and Tengfei Chang
4. **Pablo Modernell (UOC)** (28 May – 1 June 2018) working on F-Interop with Tengfei Chang and **Thomas Watteyne**
5. **Malisa Vucinic (U Montenegro)** (9 -16 March 2018) working on 6TiSCH Security with **Thomas Watteyne**
6. **Lance Doherty (Analog Devices)** (8-9 February 2018) working on SmartMesh IP with **Thomas Watteyne**
7. **Malisa Vucinic (U Montenegro)** (29 January-16 February 2018) working on 6TiSCH Security with **Thomas Watteyne**

9.4.2. Internships

1. **Felipe Moran**, MSc intern from ENSTA ParisTech (1 September 2017 – 31 August 2018), EDF fellow, Research Topic: mote feeding habits, SmartMesh IP, Advisor: Thomas Watteyne
2. **Fabian Rincon Vija**, MSc intern from ENSTA ParisTech (14 May – 31 August 2018), Research Topic: Extension of F-Interop to IEEE 802.15.4 sub-GHz, Advisor: Thomas Watteyne
3. **Marcelo Augusto Ferreira**, MSc intern from ENSTA ParisTech (1 May – 31 August 2018), Research Topic: Measuring Energy Consumption in F-Interop, Advisor: Thomas Watteyne
4. **Imene Ben Haddada**, Using Support Vector Machine for Positioning Services in Vehicle Ad-hoc NETworks (ENSI- Tunisia), March-July 2018.
5. **Khalifa Hadded**, Generation of positioning data in Vehicle Ad-hoc NETworks (ENSI- Tunisia), March-July 2018.
6. **Zied Soua**, Formation d'un réseau TSCH
   et ordonnancement de ses communications dans le cadre de l'IoT industriel, (INSAT- Tunisia), February-July 2018.

9.4.3. Visits to International Teams

9.4.3.1. Research Stays Abroad

- **Thomas Watteyne** spent the month of August 2017 at UC Berkeley, working with Prof. Glaser on the SnowHow project, and with Prof. Pister on Smart Dust and OpenWSN.
- Tengfei Chang spent the month of July 2017 in California working with Prof. Pister working on Smart Dust UC Berkeley, and Prof. Krishnamachari working on testbed deployment at the Univesity of Southern California.

FOCUS Project-Team

7. Partnerships and Cooperations

7.1. National Initiatives

- ELICA (Expanding Logical Ideas for Complexity Analysis) is an ANR project that started on October 2014 and that finished on September 2018. ELICA focused on methodologies for the static analysis of programs and their resource consumption. The project's aim was to further improve on logical methodologies for complexity analysis (type systems, rewriting, etc.). More specifically, one would like to have more powerful techniques with less false negatives, being able at the same time to deal with nonstandard programming paradigms (concurrent, probabilistic, etc.). Main persons involved: Avanzini, Dal Lago, Martini.
- REPAS (Reliable and Privacy-Aware Software Systems via Bisimulation Metrics) is an ANR Project that started on October 2016 and that will finish on October 2020. The project aims at investigating quantitative notions and tools for proving program correctness and protecting privacy. In particular, the focus will be put on bisimulation metrics, which are the natural extension of bisimulation to quantitative systems. As a key application, we will develop a mechanism to protect the privacy of users when their location traces are collected. Main persons involved: Dal Lago, Gavazzo, Sangiorgi.
- COCAHOLA (Cost models for Complexity Analyses of Higher-Order Languages) is an ANR Project that started on October 2016 and that will finish on October 2019. The project aims at developing complexity analyses of higher-order computations. The focus is not on analyzing fixed programs, but whole programming languages. The aim is the identification of adequate units of measurement for time and space, i.e. what are called *reasonable* cost models. Main persons involved: Dal Lago, Martini.

7.2. European Initiatives

7.2.1. FP7 & H2020 Projects

- BEHAPI (Behavioural Application Program Interfaces) is an European Project H2020-MSCA-RISE-2017, running in the period March 2018 - February 2022. The topic of the project is behavioural types, as a suite of technologies that formalise the intended usage of API interfaces. Indeed, currently APIs are typically flat structures, i.e. sets of service/method signatures specifying the expected service parameters and the kind of results one should expect in return. However, correct API usage also requires the individual services to be invoked in a specific order. Despite its importance, the latter information is either often omitted, or stated informally via textual descriptions. The expected benefits of behavioural types include guarantees such as service compliance, deadlock freedom, dynamic adaptation in the presence of failure, load balancing etc. The proposed project aims to bring the existing prototype tools based on these technologies to mainstream programming languages and development frameworks used in industry.

7.2.2. Collaborations in European Programs, Except FP7 & H2020

- ICT COST Action IC1405 (Reversible computation - extending horizons of computing). Initiated at the end of April 2015 and with a 4-year duration, this COST Action studies reversible computation and its potential applications, which include circuits, low-power computing, simulation, biological modeling, reliability and debugging. Reversible computation is an emerging paradigm that extends the standard forwards-only mode of computation with the ability to execute in reverse, so that computation can run backwards as naturally as it can go forwards.

  Main persons involved: Lanese (vice-chair of the action).

- ICT COST Action IC1402 ARVI (Runtime Verification beyond Monitoring). Initiated in December 2014 and with a 4-year duration, this COST Action studies runtime verification, a computing analysis paradigm based on observing a system at runtime to check its expected behaviour.

  Main persons involved: Bravetti, Lanese.

7.2.3. Collaborations with Major European Organizations

We list here the cooperations and contacts with other groups, without repeating those already listed in previous sections.

- ENS Lyon (on concurrency models and resource control). Contact person(s) in Focus: Dal Lago, Martini, Sangiorgi. Some visit exchanges during the year, in both directions. A joint PhD (Adrien Durier).
- University of Innsbruck (on termination and complexity analysis of probabilistic programs). Contact person(s) in Focus: Avanzini. Some short visits during the year.
- University of Southern Denmark (on service-oriented computing). Contact person(s) in Focus: Gabbrielli, Lanese, Zavattaro.
- Universitat Politecnica de Valencia, Spain (on reversibility for Erlang). Contact person(s) in Focus: Lanese. Some visit exchanges during the year, in both directions.
- Laboratoire d'Informatique, Université Paris Nord, Villetaneuse (on implicit computational complexity). Contact person(s) in Focus: Dal Lago, Martini.
- Institut de Mathématiques de Luminy, Marseille (on lambda-calculi, linear logic and semantics). Contact person(s) in Focus: Dal Lago, Martini.
- Team PPS, IRIF Lab, University of Paris-Diderot Paris 7 (on logics for processes, resource control). Contact person(s) in Focus: Dal Lago, Martini, Sangiorgi. Some short visits in both directions during the year.
- IRILL Lab, Paris (on models for the representation of dependencies in distributed package based software distributions). Contact person(s) in Focus: Gabbrielli, Zavattaro. Some short visits in both directions during the year.
- IMDEA Software, Madrid (G. Barthe) (on implicit computational complexity for cryptography). Contact person(s) in Focus: Dal Lago. Some visits during the year.
- Facultad de Informatica, Universidad Complutense de Madrid (on web services). Contact person(s) in Focus: Bravetti. Bravetti is an external collaborator in the project "Desarrollo y Análisis formal de sistemas complejos en contextos DistribuidOS: fundamentos, herramientas y aplicaciones (DArDOS)" (Development and formal analysis of complex systems in distributed contexts: foundations, tools and applications) January 2016 - December 2018, funded by the Spanish Ministerio de Economia y Competitividad.

7.3. International Initiatives

7.3.1. Inria Associate Teams Not Involved in an Inria International Labs

7.3.1.1. CRECOGI

Title: Concurrent, Resourceful and Effectful Computation by Geometry of Interaction

International Partner (Institution - Laboratory - Researcher):

Kyoto (Japan) - Research Institute for Mathematical Sciences - Naohiko Hoshino

Start year: 2018

See also: http://crecogi.cs.unibo.it

The field of denotational semantics has successfully produced useful compositional reasoning principles for program correctness, such as program logics, fixed-point induction, logical relations, etc. The limit of denotational semantics was however that it applies only to high-level languages and to extensional properties. The situation has changed after the introduction of game semantics and the geometry of interaction (GoI), in which the meaning of programs is formalized in terms of movements of tokens, through which programs "talk to" or "play against" each other, thus having an operational flavour which renders them suitable as target language for compilers. The majority of the literature on GoI and games only considers sequential functional languages. Moreover, computational effects (e.g. state or I/O) are rarely taken into account, meaning that they are far from being applicable to an industrial scenario. This project's objective is to develop a semantic framework for concurrent, resourceful, and effectful computation, with particular emphasis on probabilistic and quantum effects. This is justified by the greater and greater interest which is spreading around these two computation paradigms, motivated by applications to AI and by the efficiency quantum parallelism induces.

7.3.2. Participation in Other International Programs

Focus has taken part in the creation of the Microservices Community (http://microservices.sdu.dk/), an international community interested in the software paradigm of Microservices. Main aims of the community are: i) sharing knowledge and fostering collaborations about microservices among research institutions, private companies, universities, and public organisations (like municipalities); ii) discussing open issues and solutions from different points of view, to create foundations for both innovation and basic research.

U. Dal Lago is "Partner Investigator" in the project "Verification and analysis of quantum programs", whose Chief Investigator is Prof Yuan Feng, University of Technology Sydney. The project is funded by the Australian Research Council.

7.3.2.1. AYAME

CRECOGI

Title: Concurrent, Resourceful and Effectful Computation by Geometry of Interaction

International Partner (Institution - Laboratory - Researcher):

JSPS (Japan) - Kyoto University /Research Institute for Mathematical Sciences - Naohiko Hoshino

Duration: 2015 - 2020 The description of the project can be found in Section 7.3.1.1 .

7.4. International Research Visitors

7.4.1. Visits of International Scientists

The following researchers have visited Focus for short periods; we list them together with the title of the talk they have given during their stay, or the topic discussed during their stay.

- Filippo Bonchi (ENS Lyon and University of Pisa) "Sound up-to techniques and complete abstract domain".
- Luis Fernando Llana Díaz (Universidad Complutense de Madrid) "Probabilistic software product lines".
- Claudia Faggian (Université Paris-Diderot – Paris 7) : "Probabilistic Lambda Calculus – beyond deterministic evaluation"
- Nao Hirokawa (Japan Advanced Institute of Science and Technology): "Transformations for Lazy Evaluation and Theorem Proving".
- Guilhem Jaber (University of Nantes): "Game semantics for higher-order functions with state".
- Thomas Leventis (Institut de Mathematiques de Marseille): "Taylor Expansion of lambda terms and differential linear logic."
- Gabriel Scherer (Inria Parsifal). "Keep (re)playing until your get all the successes".
- Emilio Tuosto (University of Leicester): "On pomsets as models of asynchronous message-passing languages".
- Akihisa Yamada (NII Tokyo): "Mathematics for Complexity in Isabelle/HOL".

7.4.2. Visits to International Teams

- Francesco Gavazzo visited the Faculty of Mathematics and Physics (University of Ljubljana) hosted by Alex Simpson, from 02/10/2017 to 31/01/2018.
- U. Dal Lago has spent overall a few weeks in Japan (University of Kyoto and University of Tokyo), collaborations with Naohiko Hoshino and Naoki Kobayashi.

7.4.2.1. Sabbatical programme

Simone Martini is Fellow at the Collegium - Lyon Institute for Advanced Studies, since September 2018 and until June 2019 https://collegium.universite-lyon.fr.

FUN Project-Team

9. Partnerships and Cooperations

9.1. Regional Initiatives

9.1.1. StoreConnect

Participants: Nathalie Mitton, Valeria Loscri [correspondant], Antonio Costanzo, Ibrahim Amadou.

Title: StoreConnect
Type: FUI
Duration: September 2016 - October 2018
Coordinator: NEOSENSYS
Others partners: Inria FUN, SPIRALS and STARS, TeVolys, Ubudu, Smile, STIME, Leroy Merlin
The aim of StoreConnect is to provide French large retailers with efficient and powerful tools in the in-store customer interaction. This project has yielded to several publications in 2018: [39], [38], [24], [40].

9.1.2. PIPA

Participants: Nathalie Mitton [correspondant], Farouk Mezghani.

Title: Partager de l'Info PArtout à bas coût
Type: Chercheur citoyen
Duration: Dec 2015 - Aug 2018
Coordinator: Inria FUN
Others partners: SpotTrotter
PIPA project aims to provide an innovative low cost solution to share information in places where communication infrastructure are lacking, insuffisant or not adapted, going beyond technical, economical or political limitations. This project has yield to several publications in 2018: [31], [19], [30].

9.2. National Initiatives

9.2.1. Inria Project Lab

9.2.1.1. CityLab@Inria

Participants: Valeria Loscri, Abdoul Aziz Mbacke, Nathalie Mitton [correspondant].

- Title: CityLab@Inria
- Type: IPL
- Duration: 2015 - 2019
- Coordinator: Valerie Issarny
- CityLab@Inria studies ICT solutions toward smart cities that promote both social and environmental sustainability. A strong emphasis of the Lab is on the undertaking of a multi-disciplinary research program through the integration of relevant scientific and technology studies, from sensing up to analytics and advanced applications, so as to actually enact the foreseen smart city Systems of Systems. Obviously, running urban-scale experiments is a central concern of the Lab, so that we are able to confront proposed approaches to actual settings. The Lab's research leverages relevant effort within Inria project-teams that is further revisited as well as integrated to meet the challenges of smart cities. Research themes span: energy-efficient wireless communication protocols, urban-scale social and physical sensing, privacy by design, cloud-based urban data management, data assimilation, visual analysis, and urban system software engineering. In addition, CityLab Inria research builds upon collaborative effort at the International level, and especially collaboration in the context of the Inria SiliconValley program. This project has yield to the set up of a full course on Smart Cities via a MOOC [48] and a set of publications [18], [29], [28], [37], [11].

9.2.2. ADT

9.2.2.1. Catimex

Participants: Matthieu Berthome, Nathalie Mitton [correspondant], Julien Vandaele.

Duration: September 2017 -June 2019

Coordinator: Inria FUN

The purpose of this project is to foster research transfer in IoT from ADT members to their industrial partners by widening experimental features and PoC realization. It is lead in closed partnership with Inria Chile and Université of Strasbourg.

9.2.3. Equipements d'Excellence

9.2.3.1. FIT

Participants: Nathalie Mitton [correspondant], Julien Vandaele, Matthieu Berthome.

Title: Future Internet of Things

Type: EquipEx

Duration: March 2010 - December 2019

Coordinator: UPMC

See also: http://fit-equipex.fr/

Abstract: FIT (Future Internet of Things) aims to develop an experimental facility, a federated and competitive infrastructure with international visibility and a broad panel of customers. It will provide this facility with a set of complementary components that enable experimentation on innovative services for academic and industrial users. The project will give French Internet stakeholders a means to experiment on mobile wireless communications at the network and application layers thereby accelerating the design of advanced networking technologies for the Future Internet. FIT is one of 52 winning projects from the first wave of the French Ministry of Higher Education and Research's "Equipements d'Excellence" (Equipex) research grant program. Coordinated by Professor Serge Fdida of UPMC Sorbonne Universités and running over a nine-year period, the project will benefit from a 5.8 million euro grant from the French government.

9.3. European Initiatives

9.3.1. H2020 Projects

9.3.1.1. VESSEDIA

Participants: Rehan Malak, Nathalie Mitton, Allan Blanchard [correspondant].

- Title: VERIFICATION ENGINEERING OF SAFETY AND SECURITY CRITICAL DYNAMIC INDUSTRIAL APPLICATIONS
- Program: H2020
- Duration: January 2017 - Dec. 2019
- TECHNIKON FORSCHUNGS UND PLANUNGSGESELLSCHAFT MBH (TEC)

The VESSEDIA project will bring safety and security to many new software applications and devices. In the fast evolving world we live in, the Internet has brought many benefits to individuals, organizations and industries. With the capabilities offered now (such as IPv6) to connect billions of devices and therefore humans together, the Internet brings new threats to the software developers and VESSEDIA will allow connected applications to be safe and secure. VESSEDIA proposes to enhance and scale up modern software analysis tools, namely the mostly open-source Frama-C Analysis platform, to allow developers to benefit rapidly from them when developing connected applications. At the forefront of connected applications is the IoT, whose growth is exponential and whose security risks are real (for instance in hacked smart phones). VESSEDIA will take this domain as a target for demonstrating the benefits of using our tools on connected applications. VESSEDIA will tackle this challenge by 1) developing a methodology that allows to adopt and use source code analysis tools efficiently and produce similar benefits than already achieved for highly-critical applications (i.e. an exhaustive analysis and extraction of faults), 2) enhancing the Frama-C toolbox to enable efficient and fast implementation, 3) demonstrating the new toolbox capabilities on typical IoT (Internet of Things) applications including an IoT Operating System (Contiki), 4) developing a standardization plan for generalizing the use of the toolbox, 5) contributing to the Common Criteria certification process, and 6) defining a label "Verified in Europe" for validating software products with European technologies such as Frama-C. This project yields to set of publications in 2018: [23], [47], [27].

9.4. International Initiatives

9.4.1. Inria International Labs

9.4.1.1. Agrinet

Participants: Abdoul Aziz Mbacke, Brandon Foubert, Valeria Loscri, Anjalalaina Jean Cristanel Razafimandimby, Nathalie Mitton [correspondant].

Agrinet

Title: Agrinet

International Partner (Institution - Laboratory - Researcher):

Type: LIRIMA Associate team

Duration: 2017-2020

See also: https://team.inria.fr/agrinet/

The current drought and limited water resources in many parts of Southern Africa and beyond, already have a significant impact on agriculture and hence, food production. Sustainable food security depends upon proper plant and crop management respectful of soils and natural re- sources, such as water. This includes very important South African farming areas, such as the Western Cape and Northern Cape. In France, agriculture is also hugely important. Not just nationally, but also in Europe. The system proposed can be applied to a variety of crops. The economic- and social consequences are profound and any contribution towards more efficient farming within increasingly onerous natural constraints, should be a priority. To address these constraints, we propose to develop a flexible, rapidly deployable, biological/agricultural data acquisition platform and associated machine learning algorithms to create advanced agricultural monitoring and management techniques, to improve crop management and use of natural resources. The project also addresses an industry with very high socioeconomic impact.

Publications issued from that project in 2018 are: [25], [45], [35].

9.4.2. Inria International Partners

9.4.2.1. Declared Inria International Partners

Université Mediterranea di Reggio Calabria (UNIC) (Italy) Objective of this collaboration is the design of an innovative architecture that enables autonomic and decentralized fruition of the services offered by the network of smart objects in many heterogeneous and dynamic environments, in a way that is independent of the network topology, reliable and flexible. The result is an 'ecosystem' of objects, self-organized and self-sustained, capable of making data and services available to the users wherever and whenever required, thus supporting the fruition of an 'augmented' reality thanks to a new environmental and social awareness.

9.4.2.2. Informal International Partners

Southern University, China

The purpose of this collaboration is to study the green (or energy-efficient) communication problem in vehicular ad hoc networks (VANETs) and the application of vehicular network communication in green transportation. In this framework, Nathalie Mitton visited the Nanjing University. It gave birth to joint project submission, joint conference organization and joint publications.

Arun Sen from Arizona State University, USA

The purpose of this collaboration is to study the joint scheduling and trajectory of RFID readers in a mobile environment. In this framework, Arun Sen visited the FUN team for 6 months in 2015 and in July 2016. It gave birth to joint project submission, joint conference submission and joint publications, among them in 2018 [14].

Anna-Maria Vegni from Roma Tre University, Italy

The purpose of this collaboration is to study alternative communication paradigms and investigate their limitations and different effects on performances. In this framework, joint publications have been obtained, among them in 2018 [17], [21], [26], [36], [43], [45].

9.4.3. Participation in Other International Programs

9.4.3.1. CROMO

Participants: Valeria Loscri, Joao Batista Pinto Neto, Nathalie Mitton [correspondant].

Title: Crowd Data In the mobile cloud

Duration: January 2015 - December 2019

CroMo (Crowd Data In the mobile cloud) is a submission to the CAPES-COFECUB project call lead by Inria from the French side and University of Rio de Janeiro from Brazilian Side. Other partner institutions are Université Pierre et Marie Curie and Université de la Rochelle.

Mobile cloud computing is an emerging paradigm to improve the quality of mobile applications by transferring part of the computational tasks to the resource-rich cloud. The multitude data sources combined with the known difficulties of wireless communications represent an important issue for mobile cloud computing. Therefore, the additional computational power added by the cloud has to deal with the constraints of the wireless medium. One could imagine a situation where different sensors collect data and require intensive computation. This data must be transmitted at high rates before becoming stale. In this case, the network becomes the main bottleneck, not the processing power or storage size. To circumvent this issue, different strategies can be envisioned. As usual alternatives, wireless data rates must be increased or the amount of data sent to the cloud must be reduced. CROMO tackles challenges from all these three components of the mobile clouds (data generation, collect and processing) to then integrate them as a whole enhanced mobile cloud with improved network performances in terms of delay, energy consumption, availability, and reliability. In this context, joint exchanges and crossed visits have been done (Aziz went to Rio, Dianne went to Lille). The project yield to several publications such as [22].

9.5. International Research Visitors

9.5.1. Visits of International Scientists

Several researchers have visited our group in 2018, mainly from our partner universities but not only:

- Gentian, Jakllari, ENSEEITH, France, January 2018
- Georgios Papadopoulos, IMT Atlantique, France, January 2018
- Bruno Quoitin, University of Mons, Belgium, January and March 2018
- Sebastien Bindel, Université de Haute Alsace, France, June 2018
- Karen Miranda Campos, Metropolitan Autonomous University Lerma Campus, Mexico, October 2018
- Zied Chtourou, University of Sfax, Tunisia, October 2018
- Fabrice Théoleyre, University of Strasbourg, October 2018
- Fabrice Valois, INSA Lyon, October 2018
- Miguel Elias Campista, Federal University of Rio de Janeiro (UFRJ), Brazil, December 2018
- Pranvera Kortoci, Aalto University, from Mar 2018 until Apr 2018
- Noura Mares Univ. Sfax, from Apr 2018 until Jul 2018
- Morgan O Kennedy, Stellenbosch University, from Jul 2018 until Sep 2018

9.5.1.1. Research Stays Abroad

- Jad Nassar visited Metropolitan Autonomous University Cuajimalpa Campus, Mexico in January-February 2018

GANG Project-Team

9. Partnerships and Cooperations

9.1. Regional Initiatives

9.1.1. Laboratory of Information, Networking and Communication Sciences (LINCS)

Gang is participating to the LINCS, a research centre co-founded by Inria, Institut Mines-Télécom, UPMC and Alcatel-Lucent Bell Labs, dedicated to research and innovation in the domains of future information and communication networks, systems and services. Gang contributes to work on online social networks, content centric networking and forwarding information verification.

9.2. National Initiatives

9.2.1. ANR DESCARTES

Participants: Carole Delporte-Gallet, Hugues Fauconnier, Pierre Fraigniaud, Adrian Kosowski, Laurent Viennot.

Cyril Gavoille (U. Bordeaux) leads this project that grants 1 Post-Doc. H. Fauconnier is the local coordinator (This project began in October 2016).

Despite the practical interests of reusable frameworks for implementing specific distributed services, many of these frameworks still lack solid theoretical bases, and only provide partial solutions for a narrow range of services. We argue that this is mainly due to the lack of a generic framework that is able to unify the large body of fundamental knowledge on distributed computation that has been acquired over the last 40 years. The DESCARTES project aims at bridging this gap, by developing a systematic model of distributed computation that organizes the functionalities of a distributed computing system into reusable modular constructs assembled via well-defined mechanisms that maintain sound theoretical guarantees on the resulting system. DESCARTES arises from the strong belief that distributed computing is now mature enough to resolve the tension between the social needs for distributed computing systems, and the lack of a fundamentally sound and systematic way to realize these systems.

9.2.2. ANR MultiMod

Participants: Adrian Kosowski, Laurent Viennot.

David Coudert (Sophia Antipolis) leads this project. L. Viennot coordinates locally. The project began in 2018.

The MultiMod project aims at enhancing the mobility of citizens in urban areas by providing them, through a unique interface enabling to express their preferences, the most convenient transportation means to reach their destinations. Indeed, the increasing involvement of actors and authorities in the deployment of more responsible and cost-effective logistics and the progress made in the field of digital technology have made possible to create synergies in the creation of innovative services for improving the mobility in cities. However, users are faced with a number of solutions that coexist at different scales, providing complementary information for the mobility of users, but that make very complex to find the most convenient itinerary at a given time for a specific user. In this context, MultiMod aims at improving the mobility of citizens in urban areas by proposing contextualized services, linking users, to facilitate multimodal transport by combining, with flexibility, all available modes (planned/dynamic carpooling, public transport (PT), car-sharing, bicycle, etc.).

We consider the use of carpooling in metropolitan areas, and so for short journeys. Such usage enables itineraries that are not possible with PT, allows for opening up areas with low PT coverage by bringing users near PT (last miles), and for faster travel-time when existing PT itineraries are too complex or with too low frequency (e.g., one bus per hour). In this context, the application must help the driver and the passenger as much as possible. In particular, the application must propose the meeting-point, indicate the driver the detour duration, and indicate the passenger how to reach this meeting-point using PT. Here, the time taken by drivers and passengers to agree becomes a critical issue and so the application must provide all needed information to quickly take a decision (i.e., in one click).

In addition, the era of Smart City gathers many emerging concepts, driven by innovative technological players, which enables the exploitation of real-time data (e.g., delay of a bus, traffic jam) made available by the various actors (e.g., communities in the framework of Open Data projects, users via their mobile terminals, traffic supervision authorities). In the MultiMod project, we will use these rich sources of data to propose itineraries that are feasible at query-time. Our findings will enable the design of a mobility companion able not only to guide the user along her journey, including when and how to change of transportation mean, but also to propose itinerary changes when the current one exceeds a threshold delay. The main originality of this project is thus to address the problem of computing itineraries in large-scale networks combining PT, carpooling and real-time data, and to satisfy the preferences of users. We envision that the outcome of this project will significantly improve the daily life of citizens.

The targeted metropolitan area for validating our solutions is Ile-de-France. Indeed, Instant-System is currently developing the new application "Vianavigo lab" which will replace the current "Vianavigo" application for the PT network of Ile-de-France. Our findings will therefore be tested at scale and eventually be integrated and deployed in production servers and mobile applications. The smaller networks of Bordeaux and Nice will be used to perform preliminary evaluations since Instant System already operates applications in these cities (Boogi Nice, Boogi Bordeaux). An important remark is that new features and algorithms can contractually be deployed in production every 4 months, thus enabling Instant System to measure and challenge the results of the MultiMod project in continue. This is a chance for the project to maximize its impact.

9.2.3. ANR FREDDA

Participants: Carole Delporte-Gallet, Hugues Fauconnier, Pierre Fraigniaud.

Arnaud Sangnier (IRIF, Univ Paris Diderot) leads this project that grants 1 PhD. (This project began in October 2017).

Distributed algorithms are nowadays omnipresent in most systems and applications. It is of utmost importance to develop algorithmic solutions that are both robust and flexible, to be used in large scale applications. Currently, distributed algorithms are developed under precise assumptions on their execution context: synchronicity, bounds on the number of failures, etc. The robustness of distributed algorithms is a challenging problem that has not been much considered until now, and there is no systematic way to guarantee or verify the behavior of an algorithm beyond the context for which it has been designed. We propose to develop automated formal method techniques to verify the robustness of distributed algorithms and to support the development of robust applications. Our methods are of two kinds: statically through classical verification, and dynamically, by synthesizing distributed monitors, that check either correctness or the validity of the context hypotheses at runtime.

9.2.4. ANR Distancia

Participants: Pierre Charbit, Michel Habib, Laurent Viennot.

Victor Chepoi (Univ. Marseille) leads this project. P. Charbit coordinates locally. The project began in early-2018.

The theme of the project is Metric Graph Theory, and we are concerned both on theoretical foundations and applications. Such applications can be found in real world networks. For example, the hub labelling problem in road networks can be directly applied to car navigation applications. Understanding key structural properties of large-scale data networks is crucial for analyzing and optimizing their performance, as well as

improving their reliability and security. In prior empirical and theoretical studies researchers have mainly focused on features such as small world phenomenon, power law degree distribution, navigability, and high clustering coefficients. Although those features are interesting and important, the impact of intrinsic geometric and topological features of large-scale data networks on performance, reliability and security is of much greater importance. Recently, there has been a surge of empirical works measuring and analyzing geometric characteristics of real-world networks, namely the Gromov hyperbolicity (called also the negative curvature) of the network. It has been shown that a number of data networks, including Internet application networks, web networks, collaboration networks, social networks, and others, have small hyperbolicity.

Metric graph theory was also indispensable in solving some open questions in concurrency and learning theory in computer science and geometric group theory in mathematics. Median graphs are exactly the 1–skeletons of CAT(0) cube complexes (which have been characterized by Gromov in a local-to-global combinatorial way). They play a vital role in geometric group theory (for example, in the recent solution of the famous Virtual Haken Conjecture). Median graphs are also the domains of event structures of Winskel, one of the basic abstract models of concurrency. This correspondence is very useful in dealing with questions on event structures.

Many classical algorithmic problems concern distances: shortest path, center and diameter, Voronoi diagrams, TSP, clustering, etc. Algorithmic and combinatorial problems related to distances also occur in data analysis. Low-distortion embeddings into l1-spaces (theorem of Bourgain and its algorithmical use by Linial et al.) were the founding tools in metric methods. Recently, several approximation algorithms for NP-hard problems were designed using metric methods. Other important algorithmic graph problems related to distances concern the construction of sparse subgraphs approximating inter-node distances and the converse, augmentation problems with distance constraints. Finally, in the distributed setting, an important problem is that of designing compact data structures allowing very fast computation of inter- node distances or routing along shortest or almost shortest paths. Besides computer science and mathematics, applications of structures involving distances can be found in archeology, computational biology, statistics, data analysis, etc. The problem of characterizing isometric subgraphs of hypercubes has its origin in communication theory and linguistics. . To take into account the recombination effect in genetic data, the mathematicians Bandelt and Dress developed in 1991 the theory of canonical decompositions of finite metric spaces. Together with geneticists, Bandelt successfully used it over the years to reconstruct phylogenies, in the evolutional analysis of mtDNA data in human genetics. One important step in their method is to build a reduced median network that spans the data but still contains all most parsimonious trees. As mentioned above, the median graphs occurring there constitute a central notion in metric graph theory.

With this project, we aim to participate at the elaboration of this new domain of Metric Graph Theory, which requires experts and knowledge in combinatorics (graphs, matroids), geometry, and algorithms. This expertise is distributed over the members of the consortium and a part of the success of our project it will be to share these knowledges among all the members of the consortium. This way we will create a strong group in France on graphs and metrics.

9.2.5. ANR HOSIGRA

Participants: Pierre Charbit, Michel Habib.

This project starting in early-2018, led by Reza Naserasr, explores the connection between minors and colorings, exploiting the notion of signed graphs. With the four colour theorem playing a central role in development of Graph Theory, the notions of minor and coloring have been branded as two of the most distinguished concepts in this field. The geometric notion of planarity has given birth to the theory of minors among others, and coloring have proven to have an algebraic nature through its extension to the theory of graph homomorphisms. Great many projects have been completed on both subjects, but what remains mostly a mystery is the correlation of the two subjects. The four color theorem itself, in slightly stronger form, claims that if a complete graph on five vertices cannot be formed by minor operation from a given graph, then the graph can be homomorphically mapped into the complete graph on four vertices (thus a 4-coloring). Commonly regarded as the most challenging conjecture on graph theory, the Hadwiger conjecture claims that

five and four in this theorem can be replaced with n and $n-1$ respectively for any value of n. The correlation of these two concepts has been difficult to study, mainly for the following reason: While the coloring or homomorphism problems roots back into intersections of odd-cycles, the minor operation is irrelevant of the parity of cycles. To overcome this barrier, the notion of signed graphs has been used implicitly since 1970s when coloring results on graphs with no odd-K4 is proved, following which a stronger form of the Hadwiger conjecture, known as Odd Hadwiger conjecture, was proposed by P. Seymour and B. Gerards, independently. Being a natural subclass of Matroids and a superclass of graphs, the notion of minor of signed graphs is well studied and many results from graph minor are either already extended to signed graphs or it is considered by experts of the subject. Observing the importance, and guided by some earlier works, in particular that of B. Guenin, we then started the study of algebraic concepts (coloring and homomormphisms) for signed graphs. Several results have been obtained in the past decade, and this project aims at exploring more of this topic.

9.3. European Initiatives

9.3.1. FP7 & H2020 Projects

Amos Korman has an ERC Consolidator Grant entitled "Distributed Biological Algorithms (DBA)", started in May 2015. This project proposes a new application for computational reasoning. More specifically, the purpose of this interdisciplinary project is to demonstrate the usefulness of an algorithmic perspective in studies of complex biological systems. We focus on the domain of collective behavior, and demonstrate the benefits of using techniques from the field of theoretical distributed computing in order to establish algorithmic insights regarding the behavior of biological ensembles. The project includes three related tasks, for which we have already obtained promising preliminary results. Each task contains a purely theoretical algorithmic component as well as one which integrates theoretical algorithmic studies with experiments. Most experiments are strategically designed by the PI based on computational insights, and are physically conducted by experimental biologists that have been carefully chosen by the PI. In turn, experimental outcomes will be theoretically analyzed via an algorithmic perspective. By this integration, we aim at deciphering how a biological individual (such as an ant) "thinks", without having direct access to the neurological process within its brain, and how such limited individuals assemble into ensembles that appear to be far greater than the sum of their parts. The ultimate vision behind this project is to enable the formation of a new scientific field, called algorithmic biology, that bases biological studies on theoretical algorithmic insights.

9.3.2. LIA Struco

Pierre Charbit is director of the LIA STRUCO, which is an Associated International Laboratory of CNRS between IÚUK, Prague, and IRIF, Paris. The director on the Czech side is Pr. Jaroslav Nešetřil. The primary theme of the laboratory is graph theory, more specifically: sparsity of graphs (nowhere dense classes of graphs, bounded expansion classes of graphs), extremal graph theory, graph coloring, Ramsey theory, universality and morphism duality, graph and matroid algorithms and model checking.

STRUCO focuses on high-level study of fundamental combinatorial objects, with a particular emphasis on comprehending and disseminating the state-of-the-art theories and techniques developed. The obtained insights shall be applied to obtain new results on existing problems as well as to identify directions and questions for future work.

One of the main goals of STRUCO is to provide a sustainable and reliable structure to help Czech and French researchers cooperate on long-term projects, disseminate the results to students of both countries and create links between these students more systematically. The chosen themes of the project indeed cover timely and difficult questions, for which a stable and significant cooperation structure is needed. By gathering an important number of excellent researchers and students, the LEA will create the required environment for making advances, which shall be achieved not only by short-term exchanges of researchers, but also by a strong involvement of Ph. D students in the learning of state-of-the-art techniques and in the international collaborations.

STRUCO is a natural place to federate and organize these many isolated collaborations between our two countries. Thus, the project would ensure long-term cooperations and allow young researchers (especially PhD students) to maintain the fruitful exchanges between the two countries in the future years, in a structured and federated way.

9.4. International Initiatives

9.4.1. Inria Associate Teams Not Involved in an Inria International Labs

Carole Delporte-Gallet and Hugues Fauconnier are members of the Inria-MEXICO Equipe Associée LiDiCo (At the Limits of Distributed Computability, https://sites.google.com/site/lidicoequipeassociee/).

9.4.2. Inria International Partners

9.4.2.1. Informal International Partners

Ofer Feinerman (Physics department of complex systems, Weizmann Institute of Science, Rehovot, Israel), is a team member in Amos Korman's ERC project DBA. This collaboration has been formally established by signing a contract between the CNRS and the Weizmann Institute of Science, as part of the ERC project.

Rachid Guerraoui (School of Computer and Communication Sciences, EPFL, Switzerland) maintains an active research collaboration with Gang team members (Carole Delporte, Hugues Fauconnier).

Sergio Rajsbaum (UNAM, Mexico) is a regular collaborator of the team, also involved formally in a joint French-Mexican research project (see next subsection).

Boaz Patt-Shamir (Tel Aviv University, Israel) is a regular collaborator of the team, also involved formally in a joint French-Israeli research project (see next subsection).

Lalla Moutadib, PhD student at Uinversity of Toronto, directed by Alan Borodin and Derek Corneil but also unformally by Michel Habib. 2 visits in 2018 in our group. She got her PhD in september 2018. See https://tspace.library.utoronto.ca/handle/1807/92081.

9.5. International Research Visitors

9.5.1. Visits of International Scientists

- Sergio Rajsbaum (UNAM Mexico) - April 1 to June 30.
- Giuliano Losa (UCLA USA)- May 17 to May 30.

9.5.2. Visits to International Teams

- Carole Delporte and Hugues Fauconnier have visited Sergio Rajsbaum at UNAM Mexico - September 2 to September 14.

HIEPACS Project-Team

8. Partnerships and Cooperations

8.1. Regional Initiatives

8.1.1. HPC Scalable Ecosystem

Participants: Emmanuel Agullo, Olivier Coulaud, Aurélien Esnard, Mathieu Faverge, Luc Giraud, Abdou Guermouche, Pierre Ramet.

Grant: Regional council
Dates: 2018 – 2020
Partners: EPIs REALOPT, STORM from Inria Bordeaux Sud-Ouest, CEA-CESTA and l'Institut pluridisciplinaire de recherche sur l'environnement et les matériaux (IPREM) .
Overview:

Numerical simulation is today integrated in all cycles of scientific design and studies, whether academic or industrial, to predict or understand the behavior of complex phenomena often coupled or multi-physical. The quality of the prediction requires having precise and adapted models, but also to have computation algorithms efficiently implemented on computers with architectures in permanent evolution. Given the ever increasing size and sophistication of simulations implemented, the use of parallel computing on computers with up to several hundred thousand computing cores and consuming / generating massive volumes of data becomes unavoidable; this domain corresponds to what is now called High Performance Computing (HPC). On the other hand, the digitization of many processes and the proliferation of connected objects of all kinds generate ever-increasing volumes of data that contain multiple valuable information; these can only be highlighted through sophisticated treatments; we are talking about Big Data. The intrinsic complexity of these digital treatments requires a holistic approach with collaborations of multidisciplinary teams capable of mastering all the scientific skills required for each component of this chain of expertise.

To have a real impact on scientific progress and advances, these skills must include the efficient management of the massive number of compute nodes using programming paradigms with a high level of expressiveness, exploiting high-performance communications layers, effective management for intensive I / O, efficient scheduling mechanisms on platforms with a large number of computing units and massive I / O volumes, innovative and powerful numerical methods for analyzing volumes of data produced and efficient algorithms that can be integrated into applications representing recognized scientific challenges with high societal and economic impacts. The project we propose aims to consider each of these links in a consistent, coherent and consolidated way.

For this purpose, we propose to develop a unified Execution Support (SE) for large-scale numerical simulation and the processing of large volumes of data. We identified four Application Challenges (DA) identified by the Nouvelle-Aquitaine region that we propose to carry over this unified support. We will finally develop four Methodological Challenges (CM) to evaluate the impact of the project. This project will make a significant contribution to the emerging synergy on the convergence between two yet relatively distinct domains, namely High Performance Computing (HPC) and the processing, management of large masses of data (Big Data); this project is therefore clearly part of the emerging field of High Performance Data Analytics (HPDA).

8.2. National Initiatives

8.2.1. ANR

8.2.1.1. SASHIMI: Sparse Direct Solver using Hierarchical Matrices

Participants: Mathieu Faverge, Pierre Ramet, Aurelien Esnard.

Grant: ANR-18-CE46-0006

Dates: 2018 – 2022
Overview: Nowadays, the number of computational cores in supercomputers has grown largely to a few millions. However, the amount of memory available has not followed this trend, and the memory per core ratio is decreasing quickly with the advent of accelerators. To face this problem, the SaSHiMi project wants to tackle the memory consumption of linear solver libraries used by many major simulation applications by using low-rank compression techniques. In particular, the direct solvers which offer the most robust solution to strategy but suffer from their memory cost. The project will especially investigate the super-nodal approaches for which low-rank compression techniques have been less studied despite the attraction of their large parallelism and their lower memory cost than for the multi-frontal approaches. The results will be integrated in the PaStiX solver that supports distributed and heterogeneous architectures.

8.2.1.2. DEDALES: Algebraic and geometric domain decomposition for subsurface/groundwater flows
Participants: Emmanuel Agullo, Mathieu Faverge, Luc Giraud, Louis Poirel.

Grant: ANR-14-CE23-0005
Dates: 2014 – 2018
Partners: Inria EPI POMDAPI (leader); Université Paris 13 - Laboratoire Analyse, Géométrie et Applications; Maison de la Simulation; Andra.
Overview: Project DEDALES aims at developing high performance software for the simulation of two phase flow in porous media. The project will specifically target parallel computers where each node is itself composed of a large number of processing cores, such as are found in new generation many-core architectures. The project will be driven by an application to radioactive waste deep geological disposal. Its main feature is phenomenological complexity: water-gas flow in highly heterogeneous medium, with widely varying space and time scales. The assessment of large scale model is of major importance and issue for this application, and realistic geological models have several million grid cells. Few, if at all, software codes provide the necessary physical features with massively parallel simulation capabilities. The aim of the DEDALES project is to study, and experiment with, new approaches to develop effective simulation tools with the capability to take advantage of modern computer architectures and their hierarchical structure. To achieve this goal, we will explore two complementary software approaches that both match the hierarchical hardware architecture: on the one hand, we will integrate a hybrid parallel linear solver into an existing flow and transport code, and on the other hand, we will explore a two level approach with the outer level using (space time) domain decomposition, parallelized with a distributed memory approach, and the inner level as a subdomain solver that will exploit thread level parallelism. Linear solvers have always been, and will continue to be, at the center of simulation codes. However, parallelizing implicit methods on unstructured meshes, such as are required to accurately represent the fine geological details of the heterogeneous media considered, is notoriously difficult. It has also been suggested that time level parallelism could be a useful avenue to provide an extra degree of parallelism, so as to exploit the very large number of computing elements that will be part of these next generation computers. Project DEDALES will show that space-time DD methods can provide this extra level, and can usefully be combined with parallel linear solvers at the subdomain level. For all tasks, realistic test cases will be used to show the validity and the parallel scalability of the chosen approach. The most demanding models will be at the frontier of what is currently feasible for the size of models.

8.2.2. FUI

8.2.2.1. ICARUS: Intensive Calculation for AeRo and automotive engines Unsteady Simulations
Participants: Cyril Bordage, Aurelien Esnard.

Grant: FUI-22
Dates: 2016-2019
Partners: SAFRAN, SIEMENS, IFPEN, ONERA, DISTENE, CENAERO, GDTECH, Inria, CORIA, CERFACS.

Overview: Large Eddy Simulation (LES) is an increasingly attractive unsteady modelling approach for modelling reactive turbulent flows due to the constant development of massively parallel supercomputers. It can provide open and robust design tools that allow access to new concepts (technological breakthroughs) or a global consideration of a structure (currently processed locally). The mastery of this method is therefore a major competitive lever for industry. However, it is currently constrained by its access and implementation costs in an industrial context. The ICARUS project aims to significantly reduce them (costs and deadlines) by bringing together major industrial and research players to work on the entire high-fidelity LES computing process by:

- increasing the performance of existing reference tools (for 3D codes: AVBP, Yales2, ARGO) both in the field of code coupling and code/machine matching;
- developing methodologies and networking tools for the LES;
- adapting the ergonomics of these tools to the industrial world: interfaces, data management, code interoperability and integrated chains;
- validating this work on existing demonstrators, representative of the aeronautics and automotive industries.

8.3. European Initiatives

8.3.1. FP7 & H2020 Projects

8.3.1.1. EoCoE

Title: Energy oriented Centre of Excellence for computer applications

Programm: H2020

Duration: October 2015 - October 2018

Coordinator: CEA

Partners:

Barcelona Supercomputing Center - Centro Nacional de Supercomputacion (Spain)

Commissariat A L Energie Atomique et Aux Energies Alternatives (France)

Centre Europeen de Recherche et de Formation Avancee en Calcul Scientifique (France)

Consiglio Nazionale Delle Ricerche (Italy)

The Cyprus Institute (Cyprus)

Agenzia Nazionale Per le Nuove Tecnologie, l'energia E Lo Sviluppo Economico Sostenibile (Italy)

Fraunhofer Gesellschaft Zur Forderung Der Angewandten Forschung Ev (Germany)

Instytut Chemii Bioorganicznej Polskiej Akademii Nauk (Poland)

Forschungszentrum Julich (Germany)

Max Planck Gesellschaft Zur Foerderung Der Wissenschaften E.V. (Germany)

University of Bath (United Kingdom)

Universite Libre de Bruxelles (Belgium)

Universita Degli Studi di Trento (Italy)

Inria contact: Michel Kern

The aim of the present proposal is to establish an Energy Oriented Centre of Excellence for computing applications, (EoCoE). EoCoE (pronounce “Echo”) will use the prodigious potential offered by the ever-growing computing infrastructure to foster and accelerate the European transition to a reliable and low carbon energy supply. To achieve this goal, we believe that the present revolution in hardware technology calls for a similar paradigm change in the way application codes are designed. EoCoE will assist the energy transition via targeted support to four renewable energy pillars: Meteo, Materials, Water and Fusion, each with a heavy reliance on numerical modelling. These four pillars will be anchored within a strong transversal multidisciplinary basis providing high-end expertise in applied mathematics and HPC. EoCoE is structured around a central Franco-German hub coordinating a pan-European network, gathering a total of 8 countries and 23 teams. Its partners are strongly engaged in both the HPC and energy fields; a prerequisite for the long-term sustainability of EoCoE and also ensuring that it is deeply integrated in the overall European strategy for HPC. The primary goal of EoCoE is to create a new, long lasting and sustainable community around computational energy science. At the same time, EoCoE is committed to deliver high-impact results within the first three years. It will resolve current bottlenecks in application codes, leading to new modelling capabilities and scientific advances among the four user communities; it will develop cutting-edge mathematical and numerical methods, and tools to foster the usage of Exascale computing. Dedicated services for laboratories and industries will be established to leverage this expertise and to foster an ecosystem around HPC for energy. EoCoE will give birth to new collaborations and working methods and will encourage widely spread best practices.

8.3.1.2. PRACE 5IP

Title: PRACE Fifth Implementation Phase (PRACE-5IP) project

Duration: January 2017 - April 2019

Partners: see the following url

Inria contact: Stéphane Lanteri

The mission of PRACE (Partnership for Advanced Computing in Europe) is to enable high-impact scientific discovery and engineering research and development across all disciplines to enhance European competitiveness for the benefit of society. PRACE seeks to realise this mission by offering world class computing and data management resources and services through a peer review process. PRACE also seeks to strengthen the European users of HPC in industry through various initiatives. PRACE has a strong interest in improving energy efficiency of computing systems and reducing their environmental impact.

The objectives of PRACE-5IP are to build on and seamlessly continue the successes of PRACE and start new innovative and collaborative activities proposed by the consortium. These include:

- assisting the transition to PRACE2 including ananalysis of TransNational Access;
- strengthening the internationally recognised PRACE brand;
- continuing and extend advanced training which so far provided more than 18 800 person-training days;
- preparing strategies and best practices towards Exascale computing;
- coordinating and enhancing the operation of the multi-tier HPC systems and services;
- supporting users to exploit massively parallel systems and novel architectures.

8.4. International Initiatives

8.4.1. Inria International Labs

In the framework of the Joint Laboratory for Extreme Scale Computing (JLESC) within a collaboration between Inria and Argonne national laboratory an new joint project studies how lossy compression can be monitored by Krylov solvers to significantly reduce the memory footprint when solving very-large sparse

linear systems. The resulting solvers will alleviate the I/O penalty paid when running large calculations using either check-point mechanisms to address resiliency or out-of-core techniques to solve huge problems. For the solution of large linear systems of the form $Ax = b$ where $A \in \mathbb{R}^{n\times n}$, x and $b \in \mathbb{R}^n$, Krylov subspace methods are among the most commonly used iterative solvers; they are further extended to cope with extreme scale computing as one can integrate features such as communication hidden in their variants referred to as pipelined Krylov solvers [7]. On the one hand, the Krylov subspace methods such as GMRES allow some inexactness when computing the orthonormal search basis; more precisely theoretical results [24], [25] show that the matrix-vector product involved in the construction of the new search directions can be more and more inexact when the convergence towards the solution takes place. An inexact scheme of that form writes into a generalized Arnoldi equality

$$[(A + E_1)v_1, \cdots, (A + E_k)v_k] = [v_1, \cdots, v_k, v_{k+1}]\overline{H}_k, \tag{1}$$

where the theory gives a bound on $\|E_k\|$ that depends on the residual norm $\|b - Ax_k\|$ at step k, where x_k is the k^{th} iterate. Such a result has a major interest in applications where the matrix is not formed explicitly, e.g., in the fast mutipole (FMM) or domain decomposition (DDM) methods context, where this allows one to drastically reduce the computational effort.

One the other hand, novel agnostic lossy data compression techniques are studied to reduce the I/O footprint of large applications that have to store snapshots of the calculation, for a posteriori analysis, because they implement out-of-core calculation or for checkpointing data for resilience. Those lossy compression techniques allow for precise control on the error introduced by the compressor to ensure that the stored data are still meaningful for the considered application. In the context of the Krylov method, the basis $V_{k+1} = [v_1, \cdots, v_k, v_{k+1}]$ represents the most demanding data in terms of memory footprint, so that, in a fault-tolerant or out-of-core context, storing it in a lossy form would allow for a tremendous saving.

The objective of this work, developped within the post-doc of N. Schenkels, is to dynamically control the compression error of V_{k+1} to comply with the inexact Krylov theory. The main difficulty is to translate the known theoretical inexactness on E_k into a suited lossy compression mechanism for v_k with loss $\|\delta v_k\|$.

INDES Project-Team

7. Partnerships and Cooperations

7.1. Inria internal funding

7.1.1. IPL SPAI

SPAI (Security Program Analyses for the IoT) is an IPL (Inria Project Lab), with a duration of 4 years, started on April 2018. Members of the Antique, Celtique, Indes,Kairos, and Privatics Inria teams are involved in the SPAI IPL.

SPAI is concerned with the design of program analyses for a multitier language for the Internet of Things (IoT). The programming abstractions will allow us to reason about IoT systems from microcontrollers to the cloud. Relying on the Inria multitier language Hop.js semantics and the current Coq formalizations of JavaScript semantics, we plan to certify these analyses in order to guarantee the impossibility of security properties violations and implement security properties' enforcements by compilation.

Tamara Rezk coordinates this project.

7.1.2. ADT FingerKit

In the context of the Inria ADT call, we are involved in a *FingerKit: a Cloud Platform to Study Browser Fingerprints at Large*, lead by Walter Rudametkin from the Spirals project-team. The funding for a two year engineering position for the 2018-2020 period was obtained and an engineer is hired in Spirals project-team. Nataliia Bielova from INDES team is part of this project.

7.2. National Initiatives

7.2.1. ANR AJACS

The AJACS project (Analyses of JavaScript Applications: Certification & Security) is funded by the ANR for 42 months, starting December 2014. The goal of the AJACS project is to provide strong security and privacy guarantees on the client side for web application scripts. The Indes members Tamara Rezk and Nataliia Bielova are involved in the tasks WP2 Certified Analyses and WP3 Security of JavaScript Applications. The partners of this project include Inria teams Celtique (coordinator), Toccata, and Prosecco.

7.2.2. ANR CISC

The CISC project (Certified IoT Secure Compilation) is funded by the ANR for 42 months, starting in April 2018. The goal of the CISC project is to provide strong security and privacy guarantees for IoT applications by means of a language to orchestrate IoT applicatoins from the microcontroller to the cloud. Tamara Rezk coordinates this project, and Manuel Serrano, Ilaria Castellani and Nataliia Bielova participate in the project. The partners of this project are Inria teams Celtique, Indes and Privatics, and Collège de France.

7.2.3. ANR PrivaWeb

The PrivaWeb project (Privacy Protection and ePrivacy Compliance for Web Users) is funded by the ANR JCJC program for 42 months, starting in December 2018. PrivaWeb aims at developing new methods for detection of new Web tracking technologies and new tools to integrate in existing Web applications that seamlessly protect privacy of users. Nataliia Bielova coordinates this project.

7.2.4. FUI UCF

The 3 years long UCF project aims at developing a reactive Web platforms for delivering multimedia contents. The partners of the project are the startups Alterway, OCamlPro, and XWiki, and the academic research laboratories of University Pierre et Marie Curie, and Denis Diderot. Manuel Serrano participates in this project.

7.3. European Initiatives

7.3.1. Collaborations in European Programs, Except FP7 & H2020

7.3.1.1. ICT Cost Action IC1405 on Reversible Computation

Program: ICT COST Action IC1405

Project title: Reversible computation - extending horizons of computing

Duration: November 2014 - April 2019

Coordinator: Irek Ulidowski, University of Leicester

Other partners: several research groups, belonging to 23 European countries.

Abstract: Reversible computation is an emerging paradigm that extends the standard mode of computation with the ability to execute in reverse. It aims to deliver novel computing devices and software, and to enhance traditional systems. The potential benefits include the design of reversible logic gates and circuits - leading to low-power computing and innovative hardware for green ICT, new conceptual frameworks and language abstractions, and software tools for reliable and recovery-oriented distributed systems. This is the first European network of excellence aimed at coordinating research on reversible computation.

7.3.1.2. Bilateral PICS project SuCCeSS

Program: CNRS Bilaterial PICS project

Project acronym: SuCCeSS

Project title: Security, Adaptability and time in Communication Centric Software Systems

Duration: June 2016 - June 2019

Coordinator: Cinzia Di Giusto, I3S, Sophia Antipolis

Partners: I3S, Inria, University of Groningen

Abstract: The project SuCCeSS is a CNRS-funded “Projet coopératif” (PICS 07313), involving two French teams in Sophia Antipolis (the MDSC team at the laboratory I3S, acting as coordinator, and the INDES team) and one Dutch team at the University of Groningen. The project started in June 2016 and is due to end in June 2019. The objective of the project is to study formal models for reliable distributed communication-centric software systems. The project focusses on analysis and validation techniques based on behavioural types, aimed at enforcing various properties (safety, liveness, security) of structured communications.

7.4. International Initiatives

7.4.1. Inria International Partners

7.4.1.1. Informal International Partners

- We are initiating a new collaboration with Prof. Robby Findler and his group from Northwestern University of Chicago. We are studying reactive synchronous programming languages and their applications.
- We are pursuing our collaboration on session types with Prof. Mariangiola Dezani Ciancaglini from the University of Torino and Prof. Paola Giannini from the University of Piemonte Orientale. We also continue to collaborate with Dr. Jorge Pérez and his PhD student Mauricio Cano, from the University of Groningen, on the integration of session types with synchronous reactive programming.
- We are initiating a new collaboration with Professor of Law, Frederik Zuiderveen Borgesius from the Radbound University Nijmegen and Amsterdam Law School (double affiliation). We are studying General Data Protection Regulation (GDPR) and ePrivacy Regulation and their application to Web tracking technologies.

- We have been collaborating with Prof. Alejandro Russo from Chalmers University of Technology and Prof. Cormac Flanagan from University of California Santa Cruz, that resulted in a joint publication at WWW conference [15].
- We have been collaborating with Prof. Benoit Baudry from KTH Royal Institute of Technology, Sweden on the survey of browser fingerprinting technologies.

7.4.2. Participation in Other International Programs

7.4.2.1. International Initiatives

DAJA

Title: Detection strategies based on Software Metrics for Multitier JavaScript

International Partners (Institution - Laboratory - Researcher):

Universidad de Chile (Chile), DDC Alexandre Bergel

Universidad Nacional del Centro de la Provincia de Buenos Aires (Argentina) - ISISTAN Research Insitute - Santiago Vidal

Duration: 2018 - 2019

Start year: 2018

See also: https://daja-sticamsud.github.io/

JavaScript is the most popular object scripting programming language. It is extensively used conceived only for scripting, it is frequently used in large applications. The rapid adoption of JavaScript has outpaced the Software Engineering community to propose solutions to ensure a satisfactory code quality production. This situation has favored the production of poor quality JavaScript applications: we have found across JavaScript applications a large presence of dead-code (i.e., source code portion that is never used) and code duplications. These symptoms are known to lead to maintenance and performance degradation. Moreover, we have previously analyzed potential security threats to JavaScript applications produced by bad coding practices.

The DAJA project will provide methodologies, techniques, and tools to ease the maintenance of software applications written in JavaScript while improving its security.

7.5. International Research Visitors

7.5.1. Visits of International Scientists

- We are collaborating with Prof. Marc Feeley from University of Montréal. For the second consecutive year, M. Feeley has visited us for studying implementation of dynamic languages.
- As part of our ongoing collaboration on session types, Prof. Paola Giannini from the University of Piemonte Orientale visited our team for two weeks, funded by the COST Action on Reversibility.
- Our team, together with Cinzia Di Giusto's team at I3S, hosted Mauricio Cano, a PhD student from the University of Groningen, for a 2-month visit. This was part of our collaboration with the University of Groningen within the project PICS SuCCeSS. The visit was funded for the most part by Academy 1 of Université Côte d'Azur.

7.5.1.1. Internships

- Tamara Rezk supervised the intern Sadry Fievet for 6 months
- Tamara Rezk supervised - as "tuteur" - the internship of El Mehdi Regragui for 6 months
- Bertrand Petit and Manuel Serrano supervised the internship of Thibaud Ardoin who studied and implemented the Skini distributed sequencer.

INFINE-POST Team

7. Partnerships and Cooperations

7.1. National Initiatives

7.1.1. Equipex FIT:

Participants: Cedric Adjih, Emmanuel Baccelli, Alexandre Abadie [SED - Inria], Ichrak Amdouni [Ecole Nationale d'Ingénieurs de Sousse & CRISTAL].

Partners: Inria (Lille, Sophia-Antipolis, Grenoble), INSA, UPMC, Institut Telecom Paris, Institut Télécom Evry, LSIIT Strasbourg.

FIT (Future Internet of Things) aims to develop an experimental facility, a federated and competitive infrastructure with international visibility and a broad panel of customers. It provides this facility with a set of complementary components that enable experimentation on innovative services for academic and industrial users. The project gives french internet stakeholders a means to experiment on mobile wireless communications at the network and application layers thereby accelerating the design of advanced networking technologies for the future internet. FIT was one of 52 winning projects from the first wave of the French Ministry of Higher Education and Research's "Équipements d'Excellence" (Equipex) research grant program, in 2011.

One component of the FIT platform is the sets of IoT-LAB testbeds (see the IoT-LAB web site). These were motivated by the observation that the world is moving towards an "Internet of Things", in which most communication over networks will be between objects rather than people.

The Infine team is more specifically managing the FIT IoT-LAB site formerly at Rocquencourt, which recently moved to Saclay (on-going re-deployment), and is participating in the deployment of an additional IoT-lab testbed in Berlin (at Freie Universitaet Berlin).

7.1.2. ANR

The team has submitted three PRC ANR projects: two projects for the CE25, i.e., on "Réseaux de communication multi-usages, infrastructures de hautes performances, sciences et technologies logicielles" and one for the CE35, i.e., on "Révolution numérique : rapports au savoir et à la culture".

7.2. European Initiatives

7.2.1. H2020 Projects

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7.2.2. AGILE (H2020 project)

Participants: Emmanuel Baccelli, Cedric Adjih.

Program: H2020 ICT-30-2015 Topic: Internet of Things and Platforms for Connected Smart Objects

Project acronym: AGILE

Project title: Adoptive Gateways for dIverse muLtiple Environments

Duration: 2015-2018

Coordinator: Emmanuel Baccelli

Other partners: Canonical (UK), Eclipse IoT Foundation (IE), Mobistar (BE), Libelium (ES), Startupbootcamp IoT (SP), CREATE-NET (IT), iMinds (BE), Atos (SP), Rulemotion (UK), Jolocom (DE), Passau University (DE), Sky-Watch (DN), BioAssist (GR), Graz Technical University (AT), Eurotech (IT), IoTango (US).

Abstract: The AGILE project is a 3-year H2020 project started in January 2016, which will deliver an integrated framework of open source tools and platforms that interoperate for enabling the delivery of adaptive, self-configurable and secure IoT elements (both software and hardware) that can be utilized in a variety of scenarios. Such tools target actors with heterogeneous skills, including entrepreneurs, researchers, and individuals, aiming to enable the realization of IoT applications respecting user privacy and data ownership.

7.3. International Initiatives

7.3.1. Inria Associate Teams Not Involved in an Inria International Labs

7.3.1.1. EMBRACE

Title: Leveraging Human Behavior and Uncertainty in 5G Networks to Build Robust Resource Allocation and Services Orchestration Models

International Partners (Institution - Laboratory - Researcher):

UTFPR (Brazil) - Departamento Acadêmico de Informática (DAINF) Curso de Pós-Graduação em Engenharia Elétrica e Informática Industrial (CPGEI) - Anelise Munaretto

UFG (Brazil) - Institute of Computational Mathematics and Scientific / Engineering Computing - Kleber Vieira Cardoso

UFMG (Brazil) - Dpt of Statistics - Antonio A. F. Loureiro

Start year: 2017

See also: https://team.inria.fr/embrace/

Abstract: EMBRACE propose une architecture novatrice pour gérer des ressources et des services opérationnels hétérogènes. EMBRACE se concentre sur les défis scientifiques liés des ensembles de données collectées dans le monde réel et décrivant le comportement du réseau des utilisateurs. En particulier, EMBRACE exploite la modélisation du comportement humain en termes de mobilité, de demande de contenu, d'intérêts communs et des interactions entre-utisateurs. En construisant des modèles d'allocation les ressources tenant compte de l'utilisateur, EMBRACE a pour objectif de diminuer l'incertitude et mieux cerner les profils humains dans les réseaux 5G. La communication D2D sera également utilisée comme service opérationnel pour gérer la croissance du trafic mobile en libérant des ressources des réseaux cellulaires, sans augmenter les coûts. La nouveauté de l'architecture réside dans les algorithmes conçus qui exploiteront les caractérisations tirés de l'analyse du comportement des utilisateurs, l'hétérogénéité du réseau, et de l'incertitude. L'évaluation par simulation et l'émulation sera également l'un des thèmes clés. Enfin, les équipes concernées (Inria Infine, UFMG, UFG, UTFPR) ont un long historique de coopération sur ces thèmes.

7.3.2. Inria International Partners

7.3.2.1. Declared Inria International Partners

1. Renewed IOTPUSH collaboration with Freie Universitaet Berlin around the long-term stay of Emmanuel Baccelli in Berlin, on research topics about the Internet of Things, RIOT and Information-Centric Networking.

7.3.2.2. Informal International Partners

1. On-going collaboration with Freie Universitaet Berlin and Hamburg University of Applied Science around RIOT.
2. Informal collaborations with UIUC and UMass.
3. Informal collaborations with ENSI Tunis and Sesame Tunis.
4. On-going strong collaboration with Sapienza University of Rome, Italy.
5. On-going strong collaboration with CNR Torino, Italy.

6. On-going collaboration with University of Porto, Portugal.
7. On-going collaboration with ENSAE/CNRS, France.
8. On-going collaboration with University of Edinburgh, UK.
9. On-going collaboration with Boston University, US.

7.3.3. Participation in Other International Programs

7.3.3.1. Indo-French project

The Inria teams Infine and Eva are part of the "D2D Communication for LTE Advanced Cellular Network" , a project funded by the Indo-French Centre for the Promotion of Advanced Research (CEFIPRA). With industrial partners, and also with Indian partners, this project is focusing on the evolution of cellular networks towards 5G: this includes exploration of device-to-device (D2D) communication, and more generally IoT communication in a cellular context. Research directions include efficient access for IoT devices (massive numbers of devices with low volume communication); combination of random access protocols/error coding/physical layer ; efficient neighbor discovery, ...

7.3.3.2. STIC AmSud MOTIf 2017

Participant: Aline Carneiro Viana.

Program: STIC AmSud

Project title: Mobile phone sensing of human dynamics in techno-social environment

Duration: 2017-2019

Coordinators: Marton Karsai (ENS/Inria) and Jussara M. Almeida (UFMG) and Alejo Salles (Univ. of Buenos Aires)

Abstract: Information and Communication Technology (ICT) is becoming increasingly social, as demonstrated by the multitude of emerging technologies and technology platforms that facilitate social interactions, taking place as communication via telephone, text message, email, online social networks etc. At the same time, our social activities are increasingly embedded in the ICT environments that enable and enhance our ability to transact, share experiences, and maintain social relationships. One of the best ways to explore these developments is through the mining and analysis of data, which are collected through mobile phones and allow us to investigate how individuals act when embedded in a technology-enabled environment. The MOTIf project builds on the analysis and modeling of geo-localized temporally detailed but fully anonymised mobile phone call networks. These datasets allow us to address the two scientific objectives about spatiotemporal patterns of service usage of anonymised individuals to learn when, where, and what people are doing; and about the fine-grained sociodemographic structure of society and its effect on the the individual social behaviour. In other words our goal in general is to understand how individuals behave in a dynamic techno-social environment.

7.4. International Research Visitors

7.4.1. Visits of International Scientists

Prof. Antonio F. Loureiro is a Visiting Researcher at Infine for 3 months, under the *DigiCosme Visiting Professor* funding. He worked with Aline C. Viana and the internship Joao Batista Borges on the inference of motifs from daily human mobility. He is also the Brazilian coordinator of the EMBRACE Inria associate team. He will give a series of lectures on *"What can a mobility trace tell us?"*.

7.4.1.1. Internships

Joao Batista Borges visited us for 2 weeks on October 2018 and will return on January 2019. The visits enter in the context of EMBRACE associated team. He work with Aline C. Viana and Antonio Loureiro on the extraction of motifs of mobility patterns of individuals that, when merged together, describe their daily motion and can be used to enhance mobility prediction.

Diego Madariaga Roman did an internship of 3 months at our team (Sep-Nov 2018). He work with Aline C. Viana, Marco Fiore and Panagiota Katsikouli on adaptive sampling frequency of human mobility.
Lucas Santos did an internship of 5 months at our team (May-Nov 2018), in the context of EMBRACE associated team. He work with Aline C. Viana and Pedro Olmo on the investigation of causalities in habits of human visits.

7.4.2. Visits to International Teams

7.4.2.1. Research Stays Abroad

Emmanuel Baccelli is Visiting Professor at Freie Universitaet (FU) Berlin, within the context of the formal collaboration IOTPUSH with this university on research topics about the Internet of Things, RIOT and Information-Centric Networking.

KERDATA Project-Team

7. Partnerships and Cooperations

7.1. National Initiatives

7.1.1. ANR

7.1.1.1. OverFlow (2015–2019)

Participants: Alexandru Costan, Pedro Silva, Paul Le Noac'h.

Project Acronym: OverFlow.

Project Title: Workflow Data Management as a Service for Multisite Applications.

Coordinator: Alexandru Costan.

Duration: Octobre 2015–October 2019.

Other Partners: None (Young Researcher Project).

External collaborators: Kate Keahey (University of Chicago and Argonne National Laboratory), Bogdan Nicolae (Argonne National Lab).

Abstract: This JCJC project led by Alexandru Costan investigates approaches to data management enabling an efficient execution of geographically distributed workflows running on multi-site clouds.

In 2018, we focused on the challenges of executing workflows on hybrid environments combining the Cloud and the Edge. First, processing live data sources at the Edge can offer a potential solution that deals with the explosion of data sizes, as the data is filtered and aggregated locally, before it gets a chance to accumulate. Then, partial results instead of full data are sent to the Cloud for stream processing. In this context, we designed Planner, a middleware for uniform and transparent stream processing across Edge and Cloud. Planner automatically selects which parts of the execution graph will be executed at the Edge in order to minimize the network cost. We also focused on understanding the conditions that enable the usage of Edge or Cloud to improve the performance or reduce costs of an application.

7.1.2. Other National Projects

7.1.2.1. HPC-Big Data Inria Project Lab (IPL)

Participants: Gabriel Antoniu, Alexandru Costan, Pedro Silva.

Project Acronym: HPC-BigData

Project Title: The HPC-BigData Inria Project Lab

Coordinator: Bruno Raffin.

Duration: 2018–2022.

Abstract: The goal of this HPC-BigData IPL is to gather teams from the HPC, Big Data and Machine Learning (ML) areas to work at the intersection between these domains. Research is organized along three main axes: high performance analytics for scientific computing applications, high performance analytics for big data applications, infrastructure and resource management. Gabriel Antoniu is a member of the Advisory Board and leader of the Frameworks work package.

7.1.2.2. ADT Damaris

Participants: Hadi Salimi, Gabriel Antoniu, Luc Bougé.

Project Acronym: ADT Damaris

Project Title: Technology development action for te Damaris environment.

Coordinator: Alexandru Costan.

Duration: 2016–2018.

Abstract: This action aims to support the development of the Damaris software. Inria's *Technological Development Office* (D2T, *Direction du Développement Technologique*) provided 2 years of funding support for a senior engineer.

Hadi Salimi has been funded through this project to document, test and extend the Damaris software and make it a safely distributable product.

In 2018, the main goal was to enforce the support Damaris provides for HDF5 storage.

7.1.2.3. Grid'5000

We are members of Grid'5000 community and run experiments on the Grid'5000 platform on a daily basis.

7.2. European Initiatives

7.2.1. FP7 and H2020 Projects

7.2.1.1. BigStorage

Title: BigStorage: Storage-based Convergence between HPC and Cloud to handle Big Data.

Programme: H2020 ETN.

Duration: January 2015–December 2018.

Coordinator: Universidad Politecnica de Madrid (UPM).

Partners:

- Barcelona Supercomputing Center — Centro Nacional de Supercomputacion (Spain)
- CA Technologies Development Spain (Spain)
- CEA — Commissariat à l'énergie atomique et aux énergies alternatives (France)
- Deutsches Klimarechenzentrum (Germany)
- Foundation for Research and Technology Hellas (Greece)
- Fujitsu Technology Solutions (Germany)
- Johannes Gutenberg Universitaet Mainz (Germany)
- Universidad Politecnica de Madrid (Spain)
- Seagate Systems UK (United Kingdom)

Inria contact: Gabriel Antoniu and Adrien Lèbre.

