Activity Report 2018

Section Partnerships and Cooperations

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.

<div align="center" style="color:red">**CELTIQUE Project-Team**</div>

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.

<p style="text-align:center">**CIDRE Project-Team**</p>

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.

<p align="center">**GALLINETTE Project-Team**</p>

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.

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).

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[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.

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[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.

<div align="center">**PACAP Project-Team**</div>

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.

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.

<p style="text-align:center">**TAMIS Project-Team**</p>

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.

<div align="center">**TEA Project-Team**</div>

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.

<p style="text-align:center;color:red;">I4S Project-Team</p>

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.

<p align="center">**MINGUS Project-Team**</p>

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.

<h1 style="text-align: center; color: red;">SIMSMART Team</h1>

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).

<p style="text-align:center; color:red; font-weight:bold;">DYLISS Project-Team</p>

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)]

<div align="center" style="color:red">**FLUMINANCE Project-Team**</div>

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.

<p align="center">**GENSCALE Project-Team**</p>

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 Investi-gação 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.

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.

<p style="text-align:center">**VISAGES Project-Team**</p>

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
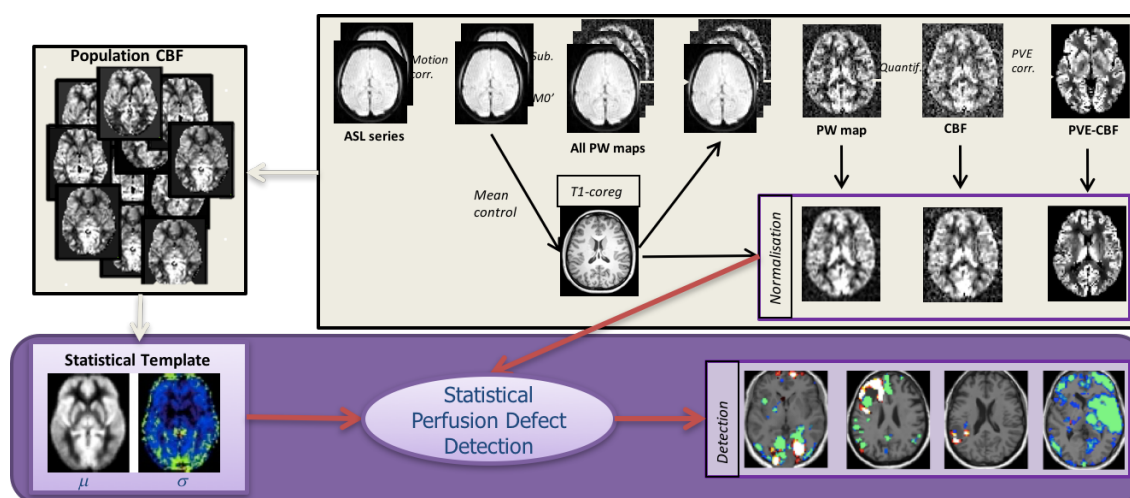
Figure 2. Processing workflow for quantification of Arterial Spin Labelling Cerebral Blood Flow with detection of abnormal perfusion

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).
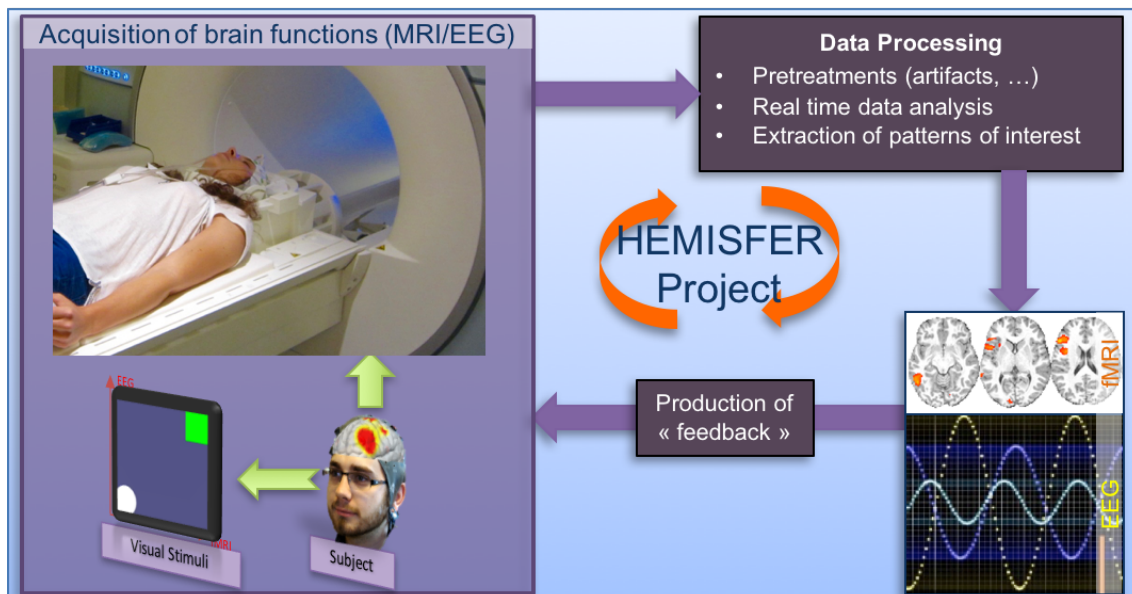

Figure 3. Principle of the Hemisfer project.

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.

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[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.

<p style="text-align:center; color:red;">**DIONYSOS Project-Team**</p>

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.

<p align="center" style="color:red">DIVERSE Project-Team</p>

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.

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

<p align="center" style="color:red">KERDATA Project-Team</p>

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.

<p style="text-align:center;color:red;font-weight:bold;">MYRIADS Project-Team</p>

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.

<p align="center" style="color:red">STACK Team</p>

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.

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[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 Data-centers) 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.

<p style="text-align: center; color: red;">**WIDE Project-Team**</p>

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.

<div align="center">

HYBRID Project-Team

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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 developing 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.

<p align="center" style="color:red">LACODAM Project-Team</p>

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.

<p style="text-align:center">**LINKMEDIA Project-Team**</p>

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

<p align="center">**MIMETIC Project-Team**</p>

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

<p align="center" style="color:red">PANAMA Project-Team</p>

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

<p align="center" style="color:red">RAINBOW Project-Team</p>

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).

<center>**SIROCCO Project-Team**</center>

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).