URL: http://www.bigstorage-project.eu/.

Description: BigStorage is a European Training Network (ETN) whose main goal is to train future *data scientists*. It aims at enabling them and us to apply holistic and interdisciplinary approaches to take advantage of a data-overwhelmed world. This world requires *HPC* and *Cloud* infrastructures with a redefinition of *storage* architectures underpinning them — focusing on meeting highly ambitious performance and *energy* usage objectives. The KerData team has hosted 2 *Early Stage Researchers* in this framework and has co-advised an extra PhD student.

7.2.2. Collaborations with Major European Organizations

7.2.2.1. BDVA and ETP4HPC

Gabriel Antoniu and Alexandru Costan are serving as Inria representatives in the working groups dedicated to *HPC-Big Data* convergence within the Big Data Value Association (BDVA) and the European Technology Platform in the area of High-Performance Computing (ETP4HPC). They are contributing to the definition of the respective Strategic Research Agendas of BDVA and ETP4HPC. A special focus this year of their contributions was the Joint BDVA-ETP4HPC report on technology convergence.

7.3. International Initiatives

7.3.1. Inria International Labs

7.3.1.1. JLESC: Joint Laboratory for Extreme Scale Computing

The Joint Laboratory on Extreme-Scale Computing is jointly run by Inria, UIUC, ANL, BSC, JSC and RIKEN/AICS. It has been created in 2014 as a follow-up of the Inria-UIUC JLPC, the *Joint Laboratory for Petascale Computing*.

The KerData team is collaborating with teams from ANL and UIUC within this lab since 2009 on several topics in the areas of I/O, storage and in situ processing and cloud computing. This collaboration has been initially formalized as the *Data@Exascale* Associate Team with ANL and UIUC (2013–2015) followed by *Data@Exascale 2* Associate Team with ANL (2016–2018). Our activities in this framework are described here: http://www.irisa.fr/kerdata/data-at-exascale/

Since 2015, Gabriel Antoniu serves as a topic leader for Inria for the *I/O, Storage and In Situ Processing* topic. Ongoing lab research directions and projects he is co-supervising in this area are described here: https://jlesc.github.io/projects/ in the *I/O, Storage and In-Situ Processing* section.

Since 2017, Gabriel Antoniu is serving as *Vice-Executive Director* of JLESC for Inria.

7.3.1.2. Associate Team involved in the JLESC International Lab: Data@Exascale 2

Title: Convergent Data Storage and Processing Approaches for Exascale Computing and Big Data Analytics

Partner: Argonne National Laboratory (United States), Department of Mathematics, Symbolic Computation Group, Robert Ross

Web site: http://www.irisa.fr/kerdata/data-at-exascale/

Start year: 2016

In the past few years, countries including United States, the European Union, Japan and China have set up aggressive plans to get closer to what appears to be the next goal in terms of high-performance computing (HPC): Exascale computing, a target which is now considered reachable by the next-generation supercomputers in 2020–2023. While these government-led initiatives have naturally focused on the big challenges of exascale for the development of new hardware and software architectures, the quite recent emergence of the Big Data phenomenon introduces what could be called a tectonic shift that is impacting the entire research landscape for exascale computing. As data generation capabilities in most science domains are now growing substantially faster than computational capabilities, causing these domains to become data-intensive, new challenges appeared in terms of volumes and velocity for data to be stored, processed and analyzed on the future exascale machines.

To face the challenges generated by the exponential data growth (a general phenomenon in many fields), a certain progress has already been made in the recent years in the rapidly-developing, industry-led field of cloud-based Big Data analytics, where advanced tools emerged, relying on machine-learning techniques and predictive analytics. Unfortunately, these advances cannot be immediately applied to exascale computing: the tools and cultures of the two worlds, HPC (High-Performance Computing) and BDA (Big Data Analytics) have developed in a divergent fashion (in terms of major focus and technical approaches), to the detriment of both. The two worlds share however multiple similar challenges and unification now appears as essential in order to address the future challenges of major application domains that can benefit from both.

The scientific program of the *Data@Exascale 2* Associate Team is defined from this new, highly-strategic perspective and builds on the idea that the design of innovative approaches to data I/O, storage and processing allowing Big Data analytics techniques and the newest HPC architectures to leverage each other clearly appears as a key catalyst factor for the convergence process.

Activities in 2018 are described on the web site of the Associate Team.

7.3.2. Inria International Partners

7.3.2.1. DataCloud@Work

Title: DataCloud@Work.

International Partner:

- Polytechnic University of Bucharest (Romania), Computer Science Department, Nicolae Tapus and Valentin Cristea.

Duration: 5 years.

Start year: 2013. The status of IIP was established right after the end of our former *DataCloud@work* Associate Team (2010–2012).

URL: https://www.irisa.fr/kerdata/doku.php?id=cloud_at_work:start.

Description: Our research topics address the area of distributed data management for cloud services, focusing on autonomic storage. The goal is explore how to build an efficient, secure and reliable storage IaaS for data-intensive distributed applications running in cloud environments by enabling an autonomic behavior.

7.3.2.2. Informal International Partners

Instituto Politécnico Nacional, IPN, Ciudad de México: We continued our informal collaboration in the area of stream processing.

7.3.3. Participation in Other International Programs

7.3.3.1. International Initiatives

7.3.3.1.1. BDEC: Big Data and Extreme Computing

Since 2015, Gabriel Antoniu has been invited to participate to the yearly workshops of the international Big Data and Extreme-scale Computing (BDEC) working group focused on the convergence of Extreme Computing (the latest incarnation of High-Performance Computing - HPC) and Big Data. BDEC is organized as an yearly series of invitation-based international workshops.

In 2018 Gabriel Antoniu was invited again to contribute to the first workshop of the BDEC2 series, where he presented a white paper on HPC-Big Data convergence at the level of data processing.

7.4. International Research Visitors

7.4.1. Visits of International Scientists

Rob Ross: Argonne National Laboratory, USA

Ryan Stutsman: University of Utah, USA

Tilmann Rabl: TU Berlin/DFKI/Berlinn Big Data Center, Germany

Nicolae Tapus: Politehnica University of Bucharest

7.4.2. Internships

Laurent Prosperi (M1, ENS Cachan) has done a 4-month internship within the team, working with Alexandru Costan and Pedro Silva on hybrid Edge/Cloud stream processing. This work lead to the Planner middleware [26], presented at the WORKS workshop at the IEEE/ACM SC18 conference.

7.4.3. Visits to International Teams

7.4.3.1. Research Stays Abroad

Nathanaël Cheriere has done a 3-month internship at Argonne National Lab, to work on optimizing data migration for efficient distributed storage system rescaling under the supervision of Robert Ross. See Section 5.1 for details.

Yacine Taleb has done a 1-month internship at the University of Utah to work on RDMA replication for in-memory storage systems under the supervision of Ryan Stutsman. See Section 5.1 for details.

Yacine Taleb has done a 3-month internship at Barcelona Supercomputing Center, to work on in-memory storage for Big Data analytics under the supervision of Toni Cortés. See Section 5.1 for details.

MIMOVE Project-Team

9. Partnerships and Cooperations

9.1. National Initiatives

"BottleNet: Understanding and Diagnosing End-to-end Communication Bottlenecks of the Internet", project funded by the French research agency (ANR), from Feb 2016 to Sep 2020.

9.1.1. Inria Support

9.1.1.1. Inria IPL CityLab@Inria

Participants: Valérie Issarny, Bruno Lefèvre.

- **Name:** CityLab@Inria – *Overcoming the Smart City Challenge – Toward Environmental and Social Sustainability*
- **Period:** [January 2014 – November 2018]
- **Inria teams:** CLIME/ANGE, DICE, FUN, MIMOVE, MYRIADS, SMIS/PETRUS, URBANET/AGORA
- **URL:** http://citylab.inria.fr

The Inria Project Lab (IPL) CityLab@Inria studies ICT solutions toward smart cities that promote both social and environmental sustainability. A strong emphasis of the Lab is on the undertaking of a multi-disciplinary research program through the integration of relevant scientific and technology studies, from sensing up to analytics and advanced applications, so as to actually enact the foreseen smart city Systems of Systems. Obviously, running experiments is a central concern of the Lab, so that we are able to confront proposed approaches to actual settings.

9.1.1.2. Inria IPL BetterNet

Participants: Renata Teixeira, Vassilis Christophides, Francesco Bronzino.

- **Name:** BetterNet – *An observatory to measure and improve Internet service access from user experience*
- **Period:** [2016 – 2019]
- **Inria teams:** Diana, Dionysos, Inria Chile, Madynes, MiMove, Spirals
- **URL:** https://project.inria.fr/betternet/

BetterNet aims at building and delivering a scientific and technical collaborative observatory to measure and improve the Internet service access as perceived by users. In this Inria Project Lab, we will propose new original user-centered measurement methods, which will associate social sciences to better understand Internet usage and the quality of services and networks. Our observatory can be defined as a vantage point, where:

1. tools, models and algorithms/heuristics will be provided to collect data,
2. acquired data will be analyzed, and shared appropriately with scientists, stakeholders and civil society,
3. and new value-added services will be proposed to end-users.

9.1.1.3. Inria ADT MOSQUITO

Participants: Renata Teixeira, Francesco Bronzino.

- **Name:** MOSQUITO – *A mobile platform to measure the quality of Internet connectivity*
- **Period:** [November 2016 – October 2018]
- **Partners:** Inria MiMove, Inria SPIRALS.

The ADT MOSQUITO is part of the Inria Project Lab (IPL) initiative BetterNet. This ADT project focuses on the design and the development of a measurement platform for the quality of mobile Internet access by federating the existing mobile platforms identified in the BetterNet IPL. Beyond the priceless value of such a measurement platform for the research community, this ADT also aims to publish live reports on the quality of mobile Internet access through the BetterNet initiative.

9.2. European Initiatives

9.2.1. FP7 & H2020 Projects

9.2.1.1. H2020 ICT FIESTA-IoT

Participants: Valérie Issarny, Nikolaos Georgantas, Rachit Agarwal.

Name: FIESTA-IoT – *Federated Interoperable Semantic IoT/cloud Testbeds and Applications*

URL: http://fiesta-iot.eu

Type: Research & Innovation Action (ICT)

Topic: FIRE+ (Future Internet Research & Experimentation)

Period: [February 2015 - January 2018]

Partners: Fraunhofer FOKUS (Germany) [**coordinator**], INSIGHT @ National University of Galway (Ireland) [**co-coordinator**], University of Southampton IT Innovation Centre (UK), Inria MiMove, University of Surrey (UK), Unparallel Innovation Lda (Portugal), Easy Global Market (France), NEC Europe Ltd (UK), University of Cantabria (Spain), Com4innov (France), Athens Information Technology (Greece), SOCIEDAD PARA EL DESARROLLO REGIONAL DE CANTABRIA (Spain), Ayuntamiento de Santander (Spain), Korea Electronics Technology Institute (Korea).

Despite the proliferation of IoT and smart cities testbeds, there is still no easy way to conduct large scale experiments that leverage data and resources from multiple geographically and administratively distributed IoT platforms. Recent advances in IoT semantic interoperability provide a sound basis for implementing novel cloud-based infrastructures that could allow testbed-agnostic access to IoT data and resources. FIESTA will open new horizons in IoT experimentation at a global scale, based on the interconnection and interoperability of diverse IoT testbeds. FIESTA will produce a first-of-a-kind blueprint experimental infrastructure (tools, techniques and best practices) enabling testbed operators to interconnect their facilities in an interoperable way, while at the same time facilitating researchers in deploying integrated experiments, which seamlessly transcend the boundaries of multiple IoT platforms. FIESTA will be validated and evaluated based on the interconnection of four testbeds (in Spain, UK, France and Korea), as well as based on the execution of novel experiments in the areas of mobile crowd-sensing, IoT applications portability, and dynamic intelligent discovery of IoT resources. In order to achieve global outreach and maximum impact, FIESTA will integrate an additional testbed and experiments from Korea, while it will also collaborate with IoT experts from USA. The participation of a Korean partner (based its own funding) will maximize FIESTA's value for EC money. Moreover, the project will take advantage of open calls processes towards attracting third-parties that will engage in the integration of their platforms within FIESTA or in the conduction of added-value experiments. As part of its sustainability strategy, FIESTA will establish a global market confidence programme for IoT interoperability, which will enable innovative platform providers and solution integrators to ensure/certify the openness and interoperability of their developments.

9.3. International Initiatives

9.3.1. Inria International Labs

Inria@SiliconValley

Associate Team involved in the International Lab:

9.3.1.1. MINES

Title: Adaptive Communication Middleware for Resilient Sensing & Actuation IN Emergency Response Scenarios

International Partner:

University of California, Irvine (United States) - Information and Computer Science - Nalini Venkatasubramanian

Start year: 2018

See also: http://mimove-apps.paris.inria.fr/mines/index.html

Emerging smart-city and smart-community efforts will require a massive deployment of connected entities (Things) to create focused smartspaces. Related applications will enhance citizen quality of life and public safety (e.g., providing safe evacuation routes in fires). However, supporting IoT deployments are heterogeneous and can be volatile and failure-prone as they are often built upon low-powered, mobile and inexpensive devices - the presence of faulty components and intermittent network connectivity, especially in emergency scenarios, tend to deliver inaccurate/delayed information. The MINES associate team addresses the resulting challenge of enabling interoperability and resilience in large-scale IoT systems through the design and development of a dedicated middleware. More specifically, focusing on emergency situations, the MINES middleware will: (i) enable the dynamic composition of IoT systems from any and all available heterogeneous devices; (ii) support the timely and reliable exchange of critical data within and across IoT in the enabled large-scale and dynamic system over heterogeneous networks. Finally, the team will evaluate the proposed solution in the context of emergency response scenario use cases.

9.3.2. Inria Associate Teams Not Involved in an Inria International Lab

9.3.2.1. HOMENET

Title: Home network diagnosis and security

International Partner:

Princeton University (United States) - Computer Science Department - Nick Feamster

Start year: 2017

See also: https://team.inria.fr/homenet/

Modern households connect a multitude of networked devices (ranging from laptops and smartphones to a number of Internet of Things devices) via a home network. Most home networks, however, do not have a technically skilled network administrator for managing the network, for example to identify faulty equipment or take steps to secure end hosts such as applying security patches. Home networks represent a particularly challenging environment due to the diversity of devices, applications, and services users may connect. The goal of HOMENET is to assist users in diagnosing and securing their home networks. Our approach is based on developing new algorithms and mechanisms that will run on the home router (or in-collaboration with the router). The router connects the home network to the rest of the Internet; it is hence the ideal place to secure home devices and to distinguish problems that happen in the home from those happening elsewhere. We will address a number of research challenges for example in device discovery and fingerprinting, anomaly detection in the Internet of Things, home network diagnosis (including wireless diagnosis). HOMENET will bring together two leading research teams in the network measurement arena with successful prior collaboration. Moreover, Princeton brings an existing home router platform and expertise in security, wireless, and software-defined networks; and MiMove brings an existing Web-based measurement platform, and expertise in traffic-based profiling and anomaly detection.

9.3.2.2. ACHOR

Title: Adaptive enactment of service choreographies

International Partner:

Universidade Federal de Goiás (Brazil) - Computer Science Department - Fabio Costa

Start year: 2016

See also: http://www.inf.ufg.br/projects/achor

Service choreographies are distributed compositions of services (e.g., Web services) that coordinate their execution and interactions without centralized control. Due to this decentralized coordination and the ability to compose third-party services, choreographies have shown great potential as an approach to automate the construction of large-scale, on-demand, distributed applications. Technologies to enable this approach are reaching maturity level, such as modeling languages for choreography specification and engines that operate the deployment of services and enactment of choreographies at Future Internet scales. Nevertheless, a number of problems remain open on the way to fully realize the approach, among them: (i) Deployment of multiple choreographies on top of a collection of shared services (considering service sharing as an effective way to increase the utilization of resources); (ii) Dynamic adaptation of functional and non-functional properties due to runtime changes in the environment and user requirements (adapting the set of services and/or the resources used to run the services in order to add/remove/change functions and maintain QoS properties, respectively); and (iii) Seamless and dynamic integration of mobile services (e.g., smartphone apps, sensors and actuators on handhelds and wearables) and cloud- based services (including the need to consider: mobility of both devices and services, resource constraints of mobile devices, temporary disconnection, interoperability between different interaction paradigms (message-passing, event-based, data-sharing) at the middleware layer, and effect of these paradigms on end-to-end QoS). The overall goal of the project is to design an architecture for adaptive middleware to support service choreographies in large-scale scenarios that involve dynamicity and diversity in terms of application requirements, service interaction protocols, and the use of shared local, mobile and cloud resources.

9.3.3. Inria International Partners

9.3.3.1. Informal International Partners

- Northeastern University (Prof. David Choffnes): We are working on methods based on active probing to diagnose poor video quality.

9.4. International Research Visitors

9.4.1. Visits of International Scientists

Mark Crovella from Boston University is visiting professor at Inria.

9.4.2. Visits to International Teams

9.4.2.1. Research Stays Abroad

- Valérie Issarny was visiting scholar at the EECS Department at UC Berkeley till August 2018. She was hosted by CITRIS in the context of which she was carrying out collaborative research in the area of smart cities and acting as scientific coordinator of the Inria@SiliconValley program.
- Renata Teixeira is visiting scholar at the Computer Science department at Stanford University.
- Georgios Bouloukakis is Inria postdoctoral fellow at University of California, Irvine, in the context of the Inria@SiliconValley program.

MYRIADS Project-Team

9. Partnerships and Cooperations

9.1. Regional Initiatives

9.1.1. INDIC - Cybersecurity Pole of Excellence (2014-2020)

Participants: Christine Morin, Louis Rilling, Amir Teshome Wonjiga, Clément Elbaz.

Our study carried out in the framework of a collaboration with DGA-MI aims at defining and enforcing SLA for security monitoring of virtualized information systems. To this aim we study three topics:

- defining relevant SLA terms for security monitoring,
- enforcing and evaluating SLA terms,
- making the SLA terms enforcement mechanisms self-adaptable to cope with the dynamic nature of clouds.

The considered enforcement and evaluation mechanisms should have a minimal impact on performance. The funding from DGA funds the PhD of Anna Giannakou (defended in 2017) and Amir Teshome Wonjiga. Clément Elbaz is partially funded by the Brittany Regional Council in the PEC framework.

9.2. National Initiatives

9.2.1. ADEME RennesGrid

Participants: Anne Blavette, Benjamin Camus, Anne-Cécile Orgerie, Martin Quinson.

The aim of the RennesGrid project is to design and implement a large-scale preindustrial microgrid demonstrator in the territory of Rennes Metropole to organize the shared self-consumption of a group of photovoltaic panels coupled to stationary storage devices. Traditional approaches to power grid management tend to overlook the costs, both energy and economic, of using computers to ensure optimal electricity network management. However, these costs can be significant. It is therefore necessary to take them into account along with the design of IT tools during studies of optimal energy management of smart grids. In addition, telecommunication networks are generally considered to have an ideal functioning, that is to say they can not negatively affect the performance of the electricity network. However, this is not realistic and it is necessary to analyze the impact of phenomena such as congestion, latency, failures related to computer equipment or impact on the batteries of sensors, etc. on strategies for optimal management of the electricity network. In this project, we closely collaborate with Anne Blavette (CR CNRS in electrical engineering, SATIE, Rennes) and co-supervise the post-doc of Benjamin Camus who started in April 2018 on evaluating the impact of the IT infrastructure in the management of smart grids.

9.2.2. Inria ADT SaaP (2016-2018)

Participants: Toufik Boubehziz, Martin Quinson.

The SaaP technological development action (SimGrid As A Platform) funded by INRIA targets the refactoring of SimGrid to make it ready to use in production and teaching contexts. Our ultimate goal is to sustain the development of the framework by involving 5 to 10 companies that are using it internally. Our target of the teaching context is thus an intermediate goal, as we think that the best solution to ensure the adoption of our tool by the industrial engineers is that they discover the tool during their studies.

The technical actions envisioned for this ADT are the complete re-factoring of the software (to make it easier to script a new model within the tool kernel) and a reorganization of the interfaces (for a better integration in the Java and python language). This work is lead by Toufik Boubehziz in collaboration with the whole SimGrid community, which provide valuable feedback.

9.2.3. Inria ADT DiFFuSE (2017-2018)

Participants: Nikos Parlavantzas, Christine Morin, Manh Linh Pham.

The DiFFuSE technological development action (Distributed framework for cloud-based epidemic simulations) funded by INRIA focuses on the DiFFuSE framework developed by Myriads in the context of MIHMES (2012-2017). MIHMES was a 5-year collaborative multidisciplinary project funded by ANR under the Investments for the Future Program, and led by BIOEPAR, INRA, ONIRIS. DiFFuSE is a framework that provides design support, reusable code, and tools for building and executing epidemic simulations in the cloud. The main objectives of this ADT were to improve the usability and robustness of DiFFuSE, to provide support to scientists for applying the framework to a new epidemic simulations as well as to provide a thorough evaluation of the framework using two case studies.

9.2.4. Inria IPL Discovery (2015-2019)

Participants: Ehsan Ahvar, Anne-Cécile Orgerie, Matthieu Simonin, Genc Tato, Cédric Tedeschi.

The Inria IPL Discovery officially started in September 2015. It targets the design, development and deployment of a distributed Cloud infrastructure within the network's backbone. It will be based upon a set of building blocks whose design will take locality as a primary constraint, so as to minimize distant communications and consequently achieve better network traffic, partition management and improved availability.

Its developments are planned to get integrated within the OpenStack framework. Myriads is involved in the design of new overlay networks for such environments so as to support efficient messaging and routing. Myriads is also involved in the energy/cost benefit analysis of distributed edge-cloud architectures.

9.2.5. Inria IPL CityLab (2015-2018)

Participants: Subarna Chatterjee, Christine Morin.

The Inria Project Lab (IPL) CityLab@Inria (http://citylab.inria.fr) studies ICT solutions toward smart cities that promote both social and environmental sustainability. A strong emphasis of the Lab is on the undertaking of a multi-disciplinary research program through the integration of relevant scientific and technology studies, from sensing up to analytics and advanced applications, so as to actually enact the foreseen smart city Systems of Systems. City-scale experiments of the proposed platforms and services are planned in cities in California and France, thereby learning lessons from diverse setups.

Myriads investigates advanced cloud solutions for the Future Internet, which are critical for the processing of urban data. It leverages its experience in cloud computing and Internet of services while expanding its research activities to the design and implementation of cloud services to support crowd-Xing applications and mobile social applications.

In 2017, Christine Morin was involved in the preparation of a SPOC entitled "Technological challenges of participatory smart cities", which is proposed in the framework of the EIT Digital professional school. She prepared seven sequences on cloud-based urban data management. This SPOC is the English version of the MOOC entitled *"Défis technologiques des villes intelligentes participatives"* run on the FUN platform in Spring and Fall 2017.

In 2017, we also conducted a comparative experimental evaluation of data stream processing environments executed on clusters and clouds. We compared the performance and energy consumption of Heron, Storm and Flink frameworks with three data streaming representative applications.

9.2.6. Inria IPL Hac Specis (2016-2020)

Participants: Anne-Cécile Orgerie, Martin Quinson, The Anh Pham.

The goal of the HAC SPECIS (High-performance Application and Computers: Studying PErformance and Correctness In Simulation) project (http://hacspecis.gforge.inria.fr/) is to answer methodological needs of HPC application and runtime developers and to allow to study real HPC systems both from the correctness and performance point of view. To this end, we gather experts from the HPC, formal verification and performance evaluation community.

During his second year of PhD thesis, The Anh Pham proposed a new algorithm to mitigate the state space explosion problem, using event folding structures to efficiently compute how to not explore equivalent execution traces more than once. This work, co-advised by Martin Quinson with Thierry Jéron (team SUMO, formal methods), was important to bridge the gap between the involved communities. The work will be submitted in the near future.

During her first year of PhD thesis, Dorra Boughzala studied the energy consumption of GPU and the simulation tools of the literature related to this aspect. Her work is co-advised by Laurent Lefèvre (Avalon team, Lyon), Martin Quinson and Anne-Cécile Orgerie.

9.2.7. COSMIC PRE (2016 - 2018)

Participants: Benjamin Camus, Anne-Cécile Orgerie, Martin Quinson.

The distributed nature of Cloud infrastructures involves that their components are spread across wide areas, interconnected through different networks, and powered by diverse energy sources and providers, making overall energy monitoring and optimization challenging. The COSMIC project aims at taking advantage of the opportunity brought by the Smart Grids to exploit renewable energy availability and to optimize energy management in distributed Clouds. This PRE, led by Anne-Cécile Orgerie also involves Fanny Dufossé from Datamove team (Inria Grenoble), Anne Blavette from SATIE laboratory (electrical engineering, Rennes), and Benjamin Camus, who finished a 18 months post-doc in March 2018 in the context of this project. Several paper on this project have been presented this year: ACM SIGSIM PADS 2018 [16], SBAC-PAD 2018 [15], IEEE Cluster 2018 [14], IEEE PES ISGT 2018 [37], and one book chapter [38].

9.2.8. SESAME ASTRID project (2016-2019)

Participants: Pascal Morillon, Christine Morin, Matthieu Simonin, Cédric Tedeschi, Mehdi Belkhiria.

The Sesame project (http://www.agence-nationale-recherche.fr/Project-ANR-16-ASTR-0026) led by IMT Atlantique aims at develop efficient infrastructures and tools for the maritime traffic surveillance. The role of Myriads is to define a robust and scalable infrastructure for the real-time and batch processing of vessel tracking information.

In 2018, we investigated the dynamic, decentralized scaling of stream processing applications. Also, we collaborated with the Inria OBELIX team to scale and deploy a machine learning application they developed to build a model of a *normal* vessel trajectory.

9.2.9. PIA ELCI (2015-2018)

Participant: Anne-Cécile Orgerie.

The PIA ELCI project deals with software environment for computation-intensive applications. It is leaded by BULL. In the context of this project, we collaborate with ROMA and Avalon teams from Lyon: we co-supervise a PhD student (Issam Rais) funded by this project on multi-criteria scheduling for large-scale HPC environments. Issam successfully defended his PhD in September 2018. This collaboration has led to two publications in 2017: two journal articles published in IJHPCA [3] and CCPE [11] and two conference papers presented at HPCS [26] and ICA3PP [27].

9.2.10. CNRS GDS EcoInfo

Participant: Anne-Cécile Orgerie.

The EcoInfo group deals with reducing environmental and societal impacts of Information and Communications Technologies from hardware to software aspects. This group aims at providing critical studies, lifecycle analyses and best practices in order to improve the energy efficiency of printers, servers, data centers, and any ICT equipment in use in public research organizations.

9.3. European Initiatives

9.3.1. FP7 & H2020 Projects

9.3.1.1. FogGuru

Participant: Guillaume Pierre.

Title: MSCA ITN EID

Program: H2020

Duration: September 2017 - August 2021

Coordinator: Guillaume Pierre

Participants:

University of Rennes 1, France (coordinator)

Technisch Universität Berlin, Germany

Elastisys AB, Sweden

U-Hopper srl, Italy

EIT Digital Rennes, France

Las Naves, Spain

FogGuru is a doctoral training project which aims to to train eight talented PhD students with an innovative and inter-sectoral research program to constitute the next generation of European Cloud and Fog computing experts. Besides their scientific and technical education, FogGuru's PhD students will receive extensive training in technological innovation and entrepreneurship as well as soft skills. These combined skills will enable them to fully master the innovation process stemming from fundamental research towards invention and development of innovative products and services, and to real-life deployment, experimentation and engagement with beta-testers.

9.3.2. Collaborations in European Programs, Except FP7 & H2020

Program: EIT Digital

Project acronym: DriveTrust

Project title: AI-Powered Driving Evaluation

Duration: January 2019 - December 2019

Coordinator: University of Rennes 1

Other partners:

Eurapco, Switzerland

Achmea, the Netherlands

Imec, Belgium

Abstract: This project aims to develop and commercialize an AI-powered dash cam with short range V2X and LTE communication capabilities. The product uses the newest AI capable hardware for real-time object detection. The device can detect street signs, traffic lights, other cars, and pedestrians. Combined with sensor data from the accelerometer, GPS and weather data from the cloud we use the data to calculate different dimensions of driving profiles. In addition the V2X and object detection capabilities allow us to warn the driver in real-time about dangers on the road.

9.3.2.1. NESUS

Participant: Anne-Cécile Orgerie.

Program: ICT COST

Project acronym: NESUS

Project title: Network for Sustainable Ultrascale Computing (ICT COST Action IC1305)

Duration: 2014 - 2018

Coordinator: Prof. Jesus Carretero, University Carlos III of Madrid, Spain, http://www.nesus.eu

Other partners: 33 COST countries and 11 non-COST countries

Abstract: Ultrascale systems are envisioned as large-scale complex systems joining parallel and distributed computing systems that will be two to three orders of magnitude larger that today's systems. The EU is already funding large scale computing systems research, but it is not coordinated across researchers, leading to duplications and inefficiencies. The goal of the NESUS Action is to establish an open European research network targeting sustainable solutions for ultrascale computing aiming at cross fertilization among HPC, large scale distributed systems, and big data management. The network will contribute to gluing disparate researchers working across different areas and provide a meeting ground for researchers in these separate areas to exchange ideas, to identify synergies, and to pursue common activities in research topics such as sustainable software solutions (applications and system software stack), data management, energy efficiency, and resilience. Some of the most active research groups of the world in this area are members of this proposal. This Action will increase the value of these groups at the European-level by reducing duplication of efforts and providing a more holistic view to all researchers, it will promote the leadership of Europe, and it will increase their impact on science, economy, and society. Anne-Cécile Orgerie is co-responsible of the focus group on metrics, monitoring, instrumentation and profiling in the Working Group 5 on Energy Efficiency. A joint paper has been accepted in 2018 on this topic at the Elsevier journal on Sustainable Computing [2]. In the context of this COST action, we closely collaborate with Pascal Felber's research group from University of Neuchâtel (Switzerland) on energy efficiency in Clouds and in particular on the design of energy cost models for virtual machines. A joint journal paper has been accepted in 2018 for publication in Sustainable Computing: Informatics and Systems, Elsevier [9].

9.4. International Initiatives

9.4.1. Inria International Labs

Inria@SiliconValley

Associate Team involved in the International Lab:

9.4.1.1. DALHIS

Title: Data Analysis on Large Heterogeneous Infrastructures for Science

International Partner (Institution - Laboratory - Researcher):

Lawrence Berkeley National Laboratory (United States) - Data Science and Technology department - Deb Agarwal

Start year: 2016

See also: https://project.inria.fr/dalhis/

Data produced by scientific instruments (large facilities like telescopes or field data), large-scale experiments, and high-fidelity simulations are increasing in magnitude and complexity. Existing data analysis methods, tools and infrastructure are often difficult to use and unable to provide the complete data management, collaboration, and curation environment needed to manage these complex, dynamic, and large-scale data analysis environments. The goal of the Inria-LBL DALHIS associate team involving the Myriads (PI) and Avalon Inria project-teams and the Data Science and Technology (DST) department at Lawrence Berkeley National Laboratory (LBL) is to create a collaborative distributed software ecosystem to manage data lifecycle and enable data analytics on distributed data sets and resources. Specifically, our goal is to build a dynamic software stack that is user-friendly, scalable, energy-efficient and fault tolerant. Our research determines appropriate execution environments that allow users to seamlessly execute their end-to-end dynamic data analysis workflows in various resource environments and scales while meeting energy-efficiency,

performance and fault tolerance goals. We engage in deep partnerships with scientific teams (Fluxnet in environmental science and SNFactory and LSST experiences in cosmology) and use a mix of user research with system software R&D to address specific challenges that these communities face. This associate team ended in 2018.

9.4.2. Inria Associate Teams Not Involved in an Inria International Labs

9.4.2.1. FogCity

Title: QoS-aware Resource Management for Smart Cities

International Partner (Institution - Laboratory - Researcher):

IITKGP (India) - Department of Computer Science and Engineering - Sudip Misra

Start year: 2018

See also: https://www.inria.fr/en/associate-team/fogcity

The FogCity associate team proposal concerns a collaboration between the Myriads project-team and a research team at Indian Institute of Technology Kharagpur led by Dr. Sudip Misra. The proposal focuses on a smart city scenario in which data from static and mobile sensors is routed to appropriate fog data centres based on application QoS requirements. The main goal of the research is to select suitable nodes within the fog data centers to optimize the QoS of the applications in terms of latency. The two teams have complementary expertise in theoretical research (Indian partner) and system research (Inria Myriads project-team) and share a strong research interest in IoT and Fog Computing.

9.4.3. Inria International Partners

9.4.3.1. Informal International Partners

We collaborate with Prof. Etienne Riviere from UC Louvain on legacy application edgification. Genc Tato spent six month at UCL.

We collaborate extensively with Prof. Gene Cooperman from Northeastern University, USA. One of his students, Onesphore Ndayishimiye, visited us for a three-month visit. Conversely, Arif Ahmed visited Northeastern University for three months as well. These informal collaborations are the basis of a proposal for a joint Inria team.

We collaborate with Dr. Djawida Dib (Tlemcen University, Algeria) on energy-efficient and fault-tolerant resource management in containerized clouds. Christine Morin and Nikos Parlavantzas are co-advising Yasmina Bouizem, who is enrolled in both Tlemcen University and University of Rennes 1.

We collaborate with Prof. Hector Duran-Limon (University of Guadalajara, Mexico) on cloud resource management. Nikos Parlavantzas co-advised Carlos Ruiz Diaz, a PhD student enrolled in the University of Guadalajara, who defended his thesis in January 2018.

9.5. International Research Visitors

9.5.1. Visits of International Scientists

9.5.1.1. Internships

- Onesphore Ndayishimiye (PhD student from Northeastern University) spend three months in the Myriads team.
- Lorenzo Civolani (master student from Bologna University) spent three months in the Myriads team.

9.5.2. Visits to International Teams

9.5.2.1. Research Stays Abroad

- Amir Teshome Wonjiga did a 3-month research internship in the Data Science and Technology department of the Lawrence Berkeley National Laboratory from January to March 2018. He worked with Sean Peisert, staff scientist, on the follow-up of his previous internship in 2017 about ensuring data integrity in the workflow of high performance applications.
- Arif Ahmed spent three months from September to December 2018 at Northeastern University. He worked with Gene Cooperman, Professor, on combining Docker cache sharing (developed in the Myriads team) with checkpoint-restart (developed at Northeastern University) to speed up the starting time of Docker containers.

Neo Project-Team

9. Partnerships and Cooperations

9.1. Regional Initiatives

MYDATA (Sept. 2018 - Nov. 2020) This is a research project in cooperation with two other labs (LJAD and GREDEG) from Univ. Côte d'Azur to study how to achieve privacy through obfuscation. The project is funded by IDEX UCA$^{\text{JEDI}}$ Academy 1 on "Networks, Information and Digital society."

9.2. National Initiatives

9.2.1. PIA ANSWER

Participants: Konstantin Avrachenkov, Abhishek Bose.

Project Acronym: ANSWER

Project Title: Advanced aNd Secured Web Experience and seaRch

Coordinator: QWANT

Duration: 15 November 2017 – 31 December 2020

Others Partners: Inria Project-Teams WIMMICS, INDES, COFFEE

Abstract: ANSWER is a joint project between QWANT and Inria, funded by the French Government's initiative PIA "Programme d'Investissement d'Avenir".

The aim of the ANSWER project is to develop the new version of the search engine http://www.qwant.com by introducing radical innovations in terms of search criteria as well as indexed content and security. This initiative is a part of the Big Data Big Digital Challenges field, since a Web search engine deals with large volumes of heterogeneous and dynamic data.

Of the five characteristics of big data, the ANSWER project will focus more particularly on the aspects of Velocity in terms of near real-time processing of results, and Variety for the integration of new indicators (emotions, sociality, etc.) and meta-data. The Volume, Value and Veracity aspects will necessarily be addressed jointly with these first ones and will also be the subject of locks, especially on the topics of crawling and indexing.

This registration of the search engine in the Big Data domain will only be reinforced by developments in the Web such as the Web of data, and generally by the current trend to integrate the Web of increasingly diverse, rich and complex resources.

9.3. European Initiatives

9.3.1. Collaborations in European Programs, Except FP7 & H2020

Participant: Konstantin Avrachenkov.

Program: EU COST

Project acronym: COSTNET

Project title: European Cooperation for Statistics of Network Data Science

Duration: May 2016 - April 2020

Coordinator: Ernst Wit (NL), Gesine Reinert (UK)

Other partners: see http://www.cost.eu/COST_Actions/ca/CA15109

Abstract: A major challenge in many modern economic, epidemiological, ecological and biological questions is to understand the randomness in the network structure of the entities they study: for example, the SARS epidemic showed how preventing epidemics relies on a keen understanding of random interactions in social networks, whereas progress in curing complex diseases is aided by a robust data-driven network approach to biology.

Although analysis of data on networks goes back to at least the 1930s, the importance of statistical network modelling for many areas of substantial science has only been recognized in the past decade. The USA is at the forefront of institutionalizing this field of science through various interdisciplinary projects and networks. Also in Europe there are excellent statistical network scientists, but until now cross-disciplinary collaboration has been slow.

This Action aims to facilitate interaction and collaboration between diverse groups of statistical network modellers, establishing a large and vibrant interconnected and inclusive community of network scientists. The aim of this interdisciplinary Action is two-fold. On the scientific level, the aim is to critically assess commonalities and opportunities for cross-fertilization of statistical network models in various applications, with a particular attention to scalability in the face of Big Data. On a meta-level, the aim is to create a broad community which includes researchers across the whole of Europe and at every stage in their scientific career and to facilitate contact with stakeholders.

9.4. International Initiatives

9.4.1. Inria Associate Teams Not Involved in an Inria International Labs

9.4.1.1. MALENA

Title: Machine Learning for Network Analytics

International Partner (Institution - Laboratory - Researcher):

Indian Institute of Technology Bombay (India) - Electrical Communication Engineering - Vivek Borkar

Start year: 2017

See also: http://www-sop.inria.fr/members/Konstantin.Avratchenkov/MALENA.html

In the past couple of decades network science has seen an explosive growth, enough to be identified as a discipline of its own, overlapping with engineering, physics, biology, economics and social sciences. Much effort has gone into modelling, performance measures, classification of emergent features and phenomena, etc, particularly in natural and social sciences. The algorithmic side, all important to engineers, has been recognised as a thrust area (e.g., two recent Nevanlinna Prize (J. Kleinberg 2006 and D. Spielman 2010) went to prominent researchers in the area of network analytics). Still, in our opinion the area is yet to mature and has a lot of uncharted territory. This is because networks provide a highly varied landscape, each flavour demanding different considerations (e.g., sparse vs dense graphs, Erdös-Rényi vs planted partition graphs, standard graphs vs hypergraphs, etc). Even adopting existing methodologies to these novel situations is often a nontrivial exercise, not to mention many problems that cry out for entirely new algorithmic paradigms. It is in this context that we propose this project of developing algorithmic tools, drawing not only upon established as well as novel methodologies in machine learning and big data analytics, but going well beyond, e.g., into statistical physics tools.

9.4.1.2. THANES

Title: THeory and Application of NEtwork Science

International Partner (Institution - Laboratory - Researcher):

Universidade Federal do Rio de Janeiro (Brazil) - Department of Computer and Systems Engineering (PESC/COPPE) - Daniel Ratton Figueiredo, Edmundo De Souza e Silva

Universidade Federal do Rio de Janeiro (Brazil) - Math institute - Giulio Iacobelli

Purdue Univ. (USA) - Computer Science Department - Bruno Ribeiro

Start year: 2017

See also: https://team.inria.fr/thanes/

We plan move beyond the study of a single network and focus on multiplex networks, i.e. multiple interacting networks. Multiplex networks have recently raised as "one of the newest and hottest themes in the statistical physics of complex networks." They originate from the observation that many complex systems, ranging from living organisms to critical infrastructures, operate through multiple layers of distinct interactions among their constituents. In particular we plan to work on the co-evolution of the different layers of a multiplex network and on how epidemics spread in such setting.

9.4.2. Inria International Partners

9.4.2.1. Informal International Partners

NEO has continued collaborations with researchers from GERAD, Univ. Montreal (Canada), Flinders Univ. (Australia), Univ. of South Australia (Australia), National Univ. of Rosario (Argentina), Technion - Israel Institute of Technology (Israel), Univ. of Arizona (USA), Univ. of Illinois at Urbana-Champaign (USA), Univ. of Liverpool (UK), Univ. of Massachusetts at Amherst (USA), Univ. of Florence (Italy), Univ. of Palermo (Italy), Univ. of Twente (The Netherlands), Saint Petersburg State Univ. (Russia), Petrozavodsk State Univ. (Russia) and Ghent Univ. (Belgium).

9.4.3. Participation in Other International Programs

9.4.3.1. Indo-French Center of Applied Mathematics (IFCAM)

NEO is involved in the IFCAM with the MALENA project. See §9.4.1.1 .

9.5. International Research Visitors

9.5.1. Visits of International Scientists

9.5.1.1. Professors/Researchers

Damiano Carra, Date: 23-27 April, Institution: Univ. of Verona (Italy)

Daniel Figueiredo, Date: 9-13 July, Institution: UFRJ (Brazil)

Giulio Iacobelli, Date: 9-13 July, Institution: UFRJ (Brazil)

Nikhil Karamchandani, Date: 11-15 June, Institution: IIT Bombay (India)

Nelly Litvak, Date: 2-14 July, Institution: Univ. of Twente (Netherlands)

Vladimir Mazalov, Date: 16-17 July, Institution: Petrozavodsk State Univ. (Russia)

Daniel Sadoc Menasché, Date: 31 August - 6 September, Date: 8-12 December, Institution: UFRJ (Brazil)

Bruno Ribeiro, Date: 9-18 July, Institution: Purdue Univ. (USA)

Vikas Vikram Singh, Date: 1-8 June, Institution: IIT Delhi (India)

Rajesh Sundaresan, Date: 15-26 January, Institution: IISc Bangalore (India)

9.5.1.2. Postdoc/PhD Students

Víctor Bucarey López, Date: 18-19 October, Institution: Université Libre de Bruxelles (Belgium)

Yuzhou Chen, Date: 7 June - 6 September, Institution: Southern Methodist Univ. (USA)

Eduardo Hargreaves, Date: 31 August - 6 September, Institution: UFRJ (Brazil)

Mayank Kakodkar, Date: 9-13 July, Institution: Purdue Univ. (USA)

Mikhail Kamalov, Date: 1 September - 30 November, Institution: Univ. St. Petersburg (Russia)

Maria Kleshnina, Date: 2-8 July, Institution: Queensland Univ. (Australia)

Suhail Mohmad Shah, Date: 18 June - 14 August, Institution: IIT Bombay (India)

9.5.2. Internships

Note: UNS is the Univ. Nice Sophia-Antipolis.

Nour Elhouda Ayari, Date: 4 April - 8 October, Institution: Tunis SUP'COM, Supervisors: E. Altman and M. Haddad (UAPV), Subject: Speed Estimation in Mobile Networks

Gianmarco Calbi, Date: 15 March - 31 August, Institution: Master RIF, UNS, Supervisor: G. Neglia, Subject: Asynchronous Approximate Distributed Computation for Machine Learning

Yu-Zhen Chen, Date: 1 June - 31 July, Institution: The Chinese Univ. of Hong Kong, Supervisor: K. Avrachenkov, Subject: Application of deep learning for graphlet statistics estimation

Kostantinos Dermentzis, Date: 20 November 2017 - 19 May 2018, Institution: National Technical Univ. of Athens (Greece), Supervisor: G. Neglia, Subject: Caching Policies with Partial Future Knowledge: the case of Spark

Vladyslav Fedchenko, Date: 1 March - 31 August, Institution: Master IFI Ubinet, UNS, Supervisor: G. Neglia, Subject: Estimating Content Popularity in Cache Networks

Pulkit Goel, Date: 15 May - 31 July, Institution: IIT New Delhi (India), Supervisor: K. Avrachenkov, Subject: Application of Deep Learning for Recovering Graph Motifs

Nisha Mishra, Date: 5 February - 20 July, Institution: ENSIMAG, Supervisor: E. Altman and C. Touati, Subject: Routing Games

Utsav Sen, Date: 15 May - 31 July, Institution: IIT New Delhi (India), Supervisor: K. Avrachenkov, Subject: Asynchronously distributed and randomized methods for computing network centralities

Adeel Siddiqui, Date: 1 October 2018 - 30 September 2019, Institution: Univ. Côte d'Azur, Supervisor: G. Neglia, Subject: Achieve Web Privacy by Obfuscation

Xing Yafei, Date: 1 March - 31 August, Institution: Master IFI Ubinet, UNS, Supervisor: K. Avrachenkov, Subject: Distributed Approaches for Graph-based Unsupervised Learning

Xiawen Zhu, Date: 1 March - 31 August, Institution: Master IFI Ubinet, UNS, Supervisor: K. Avrachenkov, Subject: Distributed Approaches for Graph-based Unsupervised Learning

9.5.3. Visits to International Teams

9.5.3.1. Research Stays Abroad

Eitan Altman

- Date: 1-8 March, Institution: Technion (Israel)
- Date: 12-23 April, Institution: Technion and Univ. Tel-Aviv (Israel)
- Date: 10-21 December, Institution: IIT Bombay (India)

Konstantin Avrachenkov

- Date: 29 January - 2 February, Institution: Univ. Liverpool (United Kingdom)
- Date: 21-22 May, Institution: Saint Petersburg State Univ. (Russia)
- Date: 17-18 September, Institution: Univ. Leiden (The Netherlands)
- Date: 19-23 September, Institution: Univ. Twente (The Netherlands)
- Date: 15-18 October, Institution: IIT Bombay (India)

Abhishek Bose

- Date: 19-23 November, Institution: IIT Bombay (India)

Swapnil Dhamal

- Date: 17-18 September, Institution: IISc Bangalore (India)
- Date: 19 September, Company: IBM Research Labs Bangalore (India)

Alain Jean-Marie

Date: 24 September - 14 October, Institution: Univ. of Montreal (Canada)

Date: 2-27 November, Institution: National Univ. of Rosario (Argentina)

Giovanni Neglia

- Date: 11-16 November, Institution: Purdue Univ. (USA)
- Date: 3-8 November, Institution: IIT Bombay (India)

PHOENIX-POST Team

7. Partnerships and Cooperations

7.1. International Initiatives

- Idex cooperation programme UB-UUW-Canada — Category B - Emerging Cooperation (2017-2018), managed by M. Fernandes and H. Sauzéon.
- Idex cooperation programme UB-UUW-Canada — Category A - Research projects - Priority topics (Aging) – (2017-2018), managed by M. Fernandes and H. Sauzéon.

POEMS-POST Team

9. Partnerships and Cooperations

9.1. National Initiatives

9.1.1. ANR

- ANR project NonlocalDD *(Non-local domain decomposition methods in electromagnetics)*
  Partners: Inria Alpines, Inria POEMS, Inria Magique 3D
  Start: 10/2015. End: 09/2019. Administrator: Inria
  Participants of POEMS: S. Chaillat, P. Joly
  Coordinator: X. Claeys (LJLL, EPI ALPINES)
- ANR project MODULATE *(Modeling lOng-perioD groUnd motions, and assessment of their effects on Large-scale infrAsTructurEs)*
  Partners: ENSTA (UME), Inria POEMS, CentraleSupelec, BRGM, GDS
  Start: 11/2018. End: 10/2021. Administrator: ENSTA
  Participant of POEMS: S. Chaillat
  Coordinator: K. Meza Fajardo (BRGM)

9.1.2. DGA

- Contracts between DGA and POEMS:
  - Contract on *inverse problems*
    Participants: L. Bourgeois
    Start: 10/2016. End: 09/2018. Administrator: ENSTA
  - Contract on *boundary element methods and high-frequency problems*
    Participants: E. Lunéville, M. Lenoir, N. Kielbasiewicz.
    Start: 10/2015. End: 2021. Administrator: ENSTA
    In partnership with F. Alouges and M. Aussal (CMAP, Ecole Polytechnique).
  - Contract on *the preconditioning of fast BEM solvers*
    Participants: S. Chaillat, F. Amlani
    Start: 10/2017. End: 12/2018. Administrator: ENSTA
- DGA provides partial funding for several PhD students:
  - A. Bera on the *design of invisible obstacles for acoustic and electromagnetic waves* (Start: 10/2016)
  - C. Beneteau on the *asymptotic analysis of time harmonic Maxwell equations in presence of metamaterials* (Start: 10/2017)
  - D. Chicaud on *domain decomposition methods for time-harmonic electromagnetic wave problems with complex media* (Start: 10/2018)

9.2. International Initiatives

9.2.1. Inria International Partners

9.2.1.1. Informal International Partners

Wilkins Aquino (Duke University, USA)

Juan Pablo Borthagaray (University of Maryland, College Park, USA)

Fioralba Cakoni (University of Rutgers, USA)

Mahadevan Ganesh (Colorado School of Mines, USA)

Camille Carvalho (UC Merced, Merced, USA)

Christophe Geuzaine (Université de Liège, Belgium)

Bojan Guzina (University of Minnesota, USA)

Marcus Grote (Universitaet Basel, Switzerland)

Jean-François Molinari (EPFL, Lausanne, Switzerland)

Sergei Nazarov (Saint-Petersburg University, Russia)

Jerónimo Rodríguez (University of Santiago de Compostela, Spain)

Adrien Semin (TU Darmstadt, Germany)

Ricardo Weder (Universidad Nacional Autonoma, Mexico)

Shravan Veerapaneni (Univ. of Michigan at Ann Arbor, USA)

Jun Zou (Chinese University of Hong Kong, HK)

9.3. International Research Visitors

9.3.1. Visits of International Scientists

- Mahadevan Ganesh (Colorado School of Mines) – July 2018
- Bojan Guzina (University of Minnesota, USA) – Summer 2018, 1 month
- Michael Weinstein (Columbia University, USA) – May-June 2018
- Fedor Bakharev (Saint Petersburg State University, Russia) – July 2018

POLARIS Project-Team

9. Partnerships and Cooperations

9.1. Regional Initiatives

9.1.1. IDEX UGA

Nicolas Gast received a grant from the IDEX UGA that funds a two-years post-doctoral researcher (Takai Kennouche) for two years (2018 and 2019) to work on the smart-grid project that focus on distributed optimization in electrical distribution networks.

Patrick Loiseau and Panayotis Mertikopoulos received a grant from the IDEX UGA that partly funds a PhD student (Benjamin Roussillon) to work on game theoretic models for adversarial classification.

9.2. National Initiatives

9.2.1. Inria Project Labs

Arnaud Legrand is the leader of the HAC SPECIS project. The goal of the HAC SPECIS (High-performance Application and Computers: Studying PErformance and Correctness In Simulation) project is to answer methodological needs of HPC application and runtime developers and to allow to study real HPC systems both from the correctness and performance point of view. To this end, we gather experts from the HPC, formal verification and performance evaluation community. Inria Teams: AVALON, POLARIS, MYRIADS, SUMO, HIEPACS, STORM, MEXICO, VERIDIS.

9.2.2. DGA Grants

Patrick Loiseau and Panayotis Mertikopoulos received a grant from DGA that complements the funding of PhD student (Benjamin Roussillon) to work on game theoretic models for adversarial classification.

9.2.3. PGMO Projects

PGMO projects are supported by the Jacques Hadamard Mathematical Foundation (FMJH). Our project (HEAVY.NET) is focused on congested networks and their asymptotic properties.

9.2.4. PEPS

Panayotis Mertikopoulos est co-PI of a PEPS I3A project: MixedGAN ("Mixed-strategy generative adversarial networks") (PI: R. Laraki, U. Dauphine).

9.2.5. Fondation Blaise Pascal

Project IAM (Informatique à la Main) funded by fondation Blaise Pascal (Jean-Marc Vincent).

9.2.6. ANR

- *ORACLESS (2016–2021)*
  ORACLESS is an ANR starting grant (JCJC) coordinated by Panayotis Mertikopoulos. The goal of the project is to develop highly adaptive resource allocation methods for wireless communication networks that are provably capable of adapting to unpredictable changes in the network. In particular, the project will focus on the application of online optimization and online learning methodologies to multi-antenna systems and cognitive radio networks.
- *CONNECTED (2016–2019)*
  CONNECTED is an ANR Tremplin-ERC (T-ERC) grant coordinated by Patrick Loiseau. The goal of the project is to work on several game-theoretic models involving learning agents and data revealed by strategic agents in response to the learning algorithms, so as to derive better learning algorithms for such special data.

9.3. International Initiatives

9.3.1. Inria International Labs

The POLARIS team is involved in the JLESC (Joint Laboratory for Extreme-Scale Computing) with University of University of Illinois Urbana Champaign, Argonne Nat. Lab and BSC.

9.3.2. Participation in Other International Programs

- *LICIA:* The CNRS, Inria, the Universities of Grenoble, Grenoble INP, and Universidade Federal do Rio Grande do Sul have created the LICIA (*Laboratoire International de Calcul intensif et d'Informatique Ambiante*). LICIA's main research themes are high performance computing, language processing, information representation, interfaces and visualization as well as distributed systems. Jean-Marc Vincent is the director of the laboratory on the French side and visited Porto Alegre for three weeks in November 2018.

  More information can be found at http://www.inf.ufrgs.br/licia/.

- *GENE*: Stochastic dynamics of large games and networks. This is a joint project (2018 - 2019) with Universidad de Buenos Aires, Argentina (Matthieu Jonckheere), Universidad de la Republica Uruguay (Federico La Rocca), CNRS (Balakrishna Prabhu) and Universidad ORT Uruguay (Andrés Ferragut).

  Through the creation and consolidation of strong research and formation exchanges between Argentina, France and Uruguay, the GENE project will contribute to the fields of performance evaluation and control of communication networks, using tools of game theory, probability theory and control theory. Some of the challenges this project will address are: (1) Mean-field games and their application to load balancing and resource allocations, (2) Scaling limits for centralized and decentralized load balancing strategies and implementation of practical policies for web servers farms, (3) Information diffusion and communication protocols in large and distributed wireless networks.

- *LEARN*: Learning algorithms for games and applications (2016-2018). POLARIS is a member of the Franco-Chilean collaboration network LEARN with CONICYT (the Chilean national research agency), formed under the ECOS-Sud framework. The main research themes of this network is the application of continuous optimization and game-theoretic learning methods to traffic routing and congestion control in data networks. Panayotis Mertikopoulos was an invited researcher at the University of Chile in October 2016.

  More information can be found at http://www.conicyt.cl/pci/2016/02/11/programa-ecos-conicyt-adjudica-proyectos-para-el-ano-2016.

9.4. International Research Visitors

9.4.1. Visits to International Teams

9.4.1.1. Research Stays Abroad

Panayotis Mertikopoulos was a visiting scientist at UC Berkeley / Simons Institute for the Theory of Computing (Feb.-March 2018) and a visiting scientist at U Athens / STSM in the framework of the EU COST Action GAMENET (Apr. - May 2018).

Jean-Marc Vincent is the director of Licia (Laboratoire de Calcul Intensif et d'Informatique Ambiante) and stayed 20 days at Porto Alegre to teaching and nurture research collaborations.

RESIST Team

9. Partnerships and Cooperations

9.1. National Initiatives

9.1.1. ANR

9.1.1.1. ANR BottleNet

Participants: Isabelle Chrisment [contact], Thibault Cholez, Vassili Rivron.

- Acronym: BottleNet
- Title: Comprendre et diagnostiquer les dégradations des communications de bout en bout dans l'Internet
- Coordinator: Inria
- Duration: October 2015- March 2018
- Others Partners: Inria Muse, Inria Diana, Lille1 University, Telecom Sud-Paris, Orange, IP-Label.
- Abstract: The Quality of Experience (QoE) when accessing the Internet, on which more and more human activities depend on, is a key factor for today's society. The complexity of Internet services and of users' local connectivity has grown dramatically in the last years with the proliferation of proxies and caches at the core and access technologies at the edge (home wireless and 3G/4G access), making it difficult to diagnose the root causes of performance bottlenecks. The objective of BottleNet is to deliver methods, algorithms, and software systems to measure end-to-end Internet QoE and to diagnose the cause of the experienced issues. The result can then be used by users, network and service operators or regulators to improve the QoE.

9.1.1.2. ANR Doctor

Participants: Thibault Cholez [contact], Xavier Marchal, Daishi Kondo, Olivier Festor.

- Acronym: DOCTOR
- Title: DeplOyment and seCurisaTion of new functiOnalities in virtualized networking enviRonments
- Coordinator: Orange Labs (Bertrand Matthieu)
- Duration: December 2014-December 2018
- Partners: Orange Labs, Thales, Montimage, UTT and LORIA
- Site: http://www.doctor-project.org
- Abstract: The DOCTOR project is an applied research project that advocates the use of virtualized network equipment (Network Functions Virtualization), to enable the co-existence of new Information-Centric Networking stacks (e.g.: Named-Data Networking) with IP, and the progressive migration of traffic from one stack to another while guaranteeing the good security and manageability of the network. Therefore in DOCTOR, the main goals of the project are: (1) the efficient deployment of NDN as a virtualized networking environment; (2) the monitoring and security of this virtualized NDN stack.

9.1.1.3. ANR FLIRT

Participants: Rémi Badonnel [contact], Olivier Festor, Thibault Cholez, Jérôme François, Abdelkader Lahmadi, Laurent Andrey.

- Acronym: FLIRT
- Title: Formations Libres et Innovantes Réseaux et Télécoms
- Coordinator: Institut Mines-Télécom (Pierre Rolin)
- Duration: January 2016-January 2020
- Others Partners: Institut Mines-Télécom, Airbus, Orange, the MOOC Agency, Isograd
- Site: http://flirtmooc.wixsite.com/flirt-mooc-telecom
- Abstract: FLIRT (Formations Libres et Innovantes Réseaux & Télécom) is an applied research project leaded by the Institut Mines-Télécom, for a duration of 4 years. It includes 14 academic partners (engineering schools including Telecom Nancy), industrial partners (Airbus, Orange), innovative startups (the MOOC agency, and Isograd), as well as professional or scientific societies (Syntec Numérique, Unetel, SEE). The project is to build a collection of 10 MOOCs (Massive Open Online Courses) in the area of networks and telecommunications, three training programmes based on this collection, as well as several innovations related to pedagogical efficiency (such as virtualization of practical labs, management of student cohorts, and adaptative assessment). The RESIST team is leading a working group dedicated to the building and operation of a MOOC on network and service management. This MOOC covers the fundamental concepts, architectures and protocols of the domain, as well as their evolution in the context of future Internet (e.g. network programming, flow monitoring). It corresponds to a training program of 5 weeks. The main targeted skills are to understand the challenges of network and service management, to know the key methods and techniques related to this area, and to get familiar with the usage and parameterization of network management solutions. We have also performed the maintenance of the different contents of the MOOC, in preparation of the second session, which will start January 2019.

9.1.1.4. Inria-Orange Joint Lab

Participants: Jérôme François [contact], Rémi Badonnel, Olivier Festor, Maxime Compastié, Paul Chaignon.

- Acronym: IOLab
- Title: Inria - Orange Joint Laboratory
- Duration: September 2015 - August 2020
- Abstract: The challenges addressed by the Inria-Orange joint laboratory relate to the virtualization of communication networks, the convergence between cloud computing and communication networks, and the underlying software-defined infrastructures. Our work concerns in particular monitoring methods for software-defined infrastructures, and management strategies for supporting software-defined security in multi-tenant cloud environnements.

9.1.2. Technological Development Action (ADT)

9.1.2.1. ADT SCUBA

Participants: Abdelkader Lahmadi [Contact], Thomas Lacour, Frédéric Beck.

- Acronym: CUBA
- Duration: January 2018-January 2020
- Abstract: The goal of this ADT is to develop a tool suite to evaluate the security of industrial and general public IoT devices in their exploitation environment. The Tool suite relies on a set of security probes to collect information through passive and active scanning of a running IoT device in its exploitation environment to build its Security Knowledge Base (SKB). The knowledge base contains all relevant information of the device regarding its network communications, the enumeration of its used hardware and software, the list of its known vulnerabilities in the CVE format associated to their Common Weakness Enumeration (CWE) and Common Attack Pattern Enumeration and Classification (CAPEC) descriptions. The collected information is used to evaluate the devices associated with their usage scenarios and to identify intrusion chains in an automated way.

9.1.3. FUI

9.1.3.1. FUI PACLIDO

Participants: Abdelkader Lahmadi [contact], Mingxiao Ma, Isabelle Chrisment, Jérôme François.

- Acronym: PACLIDO
- Title: Lightweight Cryptography Protocols and Algorithms for IoT (Protocoles et Algorithmes Cryptographiques Légers pour l'Internet des Objets)
- Coordinator: ADS (Airbus Defence and Space)
- Duration: September 2017- August 2020
- Others Partners: Sophia Conseil, Université de Limoges, Cea tech, Trusted Objects, Rtone, Saint Quentin En Yvelines.
- Abstract: The goal of PACLIDO is to propose and develop lightweight cryptography protocols and algorithms to secure IoT communications between devices and servers. The implemented algorithms and protocols will be evaluated in multiple use cases including smart home and smart city applications. PACLIDO develops in addition an advanced security monitoring layer using machine learning methods to detect anomalies and attacks while traffic is encrypted using the proposed algorithms.

9.1.3.2. FUI HUMA

Participants: Jérôme François [contact], Soline Blanc, Isabelle Chrisment, Quang Vinh Dang, Abdelkader Lahmadi, Giulia de Santis.

- Acronym: HuMa
- Title: L'HUmain au cœur de l'analyse de données MAssives pour la sécurité
- Coordinator: Intrinsec
- Duration: September 2015-March 2018
- Others Partners: ICube, Idemia, Airbus Defence and Space, Wallix, Sydo.
- Abstract: HuMa targets the analysis of Advanced Persistent Threats. APT are long and complex attacks which thus cannot be captured with standard techniques focused on short time windows and few data sources. Indeed, APTs may be several months long and involve multiple steps with different types of attacks and approaches. The project will address such an issue by leveraging data analytics and visualization techniques to guide human experts, which are the only oned able to analyze APT today, rather than targeting a fully automated approach.

9.1.4. Inria Project Lab

9.1.4.1. IPL BetterNet

Participants: Isabelle Chrisment [contact], Thibault Cholez, Vassili Rivron.

- Acronym: BetterNet
- Coordinator: RESIST (Isabelle Chrisment)
- Duration: October 2018-August 2023
- Others Partners: Inria MiMove, Inria Diana, Inria Spirals, Inria Dionysos, ENS-ERST and IP-Label
- Site: https://project.inria.fr/betternet
- Abstract: BetterNet's goal is to build and deliver a scientific and technical collaborative observatory to measure and improve the Internet service access as perceived by users. We will propose new user-centered measurement methods, which will associate social sciences to better understand Internet usage and the quality of services and networks. Tools, models and algorithms will be provided to collect data that will be shared and analyzed to offer valuable service to scientists, stakeholders and the civil society.

9.1.4.2. IPL Discovery

Participant: Lucas Nussbaum [contact].

- Partners: Orange, RENATER
- Abstract: To accommodate the ever-increasing demand for Utility Computing (UC) resources, while taking into account both energy and economical issues, the current trend consists in building larger and larger Data Centers in a few strategic locations. Although such an approach enables UC providers to cope with the actual demand while continuing to operate UC resources through a centralized software system, it is far from delivering sustainable and efficient UC infrastructures for future needs.

  The DISCOVERY initiative aims at exploring a new way of operating Utility Computing (UC) resources by leveraging any facilities available through the Internet in order to deliver widely distributed platforms that can better match the geographical spread of users as well as the ever increasing demand. Critical to the emergence of such locality-based UC (also referred as Fog/Edge Computing) platforms is the availability of appropriate operating mechanisms. The main objective of DISCOVERY is to design, implement, demonstrate and promote a new kind of Cloud Operating System (OS) that will enable the management of such a large-scale and widely distributed infrastructure in an unified and friendly manner.

9.2. European Initiatives

9.2.1. Fed4Fire+ (2017-2022)

Title: Federation for FIRE Plus

Program: H2020

Duration: January 2017 - December 2021

Coordinator: Interuniversitair Micro-Electronicacentrum Imec VZW

Partners:
Universidad de Malaga; National Technical University of Athens - NTUA; The Provost, Fellows, Foundation Scholars & the other members of board of the College of the Holy & Undivided Trinity of Queen Elizabeth Near Dublin; Ethniko Kentro Erevnas Kai Technologikis Anaptyxis; GEANT LImited; Institut Jozef Stefan; Mandat International Alias Fondation Pour la Cooperation Internationale; Universite Pierre et Marie Curie - Paris 6; Universidad De Cantabria; Fundacio Privada I2CAT, Internet I Innovacio Digital A Catalunya; EURESCOM-European Institute For Research And Strategic Studies in Telecommunications GMBH; Nordunet A/S; Technische Universitaet Berlin; Instytut Chemii Bioorganicznej Polskiej Akademii Nauk; Fraunhofer Gesellschaft zur Foerderung Der Angewandten Forschung E.V.; Universiteit Van Amsterdam; University of Southampton; Martel GMBH; Atos Spain SA; Institut National de Recherche en Informatique et automatique.

Inria contact: David Margery (for RESIST: Lucas Nussbaum)

Fed4FIRE+ is a successor project to Fed4FIRE. In Fed4FIRE+, we more directly integrate Grid'5000 into the wider eco-system of experimental platforms in Europe and beyond using results we developped in Fed4FIRE. We will also provide a generalised proxy mechanisms to allow users with Fed4FIRE identities to interact with services giving access to different testbeds but not designed to support Fed4FIRE identities. Finally, we will work on orchestration of experiments in a federation context.

9.2.2. SecureIoT

Title: Predictive Security for IoT Platforms and Networks of Smart Objects

Duration: 3 years

Coordinator: INTRASOFT International SA

Partners:
Fujitsu Technology Solutions GMBH; Atos Spain S.A; Siemens SRL; Singularlogic S.A.; IDIADA Automotive Technology SA; P@SSPORT Holland B.V.; UBITECH LIMITED; Innovation Sprint Sprl; DWF Germany Rechtsanwaltsgesellschaft mbH; LuxAI S.A.; Institut National de Recherche en Informatique et automatique; it's OWL Clustermanagement GmbH; Research and Education Laboratory in Information Technologies – Athens Information Technology (AIT).

Inria contact: Jérôme François

SecureIoT is a a joint effort of global leaders in IoT services and IoT cybersecurity to secure the next generation of dynamic, decentralized IoT systems, that span multiple IoT platforms and networks of smart objects, through implementing a range of predictive IoT security services. SecureIoT will integrate its security services in three different application scenarios in the areas of: Digital Automation in Manufacturing (Industry 4.0), Socially assistive robots for coaching and healthcare and Connected cars and Autonomous Driving.

Emerging cross-platform interactions and interactions across networks of smart objects require more dynamic, scalable, decentralized and intelligent IoT security mechanisms. Such mechanisms are highly demanded by the industry in order to secure a whole new range of IoT applications that transcend the boundaries of multiple IoT platforms, while involving autonomous interactions between intelligent CPS systems and networks of smart objects. In this direction, the main objectives of the project are to: Predict and anticipate the behavior of IoT systems, facilitate compliance to security and privacy regulations and provide APIs and tools for trustworthy IoT solutions.

9.3. International Initiatives

9.3.1. Inria Associate Teams Not Involved in an Inria International Labs

9.3.1.1. Masdin

Title: MAnagement of Software-Defined INfrastructure

International Partner (Institution - Laboratory - Researcher):

University of Luxembourg (Luxembourg) - SnT (Interdisciplinary Centre for Security, Reliability and Trust) - Radu State

Start year: 2016

See also: https://project.inria.fr/masdin

Networking is deeply evolving with the rise of programmability and virtualization. The concept of SDI (Software-Defined Infrastructure) has emerged from SDN (Software-Defined Networking) and NFV (Network Function Virtualization) making thus the configuration of the network highly dynamic and adaptable in real-time. However, new methods and tools have to be defined to properly monitor and configure this type of infrastructure. Current works are mainly limited to applying former approaches but do not exploit the novel capabilities offered by SDI. The goal of the associate team is thus to define methodologies taking benefit of them for an efficient monitoring and use of SDI resources while investigating the security issues it brings.

9.3.1.2. NetMSS

Title: NETwork Monitoring and Service orchestration for Softwarized networks

International Partner (Institution - Laboratory - Researcher):

University of Waterloo (Canada), David R. Cheriton School of Computer Science - Raouf Boutaba

Start year: 2018

See also: https://team.inria.fr/netmss/

Evolution towards softwarized networks are greatly changing the landscape in networking. In the last years, effort was focused on how to integrate network elements in cloud-based models. This lead to the advent of network function virtualization primarily relying on regular virtualization technologies and on some advances in network programmability. Several architectural models have been proposed and, even if no full consensus has been reached yet, they highlight the major components. Among them, monitoring and orchestration are vital elements in order to ensure a proper assessment of the network conditions (network monitoring) serving as the support for the decision when deploying services (orchestration). With softwarization of networks, these elements can benefit from a higher flexibility but the latter requires new methods to be efficiently handled. For example, monitoring softwarized networks necessitates the collection of heterogeneous information, regarding the network but also cloud resources, from many locations. Targeting such a holistic monitoring will then support better decision algorithms, to be applied in a scalable and efficient manner, taking advantage of the advanced capabilities in terms of network configuration and programmability. In addition, real-time constraints in networking are very strong due to the transient nature of network traffic and are faced with high throughputs, especially in data-center networks where softwarization primarily takes place. Therefore, the associate team will promote (1) line-rate and accurate monitoring and (2) efficient resource uses for service orchestration leveraging micro-services.

9.3.2. Participation in Other International Programs

9.3.2.1. ThreatPredict

- Title: ThreatPredict, From Global Social and Technical Big Data to Cyber Threat Forecast
- Coordinator: Inria
- Duration: December 2017 - November 2020
- Others Partners: International University of Rabat (IUR), Carnegie Mellon University
- Funding: North Atlantic Treaty Organization
- Abstract: Predicting attacks can help to prevent them or at least reduce their impact. Nowadays, existing attack prediction methods make accurate predictions only hours in advance or cannot predict geo-politically motivated attacks. ThreatPredict aims to predict different attack types days in advance. It develops machine-learning algorithms that capture the spatio-temporal dynamics of cyber-attacks and global social, geo-political and technical events. Various sources of information are collected, enriched and correlated such as honeypot data, darknet, GDELT, Twitter, and vulnerability databases. In addition to warning about attacks, this project will improve our understanding of the effect of global events on cyber-security.

9.4. International Research Visitors

9.4.1. Visits of International Scientists

9.4.1.1. Internships

- Visit of Anthony (Anthony) Ang in RESIST, Ms Student, from June 4 to August 26 2018, new scheduler for micro-service based VNF [6]
- Visit of Shihabur Chowdhury in RESIST, PhD Student, from June 4 to August 26 2018, new scheduler for micro-service based VNF [6], intelligent traffic engineering

RMOD Project-Team

9. Partnerships and Cooperations

9.1. Regional Initiatives

9.1.1. CAR IMT Douai

Participants: Pablo Tesone, Guillermo Polito, Marcus Denker, Stéphane Ducasse with: L. Fabresse and N. Bouraqadi (IMT Douai)
From 2009, ongoing.

We have signed a convention with the CAR team led by Noury Bouraqadi of IMT Douai. In this context we co-supervised three PhD students (Mariano Martinez-Peck, Nick Papoylias and Guillermo Polito). The team is also an important contributor and supporting organization of the Pharo project.

Currently, Pablo Tesone is doing a PhD co-supervided by RMOD and Pr. L. Fabresse and N. Bouraqadi. We are collaborating in the Context of CPER Data since 2018.

9.1.2. CPER DATA

Participants: Marcus Denker, Stéphane Ducasse, Allex Oliveira with: L. Fabresse and N. Bouraqadi (IMT Douai)
From 2018, ongoing.

Funding to work one year on the PharoThings Platform. We are creating content for a website and a Demo in collaboration with IMT Douai.

9.2. National Initiatives

9.2.1. CEA List

Participants: Jason Lecerf, Stéphane Ducasse with T. Goubier (CEA List)
From 2016, ongoing.

Jason Lecerf started a shared PhD Oct 2016: *Reuse of code artifacts for embedded systems through refactoring*.

9.3. European Initiatives

9.3.1. Collaborations in European Programs, Except FP7 & H2020

Namur University, Belgium
Participants: Anne Etien, Nicolas Anquetil, Olivier Auverlot, Stéphane Ducasse.

From Sept 2016 to Dec. 2018.

Lille Nord Europe European Associated Team with the PreCISE research center of Pr. A. Cleve from Namur University (Belgium).

This project aims to study the co-evolution between database structure and programs and to propose recommendations to perform required changes on cascade. These programs are either internal to the schema as functions or triggers or external as applications written in Java or Php built on top of the DB. Our intuition is that software engineering techniques can be efficient for such issues. This project also aims to unify the abstract representation of the DB and its relationships with the internal or external program.

VUB Brussels, Belgium
Participants: Guillermo Polito, Stéphane Ducasse.

From 2016, ongoing.

Student: Matteo Marra, collaboration with Eliza Gonzalez Boix. Guillermo Polito co-supervised Matteo Marra's master thesis.

University of Prague
Participants: Stéphane Ducasse.

From 2015, ongoing.

We are working with Dr. Robert Pergl from the University of Prague. Stéphane Ducasse gave a lecture at the University of Prague in 2018.

9.4. International Initiatives

9.4.1. Inria International Partners

9.4.1.1. Informal International Partners

Uqbar Argentina

Participants: Pablo Tesone, Esteban Lorenzano, Guillermo Polito, Stéphane Ducasse.

From 2015, ongoing.

We are working with the Uqbar team from different Argentinian universities. We hired three of the people: Nicolas Passerini(engineer), Esteban Lorenzano (engineer) and Pablo Tesone (PhD).

Pharo in Research:

Participants: Pablo Tesone, Esteban Lorenzano, Guillermo Polito, Marcus Denker, Stéphane Ducasse.
From 2009, ongoing.

We are building an ecosystem around Pharo with international research groups, universities and companies. Several research groups (such as Software Composition Group – Bern, and Pleaid – Santiago) are using Pharo. Many universities are teaching OOP using Pharo and its books. Several companies worldwide are deploying business solutions using Pharo.

9.5. International Research Visitors

9.5.1. Visits of International Scientists

- Abdelghani Alidra [University of Skikda Algeria, from Nov 2018]
- Andy Amoordon [Utocat, from Oct 2018]
- Jan Bliznicenko [University of Prague , Mar 2018]
- Abdelhakim Bouremel [University of Skikda Algeria, May 2018]
- Thomas Dupriez [Ecole Normale Supŕieure Paris, Sep 2018]
- Christopher Fuhrman [Ecole de technologie superieure de montreal, from Oct 2018]
- Tomohiro Oda [Key Technology Laboratory, Japan, from Aug 2018 until Sep 2018]
- Giuseppe Antonio Pierro [University of Cagliari, from Aug 2018]
- Ronie Salgado Faila [niversity of Chile at Santiago, Chile, from Aug 2018 until Sep 2018]
- Serge Demeyer [Universiteit Antwerpen, Belgium, from Jun 2018 until Jul 2018

9.5.1.1. Internships

- Lionel Akue [Inria, from Jul 2018 until Sep 2018]
- Asbathou Biyalou Sama [Inria, from Apr 2018 until Aug 2018]
- Quentin Ducasse [Inria, from Jun 2018 until Aug 2018]
- Thomas Dupriez [Ecole Normale Supŕieure Cachan, until Feb 2018]
- Yoan Geran [Ecole Normale Supŕieure Paris, from Jun 2018 until Jul 2018]
- Pierre Tsapliayeu [Univ de Lille, from Apr 2018 until Aug 2018]
- Eleonore Wald [Univ de Lille, from Apr 2018 until Jul 2018]
- Oleksandr Zaitsev [Inria, from Oct 2018]
- Myroslava Romaniuk [Inria, from Jul 2018 until Sep 2018]

9.5.2. Visits to International Teams

- Marcus Denker: VUB Brussels in spring and fall 2018 (Lecture).

ROMA Project-Team

9. Partnerships and Cooperations

9.1. Regional Initiatives

9.1.1. PhD grant laboratoire d'excellence MILYON-Mumps consortium

The doctoral program from Labex MILYON dedicated to applied research in collaboration with industrial partners funded 50% of a 3-year PhD grant (the other 50% being funded by the MUMPS consortium) to work on improvements of the solution phase of the MUMPS solver. The PhD aimed at answering industrial needs in application domains where the cost of the solution phase of sparse direct solvers is critical. The PhD was defended on December 10, 2018 [2].

9.2. National Initiatives

9.2.1. ANR

ANR Project SOLHAR (2013-2018), 4,5 years. The ANR Project SOLHAR was launched in November 2013, for a duration of 48 months. It gathers five academic partners (the HiePACS, Cepage, ROMA and Runtime Inria project-teams, and CNRS-IRIT) and two industrial partners (CEA/CESTA and EADS-IW). This project aims at studying and designing algorithms and parallel programming models for implementing direct methods for the solution of sparse linear systems on emerging computers equipped with accelerators.

The proposed research is organized along three distinct research thrusts. The first objective deals with linear algebra kernels suitable for heterogeneous computing platforms. The second one focuses on runtime systems to provide efficient and robust implementation of dense linear algebra algorithms. The third one is concerned with scheduling this particular application on a heterogeneous and dynamic environment.

9.3. International Initiatives

9.3.1. Inria International Labs

9.3.1.1. JLESC — Joint Laboratory on Extreme Scale Computing

The University of Illinois at Urbana-Champaign, Inria, the French national computer science institute, Argonne National Laboratory, Barcelona Supercomputing Center, Jülich Supercomputing Centre and the Riken Advanced Institute for Computational Science formed the Joint Laboratory on Extreme Scale Computing, a follow-up of the Inria-Illinois Joint Laboratory for Petascale Computing. The Joint Laboratory is based at Illinois and includes researchers from Inria, and the National Center for Supercomputing Applications, ANL, BSC and JSC. It focuses on software challenges found in extreme scale high-performance computers.

Research areas include:

- Scientific applications (big compute and big data) that are the drivers of the research in the other topics of the joint-laboratory.
- Modeling and optimizing numerical libraries, which are at the heart of many scientific applications.
- Novel programming models and runtime systems, which allow scientific applications to be updated or reimagined to take full advantage of extreme-scale supercomputers.
- Resilience and Fault-tolerance research, which reduces the negative impact when processors, disk drives, or memory fail in supercomputers that have tens or hundreds of thousands of those components.
- I/O and visualization, which are important part of parallel execution for numerical silulations and data analytics
- HPC Clouds, that may execute a portion of the HPC workload in the near future.

Several members of the ROMA team are involved in the JLESC joint lab through their research on scheduling and resilience. Yves Robert is the Inria executive director of JLESC.

9.3.2. Inria Associate Teams Not Involved in an Inria International Labs

9.3.2.1. Keystone

Title: Scheduling algorithms for sparse linear algebra at extreme scale

International Partner (Vanderbilt University - Department of Electrical Engineering and Computer Science - Padma Raghavan):

Start year: 2016

See also: http://graal.ens-lyon.fr/~abenoit/Keystone

The Keystone project aims at investigating sparse matrix and graph problems on NUMA multicores and/or CPU-GPU hybrid models. The goal is to improve the performance of the algorithms, while accounting for failures and trying to minimize the energy consumption. The long-term objective is to design robust sparse-linear kernels for computing at extreme scale. In order to optimize the performance of these kernels, we plan to take particular care of locality and data reuse. Finally, there are several real-life applications relying on these kernels, and the Keystone project is assessing the performance and robustness of the scheduling algorithms in applicative contexts.

9.3.3. Inria International Partners

9.3.3.1. Declared Inria International Partners

- Anne Benoit, Frederic Vivien and Yves Robert have a regular collaboration with Henri Casanova from Hawaii University (USA). This is a follow-on of the Inria Associate team that ended in 2014.

9.3.4. Cooperation with ECNU

ENS Lyon has launched a partnership with ECNU, the East China Normal University in Shanghai, China. This partnership includes both teaching and research cooperation.

As for teaching, the PROSFER program includes a joint Master of Computer Science between ENS Rennes, ENS Lyon and ECNU. In addition, PhD students from ECNU are selected to conduct a PhD in one of these ENS. Yves Robert is responsible for this cooperation. He has already given two classes at ECNU, on Algorithm Design and Complexity, and on Parallel Algorithms, together with Patrice Quinton (from ENS Rennes).

As for research, the JORISS program funds collaborative research projects between ENS Lyon and ECNU. Anne Benoit and Minsong Chen are leading a JORISS project on scheduling and resilience in cloud computing. Frédéric Vivien and Jing Liu (ECNU) are leading a JORISS project on resilience for real-time applications. In the context of this collaboration two students from ECNU, Li Han and Changjiang Gou, have joined Roma for their PhD.

9.4. International Research Visitors

9.4.1. Visits to International Teams

9.4.1.1. Research Stays Abroad

- Yves Robert has been appointed as a visiting scientist by the ICL laboratory (headed by Jack Dongarra) at the University of Tennessee Knoxville since 2011. He collaborates with several ICL researchers on high-performance linear algebra and resilience methods at scale.
- Anne Benoit and Bora Uçar visited the School of Computational Science and Engineering Georgia Institute of Technology, Atlanta, GA, USA. During their stay August 2017–June 2018, they worked with the research group of Prof. Umit V. Çatalyürek.

SOCRATE Project-Team

8. Partnerships and Cooperations

8.1. National Initiatives

8.1.1. Equipex FIT- Future Internet of Things

The FIT projet is a national equipex (*equipement d'excellence*), headed by the Lip6 laboratory. As a member of Inria, Socrate is in charge of the development of an Experimental Cognitive Radio platform that is used as test-bed for SDR terminals and cognitive radio experiments. This has been operational since 2014 and is maintained for a duration of 7 years. To give a quick view, the user will have a way to configure and program through Internet several SDR platforms (MIMO, SISO, and baseband processing nodes).

8.1.2. Insa-Spie IoT Chair

The Insa-Spie IoT Chair http://www.citi-lab.fr/chairs/iot-chair/ relies on the expertise of the CITI Lab. The skills developed within the different teams of the lab integrate the study, modelling, conception and evaluation of technologies for communicating objects and dedicated network architectures. It deals with network, telecom and software matters as well as societal issues such as privacy. The chair will also lean on the skills developed at INSA Lyon or in IMU LabEx.

8.1.3. Inria Project Lab: ZEP

The ZEP project addresses the issue of designing tiny computing objects with no battery by combining non-volatile memory (NVRAM), energy harvesting, micro-architecture innovations, compiler optimizations, and static analysis. The main application target is Internet of Things (IoT) where small communicating objects will be composed of this computing part associated to a low-power wake-up radio system. The ZEP project gathers four Inria teams that have a scientific background in architecture, compilation, operating system and low power together with the CEA Lialp and Lisan laboratories of CEA LETI & LIST. The major outcomes of the project will be a prototype harvesting board including NVRAM and the design of a new microprocessor associated with its optimizing compiler and operating system.

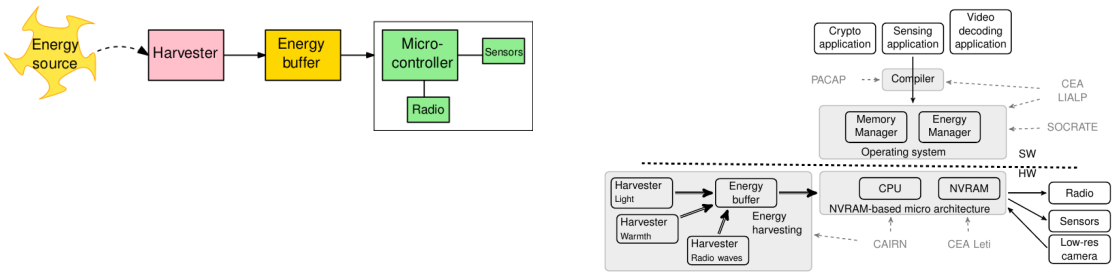

Figure 4. Example of system targeted by the ZEP project on the left, and on the right: the ZEP research program.

The scientific work (in progress) is organized around three fields :

- specific NVRAM-based architecture
- dedicated compiler pass that computes a worst-case energy consumption
- operating system managing NVRAM and energy, ensuring memory consistency across power outages

The project is illustrated by the figure 4 , where PACAP, SOCRATE, CORSE, and CAIRN are the teams involved in the project.

Another important goal of the project is to structure the research and innovation that should occur within Inria to prepare the important technological shift brought by NVRAM technologies.

8.1.4. ANR - Imprenum

The objective of this project (INSA-Lyon, École Normale Supérieure de Lyon, CEA LETI) is to promote **accuracy as a first class concern** in all the levels of a computing system:

- at the hardware level, with better support for lower-than-standard and higher-than-standard precisions;
- at the level of run-time support software, in particular answering the memory management challenges entailed by adaptive precision;
- at the lower level of mathematical libraries (kernel level), for instance BLAS for linear algebra, enhancing well established libraries with precision and accuracy control;
- at the higher level of mathematical libraries (solver level, including algebraic linear solvers such as LAPACK, ad hoc steppers for Ordinary Differential Equation, eigenvalues kernels, triangularization problems for computational geometry, etc.) Here, accuracy and precision control of the lower levels should enable higher-level properties such as convergence and stability;
- at the compiler level, enhancing optimising compilers with novel optimisations related to precision and accuracy;
- at the language level, embedding accuracy specification and control in existing languages, and possibly defining domain-specific languages with accuracy-aware semantics for some classes of applications.

8.1.5. ADT CorteXlab

The Socrate project-team is in charge of the FIT/CorteXlab platform. This platform (ADT Inria 2015-2017) makes use of many complex technologies from signal processing to computer science through microelectornics and FPGA. The objectiv of the CorteXlab ADT is to maintain a support to the user of the FPGA-based platform of CorteXlab and to provide tutorial and running experiment that will help them in builing experimentation using the PicoSDR machines.

8.1.6. ANR - Ephyl

The general objective of the project EPHYL - “Enhanced PHY for Cellular Low Power Communication IoT” (2016-2019, 183 keuros) is to investigate coming and future LPWA technologies with the aim to improve coverage, data rate and connectivity while keeping similar level of complexity and power consumption at the node for the access. New waveforms enablers will be investigated and trialled in order to increase the efficiency of future systems and to provide efficient and fair access to the radio resource. The proposed new waveforms should comply with system constraints and with the coexistence of multiple communications.

8.1.7. ANR - Arburst

In this project Arburst - “Achievable region of bursty wireless networks” (2016-2020, 195 KEuros), we propose an original approach complementary to other existing projects. Instead of proposing one specific technical solution, our objective is to define a unified theoretical framework devoted to the study of IoT networks fundamental limits. We aim at establishing the fundamental limits for a decentralized system in a bursty regime which includes short packets of information and impulsive interference regime. We are targeting the fundamental limits, their mathematical expression (according to the usual information theory framework capturing the capacity region by establishing a converse and achievability theorems). We will use the recent results relative to finite block-length information theory and we will evaluate the margin for improvement between existing approaches and these limits and we will identify the scientific breakthrough that may bring significant improvements for IoT/M2M communications. This project will contribute to draw the roadmap

for the development of IoT/M2M networks and will constitute a unified framework to compare existing techniques, and to identify the breakthrough concepts that may afford the industry the leverage to deploy IoT/M2M technical solutions.

8.2. European Initiatives

8.2.1. FP7 & H2020 Projects

8.2.1.1. COM-MED

Title: COMMunication systems with renewable Energy micro-griD

Programm: H2020

Duration: October 2016 - October 2019

Coordinator: Inria

Inria contact: Samir M. Perlaza

A smart micro-grid is a small-scale power-grid system consisting of a number of distributed energy sources and loads which is responsible to ensure power sufficiency in a small area. The effectiveness of a smart micro-grid depends on the proper implementation of a communications and networking system which monitors, controls and manages the grid's operations. Due to the ever growing worldwide energy consumption, the need of an efficient framework for managing the way power is distributed and utilized has increased. The main objective of the project COM-MED is to study the fundamental interplay between communications and power networks in the context of smart micro-grids and renewable energy sources. On one hand, we study advanced signal processing techniques and communications methods to optimize the operation of smart micro-grid systems. On the other hand, we focus on mobile communications networks with renewable energy base-stations (BSs) and we investigate communications and networking techniques that take into account both data traffic and energy profiles to support high quality-of-service (QoS). The objectives of each technical WP have been assigned in such a way as to ensure that the project's target is realized during the project's time period. The theoretical results derived from the WPs 3, 4 and 5 will be tested using the telecommunication network of MTN in Cyprus but also the state-of-the-art equipment of the CITI/Inria research lab in France. The outcome of this project will provide a theoretical framework for the optimal cooperation between communications networks and power networks in the context of smart micro-grids and renewable energy sources. This is in line with the objectives of the call's theme "Renewable Energy" and is of paramount importance for the Mediterranean area. The consortium of the project has the expertise and the infrastructure to implement the objectives set and to bring the project to a successful end.

8.2.2. Collaborations in European Programs, Except FP7 & H2020

Socrate is very active in COST IRACON CA15104: Guillaume Villemaud is National Delegate (Alt.) and FIT/CorteXlab is identify as one of the COST platform: .

8.3. International Initiatives

8.3.1. Inria International Partners

8.3.1.1. Informal International Partners

Socrate has strong collaborations with several international partners.

- **Princeton University**, School of Applied Science, Department of Electrical Engineering, NJ. USA. This cooperation with Prof. H. Vincent Poor is on topics related to decentralized wireless networks. Samir M. Perlaza has been appointed as Visiting Research Collaborator at the EE Department for the academic period 2016-2017. Scientific-Leaders at Inria: Samir M. Perlaza and Jean-Marie Gorce.

- **Technical University of Berlin**, Dept. of Electrical Engineering and Computer Science, Germany. This cooperation with Prof. Rafael Schaffer is on secrecy and covert communications. Scientific-Leaders at Inria: Samir M. Perlaza.
- **National University Singapore (NUS)**, Department of Electrical and Computer Engineering, Singapore. This collaboration with Prof. Vincent Y. F. Tan is on the study of finite block-length transmissions in multi-user channels and the derivation of asymptotic capacity results with non-vanishing error probabilities. Scientific-Leaders at Inria: Samir M. Perlaza
- **University of Sheffield**, Department of Automatic Control and Systems Engineering, Sheffield, UK. This cooperation with Prof. Inaki Esnaola is on topics related to information-driven energy systems and multi-user information theory. Scientific-in-charge at Inria: Samir M. Perlaza.
- **Rutgers University**, Winlab, Orbit testbed. This cooperation with Ivan Seskar is related to experimental wireless testbed. Orbit has been one of the first wireless testbeds of its type. Tanguy Risset and Leonardo Sampaio-Cardoso have visited Winlab and I. Seskar visited the Socrate team for one week. Their collaboration is on the development of tools to ease experiment handling on wireless testbeds: visualisation, synchronization etc. Scientific-Leader at Inria: Tanguy Risset
- **University of Arizona**, Department of Electrical and Computer Engineering, Tucson, AZ, USA. This cooperation with Prof. Ravi Tandon is on topics related to channel-output feedback in wireless networks. Scientific-Leader at Inria: Samir M. Perlaza.
- **University of Cyprus**, Department of Electrical and Computer Engineering, University of Cyprus, Nicosia, Cyprus. This cooperation with Prof. Ioannis Krikidis is on topics related to energy-harvesting and wireless communications systems. Scientific-Leaders at Inria: Guillaume Villemaud and Samir M. Perlaza.
- **Universidade Federal do Ceará**, GTEL, Departamento de Teleinformática, Fortaleza, Brazil. This recently started cooperation with Prof. Tarcisio Ferreira Maciel is on topics related to the optimization of radio ressources for massive MIMO in 5G and 5G-like wireless communications systems. Scientific-in-charge at Inria: Leonardo Sampaio-Cardoso.
- **Universidad Nacional del Sur**, LaPSyC laboratory, Bahía Blanca , Argentina. This cooperation with Prof. Juan Cousseau is on topics related to Full-Duplex communications and Interference Alignment. Scientific-in-charge at Inria: Guillaume Villemaud.
- **Bell Labs New Jersey, USA**, This cooperation with Prof. Antonia Tulino (affiliated to Bell Labs and to University of Napoli, Italy) is on caching in wireless networks. The objective is to demonstrate the efficiency of caching at the edge of wireless networks through experimentations on CorteXlab. This work will be published in 2017 in a special issue of IEEE Communication magazine (Yasser Fadlallah, Antonia M. Tulino, Dario Barone, Giuseppe Vettigli, Jaime Llorca and Jean-Marie Gorce: Coding for caching in 5G networks, IEEE Communication Magazine, 2017, accepted for publication). Scientific leader at Inria : Jean-Marie Gorce.
- **Technical University "Gh. Asachi" of Iasi, Romania**, Department of Electronics, Telecommunications and Information Technology. This recent collaboration has started on topics related on the theoretical aspects of the ultra-low power radio communications. Scientific-in-charge at Inria: Florin Hutu
- **Queen's University Belfast**, UK. This collaboration is on molecular communication and massive MIMO with Prof. Trung Q. Duong. Scientific-in-charge at Inria: Malcolm Egan
- **Czech Technical University in Prague**, Czech Republic. This collaboration is on optimisation methods related to machine learning with Dr. Vyacheslav Kungurtsev. Scientific-in-charge at Inria: Malcolm Egan
- **TUMCREATE**, Singapore. This collaboration is on signal processing in communications with Dr. Ido Nevat. Scientific-in-charge at Inria: Malcolm Egan
- **telecommunications department of UMNG (Universidad Militar de Nueva Granada), Bogota, Colombia. Ongoing collaboration on security for GSM networks using deep learning. Scientific-in-charge at Inria: Leonardo Sampaio-Cardoso.**

8.4. International Research Visitors

8.4.1. Visits from International Teams

- Prof. Edward Guillen and his joint PhD student with Leonardo Sampaio-Cardoso, José Rugeles, came to Lyon in June 2018 for a 1-month academic stay, to develop work on FIT/CorteXlab for the security for GSM networks using deep learning project

8.4.2. Visits to International Teams

8.4.2.1. Sabbatical programme

Samir M. Perlaza has been on Sabatical year at Princeton University up to septembre 2018.

Malcolm Egan has been a visiting research collaborator in Prof. Poor's group in Princeton University March-April 2018.

SPIRALS Project-Team

9. Partnerships and Cooperations

9.1. Regional Initiatives

9.1.1. Région Hauts-de-France

9.1.1.1. CIRRUS

Participants: Yahya Al-Dhuraibi, Stéphanie Challita, Guillaume Fieni, Alexandre Garnier, Christophe Gourdin, Philippe Merle [correspondant], Romain Rouvoy, Lionel Seinturier, Faiez Zalila.

CIRRUS is an 3-year (2017–20) joint team with the Scalair cloud operator and architect company funded by the Hauts-de-France region. The CIRRUS joint team is developing novel solutions in the domains of the on demand configuration of heterogeneous cloud resources, the management of cloud elasticity for all deployed services (SaaS, PaaS, IaaS) in order to guarantee quality of service and user quality of experience, and the taming of financial costs of cloud infrastructures.

9.1.1.2. Alloy@Scale

Participants: Philippe Merle [correspondant], Romain Rouvoy, Lionel Seinturier, Zakaria Ournani.

Alloy@Scale is a 12-month project funded in the context of CPER Data program. Alloy@Scale aims at overcoming the limits of the formal verification of large software systems specified with the Alloy formal specification language. For that, the program combines the Grid'5000 infrastructure and the Docker container technology.

9.1.2. Inria Lille - Nord Europe

9.1.2.1. ADT LibRepair

Participants: Benjamin Danglot, Martin Monperrus, Lionel Seinturier [correspondant], Simon Urli.

ADT LibRepair (2016–18) is a technology development initiative supported by the Inria Lille - Nord Europe Center that aims at supporting the development of an integrated library of automated software repair algorithms and techniques. This ADT builds on our results about with the Astor, Nopol and NpeFix that have been obtained in the context of the defended PhD theses of Matias Martinez [57] and Benoit Cornu [46].

9.1.2.2. ADT FingerKit

Participants: Antoine Canda, Walter Rudametkin Ivey [correspondant], Antoine Vastel.

ADT FingerKit (2018–20) is a technology development initiative supported by the Inria Lille - Nord Europe Center that focuses on the design and development of a new and enhanced version of the AmIUnique platform. AmIUnique is a data collection and analysis platform to better understand, analyze and vulgarize the uses and threats of browser fingerprinting. This initiative led by Inria is a key asset to better understand novel techniques that threatens the user privacy on Internet. This ADT builds on our first results with the ongoing PhD thesis of Antoine Vastel.

9.1.2.3. ADT e-Lens

Participants: Arthur d'Azémar, Guillaume Fieni, Romain Rouvoy [correspondant].

ADT e-Lens (2018–20) is a technology development initiative supported by the Inria Lille - Nord Europe Center that aims at extending the PowerAPI energy monitoring library that we develop in the team since 2011. The extension deals with the integration of new power models (for GPU, disk, network interface), the implementation of a self-optimization algorithm, the port of the platform to embedded systems running with Raspberry Pi, ROS and Android, and the implementation of an active learning algorithm for power models. This ADT builds on our results with the defended PhD theses of Adel Nouredine [59] and Maxime Colmant [45], and with the ongoing PhD thesis of Guillaume Fieni.

9.2. National Initiatives

9.2.1. ANR

9.2.1.1. ANR BottleNet

Participants: Romain Rouvoy [correspondant], Walter Rudametkin Ivey, Lionel Seinturier.

BottleNet is a 48-month project (2015–19) funded by ANR. The objective of BottleNet is to deliver methods, algorithms, and software systems to measure Internet *Quality of Experience* (QoE) and diagnose the root cause of poor Internet QoE. Our goal calls for tools that run directly at users' devices. We plan to collect network and application performance metrics directly at users' devices and correlate it with user perception to model Internet QoE, and to correlate measurements across users and devices to diagnose poor Internet QoE. This data-driven approach is essential to address the challenging problem of modeling user perception and of diagnosing sources of bottlenecks in complex Internet services. BottleNet will lead to new solutions to assist users, network and service operators as well as regulators in understanding Internet QoE and the sources of performance bottleneck.

9.2.1.2. ANR SATAS

Participants: Philippe Merle [correspondant], Romain Rouvoy, Lionel Seinturier.

SATAS is a 48-month project (2015–19) funded by ANR. SATAS aims to advance the state of the art in massively parallel SAT solving with a particular eye to the applications driving progress in the field. The final goal of the project is to be able to provide a "pay as you go" interface to SAT solving services, with a particular focus on their power consumption. This project will extend the reach of SAT solving technologies, daily used in many critical and industrial applications, to new application areas, which were previously considered too hard, and lower the cost of deploying massively parallel SAT solvers on the cloud.

9.2.1.3. ANR Headwork

Participants: Pierre Bourhis [correspondant], Marion Tommasi.

Headwork is a 48-month project (2016–21) funded by ANR. The main objective of Headwork is to develop data-centric workflows for programming crowd sourcing systems in flexible declarative manner. The problem of crowd sourcing systems is to fill a database with knowledge gathered by thousands or more human participants. A particular focus is to be put on the aspects of data uncertainty and for the representation of user expertise. This project is coordinated by D. Gross-Amblard from the Druid Team (Rennes 1). Other partners include the Dahu team (Inria Saclay), Sumo (Inria Bretagne), and Links (Inria Lille) with J. Nierhen and M. Sakho.

9.2.1.4. ANR Delta

Participant: Pierre Bourhis [correspondant].

Delta is a 48-month project (2016–21) funded by ANR. The project focuses on the study of logic, transducers and automata. In particular, it aims at extending classical framework to handle input/output, quantities and data. This project is coordinated by M. Zeitoun from LaBRI. Other partners include LIF (Marseille), IRIF (Paris-Diderot), and D. Gallois from the Inria Lille Links team.

9.2.2. Competitivity Clusters

9.2.2.1. FUI StoreConnect

Participants: Aurélien Bourdon, Julien Duribreux, Romain Rouvoy, Lionel Seinturier [correspondant], Antoine Veuiller.

StoreConnect is a 36-month project (2016–19) funded by FUI and labelled by the PICOM (Pôle des Industries du COMmerce) competitivity cluster. The partners are Tevolys, Ubudu (leader), Smile, STIME, Leroy Merlin, Insiteo, Inria Spirals, Inria Fun, Inria Stars. The goal of the project is to define a modular multi-sensors middleware platform for indoor geolocation.

9.2.3. Inria National Initiatives

9.2.3.1. Inria IPL BetterNet

Participants: Lakhdar Meftah, Romain Rouvoy [correspondant], Romain Sommerard, Antoine Veuiller.

BetterNet (2016–19) aims at building and delivering a scientific and technical collaborative observatory to measure and improve the Internet service access as perceived by users. In this Inria Project Lab, we will propose new original user-centered measurement methods, which will associate social sciences to better understand Internet usage and the quality of services and networks. Our observatory can be defined as a vantage point, where: (1) tools, models and algorithms/heuristics will be provided to collect data, (2) acquired data will be analyzed, and shared appropriately with scientists, stakeholders and civil society, and (3) new value-added services will be proposed to end-users. IPL BetterNet is led by Isabelle Chrisment (Inria Madynes), with the participation of the Diana, Dionysos, Inria Chile, Muse, and Spirals Inria project-teams, as well as the ARCEP French agency and the ip-label company.

9.2.4. CNRS Momentum

9.2.4.1. Manage Your Data Without Information Leakage

Participants: Pierre Bourhis [correspondant], Louis Jachiet.

“Gérer vos données sans fuite d’information” is a 3-year (2018–20) project granted in the context of the CNRS-Momentum call for projects. Data manipulated by modern applications are stored in large databases. To protect these pieces of data, security policies limit a user’s access to what she is allowed to see. However, by using the semantics of the data, a user can deduce information that she was not supposed to have access to. The goal of this project is to establish methods and tools for understanding and detecting such data leaks.

9.3. European Initiatives

9.3.1. FP7 & H2020 Projects

Program: H2020 ICT-10-2016.

Project acronym: STAMP.

Project title: Software Testing Amplification.

Duration: 36 months (2016–19).

Coordinator: Inria.

Other partners: ActiveEon (France), Atos (Spain), Engineering (Italy), OW2 (France), SINTEF (Norway), TellU (Norway), TU Delft (The Netherlands), XWiki (France).

Abstract: By leveraging advanced research in automatic test generation, STAMP aims at pushing automation in DevOps one step further through innovative methods of test amplification. It will reuse existing assets (test cases, API descriptions, dependency models), in order to generate more test cases and test configurations each time the application is updated. Acting at all steps of development cycle, STAMP techniques aim at reducing the number and cost of regression bugs at unit level, configuration level and production stage.

Participants: Benjamin Danglot, Martin Monperrus [correspondant].

Program: H2020 JU Shift2Rail.

Project acronym: X2Rail-1.

Project title: Start-up activities for Advanced Signalling and Automation System.

Duration: 36 months (2016–19).

Coordinator: Siemens.

Other partners: 19 partners, among others Bombardier, Siemens, Thales, IRT Railenium.

Abstract: Our contribution to the project is focused on adaptive communication middleware for cyber-physical railway systems.

Participants: Lionel Seinturier [correspondant].

Program: EIT Digital.

Project acronym: MCS.

Project title: Multi-Cloud Studio.

Duration: 12 months (2018).

Coordinator: Inria.

Other partners: Santer Reply (Italy) and Scalair (France).

Abstract: The goal of this EIT Digital activity is to create the Xscalibur start-up and develop its first Multi-Cloud Studio product. This product is a model-driven graphical interface to design, deploy and administrate multi-cloud systems based on Amazon Web Service, OpenStack, and VMware.

Participants: Jamal Boudjaj, Rida Darmal, Julien Decaudin, Bénédicte Delcourt, Christophe Gourdin, Philippe Merle [correspondant].

Program: EIT Digital.

Project acronym: Bankable.

Project title: Bankable, Deliver the best mobile banking services and customer experience

Duration: 12 months (2018).

Coordinator: Alfstore.

Other partners: Inria, Cefriel

Abstract: BANKABLE helps consumer banks continuously deliver the best mobile banking experience. The platform will anonymously analyze data gathered from mobile sensors, user context and interactions. Enriched by online customers' feedbacks, the bank will find deeper insights & drive real-time actions.

Participants: Romain Rouvoy [correspondant].

9.3.2. Collaborations in European Programs, Except FP7 & H2020

Program: EUREKA Celtic-Plus.

Project acronym: SENDATE.

Project title: SEcure Networking for a DATa Center Cloud in Europe.

Duration: 36 months (2016–19).

Coordinator: Nokia.

Other partners: 50+ partners in Finland, France, Germany, Norway, and Sweden. Selected partners involved: Nokia, Orange.

Abstract: The project addresses the convergence of telecommunication networks and IT in the context of distributed data centers. We are involved in the TANDEM subproject that targets the infrastructure of such a distributed system. More specifically, we are studying new approaches in terms of software engineering and component-based solutions for enabling this convergence of network and IT.

Participants: Lionel Seinturier [correspondant].

9.4. International Initiatives

9.4.1. Inria Associate Teams Not Involved in an Inria International Labs

9.4.1.1. SOMCA

Title: Self-Optimization of Service Oriented Architectures for Mobile and Cloud Applications

International Partner (Institution - Laboratory - Researcher):

Université du Québec À Montréal (Canada) - LATECE - Naouel MOHA

Start year: 2017

See also: http://sofa.uqam.ca/somca.php

The long-term goal of this research program is to propose a novel and innovative methodology embodied in an software platform, to support the runtime detection and correction of anti-patterns in large-scale service-oriented distributed systems in order to continuously optimize their quality of service. One originality of this program lies in the dynamic nature of the service-oriented environments and the application on emerging frameworks for embedded and distributed systems (e.g., Android/iOS for mobile devices, PaaS/SaaS for Cloud environments), and in particular mobile systems interacting with remote services hosted on the Cloud.

9.4.2. Participation in Other International Programs

9.4.2.1. PHC Zenon Cyprus - Project RRI-MobDev

Participants: Sarra Habchi, Lakhdar Meftah, Mohammad Naseri, Romain Rouvoy [correspondant], Walter Rudametkin Ivey, Romain Sommerard, Antoine Vastel.

RRI-MobDev (*Responsible Research and Innovation for Mobile Application Development*) is a 2-year (2017–2018) bilateral collaboration with UCLan Cyprus, an overseas campus of the University of Central Lancashire. Mobile applications are part of a complex ecosystem involving various stakeholders (developers, users, app stores, etc.) exposed to various threats, including not only malware, but also potential information leaks through the continuous interactions with remote servers. This project aims to study and alleviate this problem by intervening both with the users and the developers of mobile apps, with an aim of enabling a cleaner, safer and more responsible mobile app ecosystem.

9.5. International Research Visitors

9.5.1. Visits of International Scientists

Rajkumar Buyya, Redmond Barry Distinguished Professor and Director of the Cloud Computing and Distributed Systems (CLOUDS) Laboratory at the University of Melbourne, visited us in February 2018.

9.5.1.1. Internships

Mohammad Naseri, MSc. Student in Computer Science from Saarland University, Germany, visited us for 3 months, from November 2017 to January 2018.

Chaima Chakhaba, MSc. Student in Computer Science from ESI Alger, Algeria, visited us for 9 months, from December 2017 to August 2018.

9.5.2. Visits to International Teams

9.5.2.1. Research Stays Abroad

Thomas Durieux, PhD Student, spent 3 months from April to June 2018 in KTH, Sweden.

STACK Team

9. Partnerships and Cooperations

9.1. Regional Initiatives

9.1.1. CoMe4ACloud

Participant: Thomas Ledoux [coordinator].

The project, started in October 2016, was completed in March 2018. CoMe4ACloud was an Atlanstic 2020 funded project and supported a one year post-doc position. The project was led by STACK research team and involved also AtlanModels and TASC, all of them from the LS2N and situated at IMT Atlantique.

The high-level objective of the CoMe4ACloud (Constraints and Model Engineering for Autonomic Clouds) project was to provide an end-to-end solution for autonomic Cloud services. To that end, we relied on techniques of Constraint Programming so as a decision-making tool and Model-driven Engineering to ease the automatic generation of the so-called autonomic managers as well as their synchronization with the managed system (i.e., the Cloud layers).

This year, we have focus on the dissemination of the results. We got the best paper award of CLOSER 2018 (the 8th International Conference on Cloud Computing and Services Science) [12] and published in the journal FGCS [3]. We also gave a pitch in the annual Atlanstic 2020 meeting in November.

See https://come4acloud.github.io for more information.

9.1.2. Oncoshare

Participant: Mario Südholt [coordinator].

The ONCOSHARe project (ONCOlogy big data SHAring for Research) will demonstrate, through a multi-disciplinary cooperation within the Western CANCEROPOLE network, the feasibility and the added value of a Cancer Patient Centered Information Common for in-silico research. The STACK team will work on challenges to the security and the privacy of user data in this context.

This project is financed by three French regions from 2018-2021.

9.1.3. SyMeTRIC

Participant: Jean-Marc Menaud [coordinator].

SyMeTRIC is a regional federated project in Systems Medicine funded by the Pays de la Loire french region. Systems Medicine approaches can be compared to Systems Biology. They aim at integrating several information sources to design and validate bio-models and biomarkers to anticipate and enhance patients follow-up (diagnosis, treatment response prediction, prognosis).

This project is ending in 2018.

9.1.4. SysMics

Participants: Jean-Marc Menaud, Mario Südholt [coordinator].

The SysMics project aims at federating the NExT scientific community toward a common objective: anticipate the emergence of systems medicine by co-developing 3 approaches in population-scale genomics: genotyping by sequencing, cell-by-cell profiling and microbiome analysis. STACK investigates new means for secure and privacy-aware computations in the context of personalized medecine, notably genetic analyses.

This project is financed by the Nantes excellency initiative in Medecine and Informatics (NExT) from 2018-22.

9.2. National Initiatives

9.2.1. CominLabs laboratory of excellence

9.2.1.1. PrivGen

Participants: Fatima-Zahra Boujdad, Mario Südholt [coordinator].

PrivGen ("Privacy-preserving sharing and processing of genetic data") is a three-year project that has been started in Oct. 2016 and is conducted by three partners: a team of computer scientists from the LATIM Inserm institute in Brest mainly working on data watermarking techniques, a team of geneticians from an Inserm institute in Rennes working on the gathering and interpretation of genetic data, and the STACK team. The project provides funding of 330 KEUR altogether with an STACK share of 120 KEUR.

The project considers challenges related to the outsourcing of genetic data that is in the Cloud by different stakeholders (researchers, organizations, providers, etc.). It tackles several limitations of current security solutions in the cloud, notably the lack of support for different security and privacy properties at once and computations executed at different sites that are executed on behalf of multiple stakeholders.

The partners are working on three main challenges:

- Mechanisms for a continuous digital content protection
- Composition of security and privacy-protection mechanisms
- Distributed processing and sharing of genetic data

The Ascola team is mainly involved in providing solutions for the second and third challenges.

9.2.1.2. SeDuCe++

Participants: Jonathan Pastor, Jean-Marc Menaud [coordinator].

SeDuCe++ is an extended version of the SeDuCe project. Funded by the LS2N (CNRS), an allocated budget of 10KEuros for one year, it aims at studying the energy footprint of extreme edge infrastructure.

9.2.2. ANR

9.2.2.1. GRECO (ANR)

Participants: Adrien Lebre [Contact point], Alexandre Van Kempen.

The GRECO project (Resource manager for cloud of Things) is an ANR project (ANR-16-CE25-0016) running for 42 months (starting in January 2017 with an allocated budget of 522KEuros, 90KEuro for ASCOLA).

The consortium is composed of 4 partners: Qarnot Computing (coordinator) and 3 academic research group (DATAMOVE and AMA from the LIG in Grenoble and ASCOLA from Inria Rennes Bretagne Atlantique).

The goal of the GRECO project (https://anr-greco.net) is to design a manager for cloud of things. The manager should act at the IaaS, PaaS and SaaS layer of the cloud. One of the principal challenges will consist in handling the execution context of the environment in which the cloud of things operates. Indeed, unlike classical resource managers, connected devices imply to consider new types of networks, execution supports, sensors and new constraints like human interactions. The great mobility and variability of these contexts complexify the modelling of the quality of service. To face this challenge, we intend to innovate in designing scheduling and data management systems that will use machine learning techniques to automatically adapt their behaviour to the execution context. Adaptation here requires a modelling of the recurrent cloud of things usages, the modelling of the dynamics of physical cloud architecture.

9.2.2.2. KerStream (ANR)

Participant: Shadi Ibrahim [Coordinator].

The KerStream project (Big Data Processing: Beyond Hadoop!) is an ANR JCJC (Young Researcher) project (ANR-16-CE25-0014-1) running for 48 months (starting in January 2017 with an allocated budget of 238KEuros).

The goal of the KerStream project is to address the limitations of Hadoop when running Big Data stream applications on large-scale clouds and do a step beyond Hadoop by proposing a new approach, called KerStream, for scalable and resilient Big Data stream processing on clouds. The KerStream project can be seen as the first step towards developing the first French middleware that handles Stream Data processing at Scale.

9.2.3. FSN

9.2.3.1. Hydda (FSN)

Participants: Helene Coullon, Jean-Marc Menaud [coordinator].

The HYDDA project aims to develop a software solution allowing the deployment of Big Data applications (with hybrid design (HPC/CLoud)) on heterogeneous platforms (cluster, Grid, private Cloud) and orchestrators (Task scheduler like Slurm, Virtual orchestrator (like Nova for OpenStack or Swarm for Docker). The main questions we are investigating are :

- How to propose an easy-to-use service to host (from deployment to elimination) application components that are both typed Cloud and HPC?
- How propose a service that unifies the HPCaaS (HPC as a service) and the Infrastructure as a Service (IaaS) in order to offer resources on demand and to take into account the specificities of scientific applications?
- How optimize resources usage of these platforms (CPU, RAM, Disk, Energy, etc.) in order to propose solutions at the least cost?

9.2.4. CPER

9.2.4.1. SeDuCe

Participants: Adrien Lebre, Jean-Marc Menaud [coordinator], Jonathan Pastor.

The SeDuCe project (Sustainable Data Centers: Bring Sun, Wind and Cloud Back Together), aims to design an experimental infrastructure dedicated to the study of data centers with low energy footprint. This innovative data center will be the first experimental data center in the world for studying the energy impact of cloud computing and the contribution of renewable energy (solar panels, wind turbines) from the scientific, technological and economic viewpoints. This project is integrated in the national context of grid computing (Grid'5000), and the Constellation project, which will be an inter-node (Pays de la Loire, Brittany).

9.2.5. Inria Project Labs

9.2.5.1. DISCOVERY

Participants: Helene Coullon, Marie Delavergne, Shadi Ibrahim, Adrien Lebre [coordinator], Dimitri Pertin [Until May 2018], Ronan Alexandre Rcherreau, Matthieu Simonin, Alexandre Van Kempen.

To accommodate the ever-increasing demand for Utility Computing (UC) resources, while taking into account both energy and economical issues, the current trend consists in building larger and larger Data Centers in a few strategic locations. Although such an approach enables UC providers to cope with the actual demand while continuing to operate UC resources through centralized software system, it is far from delivering sustainable and efficient UC infrastructures for future needs.

The DISCOVERY initiative [0] aims at exploring a new way of operating Utility Computing (UC) resources by leveraging any facilities available through the Internet in order to deliver widely distributed platforms that can better match the geographical dispersal of users as well as the ever increasing demand. Critical to the emergence of such locality-based UC (also referred as Fog/Edge Computing) platforms is the availability of appropriate operating mechanisms. The main objective of DISCOVERY is to design, implement, demonstrate and promote a new kind of Cloud Operting System (OS) that will enable the management of such a large-scale and widely distributed infrastructure in an unified and friendly manner.

[0] http://beyondtheclouds.github.io

The consortium is composed of experts in the following research areas: large-scale infrastructure management systems, networking and P2P algorithms. Moreover, two key network operators, namely Orange and RENATER, are involved in the project.

By deploying and using a Fog/Edge OS on backbones, our ultimate vision is to enable large parts of the Internet to be hosted and operated by its internal structure itself: a scalable set of resources delivered by any computing facilities forming the Internet, starting from the larger hubs operated by ISPs, governments and academic institutions, to any idle resources that may be provided by end users.

STACK leads the DISCOVERY IPL and contributes mainly around two axes: VM life cycle management and deployment/reconfiguration concerns.

9.2.6. InriaHub

9.2.6.1. MERCURY

Participants: Ronan-Alexandre Cherrueau, Adrien Lebre [coordinator], Matthieu Simonin.

STACK, in particular within the framework of the DISCOVERY initiative has been working on the massively distributed use case since 2013. With the development of several proof-of-concepts around OpenStack, the team has had the opportunity to start an InriaHub action. Named MERCURY, the goal of this action is twofold: (i) support the research development made within the context of DISCOVERY and (ii) favor the transfer toward the OpenStack community.
Further information available at: http://beyondtheClouds.github.io.

9.2.6.2. APOLLO/SOYUZ

Participants: Ronan-Alexandre Cherrueau, Adrien Lebre [coordinator], Matthieu Simonin.

The Apollo/Soyuz is the second InriaHub action attached the DISCOVERY IPL. While MERCURY aims mainly at supporting development efforts within the DISCOVERY IPL, the APOLLO/SOYUZ is focusing on the animation and the dissemination of the DISCOVERY activities within the different open-source ecosystem (*i.e.*, OpenStack, OPNFV, etc.). One additional engineer will join the current team in January 2019.
Further information available at: http://beyondtheClouds.github.io.

9.2.7. Fond d'amorçage IMT Industrie du Futur 2017

9.2.7.1. aLIFE

Participants: Hélène Coullon [coordinator], Jacques Noyé.

We have organized, in partnership with colleagues from IMT Atlantique, the aLIFE workshop between industry and academia, which took place in Nantes during two days on 30-31 January.

The objective was to share experience and success stories, as well as open challenges related to the contribution of software-related research to Factories of the Future, in French *Apport de l'industrie du Logiciel à l'Industrie du Futur Européenne (aLIFE)*. 86 people registered to the workshop, organized around plenary sessions and discussion panels, with speakers from Airbus, Baldwin Partners, Comau (Italy), Dassault Systèmes, e.l.m. Leblanc, La Poste, Naval Group, Predict, Fraunhofer (Germany), KTH (Sweden), Polytechnique Montréal (Canada), and TUM (Germany).

9.2.8. Connect Talent

9.2.8.1. Apollo (Connect Talent)

Participant: Shadi Ibrahim [Coordinator].

The Apollo project (Fast, efficient and privacy-aware Workflow executions in massively distributed Datacenters) is an individual research project "'Connect Talent" running for 36 months (starting in November 2017 with an allocated budget of 201KEuros).

The goal of the Apollo project is to investigate novel scheduling policies and mechanisms for fast, efficient and privacy-aware data-intensive workflow executions in massively distributed data-centers.

9.2.9. Etoiles Montantes

9.2.9.1. VeRDi

Participant: Hélène Coullon [Coordinator].

VeRDi is an acronym for Verified Reconfiguration Driven by execution. The VeRDi project is funded by the French region Pays De La Loire where Nantes is located. The project starts in November 2018 and ends on December 2020 with an allocated budget of 172800€.

It aims at addressing distributed software reconfiguration in an efficient and verified way. The aim of the VeRDi project is to build an argued disruptive view of the problem. To do so we want to validate the work already performed on the deployment in the team and extend it to reconfiguration.

9.3. European Initiatives

9.3.1. H2020 Projects

9.3.1.1. BigStorage

Title: BigStorage: Storage-based Convergence between HPC and Cloud to handle Big Data
Programm: H2020
Duration: January 2015 - December 2018
Coordinator: Universidad politecnica de Madrid
Partners:

- Barcelona Supercomputing Center - Centro Nacional de Supercomputacion (Spain)
- Ca Technologies Development Spain (Spain)
- Commissariat A L Energie Atomique et Aux Energies Alternatives (France)
- Deutsches Klimarechenzentrum (Germany)
- Foundation for Research and Technology Hellas (Greece)
- Fujitsu Technology Solutions (Germany)
- Johannes Gutenberg Universitaet Mainz (Germany)
- Universidad Politecnica de Madrid (Spain)
- Seagate Systems Uk (United Kingdom)

Inria contact: G. Antoniu & A. Lebre

The consortium of this European Training Network (ETN) 'BigStorage: Storage-based Convergence between HPC and Cloud to handle Big Data' will train future data scientists in order to enable them and us to apply holistic and interdisciplinary approaches for taking advantage of a data-overwhelmed world, which requires HPC and Cloud infrastructures with a redefinition of storage architectures underpinning them - focusing on meeting highly ambitious performance and energy usage objectives. There has been an explosion of digital data, which is changing our knowledge about the world. This huge data collection, which cannot be managed by current data management systems, is known as Big Data. Techniques to address it are gradually combining with what has been traditionally known as High Performance Computing. Therefore, this ETN will focus on the convergence of Big Data, HPC, and Cloud data storage, ist management and analysis. To gain value from Big Data it must be addressed from many different angles: (i) applications, which can exploit this data, (ii) middleware, operating in the cloud and HPC environments, and (iii) infrastructure, which provides the Storage, and Computing capable of handling it. Big Data can only be effectively exploited if techniques and algorithms are available, which help to understand its content, so that it can be processed by decision-making models. This is the main goal of Data Science. We claim that this ETN project will be the ideal means to educate new researchers on the different facets of Data Science (across storage hardware and software architectures, large-scale distributed systems, data management services, data analysis, machine learning, decision making). Such a multifaceted expertise is mandatory to enable researchers to propose appropriate answers to applications requirements, while leveraging advanced data storage solutions unifying cloud and HPC storage facilities.'

9.4. International Initiatives

9.4.1. Inria International Partners

9.4.1.1. Informal International Partners

Huazhong university of Science and Technology (HUST): We collaborate on resource management and task scheduling for stream data applications in the cloud.

National University of Singapore (NUS): We collaborate on mitigating stragglers for Big Data applications in clouds and optimizing graph processing in geo-distributed data-centers.

ShenZhen University: We collaborate on data management in HPC systems, mitigating stragglers for Big Data applications in clouds and optimizing graph processing in geo-distributed data-centers.

9.5. International Research Visitors

9.5.1. Visits to International Teams

9.5.1.1. Research Stays Abroad

HUST, China: From October 20 to November 5, S. Ibrahim visited the Services Computing Technology and System Lab at Huazhong university of Science and Technology.

Flagstaff, Northern Arizona University, USA: From September10 to September 16, H. Coullon visited the School of Informatics, Computing and Cyber Systems, Northern Arizona University, Flagstaff, USA.

STORM Project-Team

8. Partnerships and Cooperations

8.1. Regional Initiatives

HPC Cloud Computing

Participants: Olivier Aumage, Nathalie Furmento, Samuel Thibault.

Other participants : David Auber, Olivier Beaumont, Lionel Eyraud-Dubois, Gérald Point

Abstract: The goal of this project is to gather teams from the HPC and Big Data communities to work at the intersection between these domains. We will focus on how StarPU can be adapted to achieve good performances on Big Data platforms.

8.2. National Initiatives

ELCI The ELCI PIA project (Software Environment for HPC) aims to develop a new generation of software stack for supercomputers, numerical solvers, runtime and programming development environments for HPC simulation. The ELCI project also aims to validate this software stack by showing its capacity to offer improved scalability, resilience, security, modularity and abstraction on real applications. The coordinator is Bull, and the different partners are CEA, Inria, SAFRAN, CERFACS, CNRS CORIA, CENAERO, ONERA, UVSQ, Kitware and AlgoTech.

8.2.1. ANR

ANR SOLHAR (http://solhar.gforge.inria.fr/doku.php?id=start).

ANR MONU 2013 Program, 2013 - 2018 (36 months extended)

Identification: ANR-13-MONU-0007

Coordinator: Inria Bordeaux/LaBRI

Other partners: CNRS-IRIT, Inria-LIP Lyon, CEA/CESTA, EADS-IW

Abstract: This project aims at studying and designing algorithms and parallel programming models for implementing direct methods for the solution of sparse linear systems on emerging computers equipped with accelerators. The ultimate aim of this project is to achieve the implementation of a software package providing a solver based on direct methods for sparse linear systems of equations. Several attempts have been made to accomplish the porting of these methods on such architectures; the proposed approaches are mostly based on a simple offloading of some computational tasks (the coarsest grained ones) to the accelerators and rely on fine hand-tuning of the code and accurate performance modeling to achieve efficiency. This project proposes an innovative approach which relies on the efficiency and portability of runtime systems, such as the StarPU tool developed in the runtime team (Bordeaux). Although the SOLHAR project will focus on heterogeneous computers equipped with GPUs due to their wide availability and affordable cost, the research accomplished on algorithms, methods and programming models will be readily applicable to other accelerator devices such as ClearSpeed boards or Cell processors.

ANR EXACARD

AAPG ANR 2018 (42 months)

Coordinator: Yves Coudière (Carmen) Inria Bordeaux

Abstract: Cardiac arrhythmia affect millions of patients and cause 300,000 deaths each year in Europe. Most of these arrhythmia are due to interaction between structural and electrophysiological changes in the heart muscle. A true understanding of these phenomena requires numerical simulations at a much finer resolution, and larger scale, than currently possible. Next-generation, heterogeneous, high-performance computing (HPC) systems provide the power for this. But the large scale of the computations pushes the limits of current runtime optimization systems, and together with task-based parallelism, prompts for the development of dedicated numerical methods and HPC runtime optimizations. With a consortium including specialists of these domains and cardiac modeling, we will investigate new task-based optimization techniques and numerical methods to utilize these systems for cardiac simulations at an unprecedented scale, and pave the way for future use cases.

8.2.2. ADT - Inria Technological Development Actions

ADT SwLoc (http://swloc.gforge.inria.fr/)

Participants: Raymond Namyst, Pierre-André Wacrenier, Andra Hugo, Brice Goglin, Corentin Salingue.

Inria ADT Campaign 2017, 10/2017 - 9/2019 (24 months)

Coordinator: Raymond Namyst

Abstract: The Inria action ADT SwLoc is aiming at developing a library allowing dynamic flexible partitioning of computing resources in order to execute parallel regions concurrently inside the same processes.

ADT Gordon

Participants: Denis Barthou, Nathalie Furmento, Samuel Thibault, Pierre-André Wacrenier.

Inria ADT Campaign 2018, 11/2018 - 11/2020 (24 months)

Coordinator: Emmanuel Jeannot (Tadaam)

Other partners: HiePACS, PLEIADE, Tadaam (Inria Bordeaux)

Abstract: Teams HiePACS, Storm and Tadaam develop each a brick of an HPC software stack, namely solver, runtime, and communication library. The goal of the Gordon project is to consolidate the HPC stack, to improve interfaces between each brick, and to target a better scalability. The bioinformatics application involved in the project has been selected so as to stress the underlying systems.

ADT AFF3CT Matlab

Participants: Denis Barthou, Olivier Aumage, Adrien Cassagne.

Inria ADT Campaign 2018, 12/2018 - 12/2019 (12 months)

Coordinator: Denis Barthou

Other partners: C.Jego and C.Leroux (IMS lab, U.Bordeaux)

Abstract: AFF3CT is a toolchain for designing, validation and experimentation of new Error Correcting codes. This toolchain is written in C++, and this constitutes a difficulty for many industrial users, who are mostly electronicians. The goal of this ADT is to widen the number of possible users by designing a Matlab and Python interface for AFF3CT, in collaboration with existing users, and proposing a parallel framework in OpenMP.

8.2.3. IPL - Inria Project Lab

HAC-SPECIS (High-performance Application and Computers, Studying PErformance and Correctness In Simulation)

Participants: Samuel Thibault, Luka Stanisic, Emmanuelle Saillard, Olivier Aumage, Idriss Daoudi.

Inria IPL 2016 - 2020 (48 months)

Coordinator: Arnaud Legrand (team Polaris, Inria Rhône Alpes)

Since June 2016, the team is participating to the HAC-SPECIS http://hacspecis.gforge.inria.fr/ Inria Project Lab (IPL). This national initiative aims at answering methodological needs of HPC application and runtime developers and allowing to study real HPC systems both from the correctness and performance point of view. To this end, it gathers experts from the HPC, formal verification and performance evaluation community.

HPC-BigData (High Performance Computing and Big Data)

Participant: Samuel Thibault.

Inria IPL 2018 - 2022 (48 months)

Coordinator: Bruno Raffin (team DataMove, Inria Rhône Alpes)

Since June 2018, the team is participating to the HPC-BigData https://project.inria.fr/hpcbigdata/ Inria Project Lab (IPL). The goal of this HPC-BigData IPL is to gather teams from the HPC, Big Data and Machine Learning (ML) areas to work at the intersection between these domains. Research is organized along three main axes: high performance analytics for scientific computing applications, high performance analytics for big data applications, infrastructure and resource management.

8.3. European Initiatives

8.3.1. H2020 Projects

INTERTWinE

- Title: Programming Model INTERoperability ToWards Exascale
- Program: H2020
- Duration: October 2015 - October 2018
- Coordinator: EPCC
- Inria contact: Olivier Aumage
- Partners:
  - Barcelona Supercomputing Center - Centro Nacional de Supercomputacion (Spain)
  - Deutsches Zentrum für Luft - und Raumfahrt Ev (Germany)
  - Fraunhofer Gesellschaft Zur Forderung Der Angewandten Forschung Ev (Germany)
  - Institut National de Recherche en Informatique et en Automatique (France)
  - Kungliga Tekniska Hoegskolan (Sweden)
  - T-Systems Solutions for Research (Germany)
  - The University of Edinburgh (United Kingdom)
  - Universitat Jaume I de Castellon (Spain)
  - The University of Manchester (United Kingdom)

This project addresses the problem of programming model design and implementation for the Exascale. The first Exascale computers will be very highly parallel systems, consisting of a hierarchy of architectural levels. To program such systems effectively and portably, programming APIs with efficient and robust implementations must be ready in the appropriate timescale. A single, “silver bullet” API which addresses all the architectural levels does not exist and seems very unlikely to emerge soon enough. We must therefore expect that using combinations of different APIs at different system levels will be the only practical solution in the short to medium term. Although there remains room for improvement in individual programming models and their implementations, the main challenges lie in interoperability between APIs. It is this interoperability,

both at the specification level and at the implementation level, which this project seeks to address and to further the state of the art. INTERTWinE brings together the principal European organisations driving the evolution of programming models and their implementations. The project will focus on seven key programming APIs: MPI, GASPI, OpenMP, OmpSs, StarPU, QUARK and PaRSEC, each of which has a project partner with extensive experience in API design and implementation. Interoperability requirements, and evaluation of implementations will be driven by a set of kernels and applications, each of which has a project partner with a major role in their development. The project will implement a co-design cycle, by feeding back advances in API design and implementation into the applications and kernels, thereby driving new requirements and hence further advances.

Exa2PRO

- Title: Enhancing Programmability and boosting Performance Portability for Exascale Computing systems
- Program: H2020-FETHPC
- Duration: May 2018 - April 2021
- Coordinator: ICCS
- Inria contact: Samuel Thibault
- Partners:
  * Institute of Communications and Computer Systems (ICCS) (Greece)
  * Linköpiung University (LIU) (Sweden)
  * Centre for Research and Technology Hellas (CERTH) (Greece)
  * Institut National de Recherche en Informatique et en Automatique (Inria) (France)
  * Maxeler Technologies Limited (MAX) (UK)
  * Forschungszentrum Jülich (JUELICH) (Germany)
  * Centre National de la Rcherche Scientifique (CNRS) (France)

The vision of EXA2PRO is to develop a programming environment that will enable the productive deployment of highly parallel applications in exascale computing systems. EXA2PRO programming environment will integrate tools that will address significant exascale challenges. It will support a wide range of scientific applications, provide tools for improving source code quality, enable efficient exploitation of exascale systems' heterogeneity and integrate tools for data and memory management optimization. Additionally, it will provide various fault-tolerance mechanisms, both user-exposed and at runtime system level and performance monitoring features. EXA2PRO will be evaluated using 4 use cases from 4 different domains, which will be deployed in JUELICH supercomputing center. The use cases will leverage the EXA2PRO tool-chain and we expect:

- Increased applications performance based on EXA2PRO optimization tools (data and memory management)
- Efficient exploitation of heterogeneity by the applications that will allow the evaluation of more complex problems.
- Identification of trade-offs between design qualities (source code maintainability/reusability) and run-time constraints (performance/energy consumption).
- Evaluation of various fault-tolerance mechanisms for applications with different characteristics.

EXA2PRO outcome is expected to have major impact in a) the scientific and industrial community that focuses on application deployment in supercomputing centers: EXA2PRO environment will allow efficient application deployment with reduced effort. b) on application developers of exascale application: EXA2PRO will provide tools for improving source code maintainability/ reusability, which will allow application evaluation with reduced developers' effort. c) on the scientific community and the industry relevant to the EXA2PRO use cases. At least two of the EXA2PRO use cases will have significant impact to the CO2 capture and to the Supercapacitors industry.

8.3.2. Collaborations in European Programs, Except FP7 & H2020

PRACE-5IP

- Title: PRACE 5th Implementation Phase
- Program: PRACE
- Duration: 2017 - 2019
- Coordinator: PRACE
- Inria contact for team STORM: Olivier Aumage
- Abstract: The objectives of PRACE-5IP are to build on and seamlessly continue the successes of PRACE and start new innovative and collaborative activities proposed by the consortium. These include:
  * assisting the transition to PRACE2 including analysis of TransNational Access;
  * strengthening the internationally recognised PRACE brand;
  * continuing and extend advanced training which so far provided more than 18 800 persontraining days;
  * preparing strategies and best practices towards Exascale computing;
  * coordinating and enhancing the operation of the multi-tier HPC systems and services;
  * supporting users to exploit massively parallel systems and novel architectures.

  A high level Service Catalogue is provided. The proven project structure will be used to achieve each of the objectives in 6 dedicated work packages. The activities are designed to increase Europe's research and innovation potential especially through:
  * seamless and efficient Tier-0 services and a pan-European HPC ecosystem including national capabilities;
  * promoting take-up by industry and new communities and special offers to SMEs;
  * implementing a new flexible business model for PRACE 2;
  * proposing strategies for deployment of leadership systems;
  * collaborating with the ETP4HPC, CoEs and other European and international organisations on future architectures, training, application support and policies.

8.4. International Research Visitors

- Costin Iancu, LBNL (USA), from Oct. 8 to Oct. 12, 2018

8.4.1. Internships

- Dana Akhmetova, KTH (Sweden), PhD Internship, from Feb. 18, 2018 to Mar. 24, 2018, within the context of H2020 INTERTWinE.

TADAAM Project-Team

9. Partnerships and Cooperations

9.1. Regional Initiatives

9.1.1. CRA HPC Scalable Ecosystem, 2018-2021

2018 - 2021 (36 months)

Coordinator: Emmanuel AGULLO

Other partners: INRA, Institut Pprime, UPPA, Airbus, CEA, CATIE

Abstract: The goal is to design a unified runtime-system for numerical simulation at large-scale and with a large amount of data. We aim at contributing significantly to the convergence between HPC and BigData. TADAAM is involved in scheduling data access and managing communication efficiently on large-scale system.

9.2. National Initiatives

9.2.1. PIA ELCI, Environnement Logiciel pour le Calcul Intensif, 2014-2018

The ELCI PIA project is coordinated by BULL with several partners: CEA, Inria, SAFRAN, UVSQ.

This project aims to improve the support for numerical simulations and High Performance Computing (HPC) by providing a new generation software stack to control supercomputers, to improve numerical solvers, and pre- and post computing software, as well as programming and execution environment. It also aims at validating the relevance of these developments by demonstrating their capacity to deliver better scalability, resilience, modularity, abstraction, and interaction on some application use-cases. TADAAM is involved in WP1 and WP2 ELCI Work Packages. Emmanuel JEANNOT is the Inria representative in the ELCI steering committee.

9.2.2. ANR

ANR SATAS SAT as a Service (http://www.agence-nationale-recherche.fr/Project-ANR-15-CE40-0017).

AP générique 2015, 01/2016 - 12/2019 (48 months)

Coordinator: Laurent Simon (LaBRI)

Other partners: CRIL (Univ. Artois), Inria Lille (Spirals)

Abstract: The SATAS project aims to advance the state of the art in massively parallel SAT solving. The final goal of the project is to provide a “pay as you go” interface to SAT solving services and will extend the reach of SAT solving technologies, daily used in many critical and industrial applications, to new application areas, which were previously considered too hard, and lower the cost of deploying massively parallel SAT solvers on the cloud.

ANR DASH Data-Aware Scheduling at Higher scale (https://project.inria.fr/dash/).

AP générique JCJC 2017, 03/2018 - 02/2022 (48 months)

Coordinator: Guillaume AUPY (Tadaam)

Abstract: This project focuses on the effecient execution of I/O for High-Performance applications. The idea is to take into account some knowledge on the behavior of the different I/O steps to compute efficient schedules, and to update them dynamically with the online information.

9.2.3. ADT - Inria Technological Development Actions

ADT Gordon

10/2018 - 09/2020 (24 months)

Coordinator: Emmanuel JEANNOT

Other partners: Storm, HiePACS, PLEIADE (Inria Bordeaux)

Abstract: Teams HiePACS, Storm and Tadaam develop each a brick of an HPC software stack, namely solver, runtime, and communication library. The goal of the Gordon project is to consolidate the HPC stack, to improve interfaces between each brick, and to target a better scalability. The bioinformatics application involved in the project has been selected so as to stress the underlying systems.

9.2.4. IPL - Inria Project Lab

High-Performance computing and BigData

Participants: Guillaume Aupy, Emmanuel Jeannot, Julien Herrmann and Nicolas Vidal.

HPC and Big Data evolved with their own infrastructures (supercomputers versus clouds), applications (scientific simulations versus data analytics) and software tools (MPI and OpenMP versus Map/Reduce or Deep Learning frameworks). But Big Data analytics is becoming more compute-intensive (thanks to deep learning), while data handling is becoming a major concern for scientific computing. The goal of this HPC-BigData IPL is to gather teams from the HPC, Big Data and Machine Learning (ML) areas to work at the intersection between these domains. Research is organized along three main axes: high performance analytics for scientific computing applications, high performance analytics for big data applications, infrastructure and resource management

9.3. European Initiatives

9.3.1. Collaborations in European Programs, Except FP7 & H2020

NESUS: Network for Ultrascale Computing (http://www.nesus.eu)

Program: COST

Project acronym: NESUS

Project title: Network for Ultrascale Computing

Duration: April 2014 - April 2018

Coordinator: University Carlos III de Madrid

Other partners: more than 35 countries

Abstract: Ultrascale systems are envisioned as large-scale complex systems joining parallel and distributed computing systems that will be two to three orders of magnitude larger that today's systems. The EU is already funding large scale computing systems research, but it is not coordinated across researchers, leading to duplications and inefficiencies. The goal of the NESUS Action is to establish an open European research network targeting sustainable solutions for ultrascale computing aiming at cross fertilization among HPC, large scale distributed systems, and big data management. The network will contribute to glue disparate researchers working across different areas and provide a meeting ground for researchers in these separate areas to exchange ideas, to identify synergies, and to pursue common activities in research topics such as sustainable software solutions (applications and system software stack), data management, energy efficiency, and resilience. Some of the most active research groups of the world in this area are members of this proposal. This Action will increase the value of these groups at the European-level by reducing duplication of efforts and providing a more holistic view to all researchers, it will promote the leadership of Europe, and it will increase their impact on science, economy, and society. Emmanuel JEANNOT is the vice-chair of this Action.

9.3.2. Collaborations with Major European Organizations

Partner 1: INESC-ID, Lisbon, (Portugal)

Subject 1: Application modeling for hierarchical memory system

Partner 2: University Carlos III de Madrid, (Spain)

Subject 2: I/O Scheduling

9.4. International Initiatives

9.4.1. Inria International Labs

Joint-Lab on Extreme Scale Computing (JLESC):

Coordinators: Franck Cappello (general) and Yves Robert (Inria coordinator).

Other partners: Argonne National Lab, University of Urbanna Champaign (NCSA), Tokyo Riken, Jülich Supercomputing Center, Barcelona Supercomputing Center (BSC).

Abstract: The purpose of the Joint Laboratory for Extreme Scale Computing (JLESC) is to be an international, virtual organization whose goal is to enhance the ability of member organizations and investigators to make the bridge between Petascale and Extreme computing. The founding partners of the JLESC are Inria and UIUC. Further members are ANL, BSC, JSC and RIKEN-AICS.

9.4.2. Inria International Partners

9.4.2.1. Informal International Partners

Partner 1: Argonne National Lab

Subject 1: Binomial Checkpointing Strategies for Machine Learning (recipient of a FACCTS grant, 2018-2020)

Partner 2: Vanderbilt University

Subject 2: Scheduling for Neurosciences

Partner 3: ICL at University of Tennessee

Subject 3: on instrumenting MPI applications and modeling platforms (works on HWLOC take place in the context of the OPEN MPI consortium) and MPI and process placement

9.5. International Research Visitors

9.5.1. Visits of International Scientists

- Sri Hari Krishna Narayanan (Argonne National Lab), April 2018
- Sri Hari Krishna Narayanan(Argonne National Lab), Jan Hückelheim and Navjot Kukreja (Imperial College), June 2018
- Jesus Carretero, David E. Singh (Univ. Carlos III, Madrid), Dean Chester (Univ. of Warwick), Raymond Nou (BSC), October 2018
- Paul Hovland (Argonne National Lab) and Navjot Kukreja (Imperial College), December 2018

9.5.2. Visits to International Teams

9.5.2.1. Research Stays Abroad

Valentin HONORÉ visited Ana Gainaru, Padma Raghavan, and Hongyang Sun at Vanderbilt University (USA) for three months in the context of the project “Scheduling for Neurosciences”.

WHISPER Project-Team

9. Partnerships and Cooperations

9.1. Regional Initiatives

- City of Paris, 2016-2019, 100 000 euros. As part of the "Émergence - young team" program the city of Paris is supporting part of our work on domain-specific languages and trustworthy domain-specific compilers.

9.2. National Initiatives

9.2.1. ANR

ITrans - awarded in 2016, duration 2017 - 2020

Members: LIP6 (Whisper), David Lo (Singapore Management University)

Coordinator: Julia Lawall

Whisper members: Julia Lawall, Gilles Muller, Lucas Serrano, Van-Anh Nguyen

Funding: ANR PRCI, 287,820 euros.

Objectives:

Large, real-world software must continually change, to keep up with evolving requirements, fix bugs, and improve performance, maintainability, and security. This rate of change can pose difficulties for clients, whose code cannot always evolve at the same rate. This project will target the problems of *forward porting*, where one software component has to catch up to a code base with which it needs to interact, and *back porting*, in which it is desired to use a more modern component in a context where it is necessary to continue to use a legacy code base, focusing on the context of Linux device drivers. In this project, we will take a *history-guided source-code transformation-based* approach, which automatically traverses the history of the changes made to a software system, to find where changes in the code to be ported are required, gathers examples of the required changes, and generates change rules to incrementally back port or forward port the code. Our approach will be a success if it is able to automatically back and forward port a large number of drivers for the Linux operating system to various earlier and later versions of the Linux kernel with high accuracy while requiring minimal developer effort. This objective is not achievable by existing techniques.

VeriAmos - awarded in 2018, duration 2018 - 2021

Members: Inria (Antique, Whisper), UGA (Erods)

Coordinator: Xavier Rival

Whisper members: Julia Lawall, Gilles Muller

Funding: ANR, 121,739 euros.

Objectives:

General-purpose Operating Systems, such as Linux, are increasingly used to support high-level functionalities in the safety-critical embedded systems industry with usage in automotive, medical and cyber-physical systems. However, it is well known that general purpose OSes suffer from bugs. In the embedded systems context, bugs may have critical consequences, even affecting human life. Recently, some major advances have been done in verifying OS kernels, mostly employing interactive theorem-proving techniques. These works rely on the formalization of the programming language semantics, and of the implementation of a software component, but require significant human intervention to supply the main proof arguments. The VeriAmos project will attack this problem by building on recent advances in the design of domain-specific languages and static

analyzers for systems code. We will investigate whether the restricted expressiveness and the higher level of abstraction provided by the use of a DSL will make it possible to design static analyzers that can statically and fully automatically verify important classes of semantic properties on OS code, while retaining adequate performance of the OS service. As a specific use-case, the project will target I/O scheduling components.

9.3. International Initiatives

9.3.1. Inria International Labs

- EPFL-Inria Lab Our work on scheduling [13] and on the Ipanema DSL [48] is done as part of the EPFL-Inria Lab. Our direct partners, Willy Zwaenepoel and Baptiste Lepers, have moved to the University of Sydney in September 2018. Therefore we have migrated our cooperation.

9.3.2. Inria International Partners

9.3.2.1. Informal International Partners

- We collaborate with David Lo and Lingxiao Jiang of Singapore Management University, who are experts in software mining, clone detection, and information retrieval techniques. Our work with Lo and/or Jiang has led to 8 joint publications since 2013 [58], [69], [71], [74], [75], [76], [79], [77], at conferences including ASE and ICSME. The ITrans ANR is a joint project with them.
- We collaborate with David Lo and James Hoang of Singapore Management University and with Sasha Levin of Microsoft on the use of machine learning to identify stable-relevant patches in the Linux kernel. Preliminary results from this collaboration have been presented with Sasha Levin at the Open Source Summit North America, the Open Source Summit Europe, and the Linux Plumbers Conference kernel summit track.
- Our previous collaboration with EPFL has been transfered to the University of Sydney due to the moves of Willy Zwaenepoel and Baptiste Lepers.
- We collaborate with Christoph Reichenbach of the University of Lund and Krishna Narasimhan of Itemis (Germany) on program transformation and the design of tools for code clone management [11].
- We collaborate with Jia-Ju Bai of Tsinghua University on bug finding in Linux kernel code, particularly focusing on issues requiring interprocedural analysis [12].
- As part of the LIP6 Invited Professor program, we have initiated a collaboration between Karine Heydeman (ALSOC team – LIP6, France) and Patrick Schaumont (Virginia Tech, US) on the development of fault-resistant and side-channel attack resistant compilation techniques.

9.4. International Research Visitors

9.4.1. Visits of International Scientists

- Patrick Schaumont of Virginia Tech visited LIP6 in July and November 2018, as part of the LIP6 Invited Professor program.
- David Lo and Lingxiao Jiang of Singapore Management University visited the Whisper team for two weeks in October 2018 as part of the ANR ITrans project.
- Michele Martone of the Leibniz Supercomputing Centre in Munich Germany made two visits of one week each to the Whisper team in August and December to work on applying Coccinelle to high performance computing code.

9.4.1.1. Internships

- Jonathan Carroll of Oberlin College spent January 2018 working on using machine learning to identify stable-relevant patches for the Linux kernel.
- David Bergvelt of the University of Illinois at Urbana-Champaign spent May-August 2018 working on applying Verifiable C, developed at Princeton, to verification of process schedulers.

WIDE Project-Team

8. Partnerships and Cooperations

8.1. Regional Initiatives

8.1.1. Web of Browser's (Brittany Region and Labex CominLabs 2019-2020)

Participant: François Taïani.

Browsers are de facto the most widely deployed execution environments in the world. Initially simple HTML readers, they now run complex applications interacting with humans and web services. The recent introduction of WebRTC has further extended the capability of browsers by introducing support for browser-to-browser communication. This turns browsers into a decentralized execution environment where interactions between human and web services are enabled without third party.

The Web of browsers is a vision where the web is serverless, ephemeral and massively decentralized. Web where pages are hosted by networks of browsers connected through WebRTC. The objective of the project is to build and experiment the Web of Browsers.

8.2. National Initiatives

8.2.1. Labex CominLab Descent (2013-2018)

Participants: Davide Frey, Michel Raynal, François Taïani.

This project (2013-2018), which also involves researchers from Nantes (LS2N, former LINA), aims to provide fundamental programming blocks to support the construction of federations of plug computers (e.g. Raspberry pi). The project's overarching vision is that everyone should be able create cheap nano-clusters of domestic servers, host data and services and federate these resources with their friends, colleagues, and families.

8.2.2. ANR Project PAMELA (2016-2020)

Participants: Davide Frey, George Giakkoupis, François Taïani.

PAMELA is a collaborative ANR project involving Inria/IRISA, Inria Lille (MAGNET team), UMPC, Mediego and Snips. The project aims at developing machine learning theories and algorithms in order to learn local and personalized models from data distributed over networked infrastructures. This project seeks to provide fundamental answers to modern information systems built by interconnecting many personal devices holding private user data in the search of personalized suggestions and recommendations. A significant asset of the project is the quality of its industrial partners, Snips and Mediego, who bring in their expertise in privacy protection and distributed computing as well as use cases and datasets.

8.2.3. ANR Project OBrowser (2016-2020)

Participants: David Bromberg, Davide Frey, François Taïani.

OBrowser is a collaborative ANR project involving Inria, the University of Nantes, the University of South Brittany, and Orange. The project emerges from the vision of designing and deploying distributed applications on millions of machines using web-enabled technologies without relying on a cloud or a central authority. OBrowser proposes to build collaborative applications through a decentralized execution environment composed of users' browsers that autonomously manages issues such as communication, naming, heterogeneity, and scalability.

8.2.4. ANR Project DESCARTES (2016-2020)

Participants: George Giakkoupis, Michel Raynal, François Taïani.

DESCARTES is a collaborative ANR project involving Inria/IRISA, Labri (U. Bordeaux), IRIF (U. Paris Diderot), Inria Paris (GANG Team), Vérimag (Grenoble), LIF (Marseilles), and LS2N (former LINA, Nantes). The DESCARTES project aims at bridging the lack of a generic theoretical framework in order to unify the large body of fundamental knowledge on distributed computation that has been acquired over the last 40 years. In particular, the project's objective is to develop a systematic model of distributed computation that organizes the functionalities of a distributed computing system into reusable modular constructs assembled via well-defined mechanisms that maintain sound theoretical guarantees on the resulting system.

8.2.5. ANR-ERC Tremplin Project NDFUSION (2016-2018)

Participant: George Giakkoupis.

NDFUSION is an 18-month ANR project awarded to George Giakkoupis to support his preparation for his upcoming ERC grant application.

The idea of intervening in a network diffusion process to enhance or retard its spread has been studied in various contexts, e.g., to increase the spread or speed of diffusion by choosing an appropriate set of seed nodes, or achieve the opposite effect either by choosing a small set of nodes to remove, or by seeding a competing diffusion (e.g., to limit the spread of misinformation in a social network).

8.2.6. Labex CominLab PROFILE (2016-2019)

Participants: David Bromberg, Davide Frey, François Taïani.

The PROFILE (2016-2019) project brings together experts from law, computer science (the Inria teams DIVERSE and ASAP/WIDE, the IRISA team DRUID) and sociology to address the challenges raised by online profiling, following a multidisciplinary approach. More precisely, the project will pursue two complementary and mutually informed lines of research: first, the project will investigate, design, and introduce a new right of opposition into privacy Law to better regulate profiling and to modify the behavior of commercial companies. Second, the project aims to provide users with the technical means they need to detect stealthy profiling techniques, and to control the extent of the digital traces they routinely produce.

8.3. International Initiatives

8.3.1. Inria Associate Teams Not Involved in an Inria International Lab

8.3.1.1. LiDiCo

Title: Aux limites du calcul réparti

International Partner (Institution - Laboratory - Researcher):

UNAM (Mexico) - Instituto de Matematicas - Sergio Rajsbaum

Start year: 2017

See also: https://sites.google.com/site/lidicoequipeassociee/

Today distributed applications are pervasive, some very successful (e.g., Internet, P2P, social networks, cloud computing), and benefit everyone, but the design and the implementation of many of them still rely on ad-hoc techniques instead of on a solid theory. The next generation of distributed applications and services will be more and more complex and demands research efforts in establishing sound theoretical foundations to be able to master their design, their properties and their implementation. This proposal is a step in this inescapable direction.

8.4. International Research Visitors

8.4.1. Visits of International Scientists

Fábio Moreira Costa (Institute of Informatics, Federal University of Goiás, Goiânia, GO, Brazil); 17–28 September, 5–11 November, and 3–14 December 2018.

Paulo Ferreira (INESC ID Lisboa, Portugal); Associate Professor, in Sabbatical, 5 February–17 March 2018.

Hayk Saribekyan (University of Cambridge, UK); 2–12 April 2018

Sergio Rajsbaum (Instituto de Matematicas, Universidad Nacional Autonoma de Mexico, UNAM); 20 April 2018.

Thomas Sauerwald (University of Cambridge, UK); 2–12 April 2018.

8.4.2. Visits to International Teams

8.4.2.1. Research Stays Abroad

Quentin Dufour visited Etienne Rivière, Université de Louvain La Neuve UCL, 5–30 November 2018.

David Bromberg visited University of Sao Paulo, Brazil, 8–24 July 2018.

Michel Raynal visited Jiannong Cao, HK Politechnic University, 17 November–22 December 2018.

ALICE Project-Team

8. Partnerships and Cooperations

8.1. National Initiatives

8.1.1. EXPLORAGRAM

Inria exploratory project EXPLORAGRAM (in cooperation with MOKAPLAN): We explored new algorithms for computational optimal transport. The project allowed us to hire a post-doc for 18 months (Erica Schwindt). She worked on the semi-discrete algorithm, and its application to the simulation of fluid-structure interactions. The project allowed to strengthen the cooperation with MOKAPLAN. It also allowed us to start exploring new cooperations, with Institut d'Astrophysique de Paris, on early universe reconstruction. The results were published in [7].

8.1.2. ANR MAGA (2016-2020)

We participate in the ANR MAGA (ANR-16-CE40-0014) on the Monge Ampere equation and computational geometry. In this ANR project, we cooperate with Quentin Merigot and other researchers of the MOKAPLAN Inria team on new computational methods for optimal transport.

8.1.3. ANR ROOT (2016-2020)

We participate in the Young Researcher ANR ROOT (ANR-16-CE23-0009) on Optimal Transport for computer graphics, with Nicolas Bonneel (CNRS Lyon) as Principal Investigator. In the context of this project, we develop a new symmetric algorithm for semi-discrete optimal transport that optimizes for both the location of the samples and their Lagrange multipliers. An ENS training period will start in Jan. 2018 (Agathe Herrou), hosted in Nancy.

8.2. International Research Visitors

8.2.1. Visits of International Scientists

Oleksandr Bondarenko (KPI, Ukraine) visited the team from 19 October 2018 to 30 October 2018. The goal of the visit was to work on pendulum stabilization.

8.2.2. Visits to International Teams

8.2.2.1. Sabbatical programme

Dmitry Sokolov visited Kuban State University (Russia) from 1 August 2018 to 31 August 2018 for his CNRS sabbatical programme. As a result, two papers are being prepared for Mechantronics 2019 submission.

ALMAnaCH Team

8. Partnerships and Cooperations

8.1. National Initiatives

8.1.1. ANR

- **ANR SoSweet** (2015-2019, PI J.-P. Magué, resp. ALMAnaCH: DS; Other partners: ICAR [ENS Lyon, CRNS], Dante [Inria]). Topic: studying sociolinguistic variability on Twitter, comparing linguistic and graph-based views on tweets
- **ANR ParSiTi** (2016-2021, PI Djamé Seddah, Other partners: LIMSI, LIPN). Topic: context-aware parsing and machine translation of user-generated content
- **ANR PARSE-ME** (2015-2020, PI. Matthieu Constant, resp. Marie Candito [ALPAGE, then LLF], ALMAnaCH members are associated with Paris-Diderot's LLF for this project). Topic: multi-word expressions in parsing
- **ANR Profiterole** (2016-2020, PI Sophie Prévost [LATTICE], resp. Benoit Crabbé [ALPAGE, then LLF], ALMAnaCH members are associated with Paris-Diderot's LLF for this project). Topic: modelling and analysis of Medieval French
- **ANR TIME-US** (2016-2019, PI Manuela Martini [LARHRA], ALMAnaCH members are associated with Paris-Diderot's CEDREF for this project). Topic: Digital study of remuneration and time budget textile trades in XVIIIth and XIXth century France
- **ANR BASNUM** (2018-2021, PI Geoffrey Williams [Université Grenoble Alpes], resp. ALMAnaCH: LR). Topic: Digitalisation and computational linguistic study of Basnage de Beauval's *Dictionnaire universel* published in 1701.

8.1.2. Competitivity Clusters

- **LabEx EFL** (2010-2019, PI Christian Puech [HTL, Paris 3], Sorbonne Paris Cité). Topic: empirical foundations of linguistics, including computational linguistics and natural language processing. ALPAGE was one of the partner teams of this LabEx, which gathers a dozen of teams within and around Paris whose research interests include one aspects of linguistics or more. BS serves as deputy head (and former head) of one of the scientific strands of the LabEx, namely strand 6 dedicated to language resources. BS and DS are in charge of a number of scientific "operations" within strands 6, 5 ("computational semantic analysis") and 2 ("experimental grammar"). BS, EVdLC and DS are now individual members of the LabEx EFL since 1st January 2017, and BS still serves as the deputy head of strand 6. Main collaborations are on language resource development (strands 5 and 6), syntactic and semantic parsing (strand 5, especially with LIPN [CNRS and U.Paris 13]) and computational morphology (strands 2 and 6, especially with CRLAO [CNRS and Inalco]).

8.1.3. Other National Initiatives

- **LECTAUREP project** (2017-2018): An explorative study has been launched in collaboration with the National Archives in France, in the context of the framework agreement between Inria and the Ministry of Culture, to explore the possibility of extracting various components from digitized 19th Century notary registers.
- **Nénufar (DGLFLF - Délégation générale à la langue française et aux langues de France)**: The projects is intended to digitize and exploit the early editions (beginning of the 20th Century) of the Petit Larousse dictionary. ALMAnaCH is involve to contribute to the automatic extraction of the dictionary content by means of GROBID-Dictionaries and define a TEI compliant interchange format for all results.

- **PIA Opaline**: The objective of the project is to provide a better access to published French literature and reference material for visually impaired persons. Financed by the Programme d'Investissement d'Avenir, it will integrate technologies related to document analysis and re-publishing, textual content enrichment and dedicated presentational interfaces. Inria participate to deploy the GROBID tool suite for the automatic structuring of content from books available as plain PDF files.

8.2. European Initiatives

8.2.1. FP7 & H2020 Projects

- **H2020 Parthenos** (2015-2019, PI Franco Niccolucci [University of Florence]; LR is a work package coordinator) Topic: strengthening the cohesion of research in the broad sector of Linguistic Studies, Humanities, Cultural Heritage, History, Archaeology and related fields through a thematic cluster of European Research Infrastructures, integrating initiatives, e-infrastructures and other world-class infrastructures, and building bridges between different, although tightly interrelated, fields.
- **H2020 EHRI** "European Holocaust Research Infrastructure" (2015-2019, PI Conny Kristel [NIOD-KNAW, NL]; LR is task leader) Topic: transform archival research on the Holocaust, by providing methods and tools to integrate and provide access to a wide variety of archival content.
- **H2020 Iperion CH** (2015-2019, PI Luca Pezzati [CNR, IT], LR is task leader) Topic: coordinating infrastructural activities in the cultural heritage domain.
- **H2020 HIRMEOS**: HIRMEOS objective is to improve five important publishing platforms for the open access monographs in the humanities and enhance their technical capacities and services and rendering technologies, while making their content interoperable. Inria is responsable for improving integrating the entity-fishing component deplyed as an infrastructural service for the five platforms.
- **H2020 DESIR**: The DESIR project aims at contributing to the sustainability of the DARIAH infrastructure along all its dimensions: dissemination, growth, technology, robustness, trust and education. Inria is responsable for providing of a portfolio of text analytics services based on GROBID and entity-fishing.

8.2.2. Collaborations in European Programs, Except FP7 & H2020

- **ERIC DARIAH "Digital Research Infrastructure for the Arts and Humanities"** (set up as a consortium of states, 2014-2034; LR served president of the board of director until August 2018) Topic: coordinating Digital Humanities infrastructure activities in Europe (17 partners, 5 associated partners).
- **COST enCollect** (2017-2020, PI Lionel Nicolas [European Academy of Bozen/Bolzano]) Topic: combining language learning and crowdsourcing for developing language teaching materials and more generic language resources for NLP

8.2.3. Collaborations with Major European Organizations

Collaborations with institutions not cited above (for the SPMRL initiative, see below):

- Universität Zürich, Switzerland (Géraldine Walther) [computational morphology, lexicons]
- Berlin-Brandenburgische Akademie der Wissenschaften [Berlin-Brandenburg Academy of Sciences and Humanities], Berlin, Germany (Alexander Geyken) [lexicology]
- Österreichische Akademie der Wissenschaften [Austrian Academy of Sciences], Vienna, Austria (Karlheinz Moerth) [lexicology]
- University of Cambridge, United Kingdom (Ekaterina Kochmar) [text simplification]
- Univerza v Ljubljani [University of Ljubljana], Ljubljana, Slovenia (Darja Fišer) [wordnet development]

8.3. International Initiatives

8.3.1. Participation in International Programs

PHC Maimonide (2018-2019, PI Djamé Seddah, co-PI Yoav Goldberg (Bar Ilan University)). Topics: Building NLP resources for analyzing reactions to major events in Hebrew and French social media.

8.4. International Research Visitors

8.4.1. Visits of International Scientists

- Dr. Ekaterina Kochmar (University of Cambridge), 3 days in June
- Dr. Teresa Lynn (Dublin City University), 2 stays of 1 week each.

AUCTUS Team

9. Partnerships and Cooperations

9.1. Regional Initiatives

9.1.1. Woobot

The main objective of Woobot is to propose a methodology for designing and controlling a collaborative robotic system to assist and secure an operator's actions. The system must preserve the health and sensory expertise of the operator while guaranteeing his or her mobility. Motivated by a pilot case from carpentry, the determination of the behavior of the collaborative robot will be based on a human-centered approach and based on a precise ergonomic analysis of the task and the biomechanical performances and needs of the operator. Two scientific issues are important: the choice of the system architecture (type of collaborative robot, number of degrees of freedom, level of redundancy with respect to the task, type of interaction of the collaborative robot with the task and/or the human...), and the behavior of the collaborative robot that must be implemented in the control. To answer these questions, it is then necessary to consider in the same formalism the human and task constraints from the point of view of:

- of the performance necessary for the task (cutting forces, trajectories);
- of the operator's biomechanical performance (kinematics -i.e. dexterity; static -i.e. manipulability and human dynamics).
- ergonomic (task, work environment, human posture).

9.2. International Research Visitors

9.2.1. Visits of International Scientists

- Gionata Salvietti, Affiliated Researcher at IIT Central Research Lab Genova, Italy, visited the team on February 7-8, 2018 and gave a talk.
- Milan Hladík, Associate Professor at Charles University in Prague, Czech Republic, visited the team on August 21-24, 2018.
- Chee Yap, Professor at the Courant Institute of Mathematical Sciences at New York University, visited the team on December 6-7, 2018. He gave a talk entitled "New Approach to FIND-PATH: a Paradigmic Problem in Robotics, AI and SC".

AVIZ Project-Team

7. Partnerships and Cooperations

7.1. Regional Initiatives

- Tobias Isenberg received an equipment grant from STIC, Paris-Saclay, for approx. EUR 5K

7.2. National Initiatives

- Naviscope Inria Project Lab on Image-guided NAvigation and VIsualization of large data sets in live cell imaging and microSCOPy; collaboration with several Inria project teams and external collaborators; this grant supports a PhD position and funds travel and equipment.

7.3. European Initiatives

7.3.1. FP7 & H2020 Projects

7.3.1.1. IVAN

Title: Interactive and Visual Analysis of Networks

Programm: CHIST-ERA

Duration: May 2018 - April 2021

Coordinator: Dr. Torsten Möller, Uni Wien, Austria

Partners:

EPFL, Switzerland

Inria France

Uni Wien, Austria

Inria contact: Jean-Daniel Fekete

The main goal of IVAN is to create a visual analysis system for the exploration of dynamic or time-dependent networks (from small to large scale). Our contributions will be in three principle areas:

1. novel algorithms for network clustering that are based on graph harmonic analysis and level-of-detail methods;
2. the development of novel similarity measures for networks and network clusters for the purpose of comparing multiple network clusterings and the grouping (clustering) of different network clusterings; and
3. a system for user-driven analysis of network clusterings supported by novel visual encodings and interaction techniques suitable for exploring dynamic networks and their clusterings in the presence of uncertainties due to noise and uncontrolled variations of network properties.

Our aim is to make these novel algorithms accessible to a broad range of users and researchers to enable reliable and informed decisions based on the network analysis.

7.3.2. Collaborations in European Programs, Except FP7 & H2020

- Illustrare project co-funded by ANR, France, and FWF, Austria, funding a PhD position and funds for travel and equipment. The project investigates integrative visual abstraction of molecular data and is a collaboration with TU Wien, Austria

7.4. International Initiatives

7.4.1. Inria Associate Teams Not Involved in an Inria International Labs

7.4.1.1. SEVEN

Title: Situated and Embedded Visualization for Data Analysis

International Partner (Institution - Laboratory - Researcher):

University of Calgary (Canada) - ILab - Wesley Willett

Start year: 2018

See also: http://aviz.fr/seven

The goal of this joint work between the Aviz team at Inria Saclay and the ILab at the University of Calgary is to develop and study situated data visualizations to address the limitations of traditional platforms of data analytics. In a situated data visualization, the data is directly visualized next to the physical space, object, or person it refers to. Situated data visualizations can surface information in the physical environment and allow viewers to interpret data in-context, monitor changes over time, make decisions, and act on the physical world in response to the insights gained. However, research on this topic remains scarce and limited in scope. We will build on our track record of successfull collaborations to jointly develop situated visualization as a novel research direction. The objective for the first year is to design and implement situated visualizations to support health and aging. Our joint work is expected generate benefits at multiple levels, including to society and industry (by empowering individuals and professionals with technology), to the scientific community (by developing a new research direction), to the academic partners (by reinforcing existing research links and establishing them as leaders on the topic), and to students (by providing them with unique training opportunities with a diverse team of world-class researchers).

7.4.2. Inria International Partners

7.4.2.1. Informal International Partners

- University of Maryland (USA), University of Roma (Italy), TU Darmstadt (Germany): Jean-Daniel Fekete Fekete collaborates with Leilani Battle, Giuseppe Santucci, Carsten Binnig and colleagues on the design of database benchmarks to better support visualization;
- University of Seoul (Korea): Jean-Daniel Fekete collaborates with Jaemin Jo and Jinwook Seoh on progressive algorithms and visualization techniques;
- University of Bari (Italy): Jean-Daniel Fekete collaborates with Paolo Buono on hypergraph visualization;
- Stanford University. Pierre Dragicevic and Jean-Daniel Fekete collaborate with Sean Follmer on swarm user interfaces.
- Hasso Plattner Institute. Pierre Dragicevic and Tobias Isenberg collaborate with Amir Semmo on stylization filters for facilitating the examination of disturbing visual content.
- University of Minnesota, USA: Tobias Isenberg is collaborating with Daniel F. Keefe on topics of the interactive exploration of 3D data.
- University of Granada, Spain: Tobias Isenberg is collaborating with Domingo Martin and German Arroyo on digital stippling.
- The University of Sydney, Australia. Steve Haroz collaborate with Alex Holcombe on analyzing open practices in vision science.
- Massachusetts Institute of Technology (CSAIL). Steve Haroz collaborates with Aude Oliva on investigating the impact of titles on memory of visualized data.
- University of Washington, University of Zurich and University of Toronto. Pierre Dragicevic and Steve Haroz collaborate with Matthew Kay and Chat Wacharamanotham on transparent statistical reporting and efficient statistical communication. Pierre Dragicevic collaborates with Matthew Kay and Fanny Chevalier on supporting research transparency with interactive research papers.

- University of Calgary. Pierre Dragicevic, Tobias Isenberg, and Petra Isenberg collaborate with Wesley Willett, Sheelagh Carpendale, and Lora Oehlberg on situated data visualization.
- Microsoft Research Redmond and University of Maryland. Petra Isenberg collaborate with Bongshin Lee, Mathieu Brehmer, and Eun Kyoung Choe on Mobile Visualization
- Microsoft Research Redmond. Petra Isenberg and Tanja Blascheck collaborate with Bongshin Lee on Micro Visualizations for Smartwatches

7.5. International Research Visitors

7.5.1. Visits of International Scientists

- Claudio Silva (August 2018 – June 2019): Sabbatical from New York University (USA). Also, invited professor through a DigiCosme grant for 3 months. Claudio Silva is spending one year with Aviz. We launched a bi-weekly seminar on explainable machine-learning with visualization.
- Michael McGuffin (October – November): visit from ETS Montreal (Canada). Michael McGuffin has spent a month with Aviz working on augmented reality and visualization, collaborating with Pierre Dragicevic, Jean-Daniel Fekete, and students.

7.5.1.1. Internships

- Jung Nam from the University of Minnesota visited for 3 months in the summer of 2018. His work centered on the use of storytelling mechanisms to support and communicate results of the exploration 3D data. This collaboration is still ongoing.

CEDAR Project-Team

8. Partnerships and Cooperations

8.1. National Initiatives

8.1.1. ANR

- AIDE ("A New Database Service for Interactive Exploration on Big Data") is an ANR "Young Researcher" project led by Y. Diao, started at the end of 2016.
- CBOD ("Cloud-Based Organizational Design") is a 4-year ANR started in 2014, coordinated by prof. Ahmed Bounfour from UPS. Its goal is to study and model the ways in which cloud computing impacts the behavior and operation of companies and organizations, with a particular focus on the cloud-based management of data, a crucial asset in many companies.
- ContentCheck (2015-2018) is an ANR project in collaboration with U. Rennes 1 (F. Goasdoué), INSA Lyon (P. Lamarre), the LIMSI lab from U. Paris Sud, and the Le Monde newspaper, in particular their fact-checking team Les Décodeurs. Its aim is to investigate content management models and tools for journalistic fact-checking.

8.1.2. LabEx, IdEx

- CloudSelect is a three-years project started in October 2015. It is financed by the *Institut de la Société Numérique* (ISN) of the IDEX Paris-Saclay; it funds the PhD scholarship of S. Cebiric. The project is a collaboration with A. Bounfour from the economics department of Université Paris Sud. The project aims at exploring technical and business-oriented aspects of data mobility across cloud services, and from the cloud to outside the cloud.

8.1.3. Others

- ODIN is a four-year project started (2014-2018) funded by the Direction Générale de l'Armement, between the SemSoft company, IRISA Rennes and Cedar. The project focused on developing a complete framework for analytics on Web data, in particular taking into account uncertainty, based on Semantic Web technologies such as RDF.
- The goal of the iCODA project is to develop the scientific and technological foundations for knowledge- mediated user-in-the-loop collaborative data analytics on heterogenous information sources, and to demonstrate the effectiveness of the approach in realistic, high-visibility use-cases. The project stands at the crossroad of multiple research fields—content analysis, data management, knowledge represen- tation, visualization—that span multiple Inria themes, and counts on a club of major press partners to define usage scenarios, provide data and demonstrate achievements. This is a project funded directly by Inria ("Inria Project Lab"), and is in collaboration with GraphIK, ILDA, LINKMEDIA (coordinator), as well as the press partners AFP, Le Monde (Les Décodeurs) and Ouest-France.

8.2. European Initiatives

8.2.1. FP7 & H2020 Projects

- **IDEAA: Issue-Driven European Arena Analytics** is a project funded by the European Commission Union's Horizon 2020 research and innovation programme. The project started in July 2018 for a duration of two years. Its purpose is to allow citizens to easily explore the trove of publicly available data with the aim of building a viewpoint on specific issues. Its main strengths are: supply users with succinct and meaningful knowledge with respect to the issue they are interested in; allow users

to interact with the provided knowledge to refine their information need and advance understanding; suggest interesting or unexpected aspects in the data and support the comparison of knowledge discovered from different data sources. IDEAA is inspired by human-to-human dialogues, where questions are explorative, possibly imprecise, and answers may be a bit inaccurate but suggestive, conveying an idea that stimulates the interlocutor to further questions.

The project supports a two-years presence of Mirjana Mazuran as an experienced post-doc in our team.

8.3. International Initiatives

8.3.1. Inria Associate Teams Not Involved in an Inria International Labs

8.3.1.1. WebClaimExplain

Title: Mining for explanations to claims published on the Web

International Partner (Institution - Laboratory - Researcher):

AIST (Japan) - Julien Leblay

Start year: 2017

See also: https://team.inria.fr/cedar/projects/webclaimexplain/

The goal of this research is to create tools to find explanations for facts and verify claims made online. While this process cannot be fully automated, the main focus of our work will be explanation finding via trusted sources, based on the observation that one can only trust a statement if he/she can explain it through rules and proofs that can themselves be trusted. Our WebClaimExplain collaboration has been particularly fruitful this year in terms of publications [9], [7], [18], [16], [14].

8.3.2. Inria International Partners

8.3.2.1. Informal International Partners

We resumed our collaboration with Prof. Alin Deutsch from University of California in San Diego (UCSD), during his invited stay at U. Paris Sud. We have completed a work (started in 2015-2016) on efficient view-based query rewriting in polystores, and submitted it to a major international conference.

8.3.3. Participation in Other International Programs

8.3.3.1. AYAME

WebClaimExplain

Title: Mining for explanations to claims published on the Web

International Partner (Institution - Laboratory - Researcher):

AIST (Japan) - Leblay Julien

Duration: 2017 - 2019

Start year: 2017

See also: https://team.inria.fr/cedar/projects/webclaimexplain/

The goal of this research is to create tools to find explanations for facts and verify claims made online. While this process cannot be fully automated, the main focus of our work will be explanation finding via trusted sources, based on the observation that one can only trust a statement if he/she can explain it through rules and proofs that can themselves be trusted.

8.4. International Research Visitors

8.4.1. Visits of International Scientists

8.4.1.1. Sabbatical programme

Juliana Freire, a professor at NYU and the chair of the ACM SIGMOD chapter, has been a visitor on sabbatical in the team since September 2018.

8.4.1.2. Internships

Lars Kegel, a PhD student at the university of Dresden, has visited the team until August 2018. He has worked on characterizing and generating time series data for benchmarking time series management software.

8.4.2. Visits to International Teams

8.4.2.1. Research Stays Abroad

Yanlei Diao spent three months at U. Massachussets at Amherst, USA.

Chroma Project-Team

9. Partnerships and Cooperations

9.1. Regional Initiatives

9.1.1. COMODYS project, FIL (Federation d'Informatique de Lyon), 2017-19

Participants: Laetitia Matignon, Olivier Simonin.

Project of the Informatics Federation of Lyon (FIL) between two teams of two laboratories: CHROMA (CITI) and SMA (LIRIS), entitled "COoperative Multi-robot Observation of DYnamic human poSes", 2017-2019. Leader : L. Matignon & O. Simonin.

This project funds materials, missions and internships and its objectives are the on-line adaptation of a team of robots that observe and must recognize human activities.

9.1.2. CORDES ADT Inria project, 2017-19

Participants: Olivier Simonin, Vincent Le Doze, Jilles Dibangoye, Alessandro Renzaglia.

The project CORDES (Coordination d'une Flotte de Drones Connectés pour la Cartographie 3D d'édifices) is an Inria ADT coordinated by Olivier Simonin. It funds an Inria expert engineer position in Chroma (Vincent Le Doze, 10/17-11/19) focusing on UAVs control and path-planning. The project aims to deploy a fleet of UAVs able to autonomously fly over an unknown infrastructure and to build a 3D map.

9.2. National Initiatives

9.2.1. ANR

9.2.1.1. ANR "Valet" (2016-18)

The ANR VALET, led by A. Spalanzani, proposes a novel approach for solving car-sharing vehicles redistribution problem using vehicle platoons guided by professional drivers. An optimal routing algorithm is in charge of defining platoons drivers' routes to the parking areas where the followers are parked in a complete automated mode. The consortium is made of 2 academic partners: Inria (RITS, Chroma, Prima) and Ircyyn Ecole Centrale de Nantes and the AKKA company. The phD student (Pavan Vashista) recruited in this project focus on integrating models of human behaviors to evaluate and communicate a risk to pedestrians that may encounter the trajectory of the VALET vehicle. His phD thesis started in february 2016 and is codirected by D. Vaufreydaz (Inria/PervasiveInteraction).

9.2.1.2. ANR "HIANIC" (2017-20)

The HIANIC project, led by A. Spalanzani, proposes to endow autonomous vehicles with smart behaviors (cooperation, negotiation, socially acceptable movements) that better suit complex SharedSpace situations. It will integrate models of human behaviors (pedestrian, crowds and passengers), social rules, as well as smart navigation strategies that will manage interdependent behaviors of road users and of cybercars. The consortium is made of 3 academic partners: Inria (RITS, Chroma, Pervasive Interaction teams), Lig Laboratory (Magma team) and LS2N laboratory (ARMEN and PACCE teams). A. Spalanzani is the leader of this project.

9.2.1.3. PIA Ademe "CAMPUS" (2017-20)

The CAMPUS project aims to identify, develop and deploy new functions for the autonomous cars in urban environments. In this project, Chroma will focus on finding solutions to navigate in complex situations such as crowded environments or dense traffic. The consortium is made of 1 academic partner: Inria (Rits and Chroma teams) and 3 companies: Safran electronics, Gemalto and Valeo.

9.3. European Initiatives

9.3.1. FP7 & H2020 Projects

Program: ECSEL

Project acronym: ENABLE-S3

Project title: European Initiative to Enable Validation for Highly Automated Safe and Secure Systems

Duration: June 2016 – May 2019

Coordinator: AVL List GesmbH

Other partners: Major European Organizations, including academic partners (such as Inria or KIT) and a Large number of industrial partners from various application domains such as automotive industry or Aeronautics or Train industry

Abstract: ENABLE-S3 is *industry-driven* and therefore aims to foster the leading role of the European industry. This is also reflected in its *use case driven approach*. The main technical objectives are extracted from the use cases defined by the industrial partners, in order to validate the success of the developed methods and tools.

The ENABLE-S3 project will provide European industry with leading-edge technologies that *support the development of reliable, safe and secure functions for highly automated and/or autonomously operating systems* by enabling the *validation and verification at reduced time and costs*.

Enables-S3 is a large European consortium, involving a French consortium leaded by Renault and Inria Grenoble Rhône-Alpes. The Inria Tamis team (Rennes) is also involved in the project.

9.3.2. Collaborations in European Programs, Except FP7 & H2020

9.3.2.1. PHC DRONEM

Program: PHC franco-roumain "Brandusi"

Project acronym: DRONEM

Project title: Optimizing Data Delivery in Multi-robot Network Patrolling using Machine Learning

Duration: 01-2017 - 12-2018

Coordinator: O. Simonin, G. Czibula (University of Babes-Bolyai, Cluj-Napoca, Romania)

Abstract: The present research proposal is an interdisciplinary project that focuses on developing novel machine learning models and techniques for addressing the challenging problem of dynamic multi-robot network patrolling. This proposal brings together a team of researchers in the field of robotics (Chroma) with a team of researchers in the field of Machine Learning from Babe-Bolyai University, Cluj-Napoca (the MLyRE team) and aims to combine their expertise in autonomous robotics and machine learning, as well as to exploit the complementarity between the two fields. Deploying fleets of mobile robots in real scenarios/environments raises several scientific challenges. One of them concerns the ability of the robots to adapt to the complexity of their environment, i.e. its dynamics and uncertainty.

9.3.3. Collaborations with Major European Organizations

Partner 1 : ETHZ, Zurich, Autonomous System laboratory, (Switzerland) and University of Zurich, Robotics and Perception Group (Switzerland)

Subject 1 : Vision and IMU data Fusion for 3D navigation in GPS denied environment.

Partner 2 : Karlsruhe Institut fur Technologie (KIT, Germany)

Subject 2 :Autonomous Driving (student exchanges and common project).

Partner 3 : Vislab Parma (Italy)

Subject 3 : Embedded Perception & Autonomous Driving (visits, projects submissions, and book chapter in the new edition of the Handbook of Robotics).

9.4. International Initiatives

9.4.1. Inria International Labs

9.4.1.1. Informal International Partners

- UC Berkeley & Stanford University (CA, USA)

  Subject: Autonomous Driving (postdoc in the scope of Inria@SV, common publications and patent, visits).

- NUS Singapore & NTU Singapore.

  Subject: Autonomous Driving (visits, common ICT Asia projects, common organization of workshops, review of PhD students).

- Massachussetts Institute of Technology (MIT), Cambridge, MA (USA)

  Subject: Decentralized Control of Markov Decision Processes.

  Subject: Autonomous Driving (visits and common organization of a workshop).

9.5. International Research Visitors

9.5.1. Visits of International Scientists

- Visit of 3 researchers (Maria-Iuliana Bocicor, Vlad-Sebastian Ionescu, Ioan-Gabriel Mircea) from University Babes-Bolyai, Cluj-Napoca (Romania). In the context of our PHC project "DRONEM" (2017-18) we worked with them, in Lyon (CITI lab), on Sept. 11-14 2018.
- Jorge Villagra, Senior Scientist at the Center for Automation and Robotics (CSIC-UPM) in Madrid, visited us and given a seminar in novembre 2018. He also co-organized with C.Laugier an Autonomous Vehicle Demonstration event at IEEE IROS 2018 in Madrid (October 2018).

9.5.2. Visits to International Teams

- O. Simonin and J. Dibangoye visited the team of Prof. G. Czibula, at University Babes-Bolyai, Cluj-Napoca (Romania), on April 16-19. The visit was organized in the context of the PHC project "DRONEM" (2017-18). O. Simonin given a talk on the Chroma researches.

COML Team

8. Partnerships and Cooperations

8.1. Regional Initiatives

Collaboration with the Willow Team:

- co-advising with J. Sivic and I. Laptev of a PhD student: Ronan Riochet.
- construction of a naive physics benchmark (www.intphys.com)

8.2. National Initiatives

8.2.1. ANR

- Transatlantic Platform "Digging into Data". Title: "Analysis of Children's Language Experiences Around the World. (ACLEW)"; (coordinating PI : M. Soderstrom; Leader of tools development and co-PI : E. Dupoux), (2017–2020. 5 countries; Total budget: 1.4M€)

8.3. International Initiatives

8.3.1. Inria International Partners

8.3.1.1. Informal International Partners

- Johns Hopkins University, Baltimore, USA: S. Kudanpur, H. Hermanksy
- RIKEN Institute, Tokyo, Japan: R. Mazuka

8.4. International Research Visitors

8.4.1. Visits of International Scientists

8.4.1.1. Internships

Internship of Diego Andai Castilla (partnership Inria-PUC-Inria Chile)

8.4.2. Visits to International Teams

8.4.2.1. Research Stays Abroad

- E. Dupoux Visiting Researcher at Facebook AI Research, Paris (Feb-Mar 2018)
- E. Dupoux Visiting Researcher at Google & DeepMind, London (April-July 2018)

DEFROST Project-Team

9. Partnerships and Cooperations

9.1. Regional Initiatives

- **INVENTOR** Innovative tool for soft robot design and its application for surgery. This project is financed by **I-Site ULNE EXPAND**, supported by "le programme d'Investissements d'Avenir" and "la Métropole Européenne de Lille". The objective of this project is to develop an innovative tool for the facilitation of soft robot design.
- **COMOROS** Control of deformable robots for surgery Duration april 2017 to march 2020

  Program: FEDER Coordinator: C. Duriez Abstract: Surgical procedures are often carried out using instruments made of stiff materials that interact with delicate biological tissues such as internal organs, blood vessel walls and small cavities. This incompatibility of stiffness is one of the sources of danger in many surgical procedures. The use of robots made of soft materials, also called soft robots, would limit such risks by reducing contact pressures and stress concentrations. Their intrinsic deformability would also increase the ability to manoeuvre in confined spaces. However, the promising concept of using soft robots for surgical procedures cannot be practically implemented, due to the lack of precise modelling and control methods for soft robots. This scientific obstacle, identified as a pending issue by major surveys in this field, becomes particularly challenging when interacting with an environment as complex as the human anatomy. Drawing on our background in soft tissue simulation, contact models, surgical applications and soft robotics, our ambition in this project is to:

  – Develop accurate and generic numerical methods for continuum mechanics, adapted to strong real-time constraints in order to demonstrate the ability to model soft mechatronics systems.

  – Reconsider parametrization methodologies of digital models of the patient anatomy through the observation of mechanical interactions with soft robots via embedded sensors and medical imaging

  – Rethink motion generation and teleoperation control with force feedback so as to be compatible with the large number of degrees of freedom of soft robots and be based on accurate, rapidly-computed deformable models and interaction models.

  The project also targets the development of software with the required performance and features, as well as the experimental validation of models and methods using prototypes in realistic environments.

9.2. National Initiatives

- **SIMILAR** Soft robotIc framework for modeling, simulation and control. This project is supported by **Inria ADT**, and the objective is to design new 3D interactive software to design soft-robots. This new software will be on the top of our existing software stack relying on SOFA for all numerical simulation aspects and 3D rendering aspects.
- **Tremplin ERC** Christian Duriez received a **ANR** grant "tremplin ERC" (150k€) given the result obtained last year on the ERC proposal (evaluated at "grade A"). The project has allowed to allocate new resources on the developments that were presented in this ERC.

9.3. European Initiatives

9.3.1. Collaborations in European Programs, Except FP7 & H2020

Meichun Lin was doing a project belonged to Interreg - 2 Seas Mers Zeeën on Cooperate Brachytherapy(CoBra), it is a 4 years project which gathers the experts from the countries between English Channel and southern North Sea aiming on finding an advance method for curing prostate cancer. The project is divided by several fields which are - MR compatible robot design, radiation dose measurement, needle design and virtual real-time training tool development. Meichun was working on developing virtual real-time training tool with Defrost team. By using SOFA framework to simulate the soft tissue's deformation and the interaction with needle under the real-time, also with the Image Modelling of MRI, Organs and tissue Modelling and so on and so forth, the 3D rendering became more like the real procedure of the brachytherapy and better for training purpose.

9.4. International Initiatives

9.4.1. Inria International Labs

Christian Duriez realized a geographical mobility as part of the program Inria @ SiliconValley. More details in the Highlights section.

9.4.2. Inria International Partners

9.4.2.1. Declared Inria International Partners

Collaboration with the group of Allison Okamura at Stanford University

Christian Duriez was awarded of a Fulbright Grant for going 7 months (February to August 2018) at Stanford University to work with the group of Allison Okamura. One of a phD student of Stanford, Margaret Koehler, has been awarded of a Chateaubriand Grant for coming 6 months (September 2017 to February 2018) in our Group in Lille. The collaboration was about 2 projects. The first project is haptic rendering with deformable robotics device. The second project is about the modeling and simulation of the "vine robot" that is currently being designed at Stanford.

9.4.2.2. Informal International Partners

- Collaboration with Massachusetts Institute of Technology:

  Maxime Thieffry spent a month in the Distributed Robotics Laboratory, CSAIL, MIT, for a collaboration with Robert Katzschmann and Daniela Rus. This work led to a submission to the soft robotics conference, RoboSoft 2019.

- Collaboration with Dipartimento di Ingegneria Elettrica e delle Tecnologie dell'Informazione, Napoli:

  The project was on the control of manipulation tasks. Using the SoftRobots.Inverse plugin we allowed the control of the shape of a deformable object manipulated by a rigid hand. In the paper [20] we demonstrate the feasibility of the method.

9.5. International Research Visitors

- Prof. Shunjie LI from Nanjing University of Information Science and Technology (China) visited the team from May 10, 2018 to June 30, 2018.

9.5.1. Visits of International Scientists

9.5.1.1. Internships

Margaret Koehler, phD student at Stanford University, has been awarded of a Chateaubriand Grant for coming 6 months (September 2017 to February 2018) in our Group in Lille.

9.5.2. Visits to International Teams

9.5.2.1. Sabbatical programme

This year, Christian Duriez realized a geographical mobility, since he was invited for 7 months in the team of Allison Okamura (Stanford University). He worked on two projects: the creation of deformable haptic interfaces and the mechanical modeling of the "vine robot" (https://www.vinerobots.org). The trip was funded in part by a Fulbright scholarship.

In addition, a doctoral student of their team, Margaret Koehler, makes a stay of 6 months paid by a Chateaubriand Fellowship.

These exchanges are part of the program Inria @ SiliconValley. See the interview of C. Duriez and the interview of M. Koehler.

9.5.2.2. Research Stays Abroad

- Gang ZHENG has visited Nanjing University of Science and Technology (China) for two weeks in July 2018.

EX-SITU Project-Team

8. Partnerships and Cooperations

8.1. Regional Initiatives

8.1.1. MoveIT – Modeling the Speed/Accuracy Trade-Off of Human Aimed Movement with the Tools of Information Theory

Type: Ph.D. grant

Funding: DigiCosme Labex

Duration: 2015-2018

Coordinator: Olivier Rioul (Institut Mines Telecom)

Partners: Univ. Paris-Sud, Inria, CNRS, Institut Mines-Telecom

Inria contact: Michel Beaudouin-Lafon

Abstract: The goal of this project is to conduct fundamental studies of aimed movements based on information theory. The project studies the interaction phenomena involved in pointing, in order to discover novel, more effective pointing techniques. This project funds Wanyu Liu, a joint Ph.D. student between the COMELEC and VIA groups at Institut Mines Telecom and ExSitu. Wanyu defended her thesis in November 2018 [35] and received an Honorable Mention award for her CHI 2018 paper [22].

8.1.2. An Augmented-Reality System for Collaborative Physical Modeling and Design

Type: Equipment

Funding: STIC Paris-Saclay

Duration: 2017-2018

Coordinator: Theophanis Tsandilas

Partners: Univ. Paris-Sud, Inria

Inria contact: Theophanis Tsandilas

Abstract: The goal of the project is to develop an augmented-reality system to support collaboration over 3D models and enhance digital-fabrication approaches. It is a collaboration with the AVIZ group and provides funding (8k) for equipment.

8.1.3. Le Plateau des Recherches Infinies

Type: Equipment and subcontracting

Funding: Learning Center Paris-Saclay

Duration: 2017-2018

Coordinator: Michel Beaudouin-Lafon

Partners: Univ. Paris-Sud

Inria contact: Michel Beaudouin-Lafon

Abstract: The goal of this project (30k) is to create an interactive installation presenting the portraits of a hundred researchers from Université Paris-Saclay. It is a collaboration with portrait photographer Didier Goupy. The installation is designed to be exhibited in various sites of Université Paris-Saclay until it is permanently installed in the Learning Center of Université Paris-Saclay. This project supported Swati Swati, an intern, for two months over the summer. The project was presented at the Fête de la Science in October, 2018, and will be permanently exhibited in the future Learning Center of Université Paris-Saclay.

8.1.4. Virtual Reality for Interacting with Building Information Model at Paris-Saclay

Type: Equipment and human resources

Funding: STIC Paris-Saclay

Duration: 2018-2019

Coordinator: Jean-Marc Vézien (LIMSI-CNRS)

Partners: CNRS, Univ. Paris-Sud

Inria contact: Cédric Fleury

Abstract: The goal of this project is to develop interactive tools for BIM application in virtual reality using a user-centered design approach. The project will use as a case study the interior design of the *Learning Center* building on Paris-Saclay campus.

8.2. National Initiatives

8.2.1. ANR

ELEMENT: Enabling Learnability in Human Movement Interaction

Type: Equipment and human resources

Funding: ANR

Duration: 2019-2022

Coordinator: Baptiste Caramiaux, Sarah Fdili Alaoui, Wendy Mackay

Partners: IRCAM, LIMSI

Inria contact: Baptiste Caramiaux

Abstract: The goal of this project is to foster innovation in multimodal interaction, from non-verbal communication to interaction with digital media/content in creative applications, specifically by addressing two critical issues: the design of learnable gestures and movements; and the development of interaction models that adapt to a variety of user's expertise and facilitate human sensorimotor learning.

8.2.2. Investissements d'Avenir

8.2.2.1. Digiscope - Collaborative Interaction with Complex Data and Computation

Type: EQUIPEX (Equipement d'Excellence)

Duration: 2011-2019

Coordinator: Michel Beaudouin-Lafon

Partners: Université Paris-Saclay (coordinator), Université Paris-Sud, CNRS, CEA, Inria, Institut Mines-Telecom, CentraleSupelec, Université Versailles - Saint-Quentin, ENS Paris-Saclay, Maison de la Simulation

Overall budget: 22.5 Meuros, including 6.7 Meuros public funding from ANR

Abstract: The goal of the project is to create ten high-end interactive rooms interconnected by high-speed networks and audio-video facilities to support remote collaboration across interactive visualization environments. The equipment will be open to outside users and targets four main application areas: scientific discovery, product lifetime management, decision support for crisis management, and education and training. Digiscope includes the existing WILD room, and funded the WILDER room. ExSitu contributes its expertise in the design and evaluation of advanced interaction techniques and the development of distributed software architectures for interactive systems. All ten rooms and the telepresence network are operational. The project was successfully evaluated by an international jury in June, 2017.

8.3. European Initiatives

8.3.1. European Research Council (ERC)

8.3.1.1. Creating Human-Computer Partnerships

Program: ERC Advanced Grant

Project acronym: CREATIV

Project title: Creating Human-Computer Partnerships

Duration: June 2013 - May 2019

Coordinator: Wendy Mackay

Abstract: CREATIV explores how the concept of co-adaptation can revolutionize the design and use of interactive software. Co-adaptation is the parallel phenomenon in which users both adapt their behavior to the system's constraints, learning its power and idiosyncrasies, and appropriate the system for their own needs, often using it in ways unintended by the system designer. A key insight in designing for co-adaptation is that we can encapsulate interactions and treat them as first class objects, called interaction instruments This lets us focus on the specific characteristics of how human users express their intentions, both learning from and controlling the system. By making instruments co-adaptive, we can radically change how people use interactive systems, providing incrementally learnable paths that offer users greater expressive power and mastery of their technology. The initial goal of the CREATIV project is to fundamentally improve the learning and expressive capabilities of advanced users of creative software, offering significantly enhanced methods for expressing and exploring their ideas. The ultimate goal is to radically transform interactive systems for everyone by creating a powerful and flexible partnership between human users and interactive technology.

8.3.1.2. Unified Principles of Interaction

Program: ERC Advanced Grant

Project acronym: ONE

Project title: Unified Principles of Interaction

Duration: October 2016 - September 2020

Coordinator: Michel Beaudouin-Lafon

Abstract: The goal of ONE is to fundamentally re-think the basic principles and conceptual model of interactive systems to empower users by letting them appropriate their digital environment. The project addresses this challenge through three interleaved strands: empirical studies to better understand interaction in both the physical and digital worlds, theoretical work to create a conceptual model of interaction and interactive systems, and prototype development to test these principles and concepts in the lab and in the field. Drawing inspiration from physics, biology and psychology, the conceptual model combines *substrates* to manage digital information at various levels of abstraction and representation, *instruments* to manipulate substrates, and *environments* to organize substrates and instruments into digital workspaces.

8.3.2. Marie Skiodowska-Curie Actions

8.3.2.1. Enhancing Motion Interaction through Music Performance

Program: Marie Curie grant

Project acronym: MIM

Project title: Enhancing Motion Interaction

Duration: 2016 - 2018

Coordinator: Baptiste Caramiaux

Abstract: The goal of the project to enhance Human Motion–Computer Interaction by leveraging fa multidisciplinary approach across experimental psychology, music technology and computational modelling. Firstly, the project examines skilled activities, in particular music performance, in order to understand fundamental cognitive and psychological aspects of control and expression in human motion. The project involves computational models of motor control and expressive variations built from music performance data collected during psychophysical studies. Secondly, the project broaches the implementation of these models in Digital Musical Instruments (DMI), thus creating a new type of digital instrument based on sensorimotor learning mechanisms. The resulting DMI is then assessed through a user study in which elements of exploration and engagement will be tested over several sessions. Therefore, the project contributes to two main uncharted research areas. Firstly it contributes to the fundamental understanding of sensorimotor learning processes by considering complex human motion, specifically motion in music performance. Secondly, it represents an original application of computational modelling by modelling expressive musical gestures and transferring these models to interactive systems.

8.4. International Initiatives

8.4.1. Inria International Labs

Inria@SiliconValley
Associate Team involved in the International Lab:

8.4.1.1. DECibel

Title: Discover, Express, Create – Interaction Technologies For Creative Collaboration

International Partner (Institution - Laboratory - Researcher):

University of California Berkeley (United States) - Electrical and Computer Engineering, Center for Magnetic Resonance Research - Bjoern Hartmann

Start year: 2016

The DECibel associated team includes Inria's ExSitu and the CITRIS Connected Communities Initiative (CCI) at UC Berkeley. ExSitu explores extreme interaction, working with creative professionals and scientists who push the limits of technology to develop novel interactive technologies that offer new strategies for creative exploration. ExSitu's research activities include: developing underlying theory (co-adaptive instruments and substrates), conducting empirical studies (participatory design with creative professionals), and implementing interactive systems (creativity support tools). The CITRIS Connected Communities Initiative investigates collaborative discovery and design through new technologies that enhance education, creative work, and public engagement. It develops interactive tools, techniques and materials for the rapid design and prototyping of novel interactive products, expertise sharing among designers, and citizen science investigations. DECibel will combine the strengths of these two groups to to investigate novel tools and technologies that support Discovery, Expressivity, and Creativity.

8.5. International Research Visitors

8.5.1. Visits of International Scientists

Joanne McGrenere, Professor at the University of British Columbia, Canada and Inria Chair, visited for two months, to work with Wendy Mackay, Carla Griggio, Jessalyn Alvina, Yi Zhang and John MacCallum.

8.5.1.1. Internships

Janin Koch, Ph.D. student from Aalto University, Finland, visited for three months to work with Wendy Mackay.

FLOWERS Project-Team

9. Partnerships and Cooperations

9.1. Regional Initiatives

9.1.1. Perseverons

Perseverons
Program: eFran
Duration: January 2016 - December 2019
Coordinator: PY Oudeyer, Inria Flowers
Partners: Inria Flowers
Funding: 140 keuros

The Perseverons project (Perseverance with / by digital objects), coordinated by the university via the ESPE (Higher School of Teaching and Education) of Aquitaine, and by the Rectorat of Bordeaux via the DANE (Academic Delegation digital education), aims to measure the real effectiveness of digital techniques in education to improve school motivation and perseverance, and, in the long term, reduce dropout. The project proposes to analyze the real effects of the use of two types of objects, robots, tablets, by comparing the school and non-school contexts of the *fablabs*. It is one of the 22 winners http://www.gouvernement.fr/efran-les-22-laureats of the "E-Fran" call for projects (training, research and digital animation spaces), following the Monteil mission on digital education, as part of the Investissement d'Avenir 2 program http://ecolenumerique.education.gouv.fr/2016/09/23/1244/. Formed of 12 sub-projects, "perseverons" has many partnerships, especially with the Poppy Education project of Inria Flowers. It is funding the PhD of Thibault Desprez.

9.1.1.1. Partner schools

In 2018, we have 36 partner schools (show Fig 41). 15 directly from the Poppy Education project. 19 new establishments were equipped in September 2017 by the Perseverons project. 21 of these establishments are located in Gironde. We have 27 high schools, 5 middle school.

9.1.2. KidLearn and Region Aquitaine

KidLearn
Program: Région Aquitaine research grant
Duration: 2016 - 2018
Coordinator: PY Oudeyer and M Lopes, Inria Flowers
Partners: Inria Flowers
Funding: 140 keuros (PhD grant of Benjamin Clément)

We propose here a research project that aims at elaborating algorithms and software systems to help humans learn efficiently, at school, at home or at work, by adapting and personalizing sequences of learning activities to the particularities of each individual student. This project leverages recent innovative algorithmic models of human learning (curiosity in particular, developed as a result of ERC European project of the Flowers team), and combines it with state-of-the-art optimization algorithms and an original integration with existing expert knowledge (human teachers). Given a knowledge domain and a set of possible learning activities, it will be able to propose the right activity at the right time to maximize learning progress. It can be applied to many learning situations and potential users: children learning basic knowledge in schools and with the support of their teachers, older kids using educational software at home, of adults needing to acquire new skills through professional training (“formation professionnelle”). Because it combines innovations in computational sciences (machine learning and optimization) with theories of human cognition (theories of human learning and of education), this project is also implementing a strong cross-fertilization between technology and human sciences (SHS).

Attachement	Type	Name	Adresse	Tel	Web
Poppy Éducation	High School	Alfred Kastler	14 Avenue de l'Université,33402 Talence, France	+33 5 57 35 40 70	http://www.lyceekastler.fr/
Poppy Éducation	Middle School	Anatole France	28 Rue des Micocouliers,33410 Cadillac, France	+33 5 56 62 98 42	http://www.afcadillac.net/
PERSEVERONS	High School	André Malraux	3 Rue du 8 Mai 1945,64200 Biarritz, France	+33 5 59 01 20 40	http://lycee-malraux-biarritz.fr/
Poppy Éducation	High School	Camille Jullian	29 Rue de la Croix Blanche,33000 Bordeaux, France	+33 5 56 01 47 47	http://www.camillejullian.com/
Poppy Éducation	Middle School	de France	Rue du Cimetière Saint-Benoist,75005 Paris, France	+33 1 44 27 12 11	http://www.college-de-france.fr/
Poppy Éducation	High School	des Graves	238 Cours du Général de Gaulle,33170 Gradignan, France	+33 5 56 75 77 56	http://www.grandlebrun.com/
PERSEVERONS	High School	Élie Faure	63 Avenue de la Libération,33310 Lormont, France	+33 5 56 38 23 23	http://www.lyc-eliefaure.fr/
PERSEVERONS	High School	Elisée Reclus	7 Avenue de Verdun,33220 Pineuilh, France	+33 5 57 41 92 50	http://lycee-foyen.fr/
Poppy Éducation	High School	François Mauriac	1 Rue Henri Dunant,33000 Bordeaux, France	+33 5 56 38 52 82	http://lyceemauriac.fr/
PERSEVERONS	High School	Gaston Febus	20 Avenue Georges Moutet,64300 Orthez, France	+33 5 59 67 07 26	http://webetab.ac-bordeaux.fr/cite-gaston-febus-orthez/
PERSEVERONS	Middle School	Giraud de Borneil	10 Boulevard André Dupuy,24160 Excideuil, France	+33 5 53 62 21 16	http://www.gdeborneil.fr/
PERSEVERONS	High School	Grand Air	Avenue du Docteur Lorentz Monod,33120 Arcachon, France	+33 5 56 22 38 00	http://webetab.ac-bordeaux.fr/lycee-grand-air/
PERSEVERONS	High School	Gustave Eiffel	143 Rue Ferbos,33000 Bordeaux, France	+33 5 56 33 83 00	http://www.eiffel-bordeaux.org/
PERSEVERONS	High School	Jacques Monod	10 Rue du Parvis,64230 Lescar, France	+33 5 59 77 92 00	http://lyceejacquesmonod.fr/
Poppy Éducation	High School	Jean Moulin	Avenue de la République,33210 Langon, France	+33 5 56 63 62 30	http://webetab.ac-bordeaux.fr/lycee-jean-moulin-langon/
Poppy Éducation	Middle School	Jean Zay	41 Rue Henri Cochet,33380 Biganos, France	+33 5 57 17 01 70	http://collegebiganos.fr/
Poppy Éducation	High School	La Morlette	62 Rue du Docteur Roux,33150 Cenon, France	+33 5 57 80 37 00	http://lycee-lamorlette.fr/
PERSEVERONS	High School	Les Iris	13 Rue Sourbès,33310 Lormont, France	+33 5 57 80 10 60	http://www.lyceelesiris.fr/
PERSEVERONS	High School	Louis Barthou	2 Boulevard Barbanègre,64000 Pau, France	+33 5 59 98 98 00	http://www.cyberlycee.fr/
PERSEVERONS	High School	Louis de Foix	4 Avenue Jean Rostand,64100 Bayonne/Bayona/Baiona, France	+33 5 59 63 31 10	http://www.louisdefoix.com/
PERSEVERONS	High School	Maine de Biran	108 Rue Valette,24100 Bergerac, France	+33 5 53 74 50 00	http://webetab.ac-bordeaux.fr/lycee-maine-de-biran/
Poppy Éducation	Middle School	Mios	Route du Pujeau,33380 Mios, France	+33 5 56 03 00 77	http://www.villemios.fr/enfance-jeunesse/college/
PERSEVERONS	High School	Nord Bassin	128 Avenue de Bordeaux,33510 Andernos-les-Bains, France	+33 5 56 82 20 77	http://www.lyceenordbassin.com/
Forum Poppy	Primary School	Notre-Dame du Mur	19 Rue de Kermadiou,29600 Morlaix, France	+33 2 98 88 18 69	http://lycee.ecmorlaix.fr/
PERSEVERONS	High School	Pape Clément	1 Rue Léo Lagrange,33600 Pessac, France	+33 5 57 26 63 00	http://lyceepapeclement.fr/
PERSEVERONS	High School	Pays de Soule	Avenue Jean Monnet,64130 Chéraute, France	+33 5 59 28 22 28	http://www.lyceedupaysdesoule.fr/index.php
PERSEVERONS	High School	Pré De Cordy	5 Avenue Joséphine Baker,24200 Sarlat-la-Canéda, France	+33 5 53 31 70 70	http://lycee-predecordy-sarlat.com/
Poppy Éducation	High School	Raoul Follereau	9 Boulevard Saint-Exupéry,58000 Nevers, France	+33 3 86 60 36 00	http://lyc58-renardfollereau.ac-dijon.fr/
PERSEVERONS	High School	René Cassin	2 Rue de Lasseguette,64100 Bayonne/Bayona/Baiona, France	+33 5 59 58 42 00	http://webetab.ac-bordeaux.fr/lycee-rene-cassin/
PERSEVERONS	High School	Saint-Cricq	4 Piste Cyclable,64000 Pau, France	+33 5 59 30 50 55	http://www.lycee-saint-cricq.org/
Poppy Éducation	High School	Saint-Genès	160 Rue de Saint-Genès,33000 Bordeaux, France	+33 5 56 33 84 84	http://www.saint-genes.com/
PERSEVERONS	High School	Saint-John Perse	2 Chemin de Barincou,64000 Pau, France	+33 5 59 62 73 11	http://www.lycee-saint-john-perse.fr/
Poppy Éducation	High School	Sainte-Marie Grand Lebrun	164 Rue François Mauriac,33200 Bordeaux, France	+33 5 56 08 32 13	http://www.grandlebrun.com/
inria	High School	Sainte-Saintonge	12 Rue de Saintonge,33000 Bordeaux, France	+33 5 56 99 39 29	http://www.lyceesaintefamille.com/
Poppy Éducation	High School	Sud-Médoc	Piste du Médoc Bleu,33320 Le Taillan-Médoc, France	+33 5 56 70 10 10	http://www.lyceesudmedoc.fr/
Poppy Éducation	High School	Victor Louis	2 Rue de Mégret,33400 Talence, France	+33 5 56 80 76 40	http://lyceevictorlouis.fr/

Figure 41. List of partner schools

9.2. National Initiatives

9.2.1. Myoelectric prosthesis - PEPS CNRS

PY Oudeyer collaborated with Aymar de Rugy, Daniel Cattaert, Mathilde Couraud, Sébastien Mick and Florent Paclet (INCIA, CNRS/Univ. Bordeaux) about the design of myoelectric robotic prostheses based on the Poppy platform, and on the design of algorithms for co-adaptation learning between the human user and the prosthesis. This was funded by a PEPS CNRS grant.

9.2.2. Poppy Station structure

- Since 1 september 2017 until february 2019, PerPoppy and Poppy Station Projects : D. Roy, P.-Y. Oudeyer. These projects aim to perpetuate the Poppy robot ecosystem by creating an external structure from outside Inria, with various partners. After the Poppy Robot Project, the Poppy Education Project has ended and Poppy Station structure is born. PerPoppy is the project which is building the new structure, and Poppy Station is the name of the new structure. Poppy Station, which includes Poppy robot ecosystem (hardware, software, community) from the beginning, is a place of excellence to build future educational robots and to design pedagogical activities to teach computer science, robotics and Artificial Intelligence. https://www.poppystation.org
- Partners of Poppy Station : Inria, La Ligue de l'Enseignement, HESAM Université, SNCF Développement, IFÉ-ENS Lyon, MOBOTS – EPFL, Génération Robots, Pollen Robotics, KONEX-Inc.

9.3. European Initiatives

9.3.1. DREAM

Title: Deferred Restructuring of Experience in Autonomous Machines
Programm: H2020
Duration: January 2015 - December 2018
Coordinator: UPMC
Partners:

Armines (ENSTA ParisTech)
Edimbourgh (Scotland)
University of A Coruna (Spain)
Vrije University Amsterdam (Holland)

Contact: David Filliat
Abstract: A holy grail in robotics and artificial intelligence is to design a machine that can accumulate adaptations on developmental time scales of months and years. From infancy through adult- hood, such a system must continually consolidate and bootstrap its knowledge, to ensure that the learned knowledge and skills are compositional, and organized into meaningful hierarchies. Consolidation of previous experience and knowledge appears to be one of the main purposes of sleep and dreams for humans, that serve to tidy the brain by removing excess information, to recombine concepts to improve information processing, and to consolidate memory. Our approach – Deferred Restructuring of Experience in Autonomous Machines (DREAM) – incorporates sleep and dream-like processes within a cognitive architecture. This enables an individual robot or groups of robots to consolidate their experience into more useful and generic formats, thus improving their future ability to learn and adapt. DREAM relies on Evo- lutionary Neurodynamic ensemble methods (Fernando et al, 2012 Frontiers in Comp Neuro; Bellas et al., IEEE-TAMD, 2010) as a unifying principle for discovery, optimization, re- structuring and consolidation of knowledge. This new paradigm will make the robot more autonomous in its acquisition, organization and use of knowledge and skills just as long as they comply with the satisfaction of pre-established basic motivations. DREAM will enable robots to cope with the complexity of being an information-processing entity in domains that are open-ended both in terms of space and time. It paves the way for a new generation of robots whose existence and purpose goes far beyond the mere execution of dull tasks. http://www.robotsthatdream.eu

9.3.2. Collaborations in European Programs, except FP7 & H2020

9.3.2.1. IGLU

Title: Interactive Grounded Language Understanding (IGLU)

Programm: CHIST-ERA

Duration: October 2015 - September 2018

Coordinator: University of Sherbrooke, Canada

Partners:

University of Sherbrooke, Canada

Inria Bordeaux, France

University of Mons, Belgium

KTH Royal Institute of Technology, Sweden

University of Zaragoza, Spain

University of Lille 1 , France

University of Montreal, Canada

Inria contact: Pierre-Yves Oudeyer

Language is an ability that develops in young children through joint interaction with their caretakers and their physical environment. At this level, human language understanding could be referred as interpreting and expressing semantic concepts (e.g. objects, actions and relations) through what can be perceived (or inferred) from current context in the environment. Previous work in the field of artificial intelligence has failed to address the acquisition of such perceptually-grounded knowledge in virtual agents (avatars), mainly because of the lack of physical embodiment (ability to interact physically) and dialogue, communication skills (ability to interact verbally). We believe that robotic agents are more appropriate for this task, and that interaction is a so important aspect of human language learning and understanding that pragmatic knowledge (identifying or conveying intention) must be present to complement semantic knowledge. Through a developmental approach where knowledge grows in complexity while driven by multimodal experience and language interaction with a human, we propose an agent that will incorporate models of dialogues, human emotions and intentions as part of its decision-making process. This will lead anticipation and reaction not only based on its internal state (own goal and intention, perception of the environment), but also on the perceived state and intention of the human interactant. This will be possible through the development of advanced machine learning methods (combining developmental, deep and reinforcement learning) to handle large-scale multimodal inputs, besides leveraging state-of-the-art technological components involved in a language-based dialog system available within the consortium. Evaluations of learned skills and knowledge will be performed using an integrated architecture in a culinary use-case, and novel databases enabling research in grounded human language understanding will be released. IGLU will gather an interdisciplinary consortium composed of committed and experienced researchers in machine learning, neurosciences and cognitive sciences, developmental robotics, speech and language technologies, and multimodal/multimedia signal processing. We expect to have key impacts in the development of more interactive and adaptable systems sharing our environment in everyday life. http://iglu-chistera.github.io/

9.4. International Initiatives

9.4.1. Inria Associate Teams Not Involved in an Inria International Labs

9.4.1.1. NEUROCURIOSITY

Title: NeuroCuriosity

International Partner (Institution - Laboratory - Researcher):

Columbia Neuroscience (United States) - Cognitive Neuroscience - JACQUELINE GOTTLIEB

Start year: 2016

See also: https://flowers.inria.fr/neurocuriosity

Curiosity can be understood as a family of mechanisms that evolved to allow agents to maximize their knowledge of the useful properties of the world. In this project we will study how different internal drives of an animal, e.g. for novelty, for action, for liking, are combined to generate the rich variety of behaviors found in nature. We will approach such challenge by studying monkeys, children and by developing new computational tools.

9.4.1.2. Idex Bordeaux-Univ. Waterloo collaborative project on curiosity in HCI

Title: Curiosity

International Partner (Institution - Laboratory - Researcher):

University of Waterloo (Canada), Edith Law's HCI Lab and Dana Kulic's Robotics lab.

Start year: 2018

Pierre-Yves Oudeyer collaborated with Edith Law's HCI research group at University of Waterloo on the topic of "Curiosity in HCI system". They obtained a grant from Univ. Bordeaux to set up a project with Inria Potioc team and with Dana Kulic, Robotics lab, Univ. Waterloo. They organized several cross visits and collaborated on the design and experimentation of an educational interactive robotic system to foster curiosity-driven learning. This led to an article accepted at CHI 2019.

9.4.1.3. Informal International Partners

Pierre-Yves Oudeyer and Didier Roy have create a collaboration with LSRO EPFL and Pr Francesco Mondada, about Robotics and education. The two teams co-organize the annual conference "Robotics and Education"in Bordeaux. Didier Roy teaches "Robotics and Education" in EPFL several times a year.

Didier Roy has created a collaboration with HEP VAud (Teachers High School) and Bernard Baumberger and Morgane Chevalier, about Robotics and education. Scientific discussions and shared professional training.

Florian Golemo and PY Oudeyer have had an active collaboration with Aaron Courville from MILA Montreal to work on the IGLU project together.

William Schueller and PY Oudeyer continued to collaborate with Vittorio Loreto (CNR Rome and Sony CSL Paris).

A collaboration with Johan Lilius and Sebastien Lafond from Abo Akademi University, Turku (Finland) is ongoing to sign an Erasmus contract for researchers and students visits on the topic of autonomous boats.

Funding applications have been submitted jointly with Davide Maltoni and Vincenzo Lomonaco from University of Bologna (Italy) on the topic of continual learning. Also the project https://www.continualai.org/ is being further developed jointly and on the way to become a non-profit organization.

9.4.2. Participation in Other International Programs

David Filliat participates in the ITEA3 DANGUN project with Renault S.A.S. in france and partners in Korea. The purpose of the DANGUN project is to develop a Traffic Jam Pilot function with autonomous capabilities using low-cost automotive components operating in France and Korea. By incorporating low-cost advanced sensors and simplifying the vehicle designs as well as testing in different scenarios (France & Korea), a solution that is the result of technical cooperation between both countries should lead to more affordable propositions to respond to client needs in the fast moving market of intelligent mobility.

9.5. International Research Visitors

9.5.1. Visits of International Scientists

- Bart de Boer, VUB Brussels (Dec 2018)
- Dan Dediu, Univ. Lyon (Dec 2018)
- Kenny Smith, Univ. Edinburgh (Dec 2018)
- Jochen Triesch, Univ. Frankfurt (Nov 2018)
- Vincenzo Lomonaco, University of Bologna, Italy (Aug. 2018)

9.5.2. Internships

- Ashley Hill, Univ. Paris-Sud, Paris Saclay.
- René Traoré, UPMC, Sorbonne Universite, Paris.
- Josias Lévi Alvarès, ENSC, Bordeaux.
- Sandy Manolios, Univ. de Lyon, Lyon.
- Rémy Portelas, UPMC, Paris.
- Chuan Qin, ENSTA, Paris Saclay.

GRAPHDECO Project-Team

8. Partnerships and Cooperations

8.1. National Initiatives

8.1.1. ADT PicPlay

Participants: Sebastien Bonopera, George Drettakis.

The Technology Development Action (ADT) PicPlay a technology tranfer pre-maturation project, supported by Inria and by UCA Jedi. The objective is to create a startup company based on image based rendering technologies, taking benefit from the team's research and experience over the last 8 years. At this early stage, we evaluated the market and produced several Proof-of-Concept demonstrations for potential clients. One of the demonstrations is our new asset streaming capability that allows the use for huge datasets. We also developed a new solution to improve rendering quality. This solution uses a 3D mesh for each view and refines it according to this view only, before blending each view. PicPlay involved the development of several tools for converting and processing datasets. During this year we established contacts with industrial partners in the automobile industry and in the construction/public works industry who expressed interest in using the technology in their projects for visualization and navigation of captured environments.

8.2. European Initiatives

8.2.1. FP7 & H2020 Projects

8.2.1.1. ERC D3

Participants: Yulia Gryaditskaya, Tibor Stanko, Bastien Wailly, David Jourdan, Adrien Bousseau.

Designers draw extensively to externalize their ideas and communicate with others. However, drawings are currently not directly interpretable by computers. To test their ideas against physical reality, designers have to create 3D models suitable for simulation and 3D printing. However, the visceral and approximate nature of drawing clashes with the tediousness and rigidity of 3D modeling. As a result, designers only model finalized concepts, and have no feedback on feasibility during creative exploration. Our ambition is to bring the power of 3D engineering tools to the creative phase of design by automatically estimating 3D models from drawings. However, this problem is ill-posed: a point in the drawing can lie anywhere in depth. Existing solutions are limited to simple shapes, or require user input to "explain" to the computer how to interpret the drawing. Our originality is to exploit professional drawing techniques that designers developed to communicate shape most efficiently. Each technique provides geometric constraints that help viewers understand drawings, and that we shall leverage for 3D reconstruction.

Our first challenge is to formalize common drawing techniques and derive how they constrain 3D shape. Our second challenge is to identify which techniques are used in a drawing. We cast this problem as the joint optimization of discrete variables indicating which constraints apply, and continuous variables representing the 3D model that best satisfies these constraints. But evaluating all constraint configurations is impractical. To solve this inverse problem, we will first develop forward algorithms that synthesize drawings from 3D models. Our idea is to use this synthetic data to train machine learning algorithms that predict the likelihood that constraints apply in a given drawing. In addition to tackling the long-standing problem of single-image 3D reconstruction, our research will significantly tighten design and engineering for rapid prototyping.

8.2.1.2. ERC FunGraph

Participants: Sébastien Morgenthaler, George Drettakis, Rada Deeb, Diolatzis Stavros.

The ERC Advanced Grant FunGraph proposes a new methodology by introducing the concepts of rendering and input uncertainty. We define output or rendering uncertainty as the expected error of a rendering solution over the parameters and algorithmic components used with respect to an ideal image, and input uncertainty as the expected error of the content over the different parameters involved in its generation, compared to an ideal scene being represented. Here the ideal scene is a perfectly accurate model of the real world, i.e., its geometry, materials and lights; the ideal image is an infinite resolution, high-dynamic range image of this scene.

By introducing methods to estimate rendering uncertainty we will quantify the expected error of previously incompatible rendering components with a unique methodology for accurate, approximate and image-based renderers. This will allow FunGraph to define unified rendering algorithms that can exploit the advantages of these very different approaches in a single algorithmic framework, providing a fundamentally different approach to rendering. A key component of these solutions is the use of captured content: we will develop methods to estimate input uncertainty and to propagate it to the unified rendering algorithms, allowing this content to be exploited by all rendering approaches.

The goal of FunGraph is to fundamentally transform computer graphics rendering, by providing a solid theoretical framework based on uncertainty to develop a new generation of rendering algorithms. These algorithms will fully exploit the spectacular – but previously disparate and disjoint – advances in rendering, and benefit from the enormous wealth offered by constantly improving captured input content.

8.2.1.3. Emotive

Participants: Julien Philip, Sebastiàn Vizcay, George Drettakis.

https://emotiveproject.eu/

Type: COOPERATION (ICT)

Instrument: Reseach Innovation Action

Objectif: Virtual Heritage

Duration: November 2016 - October 2019

Coordinator: EXUS SA (UK)

Partner: Diginext (FR), ATHENA (GR), Noho (IRL), U Glasgow (UK), U York (UK)

Inria contact: George Drettakis

Abstract: Storytelling applies to nearly everything we do. Everybody uses stories, from educators to marketers and from politicians to journalists to inform, persuade, entertain, motivate or inspire. In the cultural heritage sector, however, narrative tends to be used narrowly, as a method to communicate to the public the findings and research conducted by the domain experts of a cultural site or collection. The principal objective of the EMOTIVE project is to research, design, develop and evaluate methods and tools that can support the cultural and creative industries in creating Virtual Museums which draw on the power of 'emotive storytelling'. This means storytelling that can engage visitors, trigger their emotions, connect them to other people around the world, and enhance their understanding, imagination and, ultimately, their experience of cultural sites and content. EMOTIVE will do this by providing the means to authors of cultural products to create high-quality, interactive, personalized digital stories.

GRAPHDECO contributes by developing novel image-based rendering techniques to help museum curators and archeologists provide more engaging experiences. In 2018, we developed a mixed reality plugin for Unity that allows the use of IBR in a VR experience used in one of the EMOTIVE user experiences using a VIVE HMD.

8.3. International Initiatives

8.3.1. Inria International Partners

8.3.1.1. Informal International Partners

We maintain close collaborations with international experts, including

- University College London (G. Brostow, P. Hedman)
- UC Berkeley (A. Efros)
- Purdue University (D. Aliaga)
- George Mason University (Y. Gingold)
- Tu Delft (M. Sypesteyn, J. W. Hoftijzer and S. Pont)

8.4. International Research Visitors

8.4.1. Visits of International Scientists

- Carol O'Sullivan, Trinity College Dublin, visited the group for one week in August.
- Peter Hedman, University College London, visited us for a few days in July.
- Miika Aittala, MIT, visited the group for one month in July.
- Yotam Gingold, George Mason University, visited the group for one month in June.

8.4.2. Visits to International Teams

8.4.2.1. Research Stays Abroad

Several students and postdocs visited our international collaborators:

- Yulia Gryaditskaya and Valentin Deschaintre visited the research group of Fredo Durand at MIT for two weeks. They presented their work to several groups (HCI, geometry, computer graphics).
- Tibor Stanko spent two weeks at RWTH Aachen University, Germany, to collaborate with David Bommes.
- Johanna Delanoy did a 3-months internship at Adobe Research (San Francisco) to collaborate with Aaron Hertzmann.
- Julien Philip spent a week at University College London to visit Gabriel Brostow and five weeks at University of California, Berkeley, to visit Alexei A. Efros. During this visit, he presented his work to the computer graphics groups of Stanford and UC Berkeley.

GRAPHIK Project-Team

8. Partnerships and Cooperations

8.1. National Initiatives

8.1.1. CQFD (ANR PRC, Jan. 2019-Dec. 2022)

Participants: Jean-François Baget, Michel Leclère, Marie-Laure Mugnier, Federico Ulliana.

CQFD (Complex ontological Queries over Federated heterogeneous Data), coordinated by Federico Ulliana (GraphIK), involves participants from Inria Saclay (CEDAR team), Inria Paris (VALDA team), Inria Nord Europe (SPIRALS team), IRISA, LIG, LTCI, and LaBRI. The aim of this project is tackle two crucial challenges in OMQA (Ontology Mediated Query Answering), namely, heterogeneity, that is, the possibility to deal with multiple types of data-sources and database management systems, and federation, that is, the possibility of cross-querying a collection of heterogeneous datasources. By featuring 8 different partners in France, this project aims at consolidating a national community of researchers around the OMQA issue.

8.1.2. ICODA (Inria Project Lab, 2017-2021)

Participants: Jean-François Baget, Michel Chein, Marie-Laure Mugnier.

The iCODA project (Knowledge-mediated Content and Data Interactive Analytics—The case of data journalism), coordinated by Guillaume Gravier and Laurent Amsaleg (LINKMEDIA), takes together four Inria teams: LINKMEDIA, CEDAR, ILDA and GraphIK, as well as three press partners: Ouest France, Le Monde (les décodeurs) and AFP.

Taking data journalism as an emblematic use-case, the goal of the project is to develop the scientific and technological foundations for knowledge-mediated user-in-the-loop big data analytics jointly exploiting data and content, and to demonstrate the effectiveness of the approach in realistic, high-visibility use-cases.
https://project.inria.fr/icoda/

8.1.3. Docamex (CASDAR project, 2017-2020)

Participants: Patrice Buche, Madalina Croitoru, Jérôme Fortin, Clément Sipieter.

DOCaMEx (Développement de prOgiciels de Capitalisation et de Mobilisation du savoir-faire et de l'Expérience fromagers en filière valorisant leur terroir), let by CFTC (centre technique des fromages de Franche-Comté) involves 7 research units (including IATE and LIRMM), 8 technical centers and 3 dairy product schools. It represents five cheese-making chains (Comté, Reblochon, Emmental de Savoie, Salers, Cantal).

Traditional cheese making requires a lot of knowledge, expertise, and experience, which is usually acquired over a long time. This knowledge is today mainly transmitted by apprenticeship and a concrete risk of knowledge forgetting is raised by the evolution of practices in the sector. Using new methods for expert knowledge capitalization the main goal of the project is to develop a new approach for expert knowledge elicitation and a dedicated software for decision making. The novel part of the decision making tool will consist in the representation power and reasoning efficiency in the context of the logic used to describe the domain knowledge.
http://www.rmtfromagesdeterroirs.com/projets-de-r-et-d/docamex/

8.1.4. Convergence Institute #DigitAg (2017-2023)

Participants: Patrice Buche, Madalina Croitoru, Marie-Laure Mugnier, Rallou Thomopoulos, Federico Ulliana.

Located in Montpellier, #DigitAg (for Digital Agriculture) gathers 17 founding members: research institutes, including Inria, the University of Montpellier and higher-education institutes in agronomy, transfer structures and companies. Its objective is to support the development of digital agriculture. GraphIK is involved in this project on the issues of designing data and knowledge management systems adapted to agricultural information systems, and of developing methods for integrating different types of information and knowledge (generated from data, experts, models). A collaboration is starting with the research laboratory UMR SYSTEM (Tropical and mediterranean cropping system functioning and management) on knowledge representation and reasoning for agro-ecological systems.
https://www.hdigitag.fr/en/

8.1.5. Informal National Partners

We continue to work informally with the following partners:

- Michael Thomazo (VALDA Inria team) on Ontology-Mediated Query Answering [37], [27].
- Jérôme Bonnet and Sarah Gouiziou, from the Center for Structural Biochemistry of Montpellier (CBS), on the encoding of Boolean functions in biological systems [15].
- Jean-Claude Léon (IMAGINE Inria team) on the developement of an ontology-mediated query answering system applied to the field of CAD (Computer Aided Design).
- Srdjan Vesic (CRIL) on logical argumentation systems [35], [28], [30], [31], [32] . In particular, Srdjan Vesic is a co-supervisor of Bruno Yun PhD thesis, started in Sept 2016.

8.2. European Initiatives

8.2.1. NoAW (H2020, Oct. 2016-Sept. 2020)

Participants: Patrice Buche, Pierre Bisquert, Madalina Croitoru, Nikolaos Karanikolas, Rallou Thomopoulos.

NoAW (No Agricultural Waste) is led by INRA-IATE. Driven by a "near zero-waste" society requirement, the goal of NoAW project is to generate innovative efficient approaches to convert growing agricultural waste issues into eco-efficient bio-based products opportunities with direct benefits for both environment, economy and EU consumer. To achieve this goal, the NoAW concept relies on developing holistic life cycle thinking able to support environmentally responsible R&D innovations on agro-waste conversion at different TRLs, in the light of regional and seasonal specificities, not forgetting risks emerging from circular management of agro-wastes (e.g. contaminants accumulation). GraphIK contributes on two aspects. On the one hand we participate in the annotation effort of knowledge bases (using the @Web tool). On the other hand we further investigate the interplay of argumentation with logically instantiated frameworks and its relation with social choice in the context of decision making.
http://cordis.europa.eu/project/rcn/203384_en.html

8.2.2. GLOPACK (H2020, June. 2018- July. 2022)

Participants: Patrice Buche, Pierre Bisquert, Madalina Croitoru.

GLOPACK is also led by INRA-IATE. It proposes a cutting-edge strategy addressing the technical and societal barriers to spread in our social system, innovative eco-efficient packaging able to reduce food environmental footprint. Focusing on accelerating the transition to a circular economy concept, GLOPACK aims to support users and consumers' access to innovative packaging solutions enabling the reduction and circular management of agro-food, including packaging, wastes. Validation of the solutions including compliance with legal requirements, economic feasibility and environmental impact will push forward the technologies tested and the related decision-making tool to TRL 7 for a rapid and easy market uptake contributing therefore to strengthen European companies' competitiveness in an always more globalised and connected world.
https://glopack2020.eu/.

8.2.3. FoodMC (European COST action, 2016-2020)

Participants: Patrice Buche, Madalina Croitoru, Rallou Thomopoulos.

COST actions aim to develop European cooperation in science and technology. FoodMC (CA 15118) is a cost action on Mathematical and Computer Science Methods for Food Science and Industry. Rallou Thomopoulos is co-leader of this action for France, and member of the action Management Committee, and other members of GraphIK (Patrice Buche, Madalina Croitoru) are participants. The action is organised in four working groups, dealing respectively with the modelling of food products and food processes, modelling for eco-design of food processes, software tools for the food industry, and dissemination and knowledge transfer. http://www6.inra.fr/foodmc

8.2.4. Informal International Partners

- University of Toronto (Canada): collaboration with Sheila McIlraith and her research group on temporal logics [22].
- Birkbeck College, University of London (UK): collaboration with Michael Zacharyaschev, Roman Kontchakov, and Stanislav Kikot on the complexity of ontology-mediated query answering [14].
- Patras University (Greece): collaboration with Nikolaos Karanikolas (formerly postdoc in the team) [16].

8.2.5. International Research Visitors

- David Carral (postdoc, TU Dresden, Germany) visited the group between 19-21 Dec. 2018.
- Joshua Sohn (PhD, DTU, Denmark) visited the group for a month in October 2018.
- Prof. Guillermo Simari (U. Nacional del Sur, Argentina) visited the group for a week in July 2018.

8.2.6. Visits to International Teams

- One-year stay (academic year 2017-2018) of Meghyn Bienvenu at University of Toronto, Computer Science Department, collaboration with Sheila McIlraith and KR group, focusing mainly on program synthesis with linear temporal logic (LTL) specifications, in particular, taking into account environment assumptions and user preferences.
- Marie-Laure Mugnier visited the Knowledge-Based Systems research group at TU Dresden (Markus Kroetzsch), mid July 2018.

HEPHAISTOS Project-Team

9. Partnerships and Cooperations

9.1. Regional Initiatives

- the HEPHAISTOS and CHORALE teams together with I3S have organized the 2-days workshop *Robopaca* supported by Inria and UCA. The purpose was to organize a meeting between academics, industry and end-users to examine together the possibility of structuring the robotic activities in PACA

9.2. National Initiatives

- the project **Craft** on collaborative cable-driven parallel robot has been funded by ANR. It involves LS2N (Nantes) and the Cetim. This project will start in 2019

9.2.1. FHU

- the team has been involved for the FHU *INOVPAIN : Innovative Solutions in Refractory Chronic Pain* that has been labeled in December 2016

9.3. International Initiatives

9.3.1. Inria International Partners

9.3.1.1. Informal International Partners

We have numerous international collaborations but we mention here only the one with activities that go beyond joint theoretical or experimental works:

- University of Bologna: 2 joint PhD student, publications
- University Innsbruck: joint conference organization
- Fraunhofer IPA, Stuttgart: joint conference organization
- Duisburg-Essen University: joint conference organization
- University of New-Brunswick: 1 joint PhD student
- University Laval, Québec: joint book
- University of Tokyo: joint conference organization
- Tianjin University, China: joint book

HYBRID Project-Team

9. Partnerships and Cooperations

9.1. Regional Initiatives

9.1.1. Labex Cominlabs SUNSET

Participants: Bruno Arnaldi, Valérie Gouranton [contact].

SUNSET is a 4-year Labex Cominlabs project (2016-2020). SUNSET partners are MediCIS-LTSI (coordinator), Hybrid, Hycomes (IRISA/Inria), and CHU Rennes. SUNSET aims at developing an innovative training software suite based on immersive and collaborative virtual reality technology for training and evaluating non-technical skills. This approach will be implemented and evaluated in the context of training neurosurgical scrub nurses. We will notably integrate methods and systems developed in the S3PM project (see bellow). By relying on Human Factors approaches, the project also addresses training and evaluation of interpersonal skills. Whereas the developed technologies and approaches will be generic and adaptable to any surgical specialty, the project will evaluate the developed system within training sessions performed with scrub nurses. We ambition to propose novel approaches for surgical non-technical skill learning and assessment, and to install the developed training factory at the University Hospital of Rennes, and evaluate it with real-scale user studies.

9.1.2. Labex Cominlabs HEMISFER

Participants: Mathis Fleury, Anatole Lécuyer [contact], Giulia Lioi.

HEMISFER is a 6-year project (2013-2019) funded by Labex CominLabs. It involves 4 Inria/IRISA teams (Hybrid, Visages (lead), Panama, Athena) and 2 medical centers: the Rennes Psychiatric Hospital (CHGR) and the Reeducation Department of Rennes Hospital (CHU Pontchaillou). The goal of HEMISFER is to make full use of neurofeedback paradigm in the context of rehabilitation and psychiatric disorders. The major breakthrough will come from the use of a coupling model associating functional and metabolic information from Magnetic Resonance Imaging (fMRI) to Electro-encephalography (EEG) to “enhance” the neurofeedback protocol. Clinical applications concern motor, neurological and psychiatric disorders (stroke, attention-deficit disorder, treatment-resistant mood disorders, etc).

9.1.3. Labex Cominlabs SABRE

Participants: Anatole Lécuyer [contact], Jussi Tapio Lindgren.

SABRE was a 4-year project (2014-2018) funded by Labex CominLabs. It involved 1 Inria/IRISA team (Hybrid) and 2 groups from TELECOM BREST engineering school. The goal of SABRE was to improve computational functionnalities and power of current real-time EEG processing pipelines. The project investigated innovative EEG solution methods empowered and speeded-up by ad-hoc, transistor-level, implementations of their key algorithmic operations.

9.1.4. IRT b<>com

Participants: Ferran Argelaguet, Bruno Arnaldi [contact], Valérie Gouranton, Anatole Lécuyer, Maud Marchal, Florian Nouviale.

b<>com is a French Institute of Research and Technology (IRT). The main goal of this IRT is to fasten the development and marketing of tools, products and services in the field of digital technologies. Our team has been regularly involved in collaborations with b<>com within various 3-year projects, such as ImData (on Immersive Interaction) and GestChir (on Augmented Healthcare) which both ended in 2016. Follow-up projects called NeedleWare (on Augmented Healthcare) and VUXIA (on Human Factors) have started respectively in 2016 and 2018.

9.1.5. CNPAO Project

Participants: Valérie Gouranton [contact], Ronan Gaugne.

CNPAO ("Conservatoire Numérique du Patrimoine Archéologique de l'Ouest") is an on-going research project partially funded by the Université Européenne de Bretagne (UEB) and Université de Rennes 1. It involves IRISA/Hybrid and CReAAH. The main objectives are: (i) a sustainable and centralized archiving of 2D/3D data produced by the archaeological community, (ii) a free access to metadata, (iii) a secure access to data for the different actors involved in scientific projects, and (iv) the support and advice for these actors in the 3D data production and exploration through the latest digital technologies, modeling tools and virtual reality systems. This project involves a collaboration with Quentin Petit (SED Inria Rennes).

9.1.6. ATT CONSORVIBE

Participants: Anatole Lécuyer [contact], Jussi Tapio Lindgren.

CONSORVIBE was a 6-month ATT Inria Project funded by Inria for supporting a prospective effort and the feasibility study of building a consortium of partners dedicated to the sustainability and promotion of the OpenViBE software.

9.2. National Initiatives

9.2.1. ANR

9.2.1.1. ANR LOBBY-BOT

Participants: Anatole Lécuyer [contact], Maud Marchal, Victor Mercado.

LOBBY-BOT is a 4-year project (2017-2021) funded by the French National Research Agency (ANR). The objective of LOBBY-BOT is to address the scientific challenges of encountered-type haptic devices (ETHD), which are an alternative category of haptic devices relying on a mobile physical prop, usually actuated by a robot, that constantly follows the user hand, and encounter it only when needed. The project follows two research axes: a first one dealing with robot control, and the second one dealing with interaction techniques adapted to ETHD. The involvement of Hybrid relates to the second research axis of the project. The final project prototype will be used to assess the benefits of ETHD when used in an industrial use-case : the perceived quality in an automotive interior.

9.2.2. Inria projects

9.2.2.1. Ilab CertiViBE

Participants: Anatole Lécuyer [contact], Jussi Tapio Lindgren, Thierry Gaugry, Cédric Riou.

CertiViBE was a 2-year "Inria Innovation Lab" (2015-2018) funded by Inria for supporting the development of OpenViBE software, and notably its evolution in order to enable and fasten the medical transfer and the medical certification of products based on OpenViBE. This joint lab involved two partners: Hybrid and Mensia Technologies startup company. The project aimed at setting up a quality environment, and developping a novel version of the software compliant with medical certification rules.

9.2.2.2. IPL BCI-LIFT

Participants: Anatole Lécuyer [contact], Jussi Tapio Lindgren, Hakim Si Mohammed.

BCI-LIFT is a 4-year "Inria Project Lab" initiative (2015-2019) funded by Inria for supporting a national research effort on Brain-Computer Interfaces. This joint lab involves several Inria teams: Hybrid, Potioc, Athena, Neurosys, Loki, Demar; as well as external partners: INSERM-Lyon, and INSA Rouen. This project aims at improving several aspects of Brain-Computer Interfaces: learning and adaptation of BCI systems, user interfaces and feedback, training protocols, etc.

9.2.2.3. IPL AVATAR

Participants: Anatole Lécuyer [contact], Ferran Argelaguet, Diane Dewez, Rebecca Fribourg.

AVATAR is a 4-year "Inria Project Lab" initiative (2018-2022) funded by Inria for supporting a national research effort on Avatars and Virtual Embodiment. This joint lab involves several Inria teams: Hybrid, Potioc, Loki, Mimetic, Graphdeco, Morpheo; as well as external partners: Univ. Bacelona, Faurecia and Technicolor companies. This project aims at improving several aspects of Avatars in immersive applications: reconstruction, animation, rendering, interaction, multi-sensory feedback, etc.

9.2.2.4. IPL NAVISCOPE

Participant: Ferran Argelaguet [contact].

NAVISCOPE is a 4-year "Inria Project Lab" initiative (2018-2022) funded by Inria for supporting a national research effort on image-guided navigation and visualization of large data sets in live cell imaging and microscopy. This joint lab involves several Inria teams: Serpico, Aviz, Beagle, Hybrid, Mosaic, Parietal, Morpheme; as well as external partners: INRA and Institute Curie. This project aims at improving visualization and machine learning methods in order to provide systems capable to assist the scientist to obtain a better understanding of massive amounts of information.

9.3. European Initiatives

9.3.1. H2020 Projects

9.3.1.1. IMAGINE

Title: IMAGINE - Robots Understanding Their Actions by Imagining Their Effects
Programm: H2020
Duration: January 2017 - December 2020
Coordinator: Univ. Innsbruck (Austria)
Partners:

- Univ. Innsbruck (Austria)
- Univ. Göttingen (Germany)
- Karlsruhe Institute of Technology (Germany)
- INSA Rennes (France)
- Institute of Robotics and Industrial Informatics (Spain)
- Univ. Bogazici (Turkey)
- Electro Cycling (Germany)

Inria contact: Maud Marchal

Abstract: Today's robots are good at executing programmed motions, but they do not understand their actions in the sense that they could automatically generalize them to novel situations or recover from failures. IMAGINE seeks to enable robots to understand the structure of their environment and how it is affected by its actions. "Understanding" here means the ability of the robot (a) to determine the applicability of an action along with parameters to achieve the desired effect, and (b) to discern to what extent an action succeeded, and to infer possible causes of failure and generate recovery actions. The core functional element is a generative model based on an association engine and a physics simulator. "Understanding" is given by the robot's ability to predict the effects of its actions, before and during their execution. This allows the robot to choose actions and parameters based on their simulated performance, and to monitor their progress by comparing observed to simulated behavior. This scientific objective is pursued in the context of recycling of electromechanical appliances. Current recycling practices do not automate disassembly, which exposes humans to hazardous materials, encourages illegal disposal, and creates significant threats to environment and health, often in third countries. IMAGINE will develop a TRL-5 prototype that can autonomously disassemble prototypical classes of devices, generate and execute disassembly actions for unseen instances of similar devices, and recover from certain failures. For robotic disassembly, IMAGINE will develop a multi-functional gripper capable of multiple types of manipulation without tool changes. IMAGINE raises the ability level of robotic systems in core areas of the work programme, including adaptability, manipulation, perception, decisional autonomy, and cognitive ability. Since only one-third of EU e-waste is currently recovered, IMAGINE addresses an area of high economical and ecological impact.

9.3.1.2. H-REALITY

Title: H-REALITY

Programm: H2020 - Fet Open

Duration: 2018 - 2021

Coordinator: Univ. Birmingham (UK)

Partners:

Univ. Birmingham (UK)

CNRS (France),

TU Delft (Netherlands),

ACTRONIKA (France),

ULTRAHAPTICS (UK)

Inria contact: Maud Marchal

Abstract: The vision of H-REALITY is to be the first to imbue virtual objects with a physical presence, providing a revolutionary, untethered, virtual-haptic reality: H-Reality. This ambition will be achieved by integrating the commercial pioneers of ultrasonic "non-contact" haptics, state-of-the-art vibrotactile actuators, novel mathematical and tribological modelling of the skin and mechanics of touch, and experts in the psychophysical rendering of sensation. The result will be a sensory experience where digital 3D shapes and textures are made manifest in real space via modulated, focused, ultrasound, ready for the unteathered hand to feel, where next-generation wearable haptic rings provide directional vibrotactile stimulation, informing users of an object's dynamics, and where computational renderings of specific materials can be distinguished via their surface properties. The implications of this technology will transform online interactions; dangerous machinery will be operated virtually from the safety of the home, and surgeons will hone their skills on thin air.

9.3.2. Collaborations in European Programs, Except FP7 & H2020

9.3.2.1. Interreg ADAPT

Program: Interreg VA France (Channel) England

Project acronym: ADAPT

Project title:Assistive Devices for empowering disAbled People through robotic Technologies

Duration: 01/2017 - 06/2021

Coordinator: ESIGELEC/IRSEEM Rouen

Other partners: INSA Rennes - IRISA, LGCGM, IETR (France), Université de Picardie Jules Verne - MIS (France), Pôle Saint Hélier (France), CHU Rouen (France), Réseau Breizh PC (France), Ergovie (France), Pôle TES (France), University College of London - Aspire CREATE (UK), University of Kent (UK), East Kent Hospitals Univ NHS Found. Trust (UK), Health and Europe Centre (UK), Plymouth Hospitals NHS Trust (UK), Canterbury Christ Church University (UK), Kent Surrey Sussex Academic Health Science Network (UK), Cornwall Mobility Center (UK).

Inria contact: Valérie Gouranton

Abstract: This project aims to develop innovative assistive technologies in order to support the autonomy and to enhance the mobility of power wheelchair users with severe physical/cognitive disabilities. In particular, the objective is to design and evaluate a power wheelchair simulator as well as to design a multi-layer driving assistance system.

9.4. International Initiatives

9.4.1. Informal International Partners

- Dr. Takuji Narumi and Prof. Michitaka Hirose from University of Tokyo (Japan), on "Virtual Embodiment"
- Dr. Hannes Kaufmann from Technical University Wien (Austria), on "3D Navigation in Virtual Environments"
- Prof. Reinhold Scherer from Graz University (Austria), on "Brain-Computer Interfaces and Augmented Reality"
- Prof. Jose Millan from Ecole Polytechnique Fédérale de Lausanne (Switzerland), on "Brain-Computer Interfaces and Sports"

9.4.2. Participation in Other International Programs

9.4.2.1. ANR-FRQSC INTROSPECT

Participants: Valérie Gouranton [contact], Bruno Arnaldi, Ronan Gaugne, Flavien Lécuyer.

INTROSPECT is a 3-year project funded by French ANR and "Fonds de Recherche Société et Culture" (FRQSC) from Quebec region, Canada. This international collaboration involves researchers in computer science and archeology from France and Canada : Hybrid (Inria-IRISA), CReAAH, Inrap, company Image ET, University Laval and INRS-ETE. INTROSPECT aims to develop new uses and tools for archaeologists that facilitate access to knowledge through interactive numerical introspection methods that combine computed tomography with 3D visualization technologies, such as Virtual Reality, tangible interactions and 3D printing. The scientific core of the project is the systematization of the relationship between the artefact, the archaeological context, the digital object and the virtual reconstruction of the archaeological context that represents it and its tangible double resulting from the 3D printing. This axiomatization of its innovative methods makes it possible to enhance our research on our heritage and to make use of accessible digital means of dissemination. This approach changes from traditional methods and applies to specific archaeological problems. Several case studies will be studied in various archaeological contexts on both sides of the Atlantic. Quebec museums are also partners in the project to spread the results among the general public.

9.5. International Research Visitors

9.5.1. Visits of International Scientists

Nami Ogawa (University of Tokyo, Japan) visited Hybrid for a 5-month collaboration on "Avatars and Virtual Embodiment" started in January 2018.

ILDA Project-Team

8. Partnerships and Cooperations

8.1. National Initiatives

8.1.1. ANR

MapMuxing - Multi-dimensional Map Multiplexing. (2014-2018) Funded by the French National Research Agency (ANR). In collaboration with IGN (Institut National de l'Information Géographique et Forestière): **208Keuros**/499Keuros. Participants: Emmanuel Pietriga (PI), Caroline Appert, Olivier Chapuis. http://mapmuxing.ign.fr

The project explores novel ways of combining different maps and data layers into a single cartographic representation, and investigates novel interaction techniques for navigating in it. The project aims at going beyond the traditional pan & zoom and overview+detail interface schemes, and at designing and evaluating novel cartographic visualizations that rely on high-quality generalization, *i.e.*, the simplification of geographic data to make it legible at a given map scale, and symbol specification.

8.1.2. Inria - Ministère de la Culture

Visual Exploration of Linked Data on BnF's data portal (2017-2018) Funded by the French Ministère de la Culture and Inria. **65Keuros**. Participants: Emmanuel Pietriga (PI), Caroline Appert, Hande Gözükan, Marie Destandau, Léo Colombaro.

The project explores novel ways of visually navigating the data exposed by the Bibliothèque Nationale de France as linked data on http://data.bnf.fr.

8.1.3. Inria Project Lab (IPL)

ILDA participates to Inria Project Lab iCODA : Data Journalism : knowledge-mediated Content and Data Interactive Analytics, that started in 2017. A key issue in data science is the design of algorithms that enable analysts to infer information and knowledge by exploring heterogeneous information sources, structured data, or unstructured content. With journalism data as a landmark use-case, iCODA aims to develop the scientific and technological foundation for collaborative, heterogeneous data analysis, guided by formalized, user-centric knowledge. The project relies on realistic scenarios in data-journalism to assess the contribution of the project to this area. iCODA is at the crossroads of several research areas (content analysis, data management, knowledge representation, visualization) and is part of a club of partners of the world of the press. Equipes-projets Inria : Graphik, Ilda, Linkmedia, Cedar. Press partners: Le Monde, OuestFrance, AFP. Participants: Anastasia Bezerianos (PI), Emmanuel Pietriga, Tong Xue, Nicole Barbosa Sultanum.

8.1.4. CNRS - PEPS

VizGest. (2018) Funded by CNRS. In collaboration with LIMSI. **17Keuros**. Participants: C. Appert (PI).

Interacting with multi-display environments often involves using mid-air gestures that do not require any proximity between users and displays. However, mid-air gestures are not *visible* to users. VizGest aims at giving some visibility to mid-air gestures by means of annotations put in the physical environment thanks to augmented reality glasses.

8.2. European Initiatives

8.2.1. Collaborations with Major European Organizations

Deutsches Elektronen-Synchrotron (DESY): Scientific collaboration on the design and implementation of user interfaces for array operations monitoring and control for the Cherenkov Telescope Array (CTA) project, to be built in the Canary Islands (Spain) and in the Atacama desert (Chile), 2 years, contract started May 2018

8.3. International Initiatives

8.3.1. Inria International Labs

Inria Chile. From 2012 to 2015, Emmanuel Pietriga was the scientific leader of the Massive Data team at Inria Chile, working on projects in collaboration with the ALMA radio-telescope and the Millenium Institute of Astrophysics. He is now scientific advisor to Inria Chile's visualization projects, and is actively involved in the collaboration between Inria Chile and the LSST on the design and development of user interfaces for operations monitoring and control (see below), and the project between ESO and Inria Chile about the design and implementation of user interfaces for ALMA's Integrated Alarm System.

8.3.2. Inria International Partners

Association of Universities for Research in Astronomy (AURA): contract, jointly with Inria Chile, on the design and implementation of user interfaces for telescope operations monitoring and control for the Large Synoptic Survey Telescope (LSST) project, under construction in the Atacama desert (Chile), started 2017. Participants: Emmanuel Pietriga (ILDA), José Galaz (Inria Chile), Sebastian Pereira (Inria Chile), Grazia Prato (Inria Chile).

8.4. International Research Visitors

8.4.1. Visits of International Scientists

8.4.1.1. Internships

- Nicole Barbosa Sultanum, Univ. Toronto, Canada, Oct 2018-Jan 2019.
- José Galaz, María Grazia Prato,Sebastian Pereira, Inria Chile, Dec 2018.

IMAGINE Project-Team

9. Partnerships and Cooperations

9.1. Regional Initiatives

9.1.1. Performance Lab (January 2018 - June 2021)

Participants: Rémi Ronfard, Qianqian Fu, Mélina Skouras, Maxime Garcia, Pierre Casati, Vaishnavi Ameya Murukutla, Rémi Colin de Verdière.

Performance Lab is a cross-disciplinary project (CDP) by IDEX Univ. Grenoble Alpes, started in January 2018, which is funding the Phd thesis of Qianqian Fu.

Conceived as an international platform, the Performance Lab brings together a community of researchers who are exploring contemporary issues that link embodiment, society and technology. The ambition of the project is to renew the ways in which research is conceived and practiced at Univ. Grenoble Alpes by developing new methods inspired by Anglo-Saxon notions of Performance as Research (PAR), research creation, practice-led and based research.

As part of the Performance Lab, tIMAGINE is actively involved in the research group on "digital dramaturgies" co-led by Remi Ronfard and Julie Valero.

9.2. National Initiatives

9.2.1. InriaHub ADT Kino Ai (October 2018-September 2020)

Participants: Rémi Ronfard, Rémi Colin de Verdière, Qianqian Fu.

This two-year contract is a follow up to the one-year InriaHub ULTRAHD project which was successfully completed in December 2017. Kino Ai is a joint research project of the IMAGINE team at Inria Grenoble Alpes, and the Performance Lab at Univ. Grenoble Alpes. Following our previous work in “multiclip video editing” and “Split Screen Video Generation”, we are working to provide a user-friendly environment for editing and watching ultra-high definition movies online, with an emphasis on recordings of live performances.

The code from Vineet Gandhi’s PhD thesis was r entirely re-designed for supporting ultra high definition video. T The software was extensively tested in 2017 on a large dataset of 4K video recordings of theatre rehearsals, in collaboration with the Litt&Arts team at Univ. Grenoble Alpes, theatre director Jean-Francois Peyret in Paris, Theatre de l’Hexagone in Meylan and Theatre de Vidy in Lausanne. The goal of the Kino AI ADT is to allow the Kino Ai python code to run in a web server, and to provide a redesigned user interface (in javascript) running on a web client. The user interface will be designed, tested and evaluated with the Litt&Arts team at Univ. Grenoble Alpes, as part of CDP project Performance Lab.

9.2.2. FUI LIVE360 TV(December 2015 - December 2018)

Participants: Frédéric Devernay, Sandra Nabil Mahrous Yacoub.

L’objectif de ce projet collaboratif est de développer une solution bout-en-bout pour la création « live », la diffusion et la restitution d’audio/vidéo 360° multi-écrans, et ce avec une qualité répondant aux exigences du marché « broadcast ».

Ce projet est né sous l’impulsion d’un consortium formé de PME (Arkamys, ATEME, Aviwest et Kolor) et de laboratoires (Inria et Télécom ParisTech). Il bénéficie du programme FUI19, le Fonds Unique Interministériel. This 3-year contract with industrial partners Arkamys, ATEME, Aviwest et Kolor (now GoPRO) was dedicated to creating an end-to-end solution for recording and broadcasting immersive multi-screen 360 degree audio/video movies with a professional quality.

The project has funded the PhD thesis of Sandra Nabil. It was completed in November 2018, with the Phd defense of Sandra Nabil and the closing FUI project meeting.

9.2.3. FUI Collodi 2 (December 2016 - April 2019)

Participants: Rémi Ronfard, Maguelonne Beaud de Brive, Julien Daval.

This 2-year contract with two industrial partners: TeamTo and Mercenaries Engineering (software for production rendering), is a follow-up and a generalization of Dynam'it and Collodi 1. The goal is to propose an integrated software for the animation and final rendering of high-quality movies, as an alternative to the ever-ageing Maya. The project is funding 2 engineers for 2 years.

The project was extended for four additional months from January to April 2019 to allow extended expert evaluation of our sketch-based animation toolkit.

9.2.4. FUI 3D-Oncochip (October 2018 - September 2021)

Participants: Jean-Claude Léon, Musaab Khalid Osman Mohammed.

3D-Oncochip project is a collaboration with Microlight 3D, with the objective of fabricating nanoscale 3D microtumors, which are human biological models of real tumors. This 3-year contract is funding the postdoc position of Musaab Khalid Osman Mohammed.

9.2.5. ANR E-ROMA (November 2017 - October 2020)

Participants: Rémi Ronfard, Stefanie Hahmann, Pierre Casati.

The eRoma project aims at revisiting the digitization and virtual restoration of archaeological and fine arts artefacts by taking advantage of the sites from which they were retrieved and the eras they belong to. To do so, e-Roma will develop a new virtual representation both versatile and unified enough to be used for both restoration and animation of digitized artworks. Traditional cardboard models with a fixed and rigid representation will therefore be replaced by interactive dynamic virtual prototypes, to help restore statues and illustrate changes over time.

This 3-year contract is a joint project with GeoMod team at LIRIS and the musée gallo-romain in Lyon. The contract started in November 2017 and is funding the PhD thesis of Pierre Casati.

9.2.6. ANR FOLD-DYN (November 2017 - October 2020)

Participant: Thomas Buffet.

The FOLDDyn project (Field-Oriented Layered Dynamics animating 3D characters) proposes the study of new theoretical approaches for the effective generation of virtual characters deformations, when they are animated. These deformations are twofolds: character skin deformations (skinning) and garment simulations. We propose to explore the possibilities offered by a novel theoretical way of addressing character deformations: the implicit skinning. This method jointly uses meshes (the standard representation for 3D animations) and volumetric scalar functions (an unusual representation in this community).

This 3-year contract is a joint project with the University of Toulouse.The contract started in November 2017 and is funding the PhD thesis of Thomas Buffet.

9.2.7. ANR ANATOMY2020 (November 2017 - October 2020)

Participants: Olivier Palombi, Rémi Ronfard, Vaishnavi Ameya Murukutla.

Anatomy2020 aims at developing an innovative educational platform to facilitate learning of functional anatomy. This platform will integrate recent advances in computer graphics, human-computer interaction together with recent insights in educational and cognitive sciences to design and test optimal scenarios for anatomy learning. The approach is based on evidences that body movements could improve learning of different knowledge by "augmenting" or "enriching" traces in long-term memory. This "embodied" perspective is particularly relevant for learning of functional anatomy as the knowledge to acquire could be specifically related to the learner's body in motion.

This 3-year contract is a joint project with TIMC (Computer-Assisted Medical Intervention team), Anatoscope, Gipsa-Lab (speech and cognition dept.), LIBM and LIG (Engineering Human-Computer Interaction team). The contract started in November 2017 and is funding the PhD thesis of Ameya Murukutla.

LACODAM Project-Team

9. Partnerships and Cooperations

9.1. National Initiatives

- **Hyptser: Hybrid Prediction of Time Series**
  Participants: T. Guyet, S. Malinowski (LinkMedia), V. Lemaire (Orange)
  HYPTSER is a collaborative project between Orange Labs and LACODAM funded by the Fondation Mathématique Jacques Hadamard (PGMO program). It aims at developping new hybrid time series prediction methods in order to improve capacity planning for server farms. Capacity planning is the process of determining the infrastructure needed to meet future customer demands for online services. A well-made capacity planning helps to reduce operational costs, and improves the quality of the provided services. Capacity planning requires accurate forecasts of the differences between the customer demands and the infrastructure theoretical capabilities. The HYPTSER project makes the assumption that this information is captured by key performance indicators (KPI), that are measured continuously in the service infrastructure. Thus, we expect to improve capacity planning capabilities by making accurate forecasts of KPI time series. Recent methods about time series forecasting make use of ensemble models. In this project, we are interested in developing hybrid models for time series forecasting. Hybrid models aim at jointly partitioning the data, learning forecasting models in each partition and learning how to combine their outputs. We are currently developing two different approaches for that purpose, one based on the MODL framework and the other based on neural networks. We describe these approaches below:
  - MODL is a mathematical framework that turns the learning task into a model selection problem. It aims at finding the most probable model given the data. The MODL approach has been applied on numerous learning tasks. In all cases, this approach leads to a regularized optimization criterion. We formalize a new MODL criterion able to learn hybrid models on time series in order to: i) make a partition of time series; ii) learn local regression models. This approach formalizes these two steps in a unified way.
  - We are also developing an hybrid neural network structure that is able to learn automatically a soft partitioning of the data together with local models on each partition.

  In the next steps of this project, we will analyze the performance of this two strategies on KPI time series provided by Orange and compare them to classical ensemble methods.

9.1.1. ANR

- **#DigitAg: Digital Agriculture**
  Participants: A. Termier, V. Masson, C. Largouët, A.I. Graux
  #DigitAg is a “Convergence Institute” dedicated to the increasing importance of digital techniques in agriculture. Its goal is twofold: First, make innovative research on the use of digital techniques in agriculture in order to improve competitiveness, preserve the environment, and offer correct living conditions to farmers. Second, prepare future farmers and agricultural policy makers to successfully exploit such technologies. While #DigitAg is based on Montpellier, Rennes is a satellite of the institute focused on cattle farming.
  LACODAM is involved in the “data mining” challenge of the institute, which A. Termier co-leads. He is also the representative of Inria in the steering comittee of the institute. The interest for the team is to design novel methods to analyze and represent agricultural data, which are challenging because they are both heterogeneous and multi-scale (both spatial and temporal).

9.1.2. National Platforms

- **PEPS: Pharmaco-epidemiology for Health Products**
  Participants: Y. Dauxais, T. Guyet, V. Masson, R. Quinou, A. Samet
  The PEPS project (Pharmaco-epidemiology des Produits de Santé) is funded by the ANSM (National Agency for Health Security). The project leader is E. Oger from the clinical investigation center CIC-1414 INSERM/CHU Rennes. The other partners located in Rennes are the Institute of Research and Technology (IRT), B<>Com, EHESP and the LTSI. The project started in January 2015 and is funded for 4 years. The PEPS project consists of two parts: a set of clinical studies and a research program dedicated to the development of innovative tools for pharmaco-epidemiological studies with medico-administrative databases. Our contribution to this project will be to propose pattern mining algorithms and reasoning techniques to analyse the typical care pathways of specific groups of insured patients. Since last year we have been working on the design and development of algorithms [27], [26] to mine patterns on care pathways.

9.2. International Research Visitors

9.2.1. Internships

From May to August 2018 we hosted Devang Kulshreshtha, a computer science student from the Indian Institute of Technology (BHU) Varanasi, who worked on “Debugging Deep Learning Algorithms via Pattern Mining Methods”. His work aimed at mining patterns of neuron activation that precede misclassifications in deep neural networks (DNN). The goal of this effort is to predict when a DNN will likely err. This can be used e.g., to obtain hints on how to retrain the network to improve its accuracy.

LARSEN Project-Team

9. Partnerships and Cooperations

9.1. Regional Initiatives

9.1.1. Project PsyPhINe: Cogitamus ergo sumus

Title: Cogitamus ergo sumus

Program: PEPS CNRS

Duration: January 2016 - January 2018

Coordinator: MSH Lorraine (USR3261)

LARSEN member: Amine Boumaza

Psyphine is an interdisciplinary and exploratory project (see 9.1.1) between philosophers, psychologists and computer scientists. The goal of the project is related to cognition and behavior. Cognition is a set of processes that are difficult to unite in a general definition. The project aims to explore the idea of assignments of intelligence or intentionality, assuming that our intersubjectivity and our natural tendency to anthropomorphize play a central role: we project onto others parts of our own cognition. To test these hypotheses, our aim is to design a "non-verbal" Turing Test, which satisfies the definitions of our various fields (psychology, philosophy, neuroscience and computer science) using a robotic prototype. Some of the questions that we aim to answer are: is it possible to give the illusion of cognition and/or intelligence through such a technical device? How elaborate must be the control algorithms or "behaviors" of such a device so as to fool test subjects? How many degrees of freedom must it have?

Partner institutions: InterPsy (EA 4432), APEMAC, EPSaM (EA4360), Archives Henri-Poincaré (UMR7117), Inria Bordeaux Sud-Ouest, Loria (UMR7503) and MSH Lorraine (USR3261).

9.2. European Initiatives

9.2.1. FP7 & H2020 Projects

9.2.1.1. RESIBOTS

Title: Robots with animal-like resilience

Program: H2020

Type: ERC

Duration: May 2015 - April 2020

Coordinator: Inria

Inria contact: Jean Baptiste Mouret

Despite over 50 years of research in robotics, most existing robots are far from being as resilient as the simplest animals: they are fragile machines that easily stop functioning in difficult conditions. The goal of this proposal is to radically change this situation by providing the algorithmic foundations for low-cost robots that can autonomously recover from unforeseen damages in a few minutes. It is here contended that trial-and-error learning algorithms provide an alternate approach that does not require diagnostic, nor pre-defined contingency plans. In this project, we will develop and study a novel family of such learning algorithms that make it possible for autonomous robots to quickly discover compensatory behaviors.

9.2.1.2. ANDY

Title: Advancing Anticipatory Behaviors in Dyadic Human-Robot Collaboration

Programme: H2020

Type: ICT RIA (No. 731540)

Duration: January 2017 - December 2020

Coordinator: IIT

PI for Inria: Serena Ivaldi

Recent technological progress permits robots to actively and safely share a common workspace with humans. Europe currently leads the robotic market for safety-certified robots, by enabling robots to react to unintentional contacts. AnDy leverages these technologies and strengthens European leadership by endowing robots with the ability to control physical collaboration through intentional interaction.

To achieve this interaction, AnDy relies on three technological and scientific breakthroughs. First, AnDy will innovate the way of measuring human whole-body motions by developing the wearable AnDySuit, which tracks motions and records forces. Second, AnDy will develop the AnDyModel, which combines ergonomic models with cognitive predictive models of human dynamic behavior in collaborative tasks, which are learned from data acquired with the AnDySuit. Third, AnDy will propose the AnDyControl, an innovative technology for assisting humans through predictive physical control, based on AnDyModel.

By measuring and modeling human whole-body dynamics, AnDy provides robots with an entirely new level of awareness about human intentions and ergonomy. By incorporating this awareness online in the robot's controllers, AnDy paves the way for novel applications of physical human-robot collaboration in manufacturing, health-care, and assisted living.

AnDy will accelerate take-up and deployment in these domains by validating its progress in several realistic scenarios. In the first validation scenario, the robot is an industrial collaborative robot, which tailors its controllers to individual workers to improve ergonomy. In the second scenario, the robot is an assistive exoskeleton which optimizes human comfort by reducing physical stress. In the third validation scenario, the robot is a humanoid, which offers assistance to a human while maintaining the balance of both.

Partners: Italian Institute of Technology (IIT, Italy, coordinator), Josef Stefan Institute (JSI, Slovenia), DLR (Germany), IMK Automotive Gmbh (Germany), XSens (Netherlands), AnyBody Technologies (Denmark)

9.3. International Initiatives

9.3.1. Lifelong Learning Machines program (DARPA) — STELLAR project

Title: STELLAR (Super Turing Evolving Lifelong Learning ARchitecture)

Coordinator: HRL laboratory (Malibu, USA)

Coordinator for Inria: Jean-Baptiste Mouret

Partners: Stanford University (USA), University of California Irvine (USA), University of Texas Austin (USA), IT University of Copenhagen (Denmark), Loughborough University (United Kingdom), Inria – Nancy Grand Est

Objective: Develop a general-purpose neural super Turing machine for lifelong learning and demonstrate supra-human performance in a simulated autonomous driving context. Our Super Turing Evolving Lifelong Learning ARchitecture (STELLAR) system will power a self-driving agent that continually improves its performance and updates its knowledge unsupervised, rapidly adapts to unforeseen contexts, and learns and consolidates new tasks without forgetting old ones. The project involves deep world models, neuroevolution, quality diversity algorithms, and plastic neural networks.

9.3.1.1. Informal International Partners

- Oxford University (Shimon Whiteson): data-efficient robot learning[22]
- Union College (John Rieffel): resilient tensegrity robots [10]
- Italian Institute of Technology (Enrico Mingo-Hoffman, Daniele Pucci, Nikos Tsagarakis): whole-body control of humanoids [11], [24], [27]
- IT University Copenhagen (Sebastian Risi): quality diversity algorithms
- Imperial College (Antoine Cully): data-efficient learning and quality diversity
- Hochschule Bonn-Rhein-Sieg (Alexander Asteroth): surrogate modelling [17], [7]
- Kyushu Institute of Technology, Japan (Sozo Inoue, Moe Matsuki): activity recognition

9.4. International Research Visitors

9.4.1. Visits of International Scientists

- Enrico Mingo Hoffman (Post-doc, Italian Institute of Technology) – from Feb 2018 to Feb 2018
- Niels Justesen (PhD student, IT University Copenhagen, Denmark) – from Sep 2018 to Dec 2018
- Marie Charbonneau (PhD student, IIT, Italy) – from May 2018 to Oct 2018
- Moe Matsuki (PhD student, Kyushu Institute of Technology, Japan) –fom sept 2018 to Dec 2018

LINKMEDIA Project-Team

8. Partnerships and Cooperations

8.1. Regional Initiatives

8.1.1. CominLabs Project Linking Media in Acceptable Hypergraphs (LIMAH)

Participants: Vincent Claveau, Guillaume Gravier, Pascale Sébillot.

Duration: 4.5 years, started in April 2014
Partners: Telecom Bretagne (IODE), Univ. Rennes II (CRPCC, PREFics), Univ. Nantes (LINA/TAL)
URL: http://limah.irisa.fr

LIMAH aims at exploring hypergraph structures for multimedia collections, instantiating actual links reflecting particular content-based proximity—similar content, thematic proximity, opinion expressed, answer to a question, etc. Exploiting and developing further techniques targeting pairwise comparison of multimedia contents from an NLP perspective, LIMAH addresses two key issues: How to automatically build from a collection of documents an hypergraph, i.e., a graph combining edges of different natures, which provides exploitable links in selected use cases? How collections with explicit links modify usage of multimedia data in all aspects, from a technology point of view as well as from a user point of view? LIMAH studies hypergraph authoring and acceptability taking a multidisciplinary approach mixing ICT, law, information and communication science as well as cognitive and ergonomy psychology.

8.1.2. CominLabs Project BigCLIN

Participants: Vincent Claveau, Ewa Kijak, Clément Dalloux.

Duration: 3 years, started in September 2016
Partners: STL-CNRS, Inserm/CHU Rennes, Inria
URL: https://bigclin.cominlabs.u-bretagneloire.fr/fr

Data collected or produced during clinical care process can be exploited at different levels and across different domains. Yet, a well-known challenge for secondary use of health big data is that much of detailed patient information is embedded in narrative text, mostly stored as unstructured data. The project proposes to address the essential needs when reusing unstructured clinical data at a large scale. We propose to develop new clinical records representation relying on fine-grained semantic annotation thanks to new NLP tools dedicated to French clinical narratives. To efficiently map this added semantic information to existing structured data for further analysis at big scale, the project also addresses distributed systems issues: scalability, management of uncertain data and privacy, stream processing at runtime, etc.

8.1.3. Computer vision for smart phones (MobilAI)

Participants: Yannis Avrithis, Mateusz Budnik.

Duration: 2 years, started in September 2018
Partners: Lamark, Quai des Apps, AriadNext

The ability of our mobile devices to process visual information is currently not limited by their camera or computing power but by the network. Many mobile apps suffer from long latency due to data transmitted over the network for visual search. MobilAI aims to provide fast visual recognition on mobile devices, offering quality user experience whatever the network conditions. The idea is to transfer efficient deep learning solutions for image classification and retrieval onto embedded platforms such as smart phones. The intention is to use such solutions in B2B and B2C application contexts, for instance recognizing products and ordering online, accessing information about artifacts in exhibitions, or identifying identity documents. In all cases, visual recognition is performed on the device, with minimal or no access to the network.

8.2. National Initiatives

8.2.1. ANR Project IDFRAud

Participant: Teddy Furon.

Duration: 3 years, started in Feb. 2015
Partners: AriadNext, IRCGN, École Nationale Supérieure de Police

The IDFRAud project consists in proposing an automatic solution for ID analysis and integrity verification. Our ID analysis goes through three processes: classification, text extraction and ID verification. The three processes rely on a set of rules that are externalized in formal manner in order to allow easy management and evolving capabilities. This leads us to the ID knowledge management module. Finally, IDFRAud addresses the forensic link detection problem and to propose an automatic analysis engine that can be continuously applied on the detected fraud ID database. Cluster analysis methods are used to discover relations between false IDs in their multidimensional feature space. This pattern extraction module will be coupled with a suitable visualization mechanism in order to facilitate the comprehension and the analysis of extracted groups of inter-linked fraud cases.

8.2.2. FUI 19 NexGenTV

Participants: Vincent Claveau, Guillaume Gravier, Ewa Kijak, Anne-Lyse Minard.

Duration: 2.5 years, started in May 2015
Partners: Eurecom, Avisto Telecom, Wildmoka, Envivio-Ericsson

Television is undergoing a revolution, moving from the TV screen to multiple screens. Today's user watches TV and, at the same time, browses the web on a tablet, sends SMS, posts comments on social networks, searches for complementary information on the program, etc. Facing this situation, NexGen-TV aims at developing a generic solution for the enrichment, the linking and the retrieval of video content targeting the cost-cutting edition of second screen and multiscreen applications for broadcast TV. The main outcome of the project will be a software platform to aggregate and distribute video content via a second-screen edition interface connected to social media. The curation interface will primarily make use of multimedia and social media content segmentation, description, linking and retrieval. Multiscreen applications will be developed on various domaine, e.g., sports, news.

8.2.3. Inria Project Lab Knowledge-driven data and content collaborative analytics (iCODA)

Participants: Laurent Amsaleg, Vincent Claveau, Cheikh Brahim El Vaigh, Guillaume Gravier, Pascale Sébillot.

Duration: 4.5 years, started in April 2017
Partners: Inria project-teams Linkmedia, CEDAR, GraphIK and ILDA, with Ouest-France, Le Monde and AFP

One of today's major issues in data science is the design of algorithms that allow analysts to efficiently infer useful information and knowledge by collaboratively inspecting heterogeneous information sources, from structured data to unstructured content. Taking data journalism as an emblematic use-case, the goal of the project is to develop the scientific and technological foundations for knowledge- mediated user-in-the-loop collaborative data analytics on heterogenous information sources, and to demonstrate the effectiveness of the approach in realistic, high-visibility use-cases. The project stands at the crossroad of multiple research fields—content analysis, data management, knowledge representation, visualization—that span multiple Inria themes, and counts on a club of major press partners to define usage scenarios, provide data and demonstrate achievements.

8.2.4. Inria-BNF: Classification d'images patrimoniales (CIP)

Participants: Laurent Amsaleg, Guillaume Gravier, Ewa Kijak, Yannis Avrithis.

Duration: 1 year, started in Dec 2018

This project is within the context of the collaborations between Inria and the French Ministry of Culture. In that context, we have started a collaboration with the French National Library (BNF) which collects, preserves and makes known the national documentary heritage. This collaboration aims at facilitating the automatic classification of heritage images through the use of recent deep-learning techniques. Such images are quite specific: they are not at all similar with what deep-learning techniques are used to work with, that is, the classification of heritage images does not target modern categories such as planes, cars, cats and dogs because this is irrelevant and because heritage collections do not include images of contemporary objects. Furthermore, heritage images come in vast quantities, but they are little annotated and deep-learning techniques can hardly rely on massive annotations to easily learn. Last, the learning has to be continuous as curators may need to add or modify existing classes, without re-learning everything from scratch.

The techniques of choice to reach that goal include the semi-supervised learning, low-shot learning techniques, knowledge transfer, fine tuning existing models, etc.

8.3. European Initiatives

8.3.1. Collaborations in European Programs, Except FP7 & H2020

Program: CHIST ERA

- Project acronym: ID_IOT
- Project title: Identification for the Internet of things
- Duration: 3 years, started in Oct 2016.
- Coordinator: Boris Skoric (Eindhoven Univ. of Technology (NL))
- Other partners: Inria-RBA (Teddy Furon, Marzieh Gheisari), Univ. of Geneva (CH)
- Abstract: The IoT will contain a huge number of devices and objects that have very low or nonexistent processing and communication resources, coupled to a small number of high-power devices. The weakest devices, which are most ubiquitous, will not be able to authenticate themselves using cryptographic methods. This project addresses these issues using physical unclonable functions (PUFs). PUFs, and especially quantum readout PUFs, are ideally suited to the IoT setting because they allow for the authentication and identification of physical objects without requiring any crypto or storage of secret information.

  Furthermore, we foresee that back-end systems will not be able to provide security and privacy via cryptographic primitives due to the sheer number of IoT devices. Our plan is to address these problems using privacy preserving database structures and algorithms with good scaling behaviour. Approximate nearest neighbour (ANN) search algorithms, which have remarkably good scaling behaviour, have recently become highly efficient, but do not yet have the right security properties and have not yet been applied to PUF data. Summarised in a nutshell, the project aims to improve the theory and practice of technologies such as PUFs and ANN search in the context of generic IoT authentication and identification scenarios.

Program: Joint Programming Initiative Cultural Heritage

- Project acronym: READ-IT
- Project title: Reading Europe: Advanced Data Investigation Tools
- Duration: June 2018 - May 2021
- Coordinator: Le Mans Université, Institute of Human and Social Sciences-Digital Humanities (FR)
- Other partners: CNRS, Institut de Recherche in Informatique et Systèmes Aléatoires (FR); The Open University (UK); Utrecht University, Digital Humanities Lab (NL); Czech Litterature Institute (CZ)

- Abstract: READ-IT will build a unique large-scale, user-friendly, open access, semantically-enriched investigation tool to identify and share groundbreaking evidence about 18th-21st century Cultural Heritage of reading in Europe. The interdisciplinary collaboration between digital humanists, human & social sciences scholars and computer researchers will investigate innovative ways of gathering new resources through crowdsourcing and web-crawling as well as linking and reusing preexisting datasets.

8.4. International Initiatives

8.4.1. NSFC Project: Using transfer learning to understand visual objects and their relationships

Participant: Miaojing Shi.

Duration: 2 years, start in Jan 2019
Partners: Tongji University, China

This project is supported by China National Joint Research Fund for Overseas Chinese Scholars. Machine Perception tasks have flourished since the advent of deep learning techniques. Next key problem lies on visual scene understanding. To make sense of visual scenes, we need to rely on the visual object relationships inside. The challenge for this task is that 1) the training data is limited, on particular those unusual seen objects/object relationships; 2) visual relationships become complicated and diverse with an increase of object numbers. This research shall employ the transfer learning methods to transfer available knowledge of visual relationships to new objects with unknown relationships. The significance of this research is not just to enhance the machine perception ability; it allows us to leverage a relatively small amount of expensively annotated images to detect new objects and their relationships in a much larger dataset without or with only cheap image-level labels.

8.4.2. Inria International Partners

8.4.2.1. Informal International Partners

- Peking University, China
- Sichuan University, China
- Czech Technical University, Czech Republic
- Computer Science Department, IT University of Copenhagen, Denmark
- Tampere University of Technology, Finland
- National Institute of Informatics, Tokyo, Japan

8.4.3. Participation in Other International Programs

- STIC-AMSUD Project : TRANSFORM
  Participants: Simon Malinowski, Guillaume Gravier, Laurent Amsaleg.

  TRANSFORM is a research project that involves Linkmedia Team, PUC Minas, Brazil and Univ. of Chile. It aims at studying complex transformations of multimedia data in order to facilitate its manipulation. TRANSFORM focuses on transforming multimedia data into compact representations that are suited for indexing and retrieval purposes.

- ConFAP-CNRS Project: FIGTEM
  Participants: Vincent Claveau, Ewa Kijak, Clément Dalloux.

  FIGTEM is a research project that involves STL-CNRS, CHU Rennes, PUC Parana, Curitiba and led by LinkMedia. This project aims at developing natural language processing methods, including information extraction and indexing, dedicated to the clinical trial domain. The goal is to populate a formal representation of patients (via their electronic patient records) and clinical trial data in different languages (French, English, Portuguese).

- NSFC Project : Perception and self-learning of service robot in dynamic scenarios
  Participant: Miaojing Shi.

  This project is the Key Program of National Natural Science Foundation of China, which involves Miaojing Shi from Linkmedia and is led by Tongji University. It aims at improving the perception of service robot in dynamic scenarios through self-learning.

8.5. International Research Visitors

8.5.1. Visits of International Scientists

Zenilton Kleber (PUC Minas, Brazil), November 2018, 2 days
Silvio Guimaraes (PUC Minas, Brazil), December 2018, 10 days
Michael Houle (National Institute of Informatics), July 2018, 7 days

8.5.1.1. Internships

Yohann Gumiel and Lucas Oliveira, PhD students at PUC Parana, Curitiba, Brazil, stayed 3 months (June-August 2018), in Rennes in the framework of the FIGTEM project.
Yanlin Qian, PhD student at Tampere University of Technology, 3 months (Jun-August 2018)

8.5.2. Visits to International Teams

8.5.2.1. Research Stays Abroad

- Guillaume Gravier & Simon Malinowski, PUC Minas, Brazil, March 2018, 1 week.
- Vincent Claveau, PUC Parana, Curitiba, Brazil, November 2018, 1 week, in the framework of the FIGTEM project.
- Miaojing Shi, Tongji University, China, March 2018, 1 week.
- Miaojing Shi, Xian Jiaotong University, China, April 2018, 1 week.
- Yannis Avrithis, National and Kapodistrian University of Athens, 3 visits on February, May and October 2018, 1 week each.
- Laurent Amsaleg & Teddy Furon, National Institute of Informatics, March 2018, 1 week

LINKS Project-Team

9. Partnerships and Cooperations

9.1. Regional Initiatives

- Links is member of the CPER Data (2016-19).
- Lozano's PhD project (2016-19) is co-funded by the Region Nord-Pas de Calais.
- Sakho's PhD project is co-funded by the Region Nord-Pas de Calais.
- Gillot's PhD project (2017-20) is co-funded by the Region Nord-Pas de Calais.
- Crosetti's PhD project (2018-21) is co-funded by the Region Haut de France. This is joined work with J. Ramon from the Inria project Magnet.

9.2. National Initiatives

ANR Aggreg (2014-19): Aggregated Queries.

- Participants: J. Niehren [correspondent], P. Bourhis, A. Lemay, A. Boiret, F. Capelli.
- The coordinator is J. Niehren and the partners are the University Paris 7 (A. Durand) including members of the Inria project DAHU (L. Ségoufin), the University of Marseille (N. Creignou) and University of Caen (E. Grandjean).
- Objective: the main goal of the Aggreg project is to develop efficient algorithms and to study the complexity of answering aggregate queries for databases and data streams of various kinds.

ANR Colis (2015-20): Correctness of Linux Scripts.

- Participants: J. Niehren [correspondent], A. Lemay, S. Tison, A. Boiret, V. Hugot, N. Bacquey, P. Gallot, S. Salvati.
- The coordinator is R. Treinen from the University of Paris 7 and the other partner is the Tocata project of Inria Saclay (C. Marché).
- Objective: This project aims at verifying the correctness of transformations on data trees defined by shell scripts for Linux software installation. The data trees here are the instance of the file system which are changed by installation scripts.

ANR DataCert (2015-20):

- Participants: I. Boneva [correspondent], S. Tison, J. Lozano.
- Partners: The coordinator is E. Contejean from the University of Paris Sud and the other partner is the University of Lyon.
- Objective: the main goals of the Datacert project are to provide deep specification in Coq of algorithms for data integration and exchange and of algorithms for enforcing security policies, as well as to design data integration methods for data models beyond the relational data model.

ANR Headwork (2016-21):

- Participants: J. Niehren, M. Sakho, N. Crosetti, F. Capelli.
- Scientific partners: The coordinateur is D. Gross-Amblard from the Druid Team (Rennes 1). Other partners include the Dahu team (Inria Saclay) and Sumo (Inria Bretagne).
- Industrial partners: Spipoll, and Foulefactory.

- Objective: The main object is to develop data-centric workflows for programming crowd sourcing systems in flexible declarative manner. The problem of crowd sourcing systems is to fill a database with knowledge gathered by thousands or more human participants. A particular focus is to be put on the aspects of data uncertainty and for the representation of user expertise.

ANR Delta (2016-21):

- Participants: J. Niehren, S. Salvati, A. Lemay, N. Bacquey, D. Gallois.
- Partners: The coordinator is M. Zeitoun from LaBRI, other partners are LIF (Marseille) and IRIF (Paris-Diderot).
- Objective: Delta is focused on the study of logic, transducers and automata. In particular, it aims at extending classical framework to handle input/output, quantities and data.

ANR Bravas (2017-22):

- Participants: S. Salvati [correspondent]
- Scientific Partners: The coordinator is Jérôme Leroux from LaBRI, University of Bordeaux. The other partner is LSV, ENS Cachan.
- Objective: The goal of the BraVAS project is to develop a new and powerful approach to decide the reachability problems for Vector Addition Systems (VAS) extensions and to analyze their complexity. The ambition here is to crack with a single hammer (ideals over well-orders) several long-lasting open problems that have all been identified as a barrier in different areas, but that are in fact closely related when seen as reachability.

9.3. European Initiatives

Oxford: A exchange project with the computer science lab of the University of Oxford is funded by the University of Lille via the Cristal Lab. Links' member produced many common publications over the years with Oxford. Links' contact is Paperman.

Wrazlaw: Staworko has regular exchange with the University of Wrazlaw. This has led to a publication at **PODS** [7] together with P. Wieczorek.

Saint Petersburg: Salvati and Niehren started a cooperation with the University of Saint Petersburg, via a 3 months visit of R. Azimov in 2018.

Oviedo: Boneva started a cooperation with the University of Oviedo, via a 3 months visit of H. Garcia Gonzalez in 2018.

9.4. International Initiatives

9.4.1. Informal International Partners

Santiago de Chile: S. Staworko started a collaboration with C. Riveros from the Pontificia Universidad Catolica de Chile in 2018.

9.5. International Research Visitors

9.5.1. Visits of International Scientists

Several researchers has visited us:

- Filip Mazowiecki, a researcher from Warsaw University and currently in post-doctorate in Bordeaux to work with Charles Paperman.
- Rustam Azimov, a Russian PhD students from Saint Petersburg State University, to collaborate with Sylvain Salvati and Joachim Niehren.
- Michaël Cadilhac, a researcher from Oxford University to work with Charles Paperman.
- Cristian Riveros, an Assistant Professor at the Department of Computer Science at the Pontificia Universidad Catolica de Chile.
- Henning Fernau, Professor at Universität Trier and Andreas Maletti, Professor at Universität Leipzig, visited us during the HDR defense of Aurelien Lemay.

9.5.1.1. Internships

- Nicolas Crosetti started an internship supervised by Florent Capelli, Joachim Niehren and Jan Ramon. His internship has evolved into the preparation of a PhD thesis.
- Chen Huan, from Centrale Lille, has done an internship under the supervision of Sylvain Salvati and Joachim Niehren.

9.5.2. Visits to International Teams

- Charles Paperman visited Michaël Cadilhac form the verification team of the University of Oxford.
- Joachim Niehren got invited by Hilal Zaid for a visit at the American University of Palestine in August 2018.

LOKI Team

8. Partnerships and Cooperations

8.1. Regional Initiatives

8.1.1. GeneaLire (CPER MAuVE, 2018-2019)

Participants: Stéphane Huot, Thomas Pietrzak [correspondent].

Interactive tools for the interpretation of manuscripts

The goal of this project is to design, implement and evaluate interactive tools for helping transcription of scanned handwritten documents. Current solutions focus on automatic recognition, with recent advances thanks to deep learning methods. However these solutions still require a significant learning base that has to be made by hand. Not only this means that part of the work cannot be done automatically, but it also means that this technique is not a solution for small collections of documents. The tools we propose to create will ingeniously take advantage of interactive and automatic techniques. The interactive tools include a text selection techniques [27], as well as advanced annotation techniques that will support collaborative work. This tool will be invaluable for bootstrapping the transcription of large collections, as well as helping transcribing small collections. We will use user-centered design, in order to make sure the tool fits historians and genealogists activities and workflow.

Partners: Inria Saclay's AVIZ team, École Polytechnique de l'Université de Tours, Laboratoire de Démographie et d'Histoire Sociale at l'École des hautes études en sciences sociales, and Geneanet.

Related publication: [27]

8.2. National Initiatives

8.2.1. ANR

8.2.1.1. TurboTouch (PRC, 2014-2019)

Participants: Géry Casiez [correspondent], Sylvain Malacria, Mathieu Nancel, Thomas Pietrzak.

High-performance touch interactions

Touch-based interactions with computing systems are greatly affected by two interrelated factors: the transfer functions applied on finger movements, and latency. This project aims at transforming the design of touch transfer functions from black art to science to support high-performance interactions. We are working on the precise characterization of the functions used and the latency observed in current touch systems. We are developing a testbed environment to support multidisciplinary research on touch transfer functions and will use this testbed to design latency reduction and compensation techniques, and new transfer functions.

Partners: Inria Lille's NON-A team and the "Perceptual-motor behavior group" from the Institute of Movement Sciences.

Web site: http://mjolnir.lille.inria.fr/turbotouch/

Related publications in 2018: [28], [15], [23], [25]

8.2.1.2. Causality (JCJC, 2019-2023)

Participant: Mathieu Nancel [correspondent].

Integrating Temporality and Causality to the Design of Interactive Systems

The project addresses a fundamental limitation in the way interfaces and interactions are designed and even thought about today, an issue we call *procedural information loss*: once a task has been completed by a computer, significant information that was used or produced while processing it is rendered inaccessible regardless of the multiple other purposes it could serve. It hampers the identification and solving of identifiable usability issues, as well as the development of new and beneficial interaction paradigms. We will explore, develop, and promote finer granularity and better-described connections between the causes of those changes, their context, their consequences, and their timing. We will apply it to facilitate the real-time detection, disambiguation, and solving of frequent timing issues related to human reaction time and system latency; to provide broader access to all levels of input data, therefore reducing the need to "hack" existing frameworks to implement novel interactive systems; and to greatly increase the scope and expressiveness of command histories, allowing better error recovery but also extended editing capabilities such as reuse and sharing of previous actions.

Web site: http://loki.lille.inria.fr/causality/

8.2.2. Inria Project Labs

8.2.2.1. BCI-LIFT (2015-2019)

Participant: Géry Casiez [correspondent].

Brain Computer Interfaces: Learning, Interaction, Feedback, Training

The goal of this large-scale initiative is to design a new generation of non-invasive Brain-Computer Interfaces (BCI) that are easier to appropriate, more efficient, and suited for a larger number of people.

Partners: Inria's ATHENA, NEUROSYS, POTIOC, HYBRID & DEMAR teams, *Centre de Recherche en Neurosciences de Lyon* (INSERM) and INSA Rouen.

Web site: https://bci-lift.inria.fr/

Related publication in 2018: [12]

8.2.2.2. AVATAR (2018-2022)

Participants: Géry Casiez, Stéphane Huot, Thomas Pietrzak [correspondent].

The next generation of our virtual selves in digital worlds

This project aims at delivering the next generation of virtual selves, or *avatars*, in digital worlds. In particular, we want to push further the limits of perception and interaction through our avatars to obtain avatars that are better embodied and more interactive. Loki's contribution in this project consists in designing novel 3D interaction paradigms for avatar-based interaction and to design new multi-sensory feedbacks to better feel our interactions through our avatars.

Partners: Inria's GRAPHDECO, HYBRID, MIMETIC, MORPHEO & POTIOC teams, Mel Slater (Event Lab, University Barcelona, Spain), Technicolor and Faurecia.

Web site: https://avatar.inria.fr/

Related publication in 2018: [17]

8.2.3. Others

8.2.3.1. ParkEvolution (Carnot Inria - Carnot STAR, 2015-2019)

Participant: Géry Casiez [correspondent].

Longitudinal analysis of fine motor control for patients with Parkinson disease

This project studies the fine motor control of patients with Parkinson disease in an ecological environment, at home, without the presence of experimenters. Through longitudinal studies, we collect raw information from pointing devices to create a large database of pointing behavior data. From the analysis of this big dataset, the project aims at inferring the individual's disease progression and influence of treatments.

Partners: the “Perceptual-motor behavior group” from the Institute of Movement Sciences and Hôpital de la Timone.

Web site: http://parkevolution.org/

8.3. International Initiatives

8.3.1. Inria International Partners

8.3.1.1. Informal International Partners

Andy Cockburn, University of Canterbury, Christchurch, NZ [19], [20]

Carl Gutwin, University of Saskatchewan, Saskatoon, CA [19], [20], [21], [22]

Nicolai Marquardt, University College London, London, UK

Antti Oulasvirta, Aalto University, Helsinki, FI [31]

Daniel Vogel, University of Waterloo, Waterloo, CA [21]

8.4. International Research Visitors

8.4.1. Visits of International Scientists

Edward Lank, Professor at the University of Waterloo, has spent two years in our team until Aug. 2018 (funded by Région Hauts-de-France, Université Lille and Inria).

Marcelo Wanderley, Professor at McGill University, who has been awarded an Inria International Chair in our team in 2016, spent 3 months in our group this year (July to September).

8.4.2. Visits to International Teams

8.4.2.1. Research Stays Abroad

Géry Casiez has spent four months in the Human Computer Interaction Lab at the University of Waterloo (September to December).

MAGNET Project-Team

9. Partnerships and Cooperations

9.1. Regional Initiatives

We conducted research in collaboration with J. Senechal from the department of law in Lille University. We are interested in studying the impact of technological choices regarding computation models in the perspective of the GDPR.

We strengthened our partnership with the linguistic laboratory STL in Lille university. We have welcomed Bert Cappelle for a stay (delegation) in the group. The topic of this collaboration was to study modal verbs and the translation of the notion of compositionality when applied to vectorial representation of words.

We initiated a collaboration with cognitive scientists (Angèle Brunellière and Jérémie Jozefowiez) from the psychology department, which resulted in a submission to a multidisciplinary Huma-Num project, to be funded by the Réseau National des Maisons des Sciences de l'Homme (RNMSH).

We started working with Christopher Fletcher (CNRS) from the History department.

These collaborations heavily rely on our work on distributional semantics and word embeddings to provide new insights into these different fields, hence also on the Mangoes toolkit developed in the team.

We participate to the *Data Advanced data science and technologies* project (CPER Data). This project is organized following three axes: internet of things, data science, high performance computing. MAGNET is involved in the data science axis to develop machine learning algorithms for big data, structured data and heterogeneous data. The project MyLocalInfo is an open API for privacy-friendly collaborative computing in the internet of things.

9.2. National Initiatives

9.2.1. ANR Pamela (2016-2020)

Participants: MARC TOMMASI [correspondent], AURÉLIEN BELLET, RÉMI GILLERON, JAN RAMON, MAHSA ASADI

The Pamela project aims at developing machine learning theories and algorithms in order to learn local and personalized models from data distributed over networked infrastructures. Our project seeks to provide first answers to modern information systems built by interconnecting many personal devices holding private user data in the search of personalized suggestions and recommendations. More precisely, we will focus on learning in a collaborative way with the help of neighbors in a network. We aim to lay the first blocks of a scientific foundation for these new types of systems, in effect moving from graphs of data to graphs of data and learned models. We argue that this shift is necessary in order to address the new constraints arising from the decentralization of information that is inherent to the emergence of big data. We will in particular focus on the question of learning under communication and privacy constraints. A significant asset of the project is the quality of its industrial partners, Snips and Mediego, who bring in their expertise in privacy protection and distributed computing as well as use cases and datasets. They will contribute to translate this fundamental research effort into concrete outcomes by developing personalized and privacy-aware assistants able to provide contextualized recommendations on small devices and smartphones. https://project.inria.fr/pamela/.

9.2.2. ANR JCJC GRASP (2016-2020)

Participants: PASCAL DENIS [correspondent], AURÉLIEN BELLET, RÉMI GILLERON, MIKAELA KELLER, MARC TOMMASI

The GRASP project aims at designing new graph-based Machine Learning algorithms that are better tailored to Natural Language Processing structured output problems. Focusing on semi-supervised learning scenarios, we will extend current graph-based learning approaches along two main directions: (i) the use of structured outputs during inference, and (ii) a graph construction mechanism that is more dependent on the task objective and more closely related to label inference. Combined, these two research strands will provide an important step towards delivering more adaptive (to new domains and languages), more accurate, and ultimately more useful language technologies. We will target semantic and pragmatic tasks such as coreference resolution, temporal chronology prediction, and discourse parsing for which proper Machine Learning solutions are still lacking. https://project.inria.fr/grasp/.

9.2.3. ANR DEEP-Privacy (2019-2023)

Participants: MARC TOMMASI [correspondent], AURÉLIEN BELLET, PASCAL DENIS, JAN RAMON, BRIJ SRIVASTAVA

DEEP-PRIVACY proposes a new paradigm based on a distributed, personalized, and privacy-preserving approach for speech processing, with a focus on machine learning algorithms for speech recognition. To this end, we propose to rely on a hybrid approach: the device of each user does not share its raw speech data and runs some private computations locally, while some cross-user computations are done by communicating through a server (or a peer-to-peer network). To satisfy privacy requirements at the acoustic level, the information communicated to the server should not expose sensitive speaker information.

9.2.4. ANR-NFS REM (2016-2020)

Participants: PASCAL DENIS [correspondent], BO LI

With colleagues from the linguistics departments at Lille 3 and Neuchâtel (Switzerland), PASCAL DENIS is a member of another ANR project (REM), funded through the bilateral ANR-NFS Scheme. This project, co-headed by I. Depreatere (Lille 3) and M. Hilpert (Neufchâtel), proposes to reconsider the analysis of English modal constructions from a multidisciplinary perspective, combining insights from theoretical, psycho-linguistic, and computational approaches.

9.2.5. EFL (2010-2020)

PASCAL DENIS is an associate member of the Laboratoire d'Excellence *Empirical Foundations of Linguistics* (EFL), http://www.labex-efl.org/.

9.3. European Initiatives

9.3.1. FP7 & H2020 Projects

Program: H2020 ICT-29-2018 (RIA)

Project acronym: COMPRISE

Project title: Cost-effective, Multilingual, Privacy-driven voice-enabled Services

Duration: Dec 2018- Nov 2021

Coordinator: Emmanuel Vincent

Other partners: Inria Multispeech, Ascora GmbH, Netfective Technology SA, Rooter Analysis SL, Tilde SIA, University of Saarland

Participants: AURÉLIEN BELLET, MARC TOMMASI, BRIJ SRIVASTAVA

Abstract: COMPRISE will define a fully private-by-design methodology and tools that will reduce the cost and increase the inclusiveness of voice interaction technologies.

9.3.2. Collaborations in European Programs, Except FP7 & H2020

9.3.2.1. TextLink (2014-2018)

Program: COST Action

Project acronym: TextLink

Project title: Structuring Discourse in Multilingual Europe

Duration: Apr. 2014 - Apr. 2018

Coordinator: Prof. Liesbeth Degand, Université Catholique de Louvain, Belgium. PASCAL DENIS is member of the Tools group.

Other partners: 26 EU countries and 3 international partner countries (Argentina, Brazil, Canada)

The Action will facilitate European multilingualism by (1) identifying and creating a portal into such resources within Europe - including annotation tools, search tools, and discourse-annotated corpora; (2) delineating the dimensions and properties of discourse annotation across corpora; (3) organizing these properties into a sharable taxonomy; (4) encouraging the use of this taxonomy in subsequent discourse annotation and in cross-lingual search and studies of devices that relate and structure discourse; and (5) promoting use of the portal, its resources and sharable taxonomy. TextLink will enhance the experience and performance of human translators, lexicographers, language technology and language learners alike.

9.4. International Initiatives

9.4.1. Inria International Labs

Inria@SiliconValley
Associate Team involved in the International Lab:

9.4.1.1. LEGO

Title: LEarning GOod representations for natural language processing

International Partner (Institution - Laboratory - Researcher):

USC (United States), Prof. Fei Sha.

Start year: 2016

See also: https://team.inria.fr/lego/

LEGO lies in the intersection of Machine Learning and Natural Language Processing (NLP). Its goal is to address the following challenges: what are the right representations for structured data and how to learn them automatically, and how to apply such representations to complex and structured prediction tasks in NLP? In recent years, continuous vectorial embeddings learned from massive unannotated corpora have been increasingly popular, but they remain far too limited to capture the complexity of text data as they are task-agnostic and fall short of modeling complex structures in languages. LEGO strongly relies on the complementary expertise of the two partners in areas such as representation/similarity learning, structured prediction, graph-based learning, and statistical NLP to offer a novel alternative to existing techniques. Specifically, we will investigate the following three research directions: (a) optimize the embeddings based on annotations so as to minimize structured prediction errors, (b) generate embeddings from rich language contexts represented as graphs, and (c) automatically adapt the context graph to the task/dataset of interest by learning a similarity between nodes to appropriately weigh the edges of the graph. By exploring these complementary research strands, we intend to push the state-of-the-art in several core NLP problems, such as dependency parsing, coreference resolution and discourse parsing.

9.4.2. Inria Associate Teams Not Involved in an Inria International Labs

North-European Associate Team PAD-ML: Privacy-Aware Distributed Machine Learning.

International Partner: the PPDA team at the Alan Turing Institute.

Start year: 2018

In the context of increasing legislation on data protection (e.g., the recent GDPR), an important challenge is to develop privacy-preserving algorithms to learn from datasets distributed across multiple data owners who do not want to share their data. The goal of this joint team is to devise novel privacy-preserving, distributed machine learning algorithms and to assess their performance and guarantees in both theoretical and practical terms.

9.5. International Research Visitors

9.5.1. Visits of International Scientists

- Tejas Kulkarni (University of Warwick) visited the team from May to August 2018 to work with AURÉLIEN BELLET, MARC TOMMASI and JAN RAMON on privacy-preserving computation of U-statistics.
- Larisa Soldatova (Brunel University) visited the team in June 2018 to work with JAN RAMON on probabilistic reasoning for biomedical applications.
- Raouf Kerkouche (Inria Privatics) visited the team for 2 weeks in July 2018 to work with AURÉLIEN BELLET and MARC TOMMASI on federated and decentralized learning from medical data.
- Guillaume Rabusseau (Université de Montréal) visited the team for 1 week in July 2018 to work with AURÉLIEN BELLET and MARC TOMMASI on multi-task distributed spectral learning.
- Daphner Ezer, Adrià Gascón, Matt Kusner, Brooks Paige (all from Alan Turing Institute) and Hamed Haddadi (Imperial College London) visited the team for 2 days in October 2018 for the kick-off of the PAD-ML associate team.

Several international researchers have also been invited to give a talk at the MAGNET seminar:

- D. Hovy (Bocconi Univ.): Retrofit Everything: Injecting External Knowledge into Neural Networks to Gain Insights from Big Data.
- A. Trask (OpenMined): OpenMined - Building Tools for Safe AI.
- C. Biemann (Univ. Hamburg): Adaptive Interpretable Language Technology.
- W. Daelemans (Univ. Antwerp): Profiling authors from social media texts.

9.5.1.1. Internships

- Igor Axinti explored several ways to compare word embeddings and studied the minimal corpus size for the comparison to be meaningful. He applied some of his findings to comparing two corpus in middle french from the 15th century, one originating from London and the other from Flanders. He produced a querying interface to allow Christopher Fletcher (IRHiS), who provided the data, explore and compare the embeddings spaces.
- Nicolas Crosetti (joint internship with Joachim Niehren and Florent Cappelli, Links) worked on dependency-weighted aggregation, i.e., aggregation where the elements to aggregate are weighted according to the extent where they correspond to independent observations.
- Arthur d'Azemar worked on decentralized recommender systems in collaboration with the WIDE team in Inria Rennes (François Taïani). Arthur has applied metric learning techniques in order to learn a K-nn graph for personalized and adaptive user-based recommendations.
- Antoine Capriski worked on the analysis of word semantic change in political texts in collaboration with Caroline Le Pennec (UC Berkeley). He used the techniques of word embeddings to analyze of corpus of political manifestos from the French general elections for the period 1958-1993.
- Most of the works on machine learning and privacy make the assumption that learners are honest but curious. Alexandre Huat worked on making protocols for private machine learning more robust again malicious attacks.

9.5.2. Visits to International Teams

9.5.2.1. Research Stays Abroad

- FABIO VITALE is on leave at Department of Computer Science of Sapienza University (Rome, Italy) in the Algorithms Randomization Computation group with Prof. Alessandro Panconesi and Prof. Flavio Chierichetti. His current work on machine learning in graphs follows three directions:
  - designing new online reciprocal recommenders analyzing their performance both in theory and in practice,
  - clustering a finite set of items from pairwise similarity information in different learning settings,
  - introducing a new online learning framework encompassing several problems where the environment changes over time, and an efficient and very scalable unifying approach to solve the related general learning problem.

  Current (and unfinished) ongoing research also includes the following topics: low-stretch spanning trees, active learning in correlation clustering problems, hierarchical clustering.
- AURÉLIEN BELLET visited the Alan Turing Institute (London) and Amazon Research Cambridge for 1 week in February 2018. He worked with Adrià Gascón and Borja Balle on privacy-preserving machine learning.

MAGRIT Project-Team

8. Partnerships and Cooperations

8.1. Regional Initiatives

- The project *Imagerie et Robotique Médicale Grand Est (IRMGE)* started in early january 2018. Clinical and interventional imagery is a major public health issue. Teams from the Grand-Est region involved in medical imaging have thus proposed a research project to broaden and strenghten cooperation. The three axis of the project are about optic imagery, nuclear imagery and medical image processing. The Magrit team is especially involved in the third axis, with the aim to improve interventional procedures.
- Lorraine regional project about AR for liver surgery (2015-2018).
  The MAGRIT and the MIMESIS teams have been working for several years on the use of augmented reality for deformable organs and especially on liver surgery. The PhD of Jaime Garcia Guevara started in October 2015 and is funded by the Région Lorraine. It follows on from our past works and aims at improving the reliability and the robustness of AR-based clinical procedures.

8.2. National Initiatives

8.2.1. Projet RAPID EVORA

Participants: M.-O. Berger, V. Gaudillière, G. Simon.
This 3-year project is supported by DGA/DGE and led by the SBS-Interactive company. The objective is to develop a prototype for location and object recognition in large-scale industrial environments (factories, ships...), with the aim to enrich the operator's field of view with digital information and media. The main issues concern the size of the environment, the nature of the objects (often non textured, highly specular...) and the presence of repeated patterns. Use cases will be provided by industrial partners such as DCNS and Areva. A class of officer cadets and professors of the Merchant Marine School will also be associated to judge the pedagogical interest of such a tool. A PhD student, Vincent Gaudillière, has been recruited to work on this project and his contract started in December 2016.

8.2.2. AEN Inria SOFA-InterMedS

Participants: R. Anxionnat (CHU Nancy), M.-O. Berger, E. Kerrien.
The SOFA-InterMedS large-scale Inria initiative is a research-oriented collaboration across several Inria project-teams, international research groups and clinical partners. Its main objective is to leverage specific competences available in each team to further develop the multidisciplinary field of Medical Simulation research. Our action within the initiative takes place in close collaboration with both the MIMESIS team and the Department of diagnostic and therapeutic interventional neuroradiology of Nancy University Hospital. Two PhD students - R. Trivisonne and J. Guarcia Guevara- are currently co-supervised by the Magrit and the MIMESIS teams.

8.3. International Initiatives

8.3.1. Inria International Labs

Inria@EastCoast
Associate Team involved in the International Lab:

8.3.1.1. CURATIVE

Title: CompUteR-based simulAtion Tool for mItral Valve rEpair

International Partner (Institution - Laboratory - Researcher):

Harvard University (United States) - Harvard Biorobotics Lab (HBL) - Robert Howe

Start year: 2017

See also: https://team.inria.fr/curative/

The mitral valve of the heart ensures one-way flow of oxygenated blood from the left atrium to the left ventricle. However, many pathologies damage the valve anatomy producing undesired backflow, or regurgitation, decreasing cardiac efficiency and potentially leading to heart failure if left untreated. Such cases could be treated by surgical repair of the valve. However, it is technically difficult and outcomes are highly dependent upon the experience of the surgeon.

One way to facilitate the repair is to simulate the mechanical behavior of the pathological valve with subject-specific data. Our main goal is to provide surgeons with a tool to study solutions of mitral valve repairs. This tool would be a computer-based model that can simulate a potential surgical repair procedure in order to evaluate its success. The surgeons would be able to customize the simulation to a patient and to a technique of valve repair. Our methodology will be to realistically simulate valve closure based on segmentation methods faithful enough to capture subject-specific anatomy and based on a biomechanical model that can accurately model the range of properties exhibited by pathological valves.

8.3.1.2. Informal International Partners

- Pierre-Frédéric Villard is a co-investigator in the INVIVE project (http://www.it.uu.se/research/scientific_computing/project/rbf/biomech) funded by the Swedish Research Council and realized within a collaboration with Uppsala University and Karolinska Institute. Within this project, he is the co-supervisor of Igor Tominec (Uppsala University) with Elisabeth Larsson (Uppsala University) as the Main advisor.
- With Gabriele Steidl (Technische Universität Kaiserslautern, Germany), we have worked about the removal of Cauchy noise in natural images. This work has led with a publication in *Journal of Mathematical Imaging and Vision* in 2018. The extension of this technique for structured data (on Riemanian variety for instance) will be considered in future works.

8.4. International Research Visitors

8.4.1. Visits of International Scientists

- Pete Hammer, a senior researcher at Harvard University (http://www.childrenshospital.org/researchers/peter-e-hammer), visited the MAGRIT team from 06/04/18 to 06/10/18. He gave a talk to the Department 1 in Loria, he helped out with mechanical modeling of the mitral valve and he provided advice to Daryna Panicheva supervision during one week.
- Rob Howe, a full professor at Harvard University (http://people.seas.harvard.edu/~howe/), visited the MAGRIT team from 06/16/18 to 06/20/18. He gave a talk to the Department 1 in Loria, he helped out with science understanding of the valve and he helped Daryna Panicheva supervision during one week.

8.4.2. Visits to International Teams

8.4.2.1. Research Stays Abroad

Pierre-Frederic Villard spent one month (May 2018) at Uppsala University working on the INVIVE project. His work there includes supervising PhD student Igor Tominec, meeting with a physiologist expert in respiration muscles and working on an implicit surface representation of the diaphragm.

MANAO Project-Team

9. Partnerships and Cooperations

9.1. National Initiatives

9.1.1. ANR

9.1.1.1. "Young Researcher" VIDA (2017-2021)

LP2N-CNRS-IOGS Inria
Leader R. Pacanowski (LP2N-CNRS-IOGS)
Participant P. Barla (Inria)
This project aims at establishing a framework for direct and inverse design of material appearance for objects of complex shape. Since the manufacturing processes are always evolving, our goal is to establish a framework that is not tied to a fabrication stage.

9.1.1.2. "Young Researcher" RichShape (2014-2018)

MANAO
Leader G. Guennebaud
This project aims at the development of novel representations for the efficient rendering and manipulation of highly detailed shapes in a multi-resolution context.

9.1.1.3. ISAR (2014-2018)

POTIOC, MANAO, LIG-CNRS-UJF, Diotasoft
Leader M. Hachet (POTIOC)
The ISAR project focuses on the design, implementation and evaluation of new interaction paradigms for spatial augmented reality, and to systematically explore the design space.

9.1.1.4. MATERIALS (2015-2019)

MAVERICK, LP2N-CNRS (MANAO), Musée d'Ethnographie de Bordeaux, OCÉ-Print
Leader N. Holzschuch (MAVERICK)
Local Leader R. Pacanowski (LP2N-CNRS)
Museums are operating under conflicting constraints: they have to preserve the artifacts they are storing, while making them available to the public and to researchers. Cultural artifacts are so fragile that simply exposing them to light degrades them. 3D scanning, combined with virtual reality and 3D printing has been used for the preservation and study of sculptures. The approach is limited: it acquires the geometry and the color, but not complex material properties. Current 3D printers are also limited in the range of colors they can reproduce. Our goal in this project is to address the entire chain of material acquisition and restitution. Our idea is to scan complex cultural artifacts, such as silk cloths, capturing all the geometry of their materials at the microscopic level, then reproduce them for study by public and researchers. Reproduction can be either done through 2.5D printing or virtual reality displays.

9.1.1.5. FOLD-Dyn (2017-2021)

IRIT, IMAGINE, MANAO, TeamTo, Mercenaries
Leader L. Barthe (IRIT)
Local Leader G. Guennebaud (Inria)

The FOLD-Dyn project proposes the study of new theoretical approaches for the effective generation of virtual characters deformations, when they are animated. These deformations are two-folds: character skin deformations (skinning) and garment simulations. We propose to explore the possibilities offered by a novel theoretical way of addressing character deformations: the implicit skinning. This method jointly uses meshes and volumetric scalar functions. By improving the theoretical properties of scalar functions, the study of their joint use with meshes, and the introduction of a new approach and its formalism - called multi-layer 3D scalar functions - we aim at finding effective solutions allowing production studios to easily integrate in their pipeline plausible character deformations together with garment simulations.

9.1.1.6. CaLiTrOp (2017-2021)

IRIT, LIRIS, MANAO, MAVERICK
Leader: M. Paulin (IRIT)
Local Leader X. Granier (Inria)
What is the inherent dimensionality, topology and geometry of light-paths space? How can we leverage this information to improve lighting simulation algorithms? These are the questions that this project wants to answer from a comprehensive functional analysis of light transport operators, with respect to the 3D scene's geometry and the reflectance properties of the objects, but also, to link operators with screen-space visual effects, with respect to the resulting picture.

9.2. International Research Visitors

9.2.1. Visits of International Scientists

Masatake Sawayama, Research Scientist, NTT Communication Science Laboratories, Japan

MAVERICK Project-Team

8. Partnerships and Cooperations

8.1. Regional Initiatives

We have frequent exchanges and on-going collaborations with Cyril Crassin from nVIDIA-Research, and Eric Heitz, Laurent Belcour, Jonathan Dupuy and Kenneth Vanhoey from Unity-Research. Maverick is part of the GPU Research Center labeled by nVIDIA at Inria Grenoble. Team contact: Fabrice Neyret.

8.2. National Initiatives

8.2.1. ANR: Materials

Participants: Nicolas Holzschuch [contact], Romain Vergne.

We are funded by the ANR for a joint research project on acquisition and restitution of micro-facet based materials. This project is in cooperation with Océ Print Logic technologies, the Museum of Ethnography at the University of Bordeaux and the Manao team at Inria Bordeaux. The grant started in October 2015, for 48 months.

8.2.2. CDP: Patrimalp 2.0

Participants: Nicolas Holzschuch [contact], Romain Vergne.

The main objective and challenge of Patrimalp 2.0 is to develop a cross-disciplinary approach in order to get a better knowledge of the material cultural heritage in order to ensure its sustainability, valorization and diffusion in society. Carried out by members of UGA laboratories, combining skills in human sciences, geosciences, digital engineering, material sciences, in close connection with stakeholders of heritage and cultural life, curators and restorers, Patrimalp 2.0 intends to develop of a new interdisciplinary science: Cultural Heritage Science. The grant starts in January 2018, for a period of 48 months.

8.2.3. ANR: CaLiTrOp

Participant: Cyril Soler [contact].

Computing photorealistic images relies on the simulation of light transfer in a 3D scene, typically modeled using geometric primitives and a collection of reflectance properties that represent the way objects interact with light. Estimating the color of a pixel traditionally consists in integrating contributions from light paths connecting the light sources to the camera sensor at that pixel.

In this ANR we explore a transversal view of examining light transport operators from the point of view of infinite dimensional function spaces of light fields (imagine, e.g., reflectance as an operator that transforms a distribution of incident light into a distribution of reflected light). Not only are these operators all linear in these spaces but they are also very sparse. As a side effect, the sub-spaces of light distributions that are actually relevant during the computation of a solution always boil down to a low dimensional manifold embedded in the full space of light distributions.

Studying the structure of high dimensional objects from a low dimensional set of observables is a problem that becomes ubiquitous nowadays: Compressive sensing, Gaussian processes, harmonic analysis and differential analysis, are typical examples of mathematical tools which will be of great relevance to study the light transport operators.

Expected results of the fundamental-research project CALiTrOp, are a theoretical understanding of the dimensionality and structure of light transport operators, bringing new efficient lighting simulation methods, and efficient approximations of light transport with applications to real time global illumination for video games.

8.3. International Initiatives

8.3.1. Inria International Partners

8.3.1.1. Declared Inria International Partners

Title: “MAIS”: Mathematical Analysis of Image SynthesisInternational Partner (Institution - Laboratory - Researcher):

University of Montreal (Canada) - Département d’Informatique et Recherche Opérationnelle - Derek Nowrouzezahrai
Duration: 2015 - 2019

8.4. International Research Visitors

8.4.1. Visits to International Teams

8.4.1.1. Research Stays Abroad

Alban Fichet has returned in October 2018 from a 12 months research stay at Charles University in Prague, to work with Alexander Wilkie and Jaroslav Krivanek on material models.

MFX Team

8. Partnerships and Cooperations

8.1. Regional Initiatives

8.1.1. Project LUE

- Funding type: Lorraine Université d'Excellence.
- Title: Passive and active 3D printed orthosis: modeling, simulation and applications.
- Project Coordinator: Sylvain Lefebvre

This project is funded by *Lorraine Université d'Excellence* for three years. It is a collaboration between IJL (Jean Lamour Institute), LORIA (Lorraine Research Laboratory in Computer Science and its Applications), LRGP (Reaction and Process Engineering Laboratory), ERPI (Research Laboratory on Innovation Process), IRR Nancy (Regional Institute for Physical and Rehabilitation Medicine) and Nancy CHU (University Hospital). The project considers the creation of flexible plates with controlled elasticity for use in medical applications (orthoses, insoles). It exemplifies our approach of doing focused collaborations around application domains of our research, to ensure that our techniques answer actual practical challenges and maximize the chances that they are deployed in the near future.

The project funds a PhD student, Thibault Tricard, who started in October 2018. Thibault is co-advised by Sylvain Lefebvre and Didier Rouxel (IJL).

8.1.2. Project PIC

- Funding type: Pacte Lorraine.
- Title: Innovative Polymers and Composites
- Project Coordinator: Sylvain Lefebvre

The project PIC (*Innovative Polymers and Composites*) is a regional project between Inria, IJL (Jean Lamour Institute – materials science), ECN (surgery school) and the company *Les Ateliers Cini*. This collaboration aimed for the creation of new high performance composite materials usable in 3D printing. It began in 2016 (within ALICE) and ended in 2018 (within MFX). The project funded an engineer, Noémie Vennin.

MFX contributed on algorithm aspects of the 3D printer control. PEEK is a material that needs a strict control of temperature: it is extruded at 400 degrees, and cooling plays an important role in the final mechanical properties. During the project, we first developed the software possibilities, adding novel features to enable a finer control over deposition and temperature management. These improvements were implemented in our IceSL software and included thermal shields (see Figure 10), novel support structures, novel infill patterns and the ability to control all print parameters within the object (*e.g.*, varying temperature in different parts). This lead to a significant increase in part quality and accuracy. We also worked on improving the 3D printer jointly with other partners, upgrading the thermal capabilities with a better heating plate (+40°C) and side mounted heating patches, with a safety and control sensor.

We are now able to produce parts in PEEK material, using IceSL for generating printer instructions. For instance, we manufactured parts used by the surgery school for training sessions.

Nevertheless, despite improvements in print quality, it remains the case that parts should be designed or modified to achieve best results with PEEK filament deposition. The high temperature gradients and thermal behavior of PEEK remain very challenging and constrain the geometries that can be reliably produced.

Figure 10. 3D printed vase in PEEK material. Left: Vase breaking during fabrication due to thermal stresses. Right: Adding a thermal shield (not shown) results in a correct 3D print.

8.1.3. Project Colored FDM

- Funding type: CPER and LORIA
- Title: Color fused filament deposition
- Project Coordinator: Sylvain Lefebvre

This project is funded both by the CPER Cyber-entreprise (axis *algorithms for novel materials*) and the LORIA laboratory. As part of the CPER, we work closely with the *Reaction and Process Engineering Laboratory* (LRGP) in Nancy on this topic.

8.1.4. Regional PhD Funding

- Funding type: Région Grand-Est.

We secured two half-PhD fundings from Région Grand-Est in 2018. The first is co-funding Semyon Efremov (PhD student) in the context of the ANR MuFFin. Semyon is co-advised by Jonàs Martínez and Sylvain Lefebvre, he joined the team in October 2018.

The second is co-funding Jimmy Etienne (PhD student), co-advised by Cédric Zanni and Sylvain Lefebvre. The other half-funding is provided by local support from the LORIA laboratory. Jimmy Etienne's topic focuses on curved printing for additive manufacturing, he started in September 2018.

8.2. National Initiatives

8.2.1. ANR

8.2.1.1. Project MuFFin (2018-2021)

- Funding type: ANR JCJC (ANR-17-CE10-0002).
- Title: Procedural and stochastic microstructures for functional fabrication
- Project Coordinator: Jonàs Martínez

MuFFin aims at contributing a unified pipeline for the efficient and scalable synthesis, visualization, and modeling of additively manufactured microstructures with tailored macroscopic physical behavior. In an interdisciplinary effort, MuFFin will blend together computer and material science perspectives to deliver an integrated approach that is both computationally and physically sound.

This year we hired Semyon Efremov as a PhD student, starting from October 2018. We have interdisciplinary collaborations with researchers in topology optimization (Perle Geoffroy-Donders and Grégoire Allaire at École Polytechnique), and material science in the context of aeronautics (Mohamed amin Ben Lassoued and Guilhem Michon at ISAE-SUPAREO, Annie Ross at Polytechnique Montréal).

8.3. International Initiatives

8.3.1. Inria International Partners

8.3.1.1. Informal International Partners

In 2018 we had collaborations with TU Delft [11], continued collaborations with Connelly Barnes (Adobe) [17] and Li-Yi Wei (Adobe) [17], [10]. We have ongoing projects with Bernhard Thomaszewski (University of Montreal), Daniele Panozzo (NYU), Marc Alexa (TU-Berlin), Charlie C.L. Wang (TU-Delft), Sara McMains (University of California) and Brian Wyvill (University of Victoria).

8.4. Visits of International Scientists

Brian Wyvill, professor at the University of Victoria, is a pioneer in the field of computer graphics. He visited us on May 10-11, 2018 and gave a seminar to the department.

Jean-Baptiste Labrune, designer and researcher in 4D printing visited on November 29, 2018. We organized an open seminar within LORIA.

MIMETIC Project-Team

9. Partnerships and Cooperations

9.1. Regional Initiatives

- SATT "Ouest valorisation" grant for the maturation of the Kimea software and projet (Franck Multon and Pierre Plantard). 12 months of three full-time people 300KE. Creation of the start-up company planned beginning of 2018.
- SATT "Ouest valorisation" grant for the maturation of the Populate software (Fabrice Lamarche). One full-time engineer (2017-2018).

9.2. National Initiatives

9.2.1. ANR

9.2.1.1. ANR PRCE Cineviz

Participants: Marc Christie [contact], Quentin Galvane.

Cineviz is a 3-year ANR LabCom project (2016-2019). Amount: 300kE. Parnters: SolidAnim, UR1.

The project is a bilateral collaboration with the SolidAnim company. The objective is to jointly progress on the design and implementation of novel tools for the preproduction in the film industry. The project will address the challenges related to (i) proposing expressive framing tools, (ii) integrating the technical aspects of shooting (how to place the cameras, lights, green sets) directly at the design stage), and (iii) novel interaction metaphors for designing and controlling the staging of lights in preproduction, using an example-based approach.

9.2.1.2. ANR JCJC Per2

Participants: Ludovic Hoyet [contact], Benjamin Niay, Anne-Hélène Olivier, Antonio Mucherino, Richard Kulpa, Franck Multon.

Per2 is a 42 month ANR JCJC project (2018-2022) entitled *Perception-based Human Motion Personalisation* (Budget: 280kE; website: https://project.inria.fr/per2/)

The objective of this project is to focus on how viewers perceive motion variations to automatically produce natural motion personalisation accounting for inter-individual variations. In short, our goal is to automate the creation of motion variations to represent given individuals according to their own characteristics, and to produce natural variations that are perceived and identified as such by users. Challenges addressed in this project consist in (i) understanding and quantifying what makes motions of individuals perceptually different, (ii) synthesising motion variations based on these identified relevant perceptual features, according to given individual characteristics, and (iii) leveraging even further the synthesis of motion variations and to explore their creation for interactive large-scale scenarios where both performance and realism are critical.

This work was performed in collabration with Julien Pettré from Rainbow team.

9.2.1.3. ANR PRCI HoBis

Participants: Franck Multon [contact], Armel Crétual, Georges Dumont, Charles Pontonnier, Anthony Sorel.

Hobis is a 42 month ANR collaborative (PRCI) project (2018-2022) entitled *HoBiS (Hominin BipedalismS): Exploration of bipedal gaits in Hominins thanks to Specimen-Specific Functional Morphology*. HoBis is leaded by the Museum Nationale d'Histoires Naturelles (CNRS), with CNRS/LAAS, and Antwerpen University (Belgium), with a total of 541KE budget (140KE for MimeTIC).

HoBiS (Hominin BipedalismS) is a pluridisciplinary research project, fundamental in nature and centred on palaeoanthropological questions related to habitual bipedalism, one of the most striking features of the human lineage. Recent discoveries (up to 7 My) highlight an unexpected diversity of locomotor anatomies in Hominins that lead palaeoanthropologists to hypothesize that habitual bipedal locomotion took distinct shapes through our phylogenetic history. In early Hominins, this diversity could reveal a high degree of locomotor plasticity which favoured their evolutionary success in the changing environments of the late Miocene and Pliocene. Furthermore, one can hypothesize based on biomechanical theory that differences in gait characteristics, even slight, have impacted the energy balance of hominin species and thus their evolutionary success. However, given the fragmented nature of fossil specimens , previous morphometric and anatomo-functional approaches developed by biologists and palaeoanthropologists, do not allow the assessment of the biomechanical and energetic impacts of such subtle morphological differences, and the manners in which hominin species walked still remains unknown. To tackle this problem, HoBiS proposes as main objective a totally new specimen-specific approach in evolutionary anthropology named Specimen-Specific Functional Morphology: inferring plausible complete locomotor anatomies based on fossil remains, to link these reconstructed anatomies and corresponding musculoskeletal models (MSM) with plausible gaits using simulations. Both sub-objectives will make use of an extensive comparative anatomical and gait biomechanical data bases (challenges). To this end, we will integrate anatomical and functional studies, tools for anatomical modelling, optimization and simulation rooted in informatics, biomechanics, and robotics, to build an in-silico decision-support system (DSS). This DSS will provide biomechanical simulations and energetic estimations of the most plausible bipedal gaits for a variety of hominin species based on available remains, from partial to well-preserved specimens. To achieve this main objective, the project will address the following sub-objectives and challenges

MimeTIC is Leader of WP3 "Biomechanical simulation", aiming at predicting plausible bipedal locomotion based on paleoanthropological heuristics and a given MSM.

9.2.2. National scientific collaborations

9.2.2.1. Cavaletic

Participant: Franck Multon [contact].

The Cavaletic collaborative project is leaded by University Bretagne Sud and also involves University Rennes2 (CREAD Lab.). It has been funded by the National IFCE (Institut Français du Cheval et de l'Equitation) in order to develop and evaluate technological assistance in horse riding learning, thanks to a user-centered approach. MimeTIC is involved in measuring expert and non-expert horse riders' motions in standardized situations in order to develop metrics to measure riders' performance. It will be used to develop a technological system embedded on users to evaluate their performance and provide them with real-time feedback to correct potential errors.

The project ended in 2018 but we are submitting a proposal to SATT Ouest Valorisation in order to finish the development of the technological prototype, and to evaluate the possibility to patent the process, and transfer it to private companies.

9.2.2.2. French Federation of Tennis

Participants: Richard Kulpa [contact], Benoit Bideau, Pierre Touzard.

An exclusive contract has been signed between the M2S laboratory and the French Federation of Tennis for three years. The goal is to perform biomechanical analyses of 3D tennis serves on a population of 40 players of the Pôle France. The objective is to determine the link between injuries and biomechanical constraints on joints and muscles depending on the age and gender of the players. At the end, the goal is to evaluate their load training.

9.2.2.3. ADT: Immerstar 2020

Participants: Ronan Gaugne [contact], Georges Dumont.

The ADT-Immerstar 2020 is driven by the SED and aims at developing new tools and facilities for the scientific community in order to develop demos and use the two immersive rooms in Rennes: Immersia and Immermove. The engineer (Quentin Petit, SED) has the responsibility of homogenizing the software modules and development facilities in each platform, of installing new upgrades and of developping collaborative applications between the two sites.

9.2.2.4. PRE

Participants: Franck Multon [contact], Ludovic Hoyet, Antonio Mucherino.

The Inria PRE projet entitled "Smart sensors and novel motion representation breakthrough for human performance analysis" aims at designing a new description for human motion in order to automatically capture, measure and transfer the intrinsic constraints of human motion. Current approached consisted in manually editing the constraints associated with a motion, to use classical skeleton representation with joint angles based on direct or indirect measurements, and then perform inverse kinematics to fulfill these constraints. We aim at designing a new representation to simplify this process pipeline and make it automatic, together with relevant motion sensors that could provide enough information to automatically extract these intrinsic constraints. To this end, this project has been jointly proposed with the Inria CAIRN team, which develops sensors based on joint orientations and distances between sensors. We aim at extending this type of device to measure new types of information that would help to simplify the above mentionned pipeline. A postdoc Zhiguang Liu arrived in November 2016 to jointly work with CAIRN.

Our results show that shape transfer could be used to transfer a pose from a source character to a target character while maintaining the contextual meaning of the original pose, even if the two characters have different morphology. The main contribution is the definition of a new data structre, named "context graph", to model relative Laplacian coordinates of sub-sampled surfaces points, enabling us to capture the topological relations betwen surfaces of the body.

We have obtained a proof of concept presented in ACM Motion in Games 2018, and we are planning to submit an extended version of the paper to IEEE TVCG.

9.2.2.5. AUTOMA-PIED

Participants: Anne-Hélène Olivier [contact], Armel Crétual, Anthony Sorel.

The AUTOMA-PIED project is driven by IFSTTAR. Using a set-up in virtual reality, the first objective of the project aims at comparing pedestrian behaviour (young and older adults) when interacting with traditional or autonomous vehicles in a street crossing scenario. The second objective is to identify postural cues that can predict whether or not the pedestrian is about to cross the street.

9.2.2.6. IPL Avatar

Participants: Ludovic Hoyet [contact], Franck Multon.

This project, led by Ludovic Hoyet, aims at design avatars (i.e., the user's representation in virtual environments) that are better embodied, more interactive and more social, through improving all the pipeline related to avatars, from acquisition and simulation, to designing novel interaction paradigms and multi-sensory feedback. It involves 6 Inria teams (GraphDeco, Hybrid, Loki, MimeTIC, Morpheo, Potioc), Prof. Mel Slater (Uni. Barcelona), and 2 industrial partners (Technicolor and Faurecia).

Website: http://avatar.inria.fr

9.3. European Initiatives

9.3.1. FP7 & H2020 Projects

- Program: Joint Program Initiative
- Project Acronym: SCHEDAR
- Project title: Safeguarding the Cultural HEritage of Dance through Augmented Reality
- Duration: June 2018-June 2021

- Coordinator: University of Cyprus
- Other partners: Algolysis LTD (Cyprus), University of Warwick (UK), University of Reims Champagne Ardennes (France)
- Abstract: Dance is an integral part of any culture. Through its choreography and costumes dance imparts richness and uniqueness to that culture. Over the last decade, technological developments have been exploited to record, curate, remediate, provide access, preserve and protect tangible CH. However, intangible assets, such as dance, has largely been excluded from this previous work. Recent computing advances have enabled the accurate 3D digitization of human motion. Such systems provide a new means for capturing, preserving and subsequently re-creating ICH which goes far beyond traditional written or imaging approaches. However, 3D motion data is expensive to create and maintain, encompassed semantic information is difficult to extract and formulate, and current software tools to search and visualize this data are too complex for most end-users. SCHEDAR will provide novel solutions to the three key challenges of archiving, re-using and re-purposing, and ultimately disseminating ICH motion data. In addition, we will devise a comprehensive set of new guidelines, a framework and software tools for leveraging existing ICH motion databases. Data acquisition will be undertaken holistically; encompassing data related to the performance, the performer, the kind of the dance, the hidden/untold story, etc. Innovative use of state-of-the-art multisensory Augmented Reality technology will enable direct interaction with the dance, providing new experiences and training in traditional dance which is key to ensure this rich culture asset is preserved for future generations. MimeTIC is responsible for WP3 "Dance Data Enhancement".

9.4. International Initiatives

9.4.1. Inria Associate Teams Not Involved in an Inria International Labs

9.4.1.1. FORMOSA

Title: Fostering Research on Models for Storytelling Applications

International Partner (Institution - Laboratory - Researcher):

NCCU (Taiwan) - Intelligent Media Lab (IML) - Tsai-Yen Li

Start year: 2016

See also: http://www.irisa.fr/mimetic/GENS/mchristi/EA-FORMOSA/

Interactive Storytelling is a new media which allows users to alter the content and outcome of narratives through role-playing and specific actions. With the quality, the availability and reasonable costs of display technologies and 3D interaction devices on one side, and the accessibility of 3D content creation tools on the other, this media is taking a significant share in entertainment (as demonstrated by the success of cinematographic games such as Heavy Rain or Beyond: two souls). These advances push us to re-think the way narratives are traditionally structured, explore new interactive modalities and provide new interactive cinematographic experiences. As a sequel of the first associate team FORMOSA 1, we propose to address new challenges pertained to interactive storytelling such as the use of temporal structures in narratives, interaction modalities and their impact in terms of immersion, and the adaptation of cinematographic real data to 3D environments. To achieve these objectives, the associate team will rely on the complementary skills of its partners and on the co-supervision of students.

9.4.2. Inria International Partners

9.4.2.1. Informal International Partners

- Dr. Rachel McDonnell, Trinity College Dublin, Ireland (on-going collaboration with Ludovic Hoyet)
- Prof. Carol O Sullivan, Trinity College Dublin, Ireland (on-going collaboration with Ludovic Hoyet)

- Prof Michael Cinelli, University Wilfrid Laurier, Waterloo, Canada (on-going collaboration with Anne-Hélène Olivier)
- Prof. Hannes Kaufmann, TU Wien, Austria (on-going collaboration with Anne-Hélène Olivier)
- Prof. Hui Huang, Shenzhen University (on-going collaboration with Marc Christie)
- Prof. Baoquan Chen, Pekin University (on-going collaboration with Marc Christie)
- Dr. Bin Wang, Beijing Film Academy University (on-going collaboration with Marc Christie)

9.5. International Research Visitors

9.5.1. Visits of International Scientists

- Prof. Pascal Madeleine, Aalborg Univeristy, Denmark, 1 week stay in may 2018 for collaborations with Georges Dumont and Charles Pontonnier about physical and cognitive load in virtual environments.
- Michael Cinelli, Associate Professor, Kinesiology and Physical Education, Wilfrid Laurier University, Canada, June 2018

9.5.1.1. Internships

- Victoria Rapos, Wilfrid Laurier University, Canada (Master supervisor: Michael Cinelli), 3 month internship from May to July 2018 with A.H. Olivier and A. Crétual about collision avoidance strategies in kids.
- Natalie Snyder, Wilfrid Laurier University, Canada (Master supervisor: Michael Cinelli), 3 month internship from May to July 2018 with A.H. Olivier and A. Crétual about collision avoidance strategies in previously concussed athletes.
- Ching Yu Kang, NCCU from July to September 2018 with Marc Christie on Virtual Staging techniques
- Wan Yu Lee, NCCU from July to September 2018 with Marc Christie on Drone Cinematography

MOEX Project-Team

5. Partnerships and Cooperations

5.1. National Initiatives

5.1.1. ANR Elker

Program: ANR-PRC

Project acronym: ELKER

Project title: Extending link keys: extraction and reasoning

Duration: October 2017 - September 2021

Coordinator: LIG/Manuel Atencia

Participants: Manuel Atencia Arcas, Jérôme David, Jérôme Euzenat

Other partners: Inria Lorraine, Université de Vincennes

Abstract: The goal of ELKER is to extend the foundations and algorithms of link keys (see §3.2) in two complementary ways: extracting link keys automatically from datasets and reasoning with link keys.

5.1.2. Framework agreement Ministère de la culture et de la communication

Program: Framework agreement Inria-Ministère de la culture et de la communication

Project acronym: GINCO V3

Project title: Outil d'aide à l'alignement pour l'élaboration du graphe culture

Duration: November 2017 - December 2018

Coordinator: Jérôme David

Participants: Jérôme David, Jérôme Euzenat, Manuel Atencia Arcas

Abstract: The GINCO V3 project aims at extending the GINCO tool with ontology alignment capabilities.

Program: Framework agreement Inria-Ministère de la culture et de la communication

Project acronym: FNE

Project title: Algorithmes d'aide à la définition de clés de liage et d'alignement d'autorités

Duration: November 2017 - December 2018

Coordinator: Jérôme David

Participants: Jérôme David, Manuel Atencia Arcas, Jérôme Euzenat

Other partners: Bibliothèque nationale de France

Abstract: The goal of the FNE cooperation is to evaluate the suitability of link key extraction algorithms to matching authorities from BnF, ABES and the ministry of Culture and to improve such algorithms if necessary.

MORPHEO Project-Team

9. Partnerships and Cooperations

9.1. National Initiatives

9.1.1. ANR

9.1.1.1. ANR PRCE CaMoPi – Capture and Modelling of the Shod Foot in Motion

The main objective of the CaMoPi project is to capture and model dynamic aspects of the human foot with and without shoes. To this purpose, video and X-ray imagery will be combined to generate novel types of data from which major breakthroughs in foot motion modelling are expected. Given the complexity of the internal foot structure, little is known about the exact motion of its inner structure and the relationship with the shoe. Hence the current state-of-the art shoe conception process still relies largely on ad-hoc know-how. This project aims at better understanding the inner mechanisms of the shod foot in motion in order to rationalise and therefore speed up and improve shoe design in terms of comfort, performance, and cost. This requires the development of capture technologies that do not yet exist in order to provide full dense models of the foot in motion. To reach its goals, the CaMoPi consortium comprises complementary expertise from academic partners : Inria (combined video and X-ray capture and modeling) and Mines St Etienne (finite element modeling), as well as industrial : CTC Lyon (shoe conception and manufacturing, dissemination). The project has effectively started in October 2017 with Claude Goubet's recruitment as a PhD candidate followed by Tomas Svaton as an engineer in April 2018.

9.1.1.2. ANR project Achmov – Accurate Human Modeling in Videos

The technological advancements made over the past decade now allow the acquisition of vast amounts of visual information through the use of image capturing devices like digital cameras or camcorders. A central subject of interest in video are the humans, their motions, actions or expressions, the way they collaborate and communicate. The goal of ACHMOV is to extract detailed representations of multiple interacting humans in real-world environments in an integrated fashion through a synergy between detection, figure-ground segmentation and body part labeling, accurate 3D geometric methods for kinematic and shape modeling, and large-scale statistical learning techniques. By integrating the complementary expertise of two teams (one French, MORPHEO and one Romanian, CLVP), with solid prior track records in the field, there are considerable opportunities to move towards processing complex real world scenes of multiple interacting people, and be able to extract rich semantic representations with high fidelity. This would enable interpretation, recognition and synthesis at unprecedented levels of accuracy and in considerably more realistic setups than currently considered. This project has funded the work of two soon to defend PhD students Vincent Leroy and Jinlong Yang, and ended during the year 2018.

9.1.2. Competitivity Clusters

9.1.2.1. FUI project Creamove

Creamove is a collaboration between the Morpheo team of the Inria Grenoble Rhône-Alpes, the 4D View Solution company specialized in multi-camera acquisition systems, the SIP company specialized in multi-media and interactive applications and a choreographer. The objective is to develop new interactive and artistic applications where humans can interact in 3D with virtual characters built from real videos. Dancer performances will be pre-recorded in 3D and used on-line to design new movement sequences based on inputs coming from human bodies captured in real time. Website: http://www.creamove.fr.

9.1.2.2. FUI24 SPINE-PDCA

The goal of the SPINE-PDCA project is to develop a unique medical platform that will streamline the medical procedure and achieve all the steps of a minimally invasive surgery intervention with great precision through a complete integration of two complementary systems for pre-operative planning (EOS platform from EOS IMAGING) and imaging/intra-operative navigation (SGV3D system from SURGIVISIO). Innovative low-dose tracking and reconstruction algorithms will be developed by Inria, and collaboration with two hospitals (APHP Trousseau and CHU Grenoble) will ensure clinical feasibility. The medical need is particularly strong in the field of spinal deformity surgery which can, in case of incorrect positioning of the implants, result in serious musculoskeletal injury, a high repeat rate (10 to 40% of implants are poorly positioned in spine surgery) and important care costs. In paediatric surgery (e. g. idiopathic scoliosis), the rate of exposure to X-rays is an additional major consideration in choosing the surgical approach to engage. For these interventions, advanced linkage between planning, navigation and postoperative verification is essential to ensure accurate patient assessment, appropriate surgical procedure and outcome consistent with clinical objectives. The project has effectively started in October 2018 with Di Meng's recruitment as a PhD candidate.

MULTISPEECH Project-Team

9. Partnerships and Cooperations

9.1. Regional Initiatives

9.1.1. CPER LCHN

Project acronym: CPER LCHN

Project title: CPER “Langues, Connaissances et Humanités Numériques”

Duration: 2015-2020

Coordinator: Bruno Guillaume (LORIA) & Alain Polguère (ATILF)

Participants: Dominique Fohr, Denis Jouvet, Odile Mella, Yves Laprie

Abstract: The main goal of the project is related to experimental platforms for supporting research activities in the domain of languages, knowledge and numeric humanities engineering.

MULTISPEECH contributes to automatic speech recognition, speech-text alignment and prosody aspects.

9.1.2. CPER IT2MP

Project acronym: CPER IT2MP

Project title: CPER “Innovation Technologique Modélisation et Médecine Personalisée”

Duration: 2015-2020

Coordinator: Faiez Zannad (Inserm-CHU-UL)

Participants: Romain Serizel, Emmanuel Vincent

Abstract: The goal of the project is to develop innovative technologies for health, and tools and strategies for personalized medicine.

MULTISPEECH will investigate acoustic monitoring using an array of microphones.

9.1.3. Dynalips

Project title: Control of the movements of the lips in the context of facial animation for an intelligible lipsync.

Duration: February 2017 - August 2018

Coordinator: Slim Ouni

Participants: Valerian Girard, Slim Ouni

Funding: SATT

Abstract: We proposed in this project the development of tools of lipsync which, from recorded speech, provide realistic mechanisms of animating the lips. These tools are meant to be integrated into existing 3D animation software and existing game engines. One objective was that these lipsync tools fit easily into the production pipeline in the field of 3D animation and video games. The goal of this maturation was to propose a product ready to be exploited in the industry whether by the creation of a start-up or by the distribution of licenses.

A first prototype of the lipsync system has been developed for French. From audio and text, the system allows animating a 3D model of the face (an avatar) realistically. This work has been presented at Annecy International Animation Film Festival.

9.2. National Initiatives

9.2.1. ANR DYCI2

Project acronym: DYCI2 (http://repmus.ircam.fr/dyci2/)

Project title: Creative Dynamics of Improvised Interaction

Duration: March 2015 - February 2018

Coordinator: Ircam (Paris)

Other partners: Inria (Nancy), University of La Rochelle

Participants: Ken Déguernel, Nathan Libermann, Emmanuel Vincent

Abstract: The goal of this project was to design a music improvisation system able to listen to the other musicians, to improvise in their style, and to modify its improvisation according to their feedback in real time.

MULTISPEECH was responsible for designing a system able to improvise on multiple musical dimensions (melody, harmony) across multiple time scales.

9.2.2. ANR ArtSpeech

Project acronym: ArtSpeech

Project title: Synthèse articulatoire phonétique

Duration: October 2015 - March 2019

Coordinator: Yves Laprie

Other partners: Gipsa-Lab (Grenoble), IADI (Nancy), LPP (Paris)

Participants: Ioannis Douros, Yves Laprie, Anastasiia Tsukanova

Abstract: The objective is to synthesize speech from text via the numerical simulation of the human speech production processes, i.e. the articulatory, aerodynamic and acoustic aspects. Corpus based approaches have taken a hegemonic place in text to speech synthesis. They exploit very good acoustic quality speech databases while covering a high number of expressions and of phonetic contexts. This is sufficient to produce intelligible speech. However, these approaches face almost insurmountable obstacles as soon as parameters intimately related to the physical process of speech production have to be modified. On the contrary, an approach which rests on the simulation of the physical speech production process makes explicitly use of source parameters, anatomy and geometry of the vocal tract, and of a temporal supervision strategy. It thus offers direct control on the nature of the synthetic speech.

Static MRI acquisition of vowels (images plus acoustic signal) have been carried out this year and their exploitation started to explore the impact of the articulatory modeling and the plane wave assumption. Manual delineations of approximately 1000 images have been done and used to generate speech signals with articulatory copy synthesis.

9.2.3. ANR JCJC KAMoulox

Project acronym: KAMoulox

Project title: Kernel additive modelling for the unmixing of large audio archives

Duration: January 2016 - September 2019

Coordinator: Antoine Liutkus (Inria Zenith)

Participants: Mathieu Fontaine, Antoine Liutkus

Abstract: The objective is to develop the theoretical and applied tools required to embed audio denoising and separation tools in web-based audio archives. The applicative scenario is to deal with large audio archives, and more precisely with the notorious “Archives du CNRS — Musée de l’homme”, gathering about 50,000 recordings dating back to the early 1900s.

9.2.4. PIA2 ISITE LUE

Project acronym: ISITE LUE

Project title: Lorraine Université d'Excellence

Duration: starting in 2016

Coordinator: Univ. Lorraine

Participants: Ioannis Douros, Yves Laprie

Abstract: The initiative aims at developing and densifying the initial perimeter of excellence, within the scope of the social and economic challenges, so as to build an original model for a leading global engineering university, with a strong emphasis on technological research and education through research. For this, we have designed LUE as an "engine" for the development of excellence, by stimulating an original dialogue between knowledge fields.

MULTISPEECH is mainly concerned with challenge number 6: "Knowledge engineering", i.e., engineering applied to the field of knowledge and language, which represent our immaterial wealth while being a critical factor for the consistency of future choices. This project funds the PhD thesis of Ioannis Douros.

9.2.5. E-FRAN METAL

Project acronym: E-FRAN METAL

Project title: Modèles Et Traces au service de l'Apprentissage des Langues

Duration: October 2016 - September 2020

Coordinator: Anne Boyer (LORIA)

Other partners: Interpsy, LISEC, ESPE de Lorraine, D@NTE (Univ. Versailles Saint Quentin), Sailendra SAS, ITOP Education, Rectorat.

Participants: Theo Biasutto-Lervat, Anne Bonneau, Vincent Colotte, Dominique Fohr, Denis Jouvet, Odile Mella, Slim Ouni, Anne-Laure Piat-Marchand, Elodie Gauthier, Thomas Girod

Abstract: METAL aims at improving the learning of languages (both written and oral components) through the development of new tools and the analysis of numeric traces associated with students' learning, in order to adapt to the needs and rythm of each learner.

MULTISPEECH is concerned by oral language learning aspects.

9.2.6. ANR VOCADOM

Project acronym: VOCADOM (http://vocadom.imag.fr/)

Project title: Robust voice command adapted to the user and to the context for ambient assisted living

Duration: January 2017 - December 2020

Coordinator: CNRS - LIG (Grenoble)

Other partners: Inria (Nancy), Univ. Lyon 2 - GREPS, THEORIS (Paris)

Participants: Dominique Fohr, Md Sahidullah, Sunit Sivasankaran, Emmanuel Vincent

Abstract: The goal of this project is to design a robust voice control system for smart home applications.

MULTISPEECH is responsible for wake-up word detection, overlapping speech separation, and speaker recognition.

9.2.7. ANR JCJC DiSCogs

Project acronym: DiSCogs

Project title: Distant speech communication with heterogeneous unconstrained microphone arrays

Duration: September 2018 – March 2022

Coordinator: Romain Serizel

Participants: Nicolas Furnon, Irina Illina, Romain Serizel, Emmanuel Vincent

Collaborators: Télécom ParisTech, 7sensing

Abstract: The objective is to solve fundamental sound processing issues in order to exploit the many devices equipped with microphones that populate our everyday life. The solution proposed is to apply machine learning methods based on deep learning to recast the problem of synchronizing devices at the signal level as a multi-view learning problem aiming at extracting complementary information from the devices at hand.

9.3. European Initiatives

9.3.1. FP7 & H2020 Projects

9.3.1.1. COMPRISE

Program: H2020 ICT-29-2018 (RIA)

Project acronym: COMPRISE

Project title: Cost-effective, Multilingual, Privacy-driven voice-enabled Services

Duration: Dec 2018- Nov 2021

Coordinator: Emmanuel Vincent

Other partners: Inria Magnet, Ascora GmbH, Netfective Technology SA, Rooter Analysis SL, Tilde SIA, University of Saarland

Participants: Irina Illina, Denis Jouvet, Emmanuel Vincent

Abstract: COMPRISE will define a fully private-by-design methodology and tools that will reduce the cost and increase the inclusiveness of voice interaction technologies.

9.3.2. Collaborations in European Programs, Except FP7 & H2020

9.3.2.1. AMIS

Program: CHIST-ERA

Project acronym: AMIS

Project title: Access Multilingual Information opinionS

Duration: Dec 2015- Nov 2018

Coordinator: Kamel Smaïli (LORIA)

Other partners: University of Avignon, University of Science and Technology Krakow, University of DEUSTO (Bilbao)

Participants: Dominique Fohr, Denis Jouvet, Odile Mella

Abstract: The idea of the project is to develop a multilingual help system of understanding without any human being intervention. This should help people understanding broadcasting news, presented in a foreign language and to compare it to a corresponding one available in the mother tongue of the user.

MULTISPEECH contributions concern mainly the speech recognition in French, English and Arabic videos.

9.4. International Initiatives

9.4.1. Inria International Partners

9.4.1.1. Informal International Partners

Jon Barker: University of Sheffield (UK)

Robust speech recognition [19]

Tomi Kinnunen: University of Eastern Finland (Finland)

Speaker verification and spoofing countermeasures for voice biometrics [47], [24], [32], [26], [41], [67]

Nicholas Evans: EURECOM (France)

Spoofing countermeasures for voice biometrics [47], [24], [32]

Hamid Eghbal-Zadeh: Johannes Kepler University (Austria)

Audio event detection [40]

Shinji Watanabe, Johns Hopkins University (USA)

Robust speech recognition [19]

Junichi Yamagishi, National Institute of Informatics (Japan)

Spoofing countermeasures for voice biometrics [47], [24], [32], [26]

ORPAILLEUR Project-Team

8. Partnerships and Cooperations

8.1. Regional Initiatives

8.1.1. AGREV-3

Participant: Jean-François Mari.

The AGREV 3 project (for "Agriculture Environment Vittel") is part of "Agrivair" –a subsidiary of Nestlé Waters– in actions to protect the natural resources of natural mineral water. We used ARPEnTAge to mine survey data about the Vittel-Contrexéville territory, which is suspected of groundwater quality risks [5]. This allowed to locate regions having the same behavior. In addition, this provided a more contrasted simulation by eliminating the influence of stable zones (forests, permanent grasslands) and a more precise definition of a "neutral" model.

8.1.2. Hydreos

Participants: Jean-François Mari, Chedy Raïssi.

Hydreos is a state organization, so-called "Pôle de compétitivité", aimed at monitoring and evaluating the quality of water and its delivery (http://www.hydreos.fr/fr). Actually, data about water resources rely on many agronomic variables, including land use successions. The data to be analyzed are obtained by surveys or by satellite images and describe the land use at the level of the agricultural parcel. Then there is a search for detecting changes in land use and for correlating these changes to groundwater quality. Accordingly, one main challenge in our participation in Hydreos is to process and analyze space-time data for reaching a better understanding of the changes in the organization of a territory. The systems ARPEnTAge and CarottAge are used in this context, especially by agronomists of INRA (ASTER Mirecourt http://www6.nancy.inra.fr/sad-aster).

On other aspects, we tested new deep graph convolutional learning over data provided by the SEDIF "Syndicat des eaux d'Île-de-France" to predict the likelihood of water leaks in a network of pipes and compared it with a master thesis where spatial point process techniques were used (master thesis of Nicolas Dante, M2 IMSD Nancy).

8.1.3. The Smart Knowledge Discovery Project

Participants: Jérémie Nevin, Amedeo Napoli, Chedy Raïssi.

The SKD project for "Smart Knowledge Discovery" aims at analyzing complex industrial data for troubleshooting and decision making, and is funded by "Grand Est Region". We are working on exploratory knowledge discovery with the Vize company, which is based in Nancy and specialized in visualization-based data mining. The data which are under study are provided by the Arcelor-Mittal Steel Company and are related to the monitoring of rolling mills. Data are complex time series and the problem is related to a so-called "predictive maintenance", or how to anticipate problems in the furnaces and avoid their stop. In this way, one main objective of SKD is to combine sequence mining and visualization tools for recognizing temperature problems in the furnaces, and thus preventing the occurrences of defects in the outputs of the rolling mills.

8.2. National Initiatives

8.2.1. ANR

8.2.1.1. Elker (2017–2020)

Participants: Nacira Abbas, Miguel Couceiro, Amedeo Napoli, Chedy Raïssi.

The objectives of the ELKER ANR Research Project is to study, formalize and implement the search for link keys in RDF data. Link keys generalize database keys in two independent directions, i.e. they deal with RDF data and they apply across two relation datasets. Then we study the automatic discovery of link keys and reasoning with link keys, in taking an FCA point of view. The projects relies on the competencies of Orpailleur in FCA for solving the problem using FCA and pattern structures algorithms, partition pattern structures which are related to the discovery of functional dependencies. This project involves the EPI Orpailleur at Inria Nancy Grand Est, the EPI MOEX at Inria Rhône Alpes, and LIASD at Université Paris 8.

8.2.1.2. PractiKPharma (2016–2020)

Participants: Adrien Coulet, Joël Legrand, Pierre Monnin, Amedeo Napoli, Malika Smaïl-Tabbone, Yannick Toussaint.

PractiKPharma for "Practice-based evidences for actioning Knowledge in Pharmacogenomics" is an ANR research project (http://practikpharma.loria.fr/) about the validation of domain knowledge in pharmacogenomics. Pharmacogenomics is interested in understanding how genomic variations related to patients have an impact on drug responses. Most of the available knowledge in pharmacogenomics (state of the art) lies in biomedical literature, with various levels of validation. An originality of PractiKPharma is to use Electronic Health Records (EHRs) to constitute cohorts of patients. These cohorts are then mined for extracting potential pharmacogenomics patterns to be then validated w.r.t. literature knowledge for becoming actionable knowledge units. More precisely, firstly we should extract pharmacogenomic patterns from the literature and secondly we should confirm or moderate the interpretation and validation of these units by mining EHRs. Comparing knowledge patterns extracted from the literature with facts extracted from EHRs is a complex task depending on the EHR language –literature is in English whereas EHRs are in French– and on knowledge level, as EHRs represent observations at the patient level whereas literature is related to sets of patients. The PractiKPharma involves three other laboratories, namely LIRMM in Montpellier, SSPIM in St-Etienne and CRC in Paris.

8.2.2. CNRS Mastodons Projects: HyQual, HyQualiBio and QCM-BioChem (2016–2018)

Participants: Nacira Abbas, Guilherme Alves Da Silva, Miguel Couceiro, Alain Gély, Nyoman Juniarta, Tatiana Makhalova, Amedeo Napoli, Chedy Raïssi, Justine Reynaud.

The HyQual project was proposed in 2016 in response to the Mastodons CNRS Call about data quality in data mining (see http://www.cnrs.fr/mi/spip.php?article819&lang=fr). This project is interested in the mining of nutritional data for discovering predictive biomarkers of diabetes and metabolic syndrome in elder populations. The considered data mining methods are hybrid, and they combine symbolic and numerical methods for mining complex and noisy metabolic data [77]. Regarding the mining process, we are interested in the quality of the data at hand and in the discovered patterns. In particular, we check the incompleteness of the data, the quality of the extracted rules and the possible existence of redescriptions.

Initially, the project involved researchers from the EPI Orpailleur, with researchers from LIRIS Lyon, ICube Strasbourg, and INRA Clermont-Ferrand. Then, the project was merged the other Mastodons project named QualiBioConsensus, about the "ranking of biological data using consensus ranking techniques". The joint Mastodons project was called "HyQualiBio". The year after, the project was a new time merged with the PEPS Decade project to form the new "QCM-BioChem" (https://www.lri.fr/~cohen/QCM-BioChem.html). The topics of interest for the participants are the mining of complex biological data, rankings and ties in rankings, and the search of dependencies in the web of data.

8.3. European Initiatives

8.3.1. FP7 & H2020 Projects

8.3.1.1. CrossCult (H2020 Project, 2016-2020)

Participants: Miguel Couceiro, Nyoman Juniarta, Amedeo Napoli, Chedy Raïssi.

CrossCult aims at making reflective history a reality in the European cultural context, by enabling the re-interpretation of European (hi)stories through cross-border interconnections among cultural digital resources, citizen viewpoints and physical venues. The project has two main goals. The first goal is to lower cultural EU barriers and create unique cross-border perspectives, by connecting existing digital historical resources and by creating new ones through the participation of the public. The second goal is to provide long-lasting experiences of social learning and entertainment that will help for achieving a better understanding and re-interpretation of European history. To achieve these goals, CrossCult aims at using cutting-edge technology to connect existing digital cultural assets and to combine them with interactive experiences that all together are intended to increase retention, stimulate reflection and help European citizens appreciate their past and present in a holistic manner. CrossCult has to be implemented on four real-world flagship pilots involving a total of 8 sites across Europe.

The role of the Orpailleur Team (in conjunction with the LORIA Kiwi Team) is to work on knowledge discovery and recommendation. The focus is on the mining of visitor trajectories for analysis purposes [32], [33] and on the definition of a visitor profile in connection with domain knowledge for recommendation [31].

The numerous partners of the Orpailleur team in the CrossCult project are: Luxembourg Institute for Science and Technology and Centre Virtuel de la Connaissance sur l'Europe (Luxembourg, leader of the project), University College London (England), University of Malta (Malta), University of Peloponnese and Technological Educational Institute of Athens (Greece), Università degli Studi di Padova (Italy), University of Vigo (Spain), National Gallery (London, England), and GVAM Guìas Interactivas (Spain).

8.4. International Initiatives

8.4.1. Inria International Labs

Inria@SiliconValley
Associate Team involved in the International Lab:

8.4.1.1. Snowball

Title: Discovering knowledge on drug response variability by mining electronic health records

International Partner (Institution - Laboratory - Researcher):

Stanford (United States) - Department of Medicine, Stanford Center for Biomedical Informatics Research (BMIR) - Nigam Shah

Start year: 2017

See also: http://snowball.loria.fr/

Snowball (2017-2019) is an Inria Associate Team and the continuation of the preceding Associate Team called Snowflake (2014-2016). The objective of Snowball is to study drug response variability through the lens of Electronic Health Records (EHRs) data. This is motivated by the fact that many factors, genetic as well as environmental, imply different responses from people to the same drug. The mining of EHRs can bring substantial elements for understanding and explaining drug response variability.

Accordingly the objectives of Snowball are to identify in EHR repositories groups of patients which are responding differently to similar treatments, and then to characterize these groups and predict patient drug sensitivity. These objectives are complementary to those of the PractiKPharma ANR project. Moreover, it should be noticed that Adrien Coulet is continuing a two-years sabbatical stay in the lab of Nigam Shah at Stanford University since September 2017 (granted by an "Inria délégation").

Participants of the Snowball Associate Team have been awarded with a Grant Seed funded by Stanford University, to pursue their efforts in AI in Medicine. The granted project will particularly focus on the building of fair and equitable predictive models for medicine (see http://medicine.stanford.edu/news/current-news/standard-news/presenceannouncesseedgrantawardees.html).

8.4.2. Informal International Partners: Research Collaboration with HSE Moscow

Participants: Nacira Abbas, Guilherme Alves Da Silva, Miguel Couceiro, Alain Gély, Nyoman Juniarta, Tatiana Makhalova, Amedeo Napoli, Chedy Raïssi, Justine Reynaud.

An on-going collaboration involves the Orpailleur team and Sergei O. Kuznetsov at Higher School of Economics in Moscow (HSE). Amedeo Napoli visited HSE laboratory several times while Sergei O. Kuznetsov visits Inria Nancy Grand Est every year. The collaboration is materialized by the joint supervision of students (such as the thesis of Aleksey Buzmakov defended in 2015 and the on-going thesis of Tatiana Makhalova), and the the organization of scientific events, as the workshop FCA4AI with six editions between 2012 and 2018 (see http://www.fca4ai.hse.ru).

This year, we participated in the writing of common publications around the thesis work of Tatiana Makhalova and the organization of one main event, namely the sixth edition of the FCA4AI workshop in July 2018 at the ECAI-IJCAI Conference which was held in Stockholm, Sweden (see http://ceur-ws.org/Vol-2149, [58]).

8.4.3. Participation in other International Programs

8.4.3.1. A stay at NASA Frontier Development Lab

In July and August 2018, Chedy Raïssi visited NASA Ames and SETI Institute as part of the Frontier Development Lab, where he worked on mentoring teams and developing meaningful research opportunities, as well as support the work of the planetary defense community and show the potential of this kind of applied research methodology to deliver breakthrough of significant value.

During the eight-week research incubator he aimed at applying cutting-edge machine-learning algorithms to challenges in the space sciences. He worked with two machine-learning students (PhD and post-doc level) that were paired with two space-science researchers (post-doc level) on the improvement of machine-learning models for exoplanet transit classification. This small team started initially from a machine-learning model that classified signals based on straightforward local and global views of the light curves that was developed by Google Brain engineer Chris Shallue. To improve upon it, the team added scientific domain knowledge –staying true to the Orpailleur idea of injecting domain knowledge– that was provided by domain experts. Using the resulting model, the team managed to classify a Kepler data set with 97.5% accuracy and 98% average precision [2].

PANAMA Project-Team

9. Partnerships and Cooperations

9.1. National Initiatives

9.1.1. Labex Comin Labs projects

ComInLabs is a Laboratoire d'Excellence funded by the PIA (Programme Investissements d'Avenir) in the broad area of telecommunications.

9.1.1.1. HEMISFER

Participant: Rémi Gribonval.

Acronym: HYBRID (Hybrid Eeg-MrI and Simultaneous neuro-feedback for brain Rehabilitation)

http://hemisfer.cominlabs.u-bretagneloire.fr/

Research axis: 3.1

ComInLabs partners : VISAGES, HYBRID and PANAMA Inria project-teams;

External partners : EA 4712 team from University of Rennes I; ATHENA Inria project-team, Sophia-Antipolis;

Coordinator: Christian Barillot, VISAGES Inria project-team

Description: The goal of HEMISFER is to make full use of neurofeedback paradigm in the context of rehabilitation and psychiatric disorders. The major breakthrough will come from the use of a coupling model associating functional and metabolic information from Magnetic Resonance Imaging (fMRI) to Electro-encephalography (EEG) to "enhance" the neurofeedback protocol. We propose to combine advanced instrumental devices (Hybrid EEG and MRI platforms), with new man-machine interface paradigms (Brain computer interface and serious gaming) and new computational models (source separation, sparse representations and machine learning) to provide novel therapeutic and neuro-rehabilitation paradigms in some of the major neurological and psychiatric disorders of the developmental and the aging brain (stroke, attention-deficit disorder, language disorders, treatment-resistant mood disorders, ...).

Contribution of PANAMA: PANAMA, in close cooperation with the VISAGES team, contributes to a coupling model between EEG and fMRI considered as a joint inverse problem addressed with sparse regularization. By combining both modalities, one expects to achieve a good reconstruction both in time and space. This new imaging technique will then be used for improving neurofeedback paradigms in the context of rehabilitation and psychiatric disorders, which is the final purpose of the HEMISFER project.

9.1.1.2. TEPN

Participant: Rémi Gribonval.

Acronym: TEPN (Toward Energy Proportional Networks)

http://tepn.cominlabs.u-bretagneloire.fr/

Research axis: 3.1

ComInLabs partners : IRISA OCIF - Telecom Bretagne; IETR SCN; IETR SCEE; PANAMA Inria project-team

Coordinator: Nicolas Montavont, IRISA OCIF - Telecom Bretagne

Description: As in almost all areas of engineering in the past several decades, the design of computer and network systems has been aimed at delivering maximal performance without regarding to the energy efficiency or the percentage of resource utilization. The only places where this tendency was questioned were battery-operated devices (such as laptops and smartphones) for which the users accept limited (but reasonable) performance in exchange for longer use periods. Even though the end users make such decisions on a daily basis by checking their own devices, they have no way of minimizing their energy footprint (or conversely, optimize the network resource usage) in the supporting infrastructure. Thus, the current way of dimensioning and operating the infrastructure supporting the user services, such as cellular networks and data centers, is to dimension for peak usage. The problem with this approach is that usage is rarely at its peak. The overprovisioned systems are also aimed at delivering maximal performance, with energy efficiency being considered as something desired, but non-essential. This project aims at making the network energy consumption proportional to the actual charge of this network (in terms of number of served users, or requested bandwidth). An energy proportional network can be designed by taking intelligent decisions (based on various constraints and metrics) into the network such as switching on and off network components in order to adapt the energy consumption to the user needs. This concept can be summarized under the general term of Green Cognitive Network Approach.

Contribution of PANAMA: PANAMA, in close cooperation with the SCEE team at IETR (thesis of Marwa Chafii, 2016), focuses on the design of new waveforms for multi carrier systems with reduced Peak to Average Power Ratio (PAPR).

9.1.2. ANR INVATE project with IRT b-com, Rennes

Participants: Rémi Gribonval, Nancy Bertin, Mohammed Hafsati.

Thesis on 3D audio scene decomposition for interactive navigation

Duration: 3 years (2016-2019)

Research axis: 3.2.2

Partners: IRT b<>com; Inria-Rennes; IRISA

Funding: ANR INVATE project (PIA)

The objective of this thesis is to develop tools to analyze audio scenes in order to identify, locate, and extract the sources present in the scene to re-spatialize them according to the user head orientation and the movement of the user in the targeted virtual scene.

9.1.3. ANR OATMIL project

Participants: Rémi Gribonval, Antoine Chatalic, Nicolas Courty.

Duration: 4 years (2017-2021)

Acronym: OATMIL (Bringing Optimal Transport and Machine Learning Together)

http://people.irisa.fr/Nicolas.Courty/OATMIL/

Research Axis 3.1

Partners: Obelix team and PANAMA Inria project-team, IRISA; LITIS, Rouen; Lagrange Laboratory, Nice; Technicolor R&I France, Rennes.

Coordinator: Nicolas Courty (Obelix team)

Description: The OATMIL project will propose novel concepts, methodologies, and new tools for exploiting large data collections. This will result from a cross-fertilization of fundamental tools and ideas from optimal transport (OT) and machine learning (ML). The main objective of OATMIL is to develop new techniques for large-scale machine learning, encompassing adaptability, scalability, and robustness, by a cross-fertilization of ideas coming from OT and ML. This cross-fertilization leads to two complementary scientific challenges : bringing OT to ML and bringing ML to OT.

Contribution of PANAMA: PANAMA will explore the use of dimension-reduction with sketching strategies in the context compressive optimal transport.

Funding: ANR

9.1.4. OSEO-FUI: voiceHome

Participants: Nancy Bertin, Frédéric Bimbot, Romain Lebarbenchon, Ewen Camberlein.

Duration: 3 years (2015-2017)

Research axis: 3.2

Partners: voicebox (formerly known as onMobile), Delta Dore, eSoftThings, Orange, Technicolor R&I France, LOUSTIC, Inria Nancy

Coordinator: voicebox

Description: The goal of the project was to design and implement a multi-channel voice interface for smart home and multimedia (set-top-box) appliances.

Contributions of PANAMA are focused on audio source localization and separation with distant microphones in real environments. This cooperation, which reached its end in November 2017, allowed us to make progress towards operational low-resource audio source localization and separation schemes, to disseminate software, collected data and scientific results published in 2018 in a journal paper [12], and to identify new research and development perspectives in adaptive microphone array processing for fast and robust audio scene analysis.

9.2. International Initiatives

9.2.1. Inria International Partners

9.2.1.1. Informal International Partners

PANAMA has strong recurrent collaborations with the LTS2 lab at EPFL, the Institute for Digital Communications at the University of Edimburgh, and the Institute for Mathematics of the Postdam University.

Nancy Bertin is "external collaborator" of the MERLIN project (project between the Acoustics Research Institute of the Austrian Academy of Sciences and the Signal Processing Laboratory at Brno University of Technology.)

9.3. International Research Visitors

9.3.1. Visits of International Scientists

- Gilles Blanchard, in Spring 2018, Professor, University of Potsdam, Germany
- Andreas Loukas, in January 2018 and December 2018, Post-doc, EPFL, Lausanne, Switzerland

9.3.1.1. Internships

- Roilhi Frajo Ibarra Hernandez, from March to August 2018, PhD Student at CICESE, Ensenada, Mexico

PERCEPTION Project-Team

7. Partnerships and Cooperations

7.1. European Initiatives

7.1.1. VHIA

Title: Vision and Hearing in Action

EU framework: FP7

Type: ERC Advanced Grant

Duration: February 2014 - January 2019

Coordinator: Inria

Inria contact: Radu Horaud

'The objective of VHIA is to elaborate a holistic computational paradigm of perception and of perception-action loops. We plan to develop a completely novel twofold approach: (i) learn from mappings between auditory/visual inputs and structured outputs, and from sensorimotor contingencies, and (ii) execute perception-action interaction cycles in the real world with a humanoid robot. VHIA will achieve a unique fine coupling between methodological findings and proof-of-concept implementations using the consumer humanoid NAO manufactured in Europe. The proposed multimodal approach is in strong contrast with current computational paradigms influenced by unimodal biological theories. These theories have hypothesized a modular view, postulating quasi-independent and parallel perceptual pathways in the brain. VHIA will also take a radically different view than today's audiovisual fusion models that rely on clean-speech signals and on accurate frontal-images of faces; These models assume that videos and sounds are recorded with hand-held or head-mounted sensors, and hence there is a human in the loop who intentionally supervises perception and interaction. Our approach deeply contradicts the belief that complex and expensive humanoids (often manufactured in Japan) are required to implement research ideas. VHIA's methodological program addresses extremely difficult issues: how to build a joint audiovisual space from heterogeneous, noisy, ambiguous and physically different visual and auditory stimuli, how to model seamless interaction, how to deal with high-dimensional input data, and how to achieve robust and efficient human-humanoid communication tasks through a well-thought tradeoff between offline training and online execution. VHIA bets on the high-risk idea that in the next decades, social robots will have a considerable economical impact, and there will be millions of humanoids, in our homes, schools and offices, which will be able to naturally communicate with us.
Website: https://team.inria.fr/perception/projects/erc-vhia/

7.1.2. VHIALab

Title: Vision and Hearing in Action Laboratory

EU framework: H2020

Type: ERC Proof of Concept

Duration: February 2018 - January 2019

Coordinator: Inria

Inria contact: Radu Horaud

The objective of VHIALab is the development and commercialization of software packages enabling a robot companion to easily and naturally interact with people. The methodologies developed in ERC VHIA propose state of the art solutions to human-robot interaction (HRI) problems in a general setting and based on audio-visual information. The ambitious goal of VHIALab will be to build software packages based on VHIA, thus opening the door to commercially available multi-party multi-modal human-robot interaction. The methodology investigated in VHIA may well be viewed as a generalization of existing single-user spoken dialog systems. VHIA enables a robot (i) to detect and to locate speaking persons, (ii) to track several persons over time, (iii) to recognize their behavior, and (iv) to extract the speech signal of each person for subsequent speech recognition and face-to-face dialog. These methods will be turned into software packages compatible with a large variety of companion robots. VHIALab will add a strong valorization potential to VHIA by addressing emerging and new market sectors. Industrial collaborations set up in VHIA will be strengthened.

7.2. International Research Visitors

7.2.1. Visits of International Scientists

- Professor Sharon Gannot, Bar Ilan University, Tel Aviv, Israel.
- Professor Tomislav Pribanic, University of Zagreb, Zagreb, Croatia.
- Doctor Christine Evers, Imperial College, London, United Kingdom.

PERVASIVE Project-Team

9. Partnerships and Cooperations

9.1. National Initiatives

9.1.1. LabEx Persyval, Project RHUM, "Robots in Human Environments"

Participants: Thierry Fraichard, Rémi Paulin, Patrick Reignier.

Partners: GIPSA, Inria, LIG, LJK and TIMC.
Dates:*[Sep. 15-Dec. 19].*

The RHUM project from the LabEx Persyval (ANR-11-LABX-0025-01) brings together ten teams from different labs from the Grenoble academic scene: GIPSA, Inria, LIG, LJK and TIMC. Its goal is to tackle scientific problems related to active perception, navigation in human environments, learning and adaptation of robots behaviors for social interaction. PERVASIVE contributes to the navigation in human environments aspects.

9.1.2. ANR Project Involved

Participants: Amr Al-Zhouri Al-Yafi, Patrick Reignier.

Other Partners: UMR G-SCOP, UMR LIG (Persuasive Interaction, IIHM, Getalp), CEA Liten, PACTE, Vesta Systems and Elithis.

Dates: Jan 2015 to Dec 2018

The ANR project Involved focuses on bringing solutions to building actors for upcoming challenges in energy management in residential buildings. The project explores a user centric energy management system, where user needs and tacit knowledge drive the search of solutions. These are calculated using a flexible energy model of the living areas. The system is personified by energy consultants with which building actors such as building owners, building managers, technical operators but also occupants, can interact with in order to co-define energy strategies, benefiting of both assets: tacit knowledge of human actors, and measurement with computation capabilities of calculators. Putting actors in the loop, i.e. making energy not only visible but also controllable is the needed step before large deployment of energy management solutions.

The project will develop interactive energy consultants for all the actors, providing energy management aided systems embedding models in order to support the decision making processes. MIRROR (interactive monitoring), WHAT-IF (interactive quantitative simulation), EXPLAIN (interactive qualitative simulation), SUGGEST- AND-ADJUST (interactive management) and RECOMMEND (interactive diagnosis) functionalities will be developed.

9.1.3. ANR Project CEEGE: Chess Expertise from Eye Gaze and Emotion

Participants: James Crowley, Dominique Vaufreydaz, Rafaellea Balzarini, Thomas Guntz

Other Partners: Dept of NeuroCognition, CITEN, Bielefeld University

Dates: Jan 2016 to Dec 2019

CEEGE is a multidisciplinary scientific research project conducted by the Inria PRIMA team in cooperation with the Dept of Cognitive Neuroscience at the University of Bielefeld. The primary impacts will be improved scientific understanding in the disciplines of Computer Science and Cognitive NeuroScience. The aim of this project is to experimentally evaluate and compare current theories for mental modelling for problem solving and attention, as well as to refine and evaluate techniques for observing the physiological reactions of humans to situation that inspire pleasure, displeasure, arousal, dominance and fear.

In this project, we will observe the visual attention, physiological responses and mental states of subject with different levels of expertise solving classic chess problems, and participating in chess matches. We will observe chess players using eye-tracking, sustained and instantaneous face-expressions (micro-expressions), skin conductivity, blood flow (BVP), respiration, posture and other information extracted from audio-visual recordings and sensor readings of players. We will use the recorded information to estimate the mental constructs with which the players understand the game situation. Information from visual attention as well as physiological reactions will be used to determine and model the degree to which a player understands the game situation in terms of abstract configurations of chess pieces. This will provide a structured environment that we will use for experimental evaluation of current theories of mental modeling and emotional response during problem solving and social interaction.

The project is organized in three phases. During the first phase, we will observe individual players of different levels of chess expertise solving known chess problems. We will correlate scan-path from eye tracking and other information about visual attention to established configurations of pieces and known solutions to chess problems. This will allow us to construct a labeled corpus of chess play that can be used to evaluate competing techniques for estimating mental models and physiological responses. In a second phase, we will observe the attention and face expressions of pairs of players of different levels of chess ability during game play. In particular, we will seek to annotate and segment recordings with respect to the difficulty of the game situation as well as situations that elicit particularly strong physiological reactions. In the final phase, we will use these recordings to evaluate the effectiveness of competing techniques for mental modeling and observation of emotions in terms of their abilities to predict the chess abilities of players, game outcomes and individual moves and player self reports. Results of our work will be published in scientific conferences and journals concerned with cognitive science and cognitive neuroscience as well as computer vision, multimodal interaction, affective computing and pervasive computing. Possible applications include construction of systems that can monitor the cognitive abilities and emotional reactions of users of interactive systems to provide assistance that is appropriate but not excessive, companion systems that can aid with active healthy ageing, and tutoring systems that can assist users in developing skills in a variety of domains including chess.

9.1.4. CDP EcoSesa - Cross Disciplinary Project of the ComUE UGA

Participants: James Crowley, Patrick Reignier, Rafaellea Balzarini Dates: Jan 2017 to Dec 2020

Cities and their energy systems are undergoing profound transformations. Electric Power networks are being transformed from centralized, high capacity, generating plants, dimensioned to meet peak loads to decentralized, local, production based on intermittent renewable sources. This transformation is made possible by integration of information and energy technologies, new energy materials and components, and the rapid spread of pervasive computing. The result is a change in the socio-economics of energy distribution, and a change in the role of users from passive consumers to active participants in a dynamically fluctuating energy market. Many cities worldwide have initiated research projects and experiments to accelerate the spread of clean technologies. However, these initiatives generally focus on a specific issue that depends on the priorities and preferences of the local decision makers and stakeholders. At the same time, academic research has generally been confined to specialized silos in energy materials and management systems, in Social Sciences as well as in Information and Communication Technologies (ICT), resulting in piecemeal knowledge.

The vision of Eco-SESA is to address the problems resulting from the transition to clean decentralized energy production based on renewable sources with a holistic integrated humansystem approach. The project will address the development of Safe, Efficient, Sustainable and Accessible energy systems, from the individual end-user to dynamic communities of stakeholders at the district and grid levels.

Pervasive is involved in two research front of the project :

- Interactive systems to involve occupants of buildings
- Emerging behaviors from individual to communities

9.1.5. ANR VALET

Participant: Dominique Vaufreydaz.

Partners: Inria (Pervasive and Chroma teams for Inria Rhône-Alpes, RITS in Paris), Ircyyn (Nantes), AKKA (Paris)
Dates:*[2016-2018]*.

The ANR VALET project investigates two aspects of car sharing. In the first one, a novel approach for solving vehicle redistribution problem is proposed by managing an autonomous platoons guided by professional drivers. The second aspect concerns autonomous parking of shared cars when they arrived at their destination parking lot. In this project, our researches address the prediction of pedestrians' behaviors during urban fleet movements and during parking phases. The PhD student (Pavan Vashista) recruited in this project focus on integrating models of human behaviors to evaluate the risk that surrounding pedestrians encounter the trajectory of the VALET vehicles. His PhD thesis started in February 2016 is co-supervised by Anne Spalanzani (Chroma team) and Dominique Vaufreydaz.

9.1.6. ANR HIANIC

Participant: Dominique Vaufreydaz.

Partners: ARMEN and PACCE teams from LS2N laboratory (Nantes), Inria (Pervasive and Chroma teams for Inria Rhône-Alpes, RITS in Paris), MAGMA from LIG laboratory (Grenoble).
Dates:*[2018-2021]*.

The HIANIC project proposes to endow autonomous vehicles with smart behaviors (cooperation, negotiation, socially acceptable movements) to address problems that arise when autonomous cars are mixed with pedestrians in urban shared environment. It aims at developing new technologies in term of autonomous navigation in dense and human populated traffic. In order to contribute to urban safety and intelligent mobility, the HIANIC project also explores the complex problem of sociable interactions between pedestrians and cars while sharing the same urban environment.

In this project, Dominique Vaufreydaz works jointly with the Chroma team on perceiving pedestrians and their behaviors around autonomous cars and on interaction between autonomous vehicles and pedestrians.

9.1.7. LabEx Persyval - Project MicroBayes: Probabilistic Machines for Low-level Sensor Interpretation

Participants: Emmanuel Mazer, Raphael Frisch Other Partners: Laurent Girin (GIPSA Lab), Didier Piau (L'Institut Fourier)

Dates: Nov 2016 to Nov 2019

The project MicroBayes builds on results of the recently completed EC FET Open project BAMBI to explore a new technique for Blind source separation and acoustic signal location using a new form of Bayesian Computer. The techniques have recently been demonstrated using a software simulation. Current plans are to implement and demonstrate the Bayesian computer using an FPGA. By the end of the project we expect to produce a hardware implementation suitable for use in low-cost low-power applications.

9.1.8. Competitivity Clusters

James Crowley is on the scientific committee for the Minalogic Competitivity Cluster. Minalogic is the global innovation cluster for digital technologies serving France's Auvergne-Rhône-Alpes region. The Scientific Committee advises the pole of strategy, advises local industry in proposal preparation, reviews FUI project proposals, and makes recommendations about labelling and support of project proposals.

9.2. European Initiatives

9.2.1. H2020 Project AI4EU - ICT-26-2018 Artificial Intelligence

From February 2018 to Sept 2018, James Crowley has participated in the core writing team for the H2020 proposal AI4EU submitted to the call ICT-26-2018 Artificial Intelligence. The project proposal was submitted in April 2018. The consortium has been notified in September 2018 that the project has been accepted for funding, and will begin on 1 January 2019.

AI4EU will bring together European researchers, educators, entrepreneurs and socio-economic innovators around a shared, crowd-sourced, innovation ecosystem that lowers barriers for education, research and innovation through AI. This ecosystem will be constructed by federating existing national innovation platforms and their user communities wherever possible, and by completing this federation with new components, new services and new enabling technologies that respond to opportunities for innovation.

9.2.2. H2020 FET Flagship Humane AI

James Crowley has participated as part of the core team for the proposal to create a FET Flagship named Humane AI. The Humane AI Flagship will develop the scientific and technological foundations needed to shape the AI revolution in a direction that is beneficial to humans on both individual and social level and strictly adheres to European ethical values and social norms. The core concept is that of AI systems that understand and adapt to complex dynamic environments and social settings in order enhance human capabilities and empower people as individuals and the society as whole.

Following a successful 1st stage proposal submitted in 2017, the consortium was invited to submit a 2nd stage proposal in Sept. 2018. We have been notified in November that this 2nd stage proposal has been accepted for funding. The project is start date is proposed for March 2019.

9.3. International Initiatives

9.3.1. Participation in Other International Programs

Vietnam

International partnership with **HUST** (Hanoi University of Science and Technology), Vietnam Joint lab unit between Grenoble INP and HUST, with the support of CNRS: **International Research Institute MICA** (Multimedia, Information, Communication and Applications) – UMI 2954 of CNRS from January 2006 to March 2018.

- Eric Castelli: French director of UMI 2954 “MICA Institute”, Vietnam, from 01 September 2001 to 5 February 2018
- Eric Castelli: now Adjunct Member of International Research Institute MICA, Vietnam (from June 2018)
- Eric Castelli: Responsible (and co-founder) of the International MASTER degree ACMI (Ambient Computing, Multimedia & Interactions), Hanoi University of Science and Technology (from January 2014 to June 2018)
- Eric Castelli: International scientific expert for the Vietnamese agency for research development NAFOSTED (National Foundation for Science and Technology Development), Ministry of Science and Technology, Vietnam (from 2015 to now)
- Eric Castelli: active participant to the bilateral French-Vietnam program PFIEV (Programme de Formation d’Ingénieurs d’Excellence au Vietnam), Grenoble INP is one of the main French partners.

Cambodia

International partnership with **ITC** (Institut de Technologie du Cambodge), Phnom Penh, Cambodia

- Eric Castelli: Member of the International Consortium of "Institut de Technologie du Cambodge (ITC)", Phnom Penh, Cambodia, representative of Hanoi University of Science and Technology (from 2008 to March 2018)
- Eric Castelli: Elected Member, representative of the International Consortium at the Administration Council of the "Institut de Technologie du Cambodge" (ITC), Phnom Penh, Cambodia (from 2014 to March 2018)

International partnership with **NIPTICT** (National Institute of Post and Telecoms, and Information Communication Technologies), Phnom Penh, Cambodia. NIPTICT Institute is under the authority of the Ministry of Posts and Telecommunications of Cambodia

- Eric Castelli: Scientific advisor for the Ministry of Posts and Telecommunications of Cambodia, for the creation of the research center CSSD (Computer Sciences for Social Development, a new research lab of NIPTICT)
- Eric Castelli: cowriter of the MELISSA international project, submitted to French AFD Agency (with NIPTICT (leader), NUOL, and HUST partners) in 2018 (1st submission) and 2019 (2nd submission)

PETRUS Project-Team

9. Partnerships and Cooperations

9.1. National Initiatives

9.1.1. ANR PerSoCloud (Jan 2017 - Dec 2020)

Partners: Orange Labs (coordinator), PETRUS (Inria-UVSQ), Cozy Cloud, U. of Versailles.
The objective of PerSoCloud is to design, implement and validate a full-fledged Privacy-by-Design Personal Cloud Sharing Platform. One of the major difficulties linked to the concept of personal cloud lies in organizing and enforcing the security of the data sharing while the data is no longer under the control of a central server. We identify three dimensions to this problem. Devices-sharing: assuming that the primary copy of user U1's personal data is hosted in a secure place, how to share and synchronize it with U1's multiple (mobile) devices without compromising security? Peers-sharing: how user U1 could exchange a subset of his-her data with an identified user U2 while providing to U1 tangible guarantees about the usage made by U2 of this data? Community-sharing: how user U1 could exchange a subset of his-her data with a large community of users and contribute to personal big data analytics while providing to U1 tangible guarantees about the preservation of his-her anonymity? In addition to tackling these three scientific and technical issues, a legal analysis will guarantee compliance of this platform with the security and privacy French and UE regulation, which firmly promotes the Privacy by Design principle, including the current reforms of personal data regulation.

9.1.2. PIA - PDP SECSi (May 2016 - Dec 2017)

Partners: Cozy Cloud (coordinator), Qwant, PETRUS (Inria-UVSQ), FING.
The objective of this PIA-PDP (Programme Investissement d'Avenir - Protection des Données Personnelles) SECSi project is to build a concrete Personal Cloud platform which can support a large scale deployment of Self Data services. Three major difficulties are identified and will be tackled in this project: (1) how to implement and enforce a fine control of the data flow when personal data are exploited by third party applications, (2) how to protect these same applications when processing is delegated to the personal cloud platform itself and (3) how to implement personalized search on the web without hurting user's privacy.

9.1.3. CityLab@Inria, Inria Project Lab (May 2014 - Oct 2018)

Inria Partners: ARLES-MIMOVE, CLIME, DICE, FUN, MYRIADS, OAK, PETRUS, URBANET, WILLOW.
External partners: UC Berkeley.
CityLab@Inria studies ICT solutions toward smart cities that promote both social and environmental sustainability. A strong emphasis of the Lab is on the undertaking of a multi-disciplinary research program through the integration of relevant scientific and technology studies, from sensing up to analytics and advanced applications, so as to actually enact the foreseen smart city Systems of Systems. PETRUS contributes to Privacy-by-Design architectures for trusted smart objects so as to ensure privacy to citizens, which is critical for ensuring that urbanscale sensing contributes to social sustainability and does not become a threat. The PhD Thesis of Dimitris Tsoulovos, co-directed by MIMOVE and PETRUS, is funded by CityLab. http://citylab.inria.fr/

9.1.4. GDP-ERE, DATA-IA project (Sept. 2018 - Aug. 2021)

Partners: DANTE (U. of Versailles), PETRUS (Inria-UVSQ).

The role of individuals and the control of their data is a central issue in the new European regulation (GDPR) enforced on 25th May 2018. Data portability is a new right provided under those regulations. It allows citizens to retrieve their personal data from the companies and governmental agencies that collected them, in an interoperable digital format. The goals are to enable the individual to get out of a captive ecosystem, and to favor the development of innovative personal data services beyond the existing monopolistic positions. The consequence of this new right is the design and deployment of technical platforms, commonly known as Personal Cloud. But personal cloud architectures are very diverse, ranging from cloud based solutions where millions of personal cloud are managed centrally, to self-hosting solutions. These diversity is not neutral both in terms of security and from the point of view of the chain of liabilities. The GDP-ERE project tends to study those issues in an interdisciplinary approach by the involvement of jurists and computers scientists. The two main objectives are (i) to analyze the effects of the personal cloud architectures on legal liabilities, enlightened by the analysis of the rules provided under the GDPR and (ii) to propose legal and technological evolutions to highlight the share of liability between each relevant party and create adapted tools to endorse those liabilities. http://dataia.eu/actualites/linstitut-dataia-vous-presente-le-projet-gdp-ere-rgpd-et-cloud-personnel-de-lempowerment

9.2. International Research Visitors

9.2.1. Visits to International Teams

9.2.1.1. Research Stays Abroad

Iulian Sandu Popa has visited the Computer Science department of NJIT (New Jersey Institute of Technology) for two months (Mars to April) during 2018. Iulian has a long history of collaboration with this department at NJIT, this being his second long stay since 2011. In particular, he collaborates at NJIT with Professor Vincent Oria on topics related to spatiotemporal data management and with Professor Cristian Borcea on topics such as privacy-preserving mobile computing for location-based applications [5] and secure and distributed crowd-sensing for smart city applications. For the latter topic, a joint journal paper has been recently submitted (see Section 7.4).

POTIOC Project-Team

9. Partnerships and Cooperations

9.1. Regional Initiatives

HOBIT:

Funding: Aquitaine Science Transfer

Duration: 2018

Local coordinator: Martin Hachet

Partners: Université de Bordeaux

We are currently moving our platform HOBIT from his lab state to a commercial product.

Erlen:

Funding: Université de Bordeaux - Hacketafac program

Duration: 2018-2019

Local coordinator: Pierre-Antoine Cinquin

We won a grant from Université de Bordeaux to explore awareness of power consumption by way of tangible and ambient interfaces.

Neuroperf:

Funding: Idex Université Bordeaux

Duration: 2017-2019

Coordinator: Jean-Arthur Micoulaud Franci

Local coordinator: Fabien Lotte

Partners: SANPSY - Potioc

This project aims at studying EEG-based Neurofeedback to reduce fatigue symptoms in sleep-deprived individuals. See http://brain.labex.u-bordeaux.fr/Actualites/Selection-projets-recherche-Clinique-2017-i5064.html

9.2. National Initiatives

eTAC: Tangible and Augmented Interfaces for Collaborative Learning:

Funding: EFRAN

Duration: 2017-2021

Coordinator: Université de Lorraine

Local coordinator: Martin Hachet

Partners: Université de Lorraine, Inria, ESPE, Canopé, OpenEdge,

the e-TAC project proposes to investigate the potential of technologies ”beyond the mouse” in order to promote collaborative learning in a school context. In particular, we will explore augmented reality and tangible interfaces, which supports active learning and favors social interaction.

ANR Rebel:

Duration: 2016-2019

Coordinator: Fabien Lotte

Funding: ANR Jeune Chercheur Jeune Chercheuse Project

Partners: Disabilities and Nervous Systems Laboratory Bordeaux

Brain-Computer Interfaces (BCI) are communication systems that enable their users to send commands to computers through brain activity only. While BCI are very promising for assistive technologies or human-computer interaction (HCI), they are barely used outside laboratories, due to a poor reliability. Designing a BCI requires 1) its user to learn to produce distinct brain activity patterns and 2) the machine to recognize these patterns using signal processing. Most research efforts focused on signal processing. However, BCI user training is as essential but is only scarcely studied and based on heuristics that do not satisfy human learning principles. Thus, currently poor BCI reliability is probably due to suboptimal user training. Thus, we propose to create a new generation of BCI that apply human learning principles in their design to ensure the users can learn high quality control skills, hence making BCI reliable. This could change HCI as BCI have promised but failed to do so far.

Inria Project Lab BCI-LIFT:

Duration: 2015-2018

Partners: Inria team Athena (Inria Sophia-Antipolis), Inria team Hybrid (Inria Rennes), Inria team Neurosys (Inria Nancy), LITIS (Université de Rouen), Inria team DEMAR (Inria Sophia-Antipolis), Inria team MINT (Inria Lille), DyCOG (INSERM Lyon)

Coordinator: Maureen Clerc (Inria Sophia Antipolis)

Local coordinator: Fabien Lotte

The aim is to reach a next generation of non-invasive Brain-Computer Interfaces (BCI), more specifically BCI that are easier to appropriate, more efficient, and suit a larger number of people. With this concern of usability as our driving objective, we will build non-invasive systems that benefit from advanced signal processing and machine learning methods, from smart interface design, and where the user immediately receives supportive feedback. What drives this project is the concern that a substantial proportion of human participants is currently categorized "BCI-illiterate" because of their apparent inability to communicate through BCI. Through this project we aim at making it easier for people to learn to use the BCI, by implementing appropriate machine learning methods and developping user training scenarios.

website: http://bci-lift.inria.fr/

Inria Project Lab AVATAR:

Duration: 2018-2022

Partners: Inria project-teams: GraphDeco, Hybrid, Loki, MimeTIC, Morpheo

Coordinator: Ludovic Hoyet (Inria Rennes)

Local coordinator: Martin Hachet

This project aims at designing avatars (i.e., the user's representation in virtual environments) that are better embodied, more interactive and more social, through improving all the pipeline related to avatars, from acquisition and simulation, to designing novel interaction paradigms and multi-sensory feedback.

website: https://avatar.inria.fr

9.3. European Initiatives

9.3.1. FP7 & H2020 Projects

BrainConquest:

Program: ERC Starting Grant

Project title: BrainConquest - Boosting Brain-Computer Communication with High Quality User Training

Duration: 2017-2022

Coordinator: Fabien Lotte

Abstract: Brain-Computer Interfaces (BCIs) are communication systems that enable users to send commands to computers through brain signals only, by measuring and processing these signals. Making computer control possible without any physical activity, BCIs have promised to revolutionize many application areas, notably assistive technologies, e.g., for wheelchair control, and man-machine interaction. Despite this promising potential, BCIs are still barely used outside laboratories, due to their current poor reliability. For instance, BCIs only using two imagined hand movements as mental commands decode, on average, less than 80% of these commands correctly, while 10 to 30% of users cannot control a BCI at all. A BCI should be considered a co-adaptive communication system: its users learn to encode commands in their brain signals (with mental imagery) that the machine learns to decode using signal processing. Most research efforts so far have been dedicated to decoding the commands. However, BCI control is a skill that users have to learn too. Unfortunately how BCI users learn to encode the commands is essential but is barely studied, i.e., fundamental knowledge about how users learn BCI control is lacking. Moreover standard training approaches are only based on heuristics, without satisfying human learning principles. Thus, poor BCI reliability is probably largely due to highly suboptimal user training. In order to obtain a truly reliable BCI we need to completely redefine user training approaches. To do so, I propose to study and statistically model how users learn to encode BCI commands. Then, based on human learning principles and this model, I propose to create a new generation of BCIs which ensure that users learn how to successfully encode commands with high signal-to-noise ratio in their brain signals, hence making BCIs dramatically more reliable. Such a reliable BCI could positively change man-machine interaction as BCIs have promised but failed to do so far.

9.3.2. Collaborations in European Programs, Except FP7 & H2020

VISTE:

Program: Erasmus + Key Action 2: Cooperation for Innovation and Exchange of Good Practices

Project title: VISTE: Empowering spatial thinking of students with visual impairment

Duration: 01/09/2016 - 31/08/2019

Coordinator: Professor Marinos Kavouras (Vice-Rector, National Technical University of Athens and VISTE Project Leader)

Partners: National Technical University of Athens, Inria, Intrasoft International S.A., Casa Corpului Didactic Cluj, Eidiko Dimotiko Sxolio Tiflon Kallitheas, Liceul Special pentru Deficienti de Vedere Cluj-Napoca. External collaborators : IRSA, RealityTech

Abstract: Six partners from four European countries are working together to develop strategies, educational components and an ICT toolkit towards effective spatial thinking of students with VI, facilitating inclusion. The competence of spatial thinking, usage and interpretation of maps or other spatial tools is not self-evident for all; it is a dexterity which must be cultivated. For students experiencing disabilities, such as visual impairment (VI), spatial thinking proves to be an imperative skill for perceiving the world far beyond their immediate experience. Learning functional ways to utilize spatial experiences as an entirety and realize the relationships between objects in space and themselves is vital. Maps and other spatial representations are a splendid source of information for

portraying space and environment. By using tactile maps and innovative ICT technologies, children may deploy their spatial notion more effectively compared to proximate orientation experiences in accordance with verbal directions. Providing thus a concrete set of such tools would empower specific spatial thinking skills not only of those with VI but of all students. VISTE aims at empowering the spatial thinking skills of students with VI. This will be accomplished by providing an innovative methodological framework and a semantic and technical infrastructure for developing appropriate inclusive educational modules to foster spatial thinking. The project's main target groups are primary/secondary education students, as well as teachers, teachers' trainers, and staff involved in their education.

RSVP-BCI:

Program: DGA-DSTL Project
Project title: Assessing and Optimising Human-Machine Symbiosis through Neural signals for Big Data Analytics
Duration: 2014-2018
Coordinator: Damien Coyle and Fabien Lotte
Partners: Ulster University, UK, Potioc, France
Abstract: This project objective is to design new tools for Big Data analysis, and in particular visual analytics tools that tap onto human cognitive skills as well as on Brain-Computer Interfaces. The goal is to enable the user to identify and select relevant information much faster than what can be achieved by using automatic tools or traditional human-computer interfaces. More specifically, this project will aim at identifying in a passive way various mental states (e.g., different kinds of attention, mental workload, relevant stimulus perception, etc.) in order to optimize the display, the arrangement of the selection of relevant information.

9.3.3. Collaborations with Major European Organizations

Partner 1: Univ. Freiburg (Germany)
EEG signal processing and decoding using robust methods
Partner 2: TU Berlin (Germany)
EEG data generation and simulation

9.4. International Initiatives

9.4.1. Inria International Partners

9.4.1.1. Informal International Partners

Partner: RIKEN Brain Science Institute, Japan
Topic: BCI, Neurofeedback and EEG signal decoding

9.4.2. Participation in Other International Programs

Partner: University of Waterloo, Canada
Program: Idex Bordeaux collaboration grant
Duration: 2018
Coordinators: Edith Law (Canada), Pierre-Yves Oudeyer (France)
Topic: Curiosity

9.5. International Research Visitors

9.5.1. Visits of International Scientists

9.5.1.1. Internships

- Marie Gonzales, Universidad Chile
- Mehdi Bugallo, University of Minho, Portugal
- Satyam Kumar, IIT Kanpur, India

9.5.2. Visits to International Teams

9.5.2.1. Research Stays Abroad

- RIKEN Brain Science Institute, Japan (Fabien Lotte)

RAINBOW Project-Team

9. Partnerships and Cooperations

9.1. Regional Initiatives

9.1.1. ARED Locoflot

Participants: Ide Flore Kenmogne Fokam, Vincent Drevelle, Eric Marchand.

no Inria Rennes 9944, duration: 36 months.

This project funded by the Brittany council started in October 2015. It supports in part Ide Flore Kenmogne Fokam's Ph.D. about cooperative localization in multi-robot fleets using interval analysis (see Section 7.1.7).

9.1.2. ARED Mod4Nav

Participants: Aline Baudry, Marie Babel.

no INSA Rennes 2016/01, duration: 36 months.

This project funded by the Brittany council started in October 2016. It supports in part Aline Baudry's Ph.D. about wheelchair modeling.

9.1.3. Allocation d'installation scientifique

Participant: Claudio Pacchierotti.

no CNRS Rennes 17C0487, duration: 36 months.

This grant from "Rennes Métropole" has been obtained in July 2017 and supported the activities related to the teleoperation of drones (quadrotor UAVs) using wearable haptics interfaces.

9.1.4. IRT Jules Verne Mascot

Participants: François Chaumette, Fabien Spindler, Souriya Trinh.

no Inria Rennes 10361, duration: 36 months.

This project ended in December 2018. It was managed by IRT Jules Verne in Nantes and achieved in cooperation with LS2N, Airbus, Renault, Faurecia and GE. Our goal in this project was to perform screwing for various industrial applications by visual servoing. We also developed an application of rivet detection and 3D localisation on an aircraft cabin.

9.1.5. IRT Jules Verne Happy

Participant: François Chaumette.

no Inria Rennes 13521, duration: 36 months.

This project started in June 2018. It is managed by IRT Jules Verne in Nantes and achieved in cooperation with LS2N and Airbus. Its goal is to develop local sensor-based control methods for the assembly of large parts of aircrafts.

9.1.6. IRT b<>com NeedleWare

Participants: Hadrien Gurnel, Alexandre Krupa.

no Inria Rennes 9072, duration: 36 months.

This project started in October 2016. It supports Hadrien Gurnel's Ph.D. about the study of a shared control strategy fusing haptic and visual control for assisting manual steering of needles for biopsy or therapy purposes in a synergetic way (see Section 7.3.1).

9.1.7. Prisme

Participants: Solenne Fortun, Marie Babel.

no Insa Rennes 2017-0004, duration: 33 months.

This project started in January 2017 and is supported by Brittany region/BPI. This project aims at designing a fall prevention strategy based on the sensing collaboration of a smart wheelchair and a smart medical bed. Fall detection and automatic positioning of the wheelchair next to the bed issues are planned to be addressed (see Section 7.4.5).

9.1.8. Silver Connect

Participant: Marie Babel.

no Insa Rennes 2018-0076, duration: 24 months.

This project started in November 2018 and is supported by Brittany region/BPI as well as FEDER. This project aims at designing a fall detection framework by means of vision-based algorithms coupled with deep learning solutions.

9.2. National Initiatives

9.2.1. ANR JCJC SenseFly

Participants: Muhammad Usman, Paolo Robuffo Giordano.

no Irisa CNRS 50476, duration: 36 months.

The ANR "Jeune Chercheur" SenseFly project started in August 2015 and ended in December 2018. Its goal is to advance the state-of-the-art in multi-UAV in the design and implementation of fully decentralized and sensor-based group behaviors by only resorting to onboard sensing (mainly cameras and IMU) and local communication (e.g., Bluetooth communication, wireless networks). Topics such as individual flight control, formation control robust against sensor limitations (e.g., limited field of view, occlusions), distributed estimation of relative positions/bearings from local sensing, maintenance of architectural properties of a multi-UAV formation are studied in the project. Part of the platforms described in Section 6.6.6 has been purchased thanks to this grant.

9.2.2. ANR PLaTINUM

Participant: Vincent Drevelle.

no Inria Sophia 10204, duration: 42 months.

This project started in November 2015. It involves a consortium managed by Litis in Rouen with IGN Matis (Paris), Le2i (Le Creusot) and Rainbow group. It aims at proposing novel solutions to robust long-term mapping of urban environments.

9.2.3. Equipex Robotex

Participants: Fabien Spindler, François Chaumette.

no Inria Rennes 6388, duration: 9 years.

Rainbow is one of the 15 French academic partners involved in the Equipex Robotex network that started in February 2011. It is devoted to get and manage significant equipment in the main robotics labs in France. In the scope of this project, we have obtained the humanoid robot Romeo (see Section 6.6.5).

9.2.4. CNRS/INS2I - PEPS JCJC ShareHaptics

Participant: Claudio Pacchierotti.

no Inria Rennes 7991, duration: 12 months.

The project addresses the need of combining wearable haptics and shared control. Shared-control techniques will enable a single user to intuitively control the coordinated motion of several robots (e.g., a team of drones/manipulators). At the same time, multi-type multi-point wearable haptic devices will provide the necessary multi-faceted feedback information to the user.

9.3. European Initiatives

9.3.1. FP7 & H2020 Projects

9.3.1.1. FP7 Space RemoveDEBRIS

Participants: Eric Marchand, François Chaumette.

Instrument: Specific Targeted Research Project

Duration: October 2013 - March 2019

Coordinator: University of Surrey (United Kingdom)

Partners: Surrey Satellite Technology (United Kingdom), Airbus (Toulouse, France and Bremen, Germany), Isis (Delft, The Netherlands), CSEM (Neuchâtel, Switzerland), Stellenbosch University (South Africa).

Inria contact: François Chaumette

Abstract: Our goal in this project is to validate model-based tracking algorithms on images acquired during an actual space debris removal mission [74],[73].

9.3.1.2. H2020 ICT Comanoid

Participants: Souriya Trinh, Fabien Spindler, François Chaumette.

Title: Multi-contact Collaborative Humanoids in Aircraft Manufacturing

Programme: H2020

Duration: January 2015 - December 2018

Coordinator: CNRS (Lirmm)

Partners: Airbus Group (France), DLR (Germany), Università Degli Studi di Roma La Sapienza (Italy), CNRS (I3S)

Inria contact: François Chaumette

Abstract: Comanoid investigates the deployment of robotic solutions in well-identified Airbus airliner assembly operations that are laborious or tedious for human workers and for which access is impossible for wheeled or rail-ported robotic platforms. As a solution to these constraints a humanoid robot is proposed to achieve the described tasks in real-use cases provided by Airbus Group. At a first glance, a humanoid robotic solution appears extremely risky, since the operations to be conducted are in highly constrained aircraft cavities with non-uniform (cargo) structures. Furthermore, these tight spaces are to be shared with human workers. Recent developments, however, in multi-contact planning and control suggest that this is a much more plausible solution than current alternatives such as a manipulator mounted on multi-legged base. Indeed, if humanoid robots can efficiently exploit their surroundings in order to support themselves during motion and manipulation, they can ensure balance and stability, move in non-gaited (acyclic) ways through narrow passages, and also increase operational forces by creating closed-kinematic chains. Bipedal robots are well suited to narrow environments specifically because they are able to perform manipulation using only small support areas. Moreover, the stability benefits of multi-legged robots that have larger support areas are largely lost when the manipulator must be brought close, or even beyond, the support borders. COMANOID aims at assessing clearly how far the state-of-the-art stands from such novel technologies. In particular the project focuses on implementing a real-world humanoid robotics solution using the best of research and innovation. The main challenge are to integrate current scientific and technological advances including multi-contact planning and control; advanced visual-haptic servoing; perception and localization; human-robot safety, and the operational efficiency of cobotics solutions in airliner manufacturing.

This year, we published [75] in the scope of this project (see Section 7.1.3). Short stays have been achieved at DLR and LIRMM for the integration of our visual tracking and visual servoing methods on the humanoid robots Toro and HRP-4.

9.3.1.3. H2020 ICT Romans

Participants: Firas Abi Farraj, Marco Cognetti, Marco Aggravi, Fabrizio Schiano, Pol Mordel, Fabien Spindler, François Chaumette, Claudio Pacchierotti, Paolo Robuffo Giordano.

Title: Robotic Manipulation for Nuclear Sort and Segregation

Programme: H2020

Duration: May 2015 - October 2018

Coordinator: University of Birmingham

Partners: NLL (UK), CEA (France), Univ. Darmstadt (Germany)

CNRS contact: Paolo Robuffo Giordano

Abstract: The goal of the RoMaNS (Robotic Manipulation for Nuclear Sort and Segregation) project has been to advance the state of the art in mixed autonomy for tele-manipulation, to solve a challenging and safety-critical "sort and segregate" industrial problem, driven by urgent market and societal needs. Cleaning up the past half century of nuclear waste, in the UK alone (mostly at the Sellafield site), represents the largest environmental remediation project in the whole of Europe. Most EU countries face related challenges. Nuclear waste must be "sorted and segregated", so that low-level waste is placed in low-level storage containers, rather than occupying extremely expensive and resource intensive high-level storage containers and facilities. Many older nuclear sites (>60 years in UK) contain large numbers of legacy storage containers, some of which have contents of mixed contamination levels, and sometimes unknown contents. Several million of these legacy waste containers must now be cut open, investigated, and their contents sorted. This can only be done remotely using robots, because of the high levels of radioactive material. Current state-of-the-art practice in the industry, consists of simple tele-operation (e.g. by joystick or teach-pendant). Such an approach is not viable in the long-term, because it is prohibitively slow for processing the vast quantity of material required. The project aimed at: 1) Develop novel hardware and software solutions for advanced bi-lateral master-slave tele-operation. 2) Develop advanced autonomy methods for highly adaptive automatic grasping and manipulation actions. 3) Combine autonomy and tele-operation methods using state-of-the-art understanding of mixed initiative planning, variable autonomy and shared control approaches. 4) Deliver a TRL 6 demonstration in an industrial plant-representative environment at the UK National Nuclear Lab Workington test facility.

9.3.1.4. H2020 ICT CrowdBot

Participants: Julien Legros, Javad Amirian, Fabien Grzeskowiak, Ceilidh Hoffmann, Marie Babel, Jean Bernard Hayet, Julien Pettré.

Title: Robot navigation in dense crowds

Programme: H2020

Duration: Jan 2018 - Jun 2021

Coordinator: Inria

Partners: UCL (UK), SoftBank Robotics (France), Univ. Aachen (Germany), EPFL (Switzerland), ETHZ (Switzerland), Locomotec (Germany)

Inria contact: Julien Pettré

Abstract: CROWDBOT will enable mobile robots to navigate autonomously and assist humans in crowded areas. Today's robots are programmed to stop when a human, or any obstacle is too close, to avoid coming into contact while moving. This prevents robots from entering densely frequented areas and performing effectively in these high dynamic environments. CROWDBOT aims to fill in the gap in knowledge on close interactions between robots and humans during navigation tasks. The project considers three realistic scenarios: 1) a semi-autonomous wheelchair that must adapt its trajectory to unexpected movements of people in its vicinity to ensure neither its user nor the pedestrians around it are injured; 2) the commercially available Pepper robot that must navigate in a dense crowd while actively approaching people to assist them; 3) the under development robot cuyBot will adapt to compact crowd, being touched and pushed by people. These scenarios generate numerous ethical and safety concerns which this project addresses through a dedicated Ethical and Safety Advisory Board that will design guidelines for robots engaging in interaction in crowded environments. CROWDBOT gathers the required expertise to develop new robot capabilities to allow robots to move in a safe and socially acceptable manner. This requires achieving step changes in a) sensing abilities to estimate the crowd motion around the robot, b) cognitive abilities for the robot to predict the short term evolution of the crowd state and c) navigation abilities to perform safe motion at close range from people. Through demonstrators and open software components, CROWDBOT will show that safe navigation tasks can be achieved within crowds and will facilitate incorporating its results into mobile robots, with significant scientific and industrial impact. By extending the robot operation field toward crowded environments, we enable possibilities for new applications, such as robot-assisted crowd traffic management.

9.3.1.5. H2020 FET-OPEN H-Reality

Participants: Claudio Pacchierotti, Paolo Robuffo Giordano, François Chaumette, Anatole Lécuyer [Hybrid], Maud Marchal [Hybrid].

Title: Mixed Haptic Feedback for Mid-Air Interactions in Virtual and Augmented Realities

Programme: H2020

Duration: October 2018 - September 2021

Coordinator: Univ. Birmingham (UK)

Partners: Univ. Birmingham (UK, coordinator), TU Delft (NL), Ultrahaptics (UK) and Actronika SAS (France)

CNRS contact: Claudio Pacchierotti

Abstract: Digital content today remains focused on visual and auditory stimulation. Even in the realm of VR and AR, sight and sound remain paramount. In contrast, methods for delivering haptic (sense of touch) feedback in commercial media are significantly less advanced than graphical and auditory feedback. Yet without a sense of touch, experiences ultimately feel hollow, virtual realities feel false, and Human-Computer Interfaces become unintuitive. Our vision is to be the first to imbue virtual objects with a physical presence, providing a revolutionary, untethered, virtual-haptic reality: H-Reality. The ambition of H-Reality will be achieved by integrating the commercial pioneers of ultrasonic "non-contact" haptics, state-of-the-art vibrotactile actuators, novel mathematical and tribological modelling of the skin and mechanics of touch, and experts in the psychophysical rendering of sensation. The result will be a sensory experience where digital 3D shapes and textures are made manifest in real space via modulated, focused, ultrasound, ready for the untethered hand to feel, where next-generation wearable haptic rings provide directional vibrotactile stimulation, informing users of an object's dynamics, and where computational renderings of specific materials can be distinguished via their surface properties. The implications of this technology will be far-reaching. The computer touch-screen will be brought into the third dimension so that swipe gestures will be augmented with instinctive rotational gestures, allowing intuitive manipulation of 3D data sets and strolling about the desktop as a virtual landscape of icons, apps and files. H-Reality will transform online interactions; dangerous machinery will be operated virtually from the safety of the home, and surgeons will hone their skills on thin air.

9.3.2. Collaborations in European Programs, Except FP7 & H2020

9.3.2.1. Interreg Adapt

Participants: Nicolas Le Borgne, Marie Babel.

Programme: Interreg VA France (Channel) England

Project acronym: Adapt

Project title: Assistive Devices for empowering disAbled People through robotic Technologies

Duration: Jan 2017 - Jun 2021

Coordinator: ESIGELEC/IRSEEM Rouen

Other partners: INSA Rennes - IRISA, LGCGM, IETR (France), Université de Picardie Jules Verne - MIS (France), Pôle Saint Hélier (France), CHU Rouen (France), Réseau Breizh PC (France), Pôle TES (France), University College of London - Aspire CREATE (UK), University of Kent (UK), East Kent Hospitals Univ NHS Found. Trust (UK), Health and Europe Centre (UK), Plymouth Hospitals NHS Trust (UK), Canterbury Christ Church University (UK), Kent Surrey Sussex Academic Health Science Network (UK), Cornwall Mobility Center (UK).

Abstract: This project aims to develop innovative assistive technologies in order to support the autonomy and to enhance the mobility of power wheelchair users with severe physical/cognitive disabilities. In particular, the objective is to design and evaluate a power wheelchair simulator as well as to design a multi-layer driving assistance system.

9.3.3. Collaborations with Major European Organizations

9.3.3.1. ANR Opmops

Participants: Florian Berton, Julen Bruneau, Julien Pettré.

Programme: ANR

Project acronym: Opmops

Project title: Organized Pedestrian Movement in Public Spaces: Preparation and Crisis Management of Urban Parades and Demonstration Marches with High Conflict Potential

Duration: June 2017 - June 2020

Coordinator: Université de Haute Alsace (for France), Technische Universität Kaiserslautern (for Germany)

Other partners: Gendarmerie Nationale, Hochschule München, ONHYS S.A.S, Polizei Rheinland-Pfalz, Universität Koblenz-Landau, VdS GmbH

Abstract: This project is about parades of highly controversial groups or of political demonstration marches that are considered as a major threat to urban security. Due to the movement of the urban parades and demonstration marches (in the following abbreviated by UPM) through large parts of cities and the resulting space and time dynamics, it is particularly difficult for forces of civil security (abbreviated in the following by FCS) to guarantee safety at these types of urban events without endangering one of the most important indicators of a free society. In this proposal, partners representing the FCS (police and industry) will cooperate with researchers from academic institutions to develop a decision support tool which can help them both in the preparation phase and crisis management situations of UPMs. Specific technical issues which the French-German consortium will have to tackle include the following: Optimization methods to plan UPM routes, transportation to and from the UPM, location and personnel planning of FCS, control of UPMs using stationary and moving cameras, and simulation methods, including their visualization, with specific emphasis on social behavior.

9.3.3.2. iProcess

Participants: Agniva Sengupta, François Chaumette, Alexandre Krupa, Eric Marchand, Fabien Spindler.

Project acronym: i-Process

Project title: Innovative and Flexible Food Processing Technology in Norway

Duration: January 2016 - December 2019

Coordinator: Sintef (Norway)

Other partners: Nofima, Univ. of Stavanger, NMBU, NTNU (Norway), DTU (Denmark), KU Leuven (Belgium), and about 10 Norwegian companies.

Abstract: This project is granted by the Norwegian Government. Its main objective is to develop novel concepts and methods for flexible and sustainable food processing in Norway. In the scope of this project, the Rainbow group is involved for visual tracking and visual servoing of generic and potentially deformable objects (see Section 7.1.2). Agniva Sengupta spent a 2-month visit at Sintef from March to April 2018.

9.3.3.3. activeVISION

Participants: Alexandre Krupa, François Chaumette, Eric Marchand, Agniva Sengupta, Fabien Spindler.

Project acronym: activeVISION

Project title: Active perception and 3D pose estimation of compliant deformable objects applicable to agricultural and ocean space sector

Duration: January 2018 - December 2018

Coordinator: Inria Rennes - Bretagne Atlantique and Sintef (Norway)

Abstract: This project is granted by the PHC Aurora 2018 program that provides travel funds for exchange between France and Norway. It concerns the development of active perception methodology by means of visual servoing for localization and exploration of the scene and the object(s) of interest. Alexandre Krupa and Fabien Spindler spent a 1-week visit at Sintef in Trondheim in March 2018. Prof. Ekrem Misimi from Sintef spent a 3-month visit in Rainbow from May to July 2018.

9.4. International Initiatives

9.4.1. Inria Associate Teams Not Involved in an Inria International Labs

9.4.1.1. ISI4NAVE

Title: Innovative Sensors and adapted Interfaces for assistive NAVigation and pathology Evaluation

International Partner (Institution - Laboratory - Researcher):

UCL London (United Kingdom) - Aspire CREATe laboratory - Tom Carlson

Duration: Jan 2016 – Dec 2018

See also: https://team.inria.fr/isi4nave/

Abstract: The global ageing population, along with disability compensation constitute major challenging societal and economic issues. In particular, achieving autonomy remains a fundamental need that contributes to the individual's wellness and well-being. In this context, innovative and smart technologies are designed to achieve independence while matching user's individual needs and desires.

Hence, designing a robotic assistive solution related to wheelchair navigation remains of major importance as soon as it compensates partial incapacities. This project will then address the following two issues. First, the idea is to design an indoor / outdoor efficient obstacle avoidance system that respects the user intention, and does not alter user perception. This involves embedding innovative sensors to tackle the outdoor wheelchair navigation problem. The second objective is to take advantage of the proposed assistive tool to enhance the user Quality of Experience by means of biofeedback. Indeed, adapted interfaces should improve the understanding of people that suffer from cognitive and/or visual impairments.

The originality of the project is to continuously integrate medical validation as well as clinical trials during the scientific research work in order to match user needs and acceptation.

9.4.2. Participation in Other International Programs

9.4.2.1. ACRV

François Chaumette is one of the five external experts of the Australian Center for Robotic Vision (see http://roboticvision.org). This center groups QUT in Brisbane, ANU in Canberra, Monash University and Adelaide University. In the scope of this project, Agniva Sengupta and Axel Lopez Gandia received a grant to participate to the 2018 Robotic Vision Summer School in Kioloa (New South Wales) and spent a 1-week visit at QUT in March 2018.

9.5. International Research Visitors

9.5.1. Visits of International Scientists

9.5.1.1. Visiting Researchers

- Claudia Elvira Esteves Jaramillo (University of Guanajuato, Mexico) from Jan 2018 until Dec 2018

9.5.1.2. Internships

- Giuseppe Sirignano (Univ. Salerno, Italy), until March 2018
- Mario Selvaggio (Univ. Naples, Italy), from October 2018 until December 2018
- Catalin Stefan Teodorescu (UCL London, UK) from November 2018 until December 2018 in the scope of the Inria Associate team ISI4NAVE (see Section 9.4.1.1)
- Noe Aldana Murillo (CIMAT, Mexico), from Sep 2018
- Jiuyang Bai (Inria), Jun 2018
- Marco Ferro (University of Rome “La Sapienza”, Italy) from Feb 2018 until Aug 2018
- Kaixiang Zhang (University of Zhejiang, China) until Jul 2018

9.5.2. Visits to International Teams

9.5.2.1. Research Stays Abroad

- Firas Abi-Farraj spent a 6-month visit at the Institute of Robotics and Mechatronics of DLR (Münich, Germany) where he worked on the humanoid robot TORO in the scope of his Ph.D. (see [50]).
- Agniva Sengupta spent a 2-month visit at Sintef in Trondheim where he worked on the tracking of deformable objects using a RGB-D camera in the scope of his Ph.D. (see Section 7.1.2).

RITS Project-Team

9. Partnerships and Cooperations

9.1. National Initiatives

9.1.1. ANR

9.1.1.1. VALET

Title: Redistribution automatique d'une flotte de véhicules en partage et valet de parking

Instrument: ANR

Duration: January 2016 - December 2018

Coordinator: Fawzi Nashashibi

Partners: Inria, Ecole Centrale de Nantes (IRCCyN), AKKA Technologies

Inria contact: Fawzi Nashashibi

Abstract: The VALET project proposes a novel approach for solving car-sharing vehicles redistribution problem using vehicle platoons guided by professional drivers. An optimal routing algorithm is in charge of defining platoons drivers' routes to the parking areas where the followers are parked in a complete automated mode. The main idea of VALET is to retrieve vehicles parked randomly on the urban parking network by users. These parking spaces may be in electric charging stations, parking for car sharing vehicles or in regular parking places. Once the vehicles are collected and guided in a platooning mode, the objective is then to guide them to their allocated parking area or to their respective parking lots. Then each vehicle is assigned a parking place into which it has to park in an automated mode.

9.1.1.2. Hianic

Title: navigation autonome dans les foules inspirée par les humains (Human Inspired Autonomous Navigation In Crowds)

Instrument: ANR

Duration: January 2018 - December 2020

Coordinator: Anne Spalanzani (Inria Rhône-Alpes, Chroma research team)

Partners: Inria Rhône-Alpes, Inria Paris, LIG Laboratoire d'Informatique de Grenoble, LS2N - ECN Laboratoire des Sciences du Numérique de Nantes

Inria contact: Fawzi Nashashibi

Abstract: The HIANIC project will try to address some problems that will arise when these cars are mixed with pedestrians. The HIANIC project will develop new technologies in term of autonomous navigation in dense and human populated traffic. It will explore the complex problem of navigating autonomously in shared-space environments, where pedestrians and cars share the same environment.

Such a system will contribute both to urban safety and intelligent mobility in "shared spaces". Negotiation will help to avoid frozen situations increasing the vehicle's reactivity and optimizing the navigable space. Negotiation, Human-Aware Navigation and Communication will contribute to a better public acceptance of such autonomous systems and facilitate their penetration in the transportation landscape.

9.1.2. FUI

9.1.2.1. Sinetic

Title: Système Intégré Numérique pour les Transports Intelligents Coopératifs

Instrument: FUI

Duration: December 2014 - January 2018

Coordinator: Thomas Nguyen (Oktal)

Partners: Oktal, ALL4TEC, CIVITEC, Dynalogic, Inria, EURECOM, Renault, Armines, IFSTTAR, VEDECOM

Inria contact: Jean-Marc Lasgouttes

Abstract: The purpose of the project SINETIC is to create a complete simulation environment for designing cooperative intelligent transport systems with two levels of granularity: the system level, integrating all the components of the system (vehicles, infrastructure management centers, etc.) and its realities (terrain, traffic, etc.) and the component-level, modeling the characteristics and behavior of the individual components (vehicles, sensors, communications and positioning systems, etc.) on limited geographical areas, but described in detail.

9.1.2.2. PAC V2X

Title: Perception augmentée par coopération véhicule avec l'infrastructure routière

Instrument: FUI

Duration: September 2016 - August 2019

Coordinator: SIGNATURE Group (SVMS)

Partners: DigiMobee, LOGIROAD, MABEN PRODUCTS, SANEF, SVMS, VICI, Inria, VEDECOM

Inria contact: Raoul de Charette

Abstract: The objective of the project is to integrate two technologies currently being deployed in order to significantly increase the time for an automated vehicle to evolve autonomously on European road networks. It is the integration of technologies for the detection of fixed and mobile objects such as radars, lidars, cameras ... etc. And local telecommunication technologies for the development of ad hoc local networks as used in cooperative systems.

9.1.3. Competitivity Clusters

RITS team is a very active partner in the competitivity clusters, especially MOV'EO and System@tic. We are involved in several technical committees like the DAS SUR of MOV'EO for example.
RITS is also the main Inria contributor in the VEDECOM institute (IEED). VEDECOM financed the PhD theses of Mr. Fernando Garrido and Mr. Zayed Alsayed.

9.2. European Initiatives

9.2.1. FP7 & H2020 Projects

9.2.1.1. AUTOCITS

Title: AUTOCITS Regulation Study for Interoperability in the Adoption of Autonomous Driving in European Urban Nodes

Program: CEF- TRANSPORT Atlantic corridor

Duration: November 2016 - March 2019

Coordinator: Indra Sistemas S.A. (Spain)

Partners: Indra Sistemas S.A. (Spain); Universidad Politécnica de Madrid (UPM), Spain; Dirección General de Tráfico (DGT), Spain; Inria (France); Instituto Pedro Nunes (IPN), Portugal; Autoridade Nacional de Segurança Rodoviária (ANSR), Portugal; Universidade de Coimbra (UC), Portugal.

Inria contact: Fawzi Nashashibi, Mohammad Abualhoul

Abstract: The aim of the Study is to contribute to the deployment of C-ITS in Europe by enhancing interoperability for autonomous vehicles as well as to boost the role of C-ITS as catalyst for the implementation of autonomous driving. Pilots will be implemented in 3 major Core Urban nodes (Paris, Madrid, Lisbon) located along the Core network Atlantic Corridor in 3 different Member States. The Action consists of Analysis and design, Pilots deployment and assessment, Dissemination and communication as well as Project Management and Coordination.

9.2.2. Collaborations with Major European Organizations

RITS is member of the **euRobotics AISBL** (Association Internationale Sans But Lucratif) and the Leader of "People transport" Topic. This makes from Inria one of the rare French robotics representatives at the European level. See also: http://www.eu-robotics.net/

RITS is a full partner of **VRA – Vehicle and Road Automation**, a support action funded by the European Union to create a collaboration network of experts and stakeholders working on deployment of automated vehicles and its related infrastructure. VRA project is considered as the cooperation interface between EC funded projects, international relations and national activities on the topic of vehicle and road automation. It is financed by the European Commission DG CONNECT and coordinated by ERTICO – ITS Europe. See also: http://vra-net.eu/

9.3. International Initiatives

9.3.1. Inria International Partners

9.3.1.1. Informal International Partners

RITS has signed 3 MoU with the following international laboratories:

- Vehicle Dynamics and Control Laboratory, Seoul National University (SNU), S. Korea: international cooperation agreement for Graduate-Level Academic and Research Collaboration
- MICA Lab, Hanoi University of Science and Technology, Vietnam: cooperation agreement for research collaboration and PhD students co-supervision
- Integrated Industrial Design Lab (INDEL) of the Department of Product and Systems Design Engineering, University of the Aegean, Greece: international cooperation agreement for Graduate-Level Academic and Research Collaboration

9.3.2. Participation in International Programs

Samuel de Champlain Québec-France collaboration program: "Vision par ordinateur en conditions difficiles", cooperation between Raoul de Charette and Jean-François Lalonde from Laval University.

9.4. International Research Visitors

9.4.1. Visits of International Scientists

Jean-François Lalonde from Laval University in October 2018 within the framework of Samuel de Champlain Québec-France collaboration program.

9.4.1.1. Internships

Shirsendu Halder, June-December 2018.

Nabila Arib, April-September 2018

9.4.2. Visits to International Teams

9.4.2.1. Research Stays Abroad

Maximilian Jaritz was at UC San Diego, visiting SU Lab directed by Hao Su, from October 1st 2018 to February 15th 2019.

SEMAGRAMME Project-Team

7. Partnerships and Cooperations

7.1. National Initiatives

7.1.1. PLURAL

- Program: Langues et Numérique 2018 (DGLFLF: Délégation générale à la langue française et aux langues de France)
- Project acronym: PLURAL
- Project title: Production LUdique de Ressources Annotées pour les Langues de France (Gamified production of annotated resources for Languages of France)
- Duration: October 2017 - June 2018
- Coordinator: Bruno Guillaume
- Other partners: Université Paris-Sorbonne (Karën Fort, Alice Millour, André Thibault) and Université de Strasbourg (Delphine Bernhard).
- Abstract: The objective of the PLURAL project is to build linguistic resources with GWAPs (Game With A Purpose) for poorly endowed languages. Unlike other languages, poorly endowed languages lack freely available raw corpora. The goal of the PLURAL project is to provide a web interface to gather corpora in poorly endowed languages of France. First target languages are Alsacian and Guadeloupean creole. The main difficulty is to take into account orthographic diversity and regional diversity for these languages.

  Nicolas Lefebvre was employed as an engineer in the PLURAL project from October 2017 to March 2018.

7.2. International Initiatives

7.2.1. Informal International Partners

Maxime Amblard continues discussing with the Centre for Linguistic Theory and Studies in Probability (CLASP, University of Gothenburg, Sweden), especially with Robin Cooper, Ellen Breitholtz and Chris Howes. The discussions are about computational treatments of dialogues modelling. We have common issues about the management corpora and models of dialogue. As for now, ongoing discussions have not yet been turned into a formal project.

7.3. International Research Visitors

7.3.1. Visits to International Teams

7.3.1.1. Explorer programme

Maxime Amblard visited Gotenborg University, Sweden, from October 21 to October 26, 2018.

SIROCCO Project-Team

9. Partnerships and Cooperations

9.1. Regional Initiatives

9.1.1. ICON 3D - Interactive COding for Navigation in 3D scenes

Participant: Thomas Maugey.

- Title : Interactive COding for Navigation in 3D scenes
- *Partners*: Inria-Rennes (Sirocco) and I3S Sophia-Antipolis (M. Antonini)
- *Funding*: CNRS GDR ISIS
- Period : Sept.2017-Sept.2018.

The project ICON 3D, funded by the GdR-Isis, aims at developing new geometry prediction algorithms for surface meshes. Given a part of a mesh, the prediction algorithm should be able to estimate a neighboring mesh subset corresponding to the one newly visible after user viewpoint angle change.

9.1.2. CominLabs InterCom project

Participants: Aline Roumy, Thomas Maugey.

- Title : Interactive Communication (INTERCOM): Massive random access to subsets of compressed correlated data .
- Research axis : 7.4.1
- Partners : Inria-Rennes (Sirocco team and I4S team); LabSTICC, IMT-Atlantique, Signal & Communications Department; External partner: M. Kieffer L2S.
- Funding : Labex CominLabs.
- Period : Oct. 2016 - Nov. 2019.

This project aims to develop novel compression techniques allowing massive random access to large databases. Indeed, we consider a database that is so large that, to be stored on a single server, the data have to be compressed efficiently, meaning that the redundancy/correlation between the data have to be exploited. The dataset is then stored on a server and made available to users that may want to access only a subset of the data. Such a request for a subset of the data is indeed random, since the choice of the subset is user-dependent. Finally, massive requests are made, meaning that, upon request, the server can only perform low complexity operations (such as bit extraction but no decompression/compression). Algorithms for two emerging applications of this problem are being developed: Free-viewpoint Television (FTV) and massive requests to a database collecting data from a large-scale sensor network (such as Smart Cities).

9.2. European Initiatives

9.2.1. FP7 & H2020 Projects

9.2.1.1. ERC-CLIM

Participants: Pierre Allain, Pierre David, Elian Dib, Simon Evain, Christian Galea, Christine Guillemot, Laurent Guillo, Xiaoran Jiang, Jinglei Shi.

- Title : Computational Light field Imaging.
- Research axis : 7.1.2 , 7.1.3 , 7.2.1 , 7.2.3 , 7.2.4 , 7.3.1 , 7.3.2 , 7.3.3
- Partners : Inria-Rennes
- Funding : European Research Council (ERC) advanced grant
- Period : Sept. 2016 - Aug. 2021.

Light fields yield a rich description of the scene ideally suited for advanced image creation capabilities from a single capture, such as simulating a capture with a different focus and a different depth of field, simulating lenses with different apertures, for creating images with different artistic intents or for producing 3D views. Light fields technology holds great promises for a number of application sectors, such as photography, augmented reality, light field microscopy, but also surveillance, to name only a few.

The goal of the ERC-CLIM project is to develop algorithms for the entire static and video light fields processing chain, going from compact sparse and low-rank representations and compression to restoration, high quality rendering and editing.

9.3. International Initiatives

9.3.1. Inria International Labs

9.3.1.1. EPFL-Inria

- Title: Graph-based Omnidirectional video Processing
- International Partner: Ecole Polytechnique Fédérale de Lausanne (Switzerland), LTS4, Pascal Frossard
- Period: 2017-2018

Due to new camera types, the format of the video data has become more complex than simple 2D images or videos as it was the case a few years ago. In particular, the omnidirectional cameras provide pixels on a whole sphere around a center point and enable a vision in 360 degrees. In addition to the fact that the data size explodes with such cameras, the inherent structure of the acquired signal fundamentally differs from the 2D images, which makes the traditional video codec obsolete. In parallel of that, an important effort of research has been led recently, especially at EPFL, to develop new processing tools for signals lying on irregular structures (graphs). It enables in particular to build efficient coding tools for new types of signals. The project studies how graphs can be built for defining a suitable structure on one or several omnidirectionnal videos and then used for compression.

9.3.2. Inria International Partners

9.3.2.1. Informal International Partners

We have international collaborations with:

- Reuben Farrugia, Prof. at the University of Malta, with whom we continue collaborating on light field super-resolution.The collaboration started during the sabbatical year (Sept. 2015-Aug. 2016) he spent within the team.
- Ehsan Miandji and Prof. Jonas Unger from Linkoping Univ. with whom we collaborate on compressive sampling of light fields.
- Mikael Le Pendu and Prof. Aljosa Smolic from Trinity College Dublin on HDR light field recovery from multiple exposures.

9.4. International Research Visitors

9.4.1. Visits of International Scientists

- Reuben Farrugia, Prof. at the University of Malta, spent 2 weeks in the team (June 2018).
- Alexander Sagel, assistant researcher at the Technical University Munich (Oct.-Nov. 2018).
- Mikael Le Pendu and Martin Alain, postdocs at Trinity College Dublin (Nov. 2018).

STARS Project-Team

9. Partnerships and Cooperations

9.1. National Initiatives

9.1.1. ANR

9.1.1.1. ENVISION

Program: ANR JCJC

Project acronym: ENVISION

Project title: Computer Vision for Automated Holistic Analysis of Humans

Duration: October 2017-September 2020.

Coordinator: Antitza Dantcheva (STARS)

Abstract: The main objective of ENVISION is to develop the computer vision and theoretical foundations of efficient biometric systems that analyze appearance and dynamics of both face and body, towards recognition of identity, gender, age, as well as mental and social states of humans in the presence of operational randomness and data uncertainty. Such dynamics - which will include facial expressions, visual focus of attention, hand and body movement, and others, constitute a new class of tools that have the potential to allow for successful holistic analysis of humans, beneficial in two key settings: (a) biometric identification in the presence of difficult operational settings that cause traditional traits to fail, (b) early detection of frailty symptoms for health care.

9.1.2. FUI

9.1.2.1. Visionum

Program: FUI

Project acronym: Visionum

Project title: Visonium.

Duration: January 2015- December 2018.

Coordinator: Groupe Genious

Other partners: Inria(Stars), StreetLab, Fondation Ophtalmologique Rothschild, Fondation Hospitalière Sainte-Marie.

Abstract: This French project from Industry Minister aims at designing a platform to re-educate at home people with visual impairment.

9.1.2.2. StoreConnect

Program: FUI

Project acronym: StoreConect.

Project title: StoreConnect.

Duration: September 2016 - September 2018.

Coordinator: Ubudu (Paris).

Other partners: Inria(Stars), STIME (groupe Les Mousquetaires (Paris)), Smile (Paris), Thevolys (Dijon).

Abstract: StoreConnect is an FUI project started in 2016 and will end in 2018. The goal is to improve the shopping experience for customers inside supermarkets by adding new sensors such as cameras, beacons and RFID. By gathering data from all the sensors and combining them, it is possible to improve the way to communicate between shops and customers in a personalized way. StoreConnect acts as a middleware platform between the sensors and the shops to process the data and extract interesting knowledge organized via ontologies.

9.1.2.3. ReMinAry

Program: FUI

Project acronym: ReMinAry.

Project title: ReMinAry.

Duration: September 2016 - September 2019.

Coordinator: GENIOUS Systèmes,

Other partners: Inria(Stars), MENSIA technologies, Institut du Cerveau et de la Moelle épinière, la Pitié-Salpêtrière hospital.

Abstract:This project is based on the use of motor imagery (MI), a cognitive process consisting of the mental representation of an action without concomitant movement production. This technique consists in imagining a movement without realizing it, which entails an activation of the brain circuits identical to those activated during the real movement. By starting rehabilitation before the end of immobilization, a patient operated on after a trauma will gain rehabilitation time and function after immobilization is over. The project therefore consists in designing therapeutic video games to encourage the patient to re-educate in a playful, autonomous and active way in a phase where the patient is usually passive. The objective will be to measure the usability and the efficiency of the reeducative approach, through clinical trials centered on two pathologies with immobilization: post-traumatic (surgery of the shoulder) and neurodegenerative (amyotrophic lateral sclerosis).

9.2. International Initiatives

9.2.1. International Initiatives

FER4HM

Title: Facial expression recognition with application in health monitoring

International Partner (Institution - Laboratory - Researcher):

Chinese Academy of Sciences (China) Institute of Computing Technology - Hu HAN

Duration: 2017 - 2019

Start year: 2017

See also: https://project.inria.fr/fer4hm/

The proposed research aims to provide computer vision methods for facial expression recognition in patients with Alzheimer's disease. Most importantly though, the work seeks to be part of a paradigm shift in current healthcare, in efficiently and cost effectively finding objective measures to (a) assess different therapy treatments, as well as to (b) enable automated human-computer interaction in remote large-scale healthcare- frameworks. Recognizing expressions in severely demented Alzheimer's disease (AD) patients is essential, since such patients have lost a substantial amount of their cognitive capacity [1-3], and some even their verbal communication ability (e.g., aphasia)2. This leaves patients dependent on clinical staff to assess their verbal and non-verbal language, in order to communicate important messages, as of discomfort associated to potential complications of the AD [9, 10]. Such assessment classically requires the patients' presence in a clinic, and time consuming examination involving medical personnel. Thus, expression monitoring is costly and logistically inconvenient for patients and clinical staff, which hinders among others large-scale monitoring. Approaches need to cater to the challenging settings of current medical recordings,

which include continuous pose variations, occlusions, camera-movements, camera-artifacts, as well as changing illumination. Additionally and importantly, the (elderly) patients exhibit generally less profound facial activities and expressions in a range of intensities and predominantly occurring in combinations (e.g., talking and smiling). Both, Inria-STARS and CAS-ICT have already initiated research activities related to the here proposed topic. While both sides have studied facial expression recognition, CAS-ICT has explored additionally the use of heart rate monitoring sensed from a webcam in this context.

SafEE

Title: Safe Easy Environment

International Partner (Institution - Laboratory - Researcher):

Duration: 2018 - 2020

Start year: 2018

SafEE (Safe Easy Environment) investigates technologies for the evaluation, stimulation and intervention for Alzheimer patients. The SafEE project aims at improving the safety, autonomy and quality of life of older people at risk or suffering from Alzheimer's disease and related disorders. More specifically the SafEE project : 1) focuses on specific clinical targets in three domains: behavior, motricity and cognition 2) merges assessment and non pharmacological help/intervention and 3) proposes easy ICT device solutions for the end users. In this project, experimental studies will be conducted both in France (at Hospital and Nursery Home) and in Taiwan.

9.3. International Research Visitors

9.3.1. Visits to International Teams

Antitza Dantcheva visited Wael Abd-Almageed's laboratory at the Information Sciences Institute of the University of Southern California Viterbi School of Engineering in August 2018.

Antitza Dantcheva, Abhijit Das and Yaohui Wang visited the Institute of Computing Technology (ICT) at the Chinese Academy of Sciences (CAS) in August 2018.

THOTH Project-Team

9. Partnerships and Cooperations

9.1. Regional Initiatives

9.1.1. DeCore (Deep Convolutional and Recurrent networks for image, speech, and text)

Participants: Jakob Verbeek, Maha Elbayad.

DeCore is a project-team funded by the Persyval Lab for 3.5 years (september 2016 - February 2020), coordinated by Jakob Verbeek. It unites experts from Grenoble's applied-math and computer science labs LJK, GIPSA-LAB and LIG in the areas of computer vision, machine learning, speech, natural language processing, and information retrieval. The purpose of DeCore is to stimulate collaborative interdisciplinary research on deep learning in the Grenoble area, which is likely to underpin future advances in machine perception (vision, speech, text) over the next decade. It provides funding for two full PhD students. Maha Elbayad is one of them, supervised by Jakob Verbeek and Laurant Besacier (LIG, UGA).

9.1.2. PEPS AMIES AuMalis POLLEN

Participant: Karteek Alahari.

This is a collaborative project with POLLEN, a startup in the Grenoble area, which develops POLLEN Metrology, a software editor specialized in signal processing, hybrid metrology and machine learning for the automatic processing of heterogeneous data. This funding supports a postdoc to accelerate the introduction of artificial intelligence, and in particular computer vision, techniques, into the manufacture of new generation of microprocessors. Karteek Alahari and Valerie Perrier (LJK, UGA) jointly supervise a postdoc as part of this collaboration.

9.2. National Initiatives

9.2.1. ANR Project Macaron

Participants: Julien Mairal, Zaid Harchaoui [Univ. Washington], Laurent Jacob [CNRS, LBBE Laboratory], Michael Blum [CNRS, TIMC Laboratory], Joseph Salmon [Telecom ParisTech], Mikita Dvornik, Thomas Dias-Alves, Daan Wynen.

The project MACARON is an endeavor to develop new mathematical and algorithmic tools for making machine learning more scalable. Our ultimate goal is to use data for solving scientific problems and automatically converting data into scientific knowledge by using machine learning techniques. Therefore, our project has two different axes, a methodological one, and an applied one driven by explicit problems. The methodological axis addresses the limitations of current machine learning for simultaneously dealing with large-scale data and huge models. The second axis addresses open scientific problems in bioinformatics, computer vision, image processing, and neuroscience, where a massive amount of data is currently produced, and where huge-dimensional models yield similar computational problems.

This is a 4 years and half project, funded by ANR under the program "Jeunes chercheurs, jeunes chercheuses", which started in October 2014. The principal investigator is Julien Mairal.

9.2.2. ANR Project DeepInFrance

Participants: Jakob Verbeek, Adria Ruiz Ovejero.

DeepInFrance (Machine learning with deep neural networks) project also aims at bringing together complementary machine learning, computer vision and machine listening research groups working on deep learning with GPUs in order to provide the community with the knowledge, the visibility and the tools that brings France among the key players in deep learning. The long-term vision of Deep in France is to open new frontiers and foster research towards algorithms capable of discovering sense in data in an automatic manner, a stepping stone before the more ambitious far-end goal of machine reasoning. The project partners are: INSA Rouen, Univ. Caen, Inria, UPMC, Aix-Marseille Univ., Univ. Nice Sophia Antipolis.

9.2.3. ANR Project AVENUE

Participant: Karteek Alahari.

This new ANR project (started in October 2018) aims to address the perception gap between human and artificial visual systems through a visual memory network for human-like interpretation of scenes. To this end, we address three scientific challenges. The first is to learn a network representation of image, video and text data collections, to leverage their inherent diverse cues. The second is to depart from supervised learning paradigms, without compromising on the performance. The third one is to perform inference with the learnt network, e.g., to estimate physical and functional properties of objects, or give cautionary advice for navigating a scene. The principal investigator is Karteek Alahari, and the project involves participants from CentraleSupelec and Ecole des Ponts in Paris.

9.3. European Initiatives

9.3.1. FP7 & H2020 Projects

9.3.1.1. ERC Advanced grant Allegro

Participants: Cordelia Schmid, Pavel Tokmakov, Konstantin Shmelkov, Vladyslav Sydorov, Daan Wynen, Mikita Dvornik, Xavier Martin.

The ERC advanced grant ALLEGRO started in April 2013 and will end in April 2019. The aim of ALLEGRO is to automatically learn from large quantities of data with weak labels. A massive and ever growing amount of digital image and video content is available today. It often comes with additional information, such as text, audio or other meta-data, that forms a rather sparse and noisy, yet rich and diverse source of annotation, ideally suited to emerging weakly supervised and active machine learning technology. The ALLEGRO project will take visual recognition to the next level by using this largely untapped source of data to automatically learn visual models. We will develop approaches capable of autonomously exploring evolving data collections, selecting the relevant information, and determining the visual models most appropriate for different object, scene, and activity categories. An emphasis will be put on learning visual models from video, a particularly rich source of information, and on the representation of human activities, one of today's most challenging problems in computer vision.

9.3.1.2. ERC Starting grant Solaris

Participants: Julien Mairal, Ghislain Durif, Andrei Kulunchakov, Alberto Bietti, Dexiong Chen, Gregoire Mialon.

The project SOLARIS started in March 2017 for a duration of five years. The goal of the project is to set up methodological and theoretical foundations of deep learning models, in the context of large-scale data processing. The main applications of the tools developed in this project are for processing visual data, such as videos, but also structured data produced in experimental sciences, such as biological sequences.

The main paradigm used in the project is that of kernel methods and consist of building functional spaces where deep learning models live. By doing so, we want to derive theoretical properties of deep learning models that may explain their success, and also obtain new tools with better stability properties. Another work package of the project is focused on large-scale optimization, which is a key to obtain fast learning algorithms.

9.4. International Initiatives

9.4.1. Inria International Labs

Inria@EastCoast

Associate Team involved in the International Lab:

9.4.1.1. GAYA

Title: Semantic and Geometric Models for Video Interpretation

International Partner (Institution - Laboratory - Researcher):

Carnegie Mellon University (United States) - Robotics Institute - Deva Ramanan

Start year: 2016

See also: https://team.inria.fr/gaya/

We propose to form an associate team GAYA, with the primary goal of interpreting videos in terms of recognizing actions, understanding the human-human and human-object interactions. Despite several years of research, it is yet unclear what is an efficient and robust video representation to attack this challenge. In order to address this, GAYA will focus on building semantic models, wherein we learn the video feature representation with limited supervision, and also geometric models, where we study the geometric properties of object shapes to better recognize them. The team consists of researchers from two Inria project-teams (LEAR and WILLOW) and a US university (Carnegie Mellon University [CMU]). It will allow the three teams to effectively combine their respective strengths in areas such as inference and machine learning approaches for vision tasks, feature representation, large-scale learning, geometric reasoning. The main expected outcomes of this collaboration are: effective learnt representations of video content, new machine learning algorithms for handling minimally annotated data, large-scale public datasets for benchmarking, theoretical analysis of objects shapes and contours.

9.4.2. Inria International Partners

9.4.2.1. Informal International Partners

- **MPI Tübingen:** Cordelia Schmid collaborates with Michael Black, a research director at MPI, starting in 2013. End of 2015 she was award a Humbolt research award funding a long-term research project with colleagues at MPI. She spent one month at MPI in April 2018. In 2018, the project resulted in the development of an approach for object interaction.
- **University of Washington:** Julien Mairal collaborates with Zaid Harchaoui, former member of the team, on the topic of large-scale optimization.

9.4.3. Participation in Other International Programs

- **Indo-French project EVEREST** with IIIT Hyderabad, India, funded by CEFIPRA (Centre Franco-Indien pour la Promotion de la Recherche Avancee). The aim of this project between Cordelia Schmid, Karteek Alahari and C. V. Jawahar (IIIT Hyderabad) is to enable the use of rich, complex models that are required to address the challenges of high-level computer vision. The work plan for the project will follow three directions. First, we will develop a learning framework that can handle weak annotations. Second, we will build formulations to solve the non-convex optimization problem resulting from the learning framework. Third, we will develop efficient and accurate energy minimization algorithms, in order to make the optimization computationally feasible.

9.5. International Research Visitors

9.5.1. Visits of International Scientists

9.5.1.1. Internships

- Pia Bideau (PhD student, Univ. Massachusetts Amherst) was an intern in the team from Sep to Dec 2018.

TITANE Project-Team

9. Partnerships and Cooperations

9.1. National Initiatives

9.1.1. ANR

9.1.1.1. PISCO: Perceptual Levels of Detail for Interactive and Immersive Remote Visualization of Complex 3D Scenes

Participants: Pierre Alliez [contact], Flora Quilichini, Florent Lafarge.

The way of consuming and visualizing this 3D content is evolving from standard screens to Virtual and Mixed Reality (VR/MR). Our objective is to devise novel algorithms and tools allowing interactive visualization, in these constrained contexts (Virtual and Mixed reality, with local/remote 3D content), with a high quality of user experience. Partners: Inria, LIRIS INSA Lyon Institut National des Sciences Appiquées (coordinator), Laboratoire d'Informatique en Images et Systèmes d'Information LS2N Nantes University. Total budget 550 KE, 121 KE for TITANE. The project started in January 2018, for a total duration of 4 years.

9.1.1.2. LOCA-3D: Localization Orientation and 3D CArtography

Participants: Fernando Ireta Munoz, Florent Lafarge, Pierre Alliez [contact].

This project is part of the ANR Challenge MALIN LOCA-3D (Localization, orientation and 3D cartography). The challenge is to develop and experiment accurate location solutions for emergency intervention officers and security forces. These solutions must be efficient inside buildings and in conditions where satellite positioning systems do not work satisfactorily. Our solution is based on an advanced inertial system, where part of the inertial sensor drift is compensated by a vision system. Partners: SME INNODURA TB (coordinator), IBISC laboratory (Evry university) and Inria. Total budget: 700 KE, 157 KE for TITANE. The project started in January 2018, for a total duration of 4 years.

9.1.1.3. EPITOME: efficient representation to structure large-scale satellite images

Participants: Nicolas Girard, Yuliya Tarabalka [PI].

The goal of this young researcher project is to devise an efficient multi-scale vectorial representation, which would structure the content of large-scale satellite images. More specifically, we seek for a novel effective representation for large-scale satellite images, that would be generic, i.e., applicable for images worldwide and for a wide range of applications, and structure-preserving, i.e. best representing the meaningful objects in the image scene. To address this challenge, we plan to bridge the gap between advanced machine learning and geometric modeling tools to devise a multi-resolution vector-based representation, together with the methods for its effective generation and manipulation. Total budget: 225 KE for TITANE. The project started in October 2017, for a total duration of 4 years.

9.1.1.4. Faults_R_GEMS: Properties of FAULTS, a key to Realistic Generic Earthquake Modeling and hazard Simulation

Participants: Lionel Matteo, Yuliya Tarabalka.

The goal of the project is to study the properties of seismic faults, using advanced math tools including learning approaches. The project is in collaboration with Geoazur lab (coordinator), Arizona State University, CALTECH, Ecole Centrale Paris, ENS Paris, ETH Zurich, Geosciences Montpellier, IFSTTAR, IPGP Paris, IRSN Fontenay-aux-Roses, LJAD Nice, UNAVCO Colorado and Pisa University. The project started in October 2017, for a total duration of 4 years.

9.1.1.5. BIOM: Building Indoor and Outdoor Modeling

Participants: Muxingzi Li, Pierre Alliez, Florent Lafarge.

The BIOM project aims at automatic, simultaneous indoor and outdoor modelling of buildings from images and dense point clouds. We want to achieve a complete, geometrically accurate, semantically annotated but nonetheless lean 3D CAD representation of buildings and objects they contain in the form of a Building Information Models (BIM) that will help manage buildings in all their life cycle (renovation, simulation, deconstruction). The project is in collaboration with IGN (coordinator), Ecole des Ponts Paristech, CSTB and INSA-ICube. Total budget: 723 KE, 150 KE for TITANE. The project started in February 2018, for a total duration of 4 years.

9.2. European Initiatives

9.2.1. FP7 & H2020 Projects

9.2.1.1. TITANIUM - Software Components for Robust Geometry Processing

ERC Proof of concept grant TITANIUM "Software Components for Robust Geometry Processing" (2017-2018), total 150 KE. Principal investigator: Pierre Alliez. Partner: Inria Spin-off Geometry Factory. Participants: Florent Lafarge, Dmitry Anisimov, Simon Giraudot and Andreas Fabri. We developed a software demonstrator for geometry processing and 3D urban modeling, in order to facilitate the pre-commercialization of novel software components for the CGAL Library. The outcome of TITANIUM is a versatile method for semantic classification of 3D point clouds and for semantic-aware reconstruction of urban scenes (in preparation).

9.3. International Initiatives

9.3.1. Inria International Partners

9.3.1.1. Declared Inria International Partners

We collaborated with Mathieu Desbrun from Caltech, David Bommes from Bern University (Switzerland), Gianmarco Cherchi and Riccardo Scateni from University of Cagliary (Sardinia).

9.4. International Research Visitors

9.4.1. Visits of International Scientists

- Mathieu Desbrun, Professor at Caltech, visited us from September to mid November.
- Michael Hemmer, research engineer at Google, visited us in December.
- Jorg Peters, Professor at University of Florida, visited us in October.

9.4.1.1. Internships

- Tong Zhao (Ecole des ponts ParisTech): geometric descriptors and robust principal component analysis. In collaboration with Mathieu Desbrun from Caltech.
- Vasudha Varadarajan (Birla Institute of Technology and Science, India): shape reconstruction using binary programming.
- Andrew Khalel (Cairo University, Egypt): Multi-task deep learning for simultaneous satellite image segmentation and pan-sharpening. In collaboration with Guillaume Charpiat.
- Andrii Zhygallo (TUM, Germany): Using deep learning for change detection from remote sensing images.

TYREX Project-Team

7. Partnerships and Cooperations

7.1. Regional Initiatives

Data-CILE

Title: Query Compilation

Call: Appel à projet Grenoble Innovation Recherche (AGIR-Pôle)

Duration: 2016-2018

Coordinator: Nabil Layaïda

Abstract: The goal of this project is to contribute to foundational and algorithmic challenges introduced by increasingly popular data-centric paradigms for programming on distributed architectures such as spark and the massive production of big linked open data. The focus of the project is on building robust and more efficient workflows of transformations of semantic and graph web data.

BioQurate

Title: Querying and Curating Hierarchies of Biological Graphs

Funding: Fédération Informatique de Lyon (FIL)

Duration: 2018-2020

Coordinator: Angela Bonifati

Others partners: LIP/LIRIS. The project involves a bio-computing team and a database team on a common research problem

Abstract: This project aims at leveraging graph rewriting techniques of ReGraph and graph data management techniques in order to provide a persistent, robust and scalable substrate for the construction and manipulation of hierarchies of biological graphs. Moreover, we wish to investigate whether the involved graphs need further expressive graph constraints for enforcing consistency and performing data cleansing.

7.2. National Initiatives

7.2.1. ANR

CLEAR

Title: Compilation of intermediate Languages into Efficient big dAta Runtimes

Call: Appel à projets générique 2016 défi 'Société de l'information et de la communication' – JCJC

Duration: January 2017 – September 2021

Coordinator: Pierre Genevès

See also: http://tyrex.inria.fr/clear

Abstract: This project addresses one fundamental challenge of our time: the construction of effective programming models and compilation techniques for the correct and efficient exploitation of big and linked data. We study high-level specifications of pipelines of data transformations and extraction for producing valuable knowledge from rich and heterogeneous data. We investigate how to synthesize code which is correct and optimized for execution on distributed infrastructures.

DataCert

Title: Coq deep specification of security aware data integration

Call: Appel à projets Sciences et technologies pour la confiance et la sécurité numérique

Duration: January 2016 – January 2020

Participant: Angela Bonifati

Others partners: Université Paris Sud/Laboratoire de Recherche en Informatique, Université de Lille/Centre de Recherche en Informatique, Signal et Automatique de Lille, Université de Lyon/Laboratoire d'InfoRmatique en Image et Systèmes d'information.

See also: http://datacert.lri.fr/

Abstract: This project's aim is to develop a comprehensive framework handling the fundamental problems underlying security-aware data integration and sharing, resulting in a paradigm shift in the design and implementation of security-aware data integration systems. To fill the gap between both worlds, we strongly rely on deep specifications and proven-correct software, develop formal models yielding highly reliable technology while controlling the disclosure of private or confidential information.

QualiHealth

Title: Enhancing the Quality of Health Data

Call: Appel à projets Projets de Recherche Collaborative – Entreprise (PRCE)

Duration: 2018-2022

Coordinator: Angela Bonifati

Others partners: LIMOS, Université Clermont Auvergne. LIS, Université d'Aix-Marseille. HEGP, INSERM, Paris. Inst. Cochin, INSERM, Paris. Gnubila, Argonay. The University of British Columbia, Vancouver (Canada)

Abstract: This research project is geared towards a system capable of capturing and formalizing the knowledge of data quality from domain experts, enriching the available data with this knowledge and thus exploiting this knowledge in the subsequent quality-aware medical research studies. We expect a quality-certified collection of medical and biological datasets, on which quality-certified analytical queries can be formulated. We envision the conception and implementation of a quality-aware query engine with query enrichment and answering capabilities.

To reach this ambitious objectives, the following concrete scientific goals must be fulfilled : (1) An innovative research approach, that starts from concrete datasets and expert practices and knowledge to reach formal models and theoretical solutions, will be employed to elicit innovative quality dimensions and to identify, formalize, verify and finally construct quality indicators able to capture the variety and complexity of medical data; those indicators have to be composed, normalized and aggregated when queries involve data with different granularities (e.g., accuracy indications on pieces of information at the patient level have to be composed when one queries cohort) and of different quality dimensions (e.g., mixing incomplete and inaccurate data); and (2) In turn, those complex aggregated indicators have to be used to provide new quality-driven query answering, refinement, enrichment and data analytics techniques. A key novelty of this project is the handling of data which are not rectified on the original database but sanitized in a query-driven fashion: queries will be modified, rewritten and extended to integrate quality parameters in a flexible and automatic way.

7.2.2. PERSYVAL-lab LabEx

Title: Mobile Augmented Reality Applications for Smart Cities

Call: Persyval Labex ("Laboratoire d'excellence").

Duration: 2014 – 2018

Coordinators: Pierre Genevès and Nabil Layaïda

Others partners: NeCS team at GIPSA-Lab laboratory.

Abstract: The goal of this project is to increase the relevance and reliability of augmented reality (AR) applications, through three main objectives:

1. Finding and developing appropriate representations for describing the physical world (3D maps, indoor buildings, ways...), integrated advanced media types (3D, 3D audio, precisely geo-tagged pictures with lat., long. and orientation, video...)
2. Integrating the different abstraction levels of these data streams (ranging from sensors data to high level rich content such as 3D maps) and bridging the gap with Open Linked Data (the semantic World). This includes opening the way to query the environment (filtering), and adapt AR browsers to users' capabilities (e.g. blind people). The objective here is to provide an open and scalable platform for mobile-based AR systems (just like the web represents).
3. Increasing the reliability and accuracy of localization technologies. Robust and high-accuracy localization technologies play a key role in AR applications. Combined with geographical data, they can also be used to identify user-activity patterns, such as walking, running or being in an elevator. The interpretation of sensor values, coupled with different walking models, allows one to ensure the continuity of the localization, both indoor and outdoor. However, dead reckoning based on Inertial Navigation Systems (INS) or Step-and-Heading Systems (SHS) is subject to cumulative errors due to many factors (sensor drift (accelerometers, gyroscopes, etc.), missed steps, bad estimation of the length of each stride, etc.). One objective is to reduce such errors by merging and mixing these approaches with various external signals such as GPS and Wi-Fi or relying on the analyses of user trajectories with the help of a structured map of the environment. Some filtering methods (Kalman Filter, observer, etc.) will be useful to achieve this task.

7.3. International Research Visitors

7.3.1. Visits of International Scientists

We had short visits from Wim Martens (University of Bayreuth, Germany) and Efthymia Tsamoura (University of Oxford, UK).

VALDA Project-Team

7. Partnerships and Cooperations

7.1. Regional Initiatives

Michaël Thomazo has obtained a 6k€ budget from the Île-de-France region (DIM RFSI – *Réseau Francilien en Sciences Informatiques*) entitled *ISORE: Indexation sémantique d'ontologies, le cas des règles existentielles.* The grant was awarded when Michaël Thomazo was part of the Inria Saclay Cedar team, but the budget was transferred to the Valda team.

7.2. National Initiatives

7.2.1. ANR

Valda has been part of two ANR projects in 2018:

- HEADWORK (budget managed by Inria), together with IRISA (Druid, coordinator), Inria Lille (Links & Spirals), and Inria Rennes (Sumo), and two application partners: MNHN (Cesco) and FouleFactory. The topic is workflows for crowdsourcing. See http://headwork.gforge.inria.fr/.
- BioQOP (budget managed by ENS), with Idemia (coordinator) and GREYC, on the optimization of queries for privacy-aware biometric data management. See http://bioqop.di.ens.fr/.

In addition, two ANR projects were accepted in 2018 and will start early 2019:

- CQFD (budget managed by Inria), with Inria Sophia (GraphIK, coordinator), LaBRI, LIG, Inria Saclay (Cedar), IRISA, Inria Lille (Spirals), and Télécom ParisTech, on complex ontological queries over federated and heterogeneous data.
- QUID (budget managed by Inria), LIGM (coordinator), IRIF, and LaBRI, on incomplete and inconsistent data.

7.3. International Initiatives

7.3.1. IIL projects

Valda has strong collaborations with the following international groups:

Univ. Edinburgh, United Kingdom: Peter Buneman and Leonid Libkin

Univ. Oxford, United Kingdom: Michael Benedikt, Evgeny Kharlamov, Dan Olteanu, and Georg Gottlob

TU Dresden, Germany: Markus Krötzsch and Sebastian Rudolph

Dortmund University, Germany: Thomas Schwentick

Warsaw University, Poland: Mikołaj Bojańczyk and Szymon Toruńczyk

Tel Aviv University, Israel: Daniel Deutch and Tova Milo

Drexel University, USA: Julia Stoyanovich

Univ. California San Diego, USA: Victor Vianu

National University of Singapore: Stéphane Bressan

7.4. International Research Visitors

7.4.1. Visits of International Scientists

Victor Vianu, Professor at UC San Diego and holder of an Inria international chair, spent 3 months within Valda, employed as an ENS invited professor.

7.4.2. Visits to International Teams

7.4.2.1. Research Stays Abroad

- Michaël Thomazo and Pierre Senellart have spent respectively two weeks and one week at TU Dresden, collaborating with Markus Krötzsch and Sebastian Rudolph.
- Pierre Senellart has spent a cumulated time of around three weeks at National University of Singapore, co-advising Debabrota Basu, PhD student working under the co-supervision of Stéphane Bressan, visiting Stéphane Bressan and other researchers at NUS, and participating in the French–Singapore workshop on AI, where Olivier Cappé represented CNRS.

WILLOW Project-Team

9. Partnerships and Cooperations

9.1. National Initiatives

9.1.1. DGA - RAPID project DRAAF

Participant: Ivan Laptev.

DGA DRAAF is a two-year collaborative effort with University of Caen (F. Jurie) and the industrial partner EVITECH (P. Bernas) focused on modelling and recognition of violent behaviour in surveillance videos. The project aims to develop image recognition models and algorithms to automatically detect weapons, gestures and actions using recent advances in computer vision and deep learning to provide an affordable real-time solution reducing effects of threats in public places.

9.2. European Initiatives

9.2.1. European Research Council (ERC) Starting Grant: “Activia" - Ivan Laptev

Participant: Ivan Laptev.

WILLOW will be funded in part from 2013 to 2018 by the ERC Starting Grant "Activia" awarded to Ivan Laptev by the European Research Council.

‘Computer vision is concerned with the automated interpretation of images and video streams. Today’s research is (mostly) aimed at answering queries such as ’Is this a picture of a dog?’, (classification) or sometimes ’Find the dog in this photo’ (detection). While categorisation and detection are useful for many tasks, inferring correct class labels is not the final answer to visual recognition. The categories and locations of objects do not provide direct understanding of their function i.e., how things work, what they can be used for, or how they can act and react. Such an understanding, however, would be highly desirable to answer currently unsolvable queries such as ’Am I in danger?’ or ’What can happen in this scene?’. Solving such queries is the aim of this proposal. My goal is to uncover the functional properties of objects and the purpose of actions by addressing visual recognition from a different and yet unexplored perspective. The main novelty of this proposal is to leverage observations of people, i.e., their actions and interactions to automatically learn the use, the purpose and the function of objects and scenes from visual data. The project is timely as it builds upon the two key recent technological advances: (a) the immense progress in visual recognition of objects, scenes and human actions achieved in the last ten years, as well as (b) the emergence of a massive amount of public image and video data now available to train visual models. ACTIVIA addresses fundamental research issues in automated interpretation of dynamic visual scenes, but its results are expected to serve as a basis for ground-breaking technological advances in practical applications. The recognition of functional properties and intentions as explored in this project will directly support high-impact applications such as detection of abnormal events, which are likely to revolutionise today’s approaches to crime protection, hazard prevention, elderly care, and many others.’

9.2.2. European Research Council (ERC) Starting Grant: "Leap" - Josef Sivic

Participant: Josef Sivic.

The contract has begun on Nov 1st 2014. WILLOW will be funded in part from 2014 to 2018 by the ERC Starting Grant "Leap" awarded to Josef Sivic by the European Research Council.

'People constantly draw on past visual experiences to anticipate future events and better understand, navigate, and interact with their environment, for example, when seeing an angry dog or a quickly approaching car. Currently there is no artificial system with a similar level of visual analysis and prediction capabilities. LEAP is a first step in that direction, leveraging the emerging collective visual memory formed by the unprecedented amount of visual data available in public archives, on the Internet and from surveillance or personal cameras - a complex evolving net of dynamic scenes, distributed across many different data sources, and equipped with plentiful but noisy and incomplete metadata. The goal of this project is to analyze dynamic patterns in this shared visual experience in order (i) to find and quantify their trends; and (ii) learn to predict future events in dynamic scenes. With ever expanding computational resources and this extraordinary data, the main scientific challenge is now to invent new and powerful models adapted to its scale and its spatio-temporal, distributed and dynamic nature. To address this challenge, we will first design new models that generalize across different data sources, where scenes are captured under vastly different imaging conditions such as camera viewpoint, temporal sampling, illumination or resolution. Next, we will develop a framework for finding, describing and quantifying trends that involve measuring long-term changes in many related scenes. Finally, we will develop a methodology and tools for synthesizing complex future predictions from aligned past visual experiences. Our models will be automatically learnt from large-scale, distributed, and asynchronous visual data, coming from different sources and with different forms of readily-available but noisy and incomplete metadata such as text, speech, geotags, scene depth (stereo sensors), or gaze and body motion (wearable sensors). Breakthrough progress on these problems would have profound implications on our everyday lives as well as science and commerce, with safer cars that anticipate the behavior of pedestrians on streets; tools that help doctors monitor, diagnose and predict patients' health; and smart glasses that help people react in unfamiliar situations enabled by the advances from this project.'

9.3. International Initiatives

9.3.1. IMPACT: Intelligent machine perception

Participants: Josef Sivic, Jean Ponce, Ivan Laptev.

IMPACT is a 5-year collaborative project with Czech Technical University, Center for Robotics, Informatics and Cybernetics (CIIRC) (2017-2022). The IMPACT project focuses on fundamental and applied research in computer vision, machine learning and robotics to develop machines that learn to perceive, reason, navigate and interact with complex dynamic environments. For example, people easily learn how to change a flat tire of a car or perform resuscitation by observing other people doing the same task. This involves advanced visual intelligence abilities such as interpreting sequences of human actions that manipulate objects to achieve a specific task. Currently, however, there is no artificial system with a similar level of cognitive visual competence. Breakthrough progress in intelligent machine perception will have profound implications on our everyday lives as well as science and commerce, with smart assistive robots that automatically learn new skills from the Internet, safer cars that autonomously navigate in difficult changing conditions, or intelligent glasses that help people navigate never seen before environments.

9.3.2. Associate team GAYA

Participants: Jean Ponce, Matthew Trager.

GAYA is a joint research team bringing together two Inria project-teams (Thoth, Grenoble and WILLOW, Paris) and Carnegie Mellon University, USA. It focuses on two research themes: (i) semantic structured interpretation of videos, and (ii) studying the geometric properties of object shapes to enhance state-of-the-art object recognition approaches.

Interpreting videos semantically in a general setting, involving various types of video content like home video clips, news broadcasts, feature films, which contain a lot of clutter, non-rigid motion, many "actors" performing actions, person-object and person-person interactions, varying viewpoints, is challenging. This task is being examined increasingly over the past decade, with the availability of large video resources, e.g., YouTube. Despite this progress, an effective video representation for recognizing actions is still missing.

To address this critical challenge, we propose a joint optimization framework, wherein we learn the video representation and also develop models for action recognition. Specifically, we aim to exploit the spatio-temporal relations among pixels in a video through graphical models and novel deep learning feature representations.

The second research theme explores geometric aspects of computer vision, in particular how to model three-dimensional objects from their two-dimensional projections, and how the appearance of these objects evolves with changes in viewpoint. Beyond its theoretical interest, this work is critical for developing object recognition algorithms that take into account the three-dimensional nature of the visual world and go beyond the template-matching approaches dominant today. Duality is an important concept in this area, and we are investigating its application to the construction of visual hulls as well as the characterization of the topology of image contours using the Gauss map. Existing results are essentially limited to the Euclidean setting, and we are investigating their generalization to the general projective case.

Partners: CMU (Deva Ramanan, Martial Hebert, Abhinav Gupta, Gunnar Sigurdsson), Inria Thoth (Cordelia Schmid, Karteek Alahari, Pavel Tokmakov).

9.4. International Research Visitors

9.4.1. Visits of International Scientists

Alexei Efros (Professor, UC Berkeley, USA) visited Willow during May-June. Ramazan Cinbis (Middle East Technical University) and David Fouhey (University of Michigan) visited Willow in July-August and September-November, respectively. Akihiko Torii (Tokyo Institute of Technology) spent sabbatical at Willow from Apr to August 2018. Finally, Pierre-Yves Masse (post-doc, Czech Technical University) spent 50% of his time at Sierra (F. Bach) and Willow teams as a visiting post-doc within the framework of collaboration with the Intelligent Machine Perception project lead by J. Sivic at the Czech Technical University in Prague.

WIMMICS Project-Team

9. Partnerships and Cooperations

9.1. Regional Initiatives

9.1.1. ALDRAI UCA Project

At the center of the project, there is a triple ambition. The first is methodological and epistemological: it is a question of contributing to the development of the field of computational humanities via new tools of exploration of corpora, beyond the lexical approach (without excluding it, obviously, but in complementing) - it is a question of learning how to mobilize Artificial Intelligence to locate arguments, ideas and not simply terms, uses of terms, semantic fields. The second ambition is academic and transdisciplinary: the field studied in the project - administrative law from 1799 to today - concerns several disciplines (the history of law, administrative law, modern and contemporary history, philosophy, political science, administrative science) and the development of digital technology will make it possible to considerably widen the sources available for its study, both from the point of view of their analysis (thanks to the exploratory tools mentioned in the previous point) and from the point of view of their nature. The third ambition is professional: practitioners already use the available databases (such as ArianeWeb [0] - for administrative case law) but they need to be able to question them more finely, in relation to the theoretical questions they ask themselves. This need is all the stronger as the so-called *digital transformation of justice* is developing in the sense of automating decision-making processes, based on the disputes already settled through the implementation of systematic line of all court decisions (pursuant to the law of 7 October 2016 on the Digital Republic). Magistrates as lawyers therefore need new digital tools to work and several start-ups have appeared in the sector called Legal Tech.

Partners: UNS (faculté de lettres and faculté de droit), Inria, UCA, École Pratique des Hautes Études [0] and Institut des Systèmes Complexes de Paris IDF [0], duration: 2018-2019.

9.1.2. IADB UCA Project

IADB, *Integration and Learning on Biomedical Data*[0], is a project funded by UCA JEDI Labex (Université Côte d'Azur). The goal of the project is to leverage medical prognosis and decision making in the clinical domain with big data analysis techniques, Natural Language Processing and Machine Learning. The partners are: I3S, Wimmics, CHU Nice and BCL (Bases, Corpus, Language) Laboratory.

9.1.3. INCERTIMMO UCA Project

INCERTIMMO, *Uncertainty in Real Estate Spatial Modeling in the City*[0], is a research and development partnership funded by UCA and Kinaxia [0] company. UCA partners are: I3S, ESPACE [0], and IMREDD [0].

9.2. National Initiatives

9.2.1. PIA GDN ANSWER

Participants: Fabien Gandon, Hai Huang, Vorakit Vorakitphan, Serena Villata, Elena Cabrio.

[0] http://arianeinternet.conseil-etat.fr/arianeinternet/
[0] https://www.ephe.fr/
[0] https://iscpif.fr/
[0] *Intégration et Apprentissage sur les Données Biomédicales*
[0] *Prise en compte de l'Incertitude pour une Modélisation Spatiale des Valeurs Immobilières dans la Ville*
[0] http://www.kinaxia.fr/
[0] http://univ-cotedazur.fr/laboratoires_old/espace
[0] http://imredd.fr/

ANSWER stands for Advanced aNd Secured Web Experience and seaRch [0]. It is a GDN project (Grands Défis du Numérique) from the PIA program (Programme d'Investissements d'Avenir) on Big Data. The project is between four Inria research teams and the Qwant company.

The aim of the ANSWER project is to develop the new version of the Qwant [0] search engine by introducing radical innovations in terms of search criteria as well as indexed content and users' privacy.

The purpose is to strengthen everyone's confidence in the search engine and increase the effectiveness of Web search. Building trust in the search engine is based on innovations in (1) Security: computer security, privacy; (2) Completeness: completeness and heterogeneity of (re)sources; and (3) Neutrality: analysis, extraction, indexing, and classification of data.

Increasing the effectiveness of Web-based research relies on innovations related to (1) Relevance: variety and value of content taken into account, measurement of emotions carried by query results; (2) Interaction with the user: adaptation of the interfaces to the types of research; and (3) Performance: perceived relevance of results and response time.

The proposed innovations include:

- Design and develop models and tools for the detection of emotions in query results:
  - Ontology, thesaurus, linguistic resources
  - Metrics, indicators, classification of emotions
- Design and develop new crawling algorithms:
  - Dynamic crawling strategies
  - Crawlers and indexes for linked open data
- Ensure respect for privacy:
  - Detection of Internet tracking
  - Preventive display of tracing techniques
  - Certified security of automatic adaptation of ads to keywords entered by the user

9.2.2. DGA CONFIRMA

Participants: Elena Cabrio, Serena Villata.

The theme of this new project with DGA is counter argumentation against fake news. Its duration is 2018-2020.

9.2.3. Ministry of Culture: MonaLIA 1.0

Participants: Anna Bobasheva, Fabien Gandon.

The MonaLIA 1.0 project is a preliminary study on the coupling of learning methods (Deep Neural Networks) and knowledge-based methods (Semantic Web) for image recognition and the enhancement of descriptive documentary records. The approach is applied and evaluated on the collection and data in the Joconde database in order to identify the possibilities and challenges offered by this coupling in assisting in the creation and maintenance of such an annotated collection.

9.2.4. ANR WASABI

Participants: Michel Buffa, Elena Cabrio, Catherine Faron Zucker.

The ANR project WASABI started in January 2017 with IRCAM, Deezer, Radio France and the SME Parisson, consists in building a 2 million songs knowledge base of commercial popular music (rock, pop, etc.) Its originality is the joint use of audio-based music information extraction algorithms, song lyrics analysis algorithms (natural language processing), and the use of the Semantic Web. Web Audio technologies then explore these bases of musical knowledge and provide innovative applications for composers, musicologists, music schools and sound engineers, music broadcasters and journalists.

[0] https://project.inria.fr/answer/
[0] http://www.qwant.com

9.2.5. ANR SIDES 3.0

Participants: Catherine Faron Zucker, Olivier Corby, Fabien Gandon, Alain Giboin, Andrea Tettamanzi.

Partners: Université Grenoble Alpes, Inria, Ecole Normale Supérieure de Lyon, Viseo, Theia.

SIDES 3.0 is an ANR project (2017-2020) which started in fall 2017. It is led by Université Grenoble Alpes (UGA) and its general objective is to introduce semantics within the existing SIDES educational platform [0] for medicine students, in order to provide them with added value educational services.

Web site: https://www.uness.fr/anr/projets/dune/sides3.0

9.2.6. DBpedia.fr

Participants: Elmahdi Korfed, Fabien Gandon.

The DBpedia.fr project proposes the creation of a French chapter of the DBpedia database. This project was the first project of the Semanticpedia convention signed by the Ministry of Culture, the Wikimedia foundation and Inria.

Web site: http://dbpedia.fr

9.2.7. Convention between Inria and the Ministry of Culture

Participant: Fabien Gandon.

We supervise the research convention with the Ministry of Culture to foster research and development at the crossroad of culture and digital sciences. This convention signed between Inria and the Ministry of Culture provides a framework to support projects at the cross-road of the cultural domain and the digital sciences.

9.2.8. Qwant-Inria Joint Laboratory

Participants: Fabien Gandon, Alain Giboin.

We supervise the Qwant-Inria Joint Laboratory where joint teams are created and funded to contribute to the search engine research and development. The motto of the joint lab is Smart Search and Privacy with five research directions:

- Crawling, Indexing, Searching
- Execution platform, privacy by design, security, ethics
- Maps and navigation
- Augmented interaction, connected objects, chatbots, personnal assistants
- Education technologies (EdTech)

We identify possibilities of exploiting the Qwant search engine to improve the search for information in the digital cultural resources of the French Ministry of Culture. At the end of the project, some possibilities will be selected and will be the subject of research actions in the context a long-term project.

9.2.9. Inria Federated Query Scaler

Participant: Olivier Corby.

Federated Query Scaler is an Exploratory Research Project (PRE) funded by Inria, together with the Dyliss team at Inria Rennes. The topic of this project is the study of distributed SPARQL queries in the context of bioinformatics.

9.2.10. GDRI Zoomathia

Participants: Catherine Faron Zucker, Franck Michel, Andrea Tettamanzi.

Wimmics is a partner of the International Research Group (GDRI) Zoomathia funded by two CNRS institutes: INEE and INSHS. This group aims at studying transmission of zoological knowledge from Antiquity to Middle-Age through material resources (bio residues, artefacts), iconography and texts.

[0] http://side-sante.org/

As a continuation of the work initiated with the *Muséum National d'Histoire Naturelle* (MNHN) during the last three years, the TAXREF-LD linked data dataset, that we produced jointly with the MNHN, now appears in the Linked Open Data cloud [0] and is published on AgroPortal [0]. Relatedly, we have reflected on modelling principles for biodiversity Linked Data [45].

Web site: http://www.cepam.cnrs.fr/zoomathia/

9.3. European Initiatives

9.3.1. CREEP EIT Project

The CREEP project (Cyberbulling Effects Prevention) aims at identifying and preventing the possible negative impacts of cyberbullying on young people. It seeks to realize advanced technologies for the early detection of cyberbullying phenomena through the monitoring of social media and the communication of preventive advices and personalized recommendations tailored to teenagers' needs through a virtual coaching system (chatbot). Partners: University of Trento, Fondazione Bruno Kessler, Inria, ExpertSystem, NeuroNation; duration: 2018-2020.

Web site: http://creep-project.eu/.

9.3.2. MIREL

MIREL, MIning and REasoning with legal text, is a Research and Innovation Staff Exchange (RISE) project, funded by Marie Skłodowska-Curie grant, duration: 2016-2019

The coordinator is Leendert van der Torre, University of Luxembourg

Other partners are: University of Bologna (Italy), University of Torino (Italy), University of Huddersfield (UK), Inria (France), APIS (Bulgaria), Nomotika s.r.l. (Italy), DLVSystem s.r.l. (Italy), Zhejiang University (China), Research Organization of Information and Systems (Japan), University of Cape Town (South Africa), National University of La Plata (Argentina), National University of Córdoba (Argentina), Universidad Nacional del Sur in Bahía Blanca (Argentina), National ICT Australia Ltd (Australia), Stanford University (USA).

The MIREL project will create an international and inter-sectorial network to define a formal framework and to develop tools for MIning and REasoning with Legal texts, with the aim of translating these legal texts into formal representations that can be used for querying norms, compliance checking, and decision support. MIREL addresses both conceptual challenges, such as the role of legal interpretation in mining and reasoning, and computational challenges, such as the handling of big legal data, and the complexity of regulatory compliance. It bridges the gap between the community working on legal ontologies and NLP parsers and the community working on reasoning methods and formal logic. Moreover, it is the first project of its kind to involve industrial partners in the future development of innovative products and services in legal reasoning and their deployment in the market. MIREL promotes mobility and staff exchange between SMEs to academies in order to create an inter-continental interdisciplinary consortium in Law and Artificial Intelligence areas including Natural Language Processing, Computational Ontologies, Argumentation, and Logic & Reasoning.

Web site: http://www.mirelproject.eu/

9.4. International Initiatives

9.4.1. Inria Associate Teams Not Involved in an Inria International Labs

MoReWAIS
MoReWAIS stands for Mobile Read Write Access and Intermittent to Semantic Web.

[0] http://lod-cloud.net/
[0] http://agroportal.lirmm.fr/ontologies/TAXREF-LD/

Partners: UGB (Senegal) - LANI - Moussa Lo; start year: 2016.

MoReWAIS proposes to explore the specificities (advantages and constraints) of mobile knowledge sharing. The mobile application targeted in MoReWAIS must allow communities and their users to enrich and access more easily the knowledge base using the user's context with its richness (e.g. location, other users close-by) and addressing its limitations (e.g. intermittent access, limited resources).

Web site: https://project.inria.fr/morewais/.

9.5. International Research Visitors

9.5.1. Visits of International Scientists

Christian Cardellino: PhD, Universidad de Córdoba, Argentina, May and July.
Andrei Ciortea: PostDoc, University of Saint Gallen, Switzerland, Labex UCN@Sophia grant, November-December.
Kaladzavi Guidedi: PostDoc CEA-MITIC University of Maroua, Cameroon, MoreWAIS grant, November-December.
Phan Hieu Ho: PhD, Polytechnic Institute, Danang, Vietnam, April-July.
Milagro Teruel: PhD, Universidad de Córdoba, Argentina, May-June.
Thuy Trieu: PhD, University of Timisoara, Romania, March-July.

9.5.2. Research Stays Abroad

- Fabien Gandon visited CSIRO, Brisbane, Australia from July to August 2018. In the context of the project MIREL he worked on the problem of aligning semantic Web schemas (argumentation and generic schemas) to support interoperable and linked arguments on the Web as an extension of Web annotation and Web provenance.
- Raphaël Gazzotti visited the Natural Language Processing research group of the Universidad Nacional de Córdoba, Argentina, for two months as a secondment of the MIREL H2020 Project, March-April. We carried out information retrieval of medical test results within free text in french Electronic Medical Records by a symbolic approach. In a future step, we could annotate automatically free texts with this method then train a machine learning algorithm in order to have a better generalization of this extraction process. We also worked on a sequential machine learning modelization suited to Electronic Medical Records. This model exploits the potential of Conditional Random Fields and consequently allows us to interpret the decision made by the algorithm across all the different consultations of a patient, moreover, all medical test results can be considered with this modelization.

ZENITH Project-Team

9. Partnerships and Cooperations

9.1. Regional Initiatives

9.1.1. Labex NUMEV, Montpellier

URL: http://www.lirmm.fr/numev

We participate in the Laboratory of Excellence (labex) NUMEV (Digital and Hardware Solutions, Modelling for the Environment and Life Sciences) headed by University of Montpellier in partnership with CNRS, and Inria. NUMEV seeks to harmonize the approaches of hard sciences and life and environmental sciences in order to pave the way for an emerging interdisciplinary group with an international profile. The project is decomposed in four complementary research themes: Modeling, Algorithms and computation, Scientific data (processing, integration, security), Model-Systems and measurements.

9.1.2. Institute of Computational Biology (IBC), Montpellier

URL: http://www.ibc-montpellier.fr

IBC is a 6 year project (2012-2018) with a funding of 2Meuros by the MENRT (PIA program) to develop innovative methods and software to integrate and analyze biological data at large scale in health, agronomy and environment. Patrick Valduriez heads the workpackage on integration of biological data and knowledge.

9.2. National Initiatives

9.2.1. Institut de Convergence Agriculture numérique #DigitAg, (2017-2023), 275Keuro.

Participants: Florent Masseglia, Esther Pacitti, Christophe Pradal, Patrick Valduriez.

#DigitAg brings together in a partnership of seventeen actors (public research and teaching organizations, transfer actors and companies) with the objective of accelerating and supporting the development of agriculture companies in France and in southern countries based on new tools, services and uses. Based in Montpellier with an office in Toulouse and Rennes and led by Irstea, #DigitAg's ambition is to become a world reference for digital agriculture. In this project, Zenith is involved in the analysis of big data from agronomy, in particular, plant phenotyping.

9.2.2. PIA (Projets Investissements d'Avenir) Floris'Tic (2015-2018), 430Keuro.

Participants: Antoine Affouard, Jean-Christophe Lombardo, Hervé Goëau, Alexis Joly.

Floris'tic aims at promoting the scientific and technical culture of plant sciences through innovative pedagogic methods, including participatory initiatives and the use of IT tools such as the one built within the Pl@ntNet project. A. Joly heads the work package on the development of the IT tools. This is a joint project with the AMAP laboratory, the TelaBotanica social network and the Agropolis foundation.

9.2.3. ANR WeedElec (2018-2021), 106 Keuro.

Participants: Jean-Christophe Lombardo, Hervé Goëau, Alexis Joly.

The WeedElec project offers an alternative to global chemical weed control. It combines an aerial means of weed detection by drone coupled to an ECOROBOTIX delta arm robot equipped with a high voltage electrical weeding tool. WeedElec's objective is to remove the major related scientific obstacles, in particular the weed detection/identification, using hyperspectral and colour imaging, and associated chemometric and deep learning techniques.

9.2.4. Others

9.2.4.1. INRA/Inria PhD program, 100Keuros

Participant: Alexis Joly.

This contract between INRA and Inria allows funding a 3-years PhD student (Christophe Botella). The addressed challenge is the large-scale analysis of Pl@ntNet data with the objective to model species distribution (a big data approach to species distribution modeling). The PhD student is supervised by Alexis Joly with François Munoz (ecologist, IRD) and Pascal Monestiez (statistician, INRA).

9.3. European Initiatives

9.3.1. FP7 & H2020 Projects

9.3.1.1. CloudDBAppliance

Participants: Reza Akbarinia, Boyan Kolev, Florent Masseglia, Esther Pacitti, Patrick Valduriez.

Project title: CloudDBAppliance
Instrument: H2020
Duration: 2016 - 2019
Total funding: 5 Meuros (Zenith: 500Keuros)
Coordinator: Bull/Atos, France
Partner: Europe: Inria Zenith, U. Madrid, INESC and the companies LeanXcale, QuartetFS, Nordea, BTO, H3G, IKEA, CloudBiz, and Singular Logic.
Inria contact: Florent Masseglia, Patrick Valduriez

The project aims at producing a European Cloud Database Appliance for providing a Database as a Service able to match the predictable performance, robustness and trustworthiness of on premise architectures such as those based on mainframes. The cloud database appliance features: (i) a scalable operational database able to process high update workloads such as the ones processed by banks or telcos, combined with a fast analytical engine able to answer analytical queries in an online manner; (ii) an operational Hadoop data lake that integrates an operational database with Hadoop, so operational data is stored in Hadoop that will cover the needs from companies on big data; (iii) a cloud hardware appliance leveraging the next generation of hardware to be produced by Bull, the main European hardware provider. This hardware is a scale-up hardware similar to the one of mainframes but with a more modern architecture. Both the operational database and the in-memory analytics engine will be optimized to fully exploit this hardware and deliver predictable performance. Additionally, CloudDBAppliance will tolerate catastrophic cloud data centres failures (e.g. a fire or natural disaster) providing data redundancy across cloud data centres. In this project, Zenith is in charge of designing and implementing the components for analytics and parallel query processing.

9.4. International Initiatives

9.4.1. Inria Associate Teams Not Involved in an Inria International Labs

9.4.1.1. SciDISC

Title: Scientific data analysis using Data-Intensive Scalable Computing

International Partner (Institution - Laboratory - Researcher):

Universidade Federal do Rio de Janeiro (Brazil) - Computer Laboratory - Marta Mattoso

Start year: 2017

See also: https://team.inria.fr/zenith/scidisc/

Data-intensive science requires the integration of two fairly different paradigms: high-performance computing (HPC) and data-intensive scalable computing (DISC). Spurred by the growing need to analyze big scientific data, the convergence between HPC and DISC has been a recent topic of interest [[Coutinho 2014, Valduriez 2015]. This project will address the grand challenge of scientific data analysis using DISC (SciDISC), by developing architectures and methods to combine simulation and data analysis. The expected results of the project are: new data analysis methods for SciDISC systems; the integration of these methods as software libraries in popular DISC systems, such as Apache Spark; and extensive validation on real scientific applications, by working with our scientific partners such as INRA and IRD in France and Petrobras and the National Research Institute (INCT) on e-medicine (MACC) in Brazil.

9.4.2. Inria International Partners

9.4.2.1. Informal International Partners

We have regular scientific relationships with research laboratories in

- North America: Univ. of Waterloo (Tamer Özsu), UCSB Santa Barbara (Divy Agrawal and Amr El Abbadi), Northwestern Univ. (Chicago), university of Florida (Pamela Soltis), Vikram Salatore (Manager of Artificial Intelligence Products Group at Intel Corporation).
- Asia: National Univ. of Singapore (Beng Chin Ooi, Stéphane Bressan), Wonkwang University, Korea (Kwangjin Park), Kyoto University (Japan)
- Europe: Univ. of Madrid (Ricardo Jiménez-Periz), UPC Barcelona (Josep Lluis Larriba Pey), HES-SO (Henning Müller), University of Catania (Concetto Spampinatto), Cork School of Music (Ireland), RWTH (Aachen, Germany), Chemnitz technical university (Stefan Kahl), Berlin Museum für Naturkunde (Mario Lasseck), Stefanos Vrochidis (Greece, ITI)
- Africa: Univ. of Tunis (Sadok Ben-Yahia), IMSP, Bénin (Jules Deliga)
- Australia: Australian National University (Peter Christen)
- Central America: Technologico de Costa-Rica (Erick Mata, former director of the US initiative Encyclopedia of Life)

9.4.3. Participation in Other International Programs

BD-FARM

Title: Big Data Management and Analytics for Agriculture and Farming

International Partner (Institution - Laboratory - Researcher):

Chubu University - International Digital Earth Applied Science Research Center (IDEAS), Kiyoshi Honda

Duration: 2016 - 2018

Start year: 2016

See also: https://team.inria.fr/zenith/bdfarm-2016-2018-stic-asia/

World population is still growing and people are living longer and older. World demand for food rises sharply and current growth rates in agriculture are clearly not sufficient. But extreme flood, drought, typhoon etc, caused by climate change, give severe damages on traditional agriculture. Today, an urgent and deep redesign of agriculture is crucial in order to increase production and to reduce environmental impact. In this context, collecting, managing and analyzing dedicated, large, complex, and various datasets (Big Data) will allow improving the understanding of complex mechanisms behind adaptive, yield and crop improvement. Moreover, sustainability will require detailed studies such as the relationships between genotype, phenotype and environment. In other words, data science and ICT for agriculture must help improving production. Moreover, it has to be done while getting properly adapted to soil, climatic and agronomic constraints as well as taking into account the genetic specificities of plants.

9.5. International Research Visitors

9.5.1. Visits of International Scientists

Several international scientists visited the team and gave seminars

- Vitor Silva (COPPE/UFRJ,Brazil): “A methodology for capturing and analyzing dataflow paths in computational simulations” on January 31.
- Dennis Shasha (NYU): “Reducing Errors by Refusing to Guess (Occasionally)” on June 1.
- Daniel de Oliveira (UFF, Brazil): “Parameter and Data Recommendation in Scientific Workflows based on Provenance” on June 5.
- Eduardo Ogasawara, (CEFET-RJ, Brazil): “Comparing Motif Discovery Techniques with Sequence Mining in the Context of Space-Time Series” on November 26.