RESEARCH CENTER
Paris

FIELD

Activity Report 2017

Section Partnerships and Cooperations

Edition: 2018-02-19

ANTIQUE Project-Team

9. Partnerships and Cooperations

9.1. National Initiatives

9.1.1. AnaStaSec

Title: Static Analysis for Security Properties

Type: ANR générique 2014

Defi: Société de l'information et de la communication

Instrument: ANR grant

Duration: January 2015 - December 2018

Coordinator: Inria Paris-Rocquencourt (France)

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

Inria contact: Jerome Feret

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

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

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

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

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

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

9.1.2. REPAS

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

9.1.3. VeriFault

This was a PEPS project for one year, coordinated by Cezara Drăgoi, on the topic of fault-tolerant distributed algorithms. These algorithms are notoriously difficult to implement correctly, due to asynchronous communication and the occurrence of faults, such as the network dropping messages or computers crashing. Although fault-tolerant algorithms are at the core of critical applications, there are no automated verification techniques that can deal with their complexity. Due to the complexity distributed systems have reached, we believe it is no longer realistic nor efficient to assume that high level specifications can be proved when development and verification are two disconnected steps in the software production process. Therefore we propose to introduce a domain specific language that has a high-level control structure which focuses on the algorithmic aspects rather than on low-level network and timer code, and makes programs amendable to automated verification.

9.1.4. TGFSYSBIO

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

Type: ANR générique 2014

Defi: Société de l'information et de la communication

Instrument: Plan Cancer 2014-2019

Duration: December 2015 - November 2018

Coordinator: INSERM U1085-IRSET

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

Inria contact: Jerome Feret

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

Our project proposes a systemic approach aiming at to identifying the potential targets that regulate the shift from anti- to pro-oncogenic effects of TGF-β. To that purpose, we will combine a rule-based model (Kappa language) to describe extracellular TGF-beta activation and large-scale state-transition based (Cadbiom formalism) model for TGF-β-dependent intracellular signaling pathways. The multi-scale integrated model will be enriched with a large-scale analysis of liver tissues using shotgun proteomics to characterize protein networks from tumor microenvironment whose remodeling is responsible for extracellular activation of TGF-β. The trajectories and upstream regulators of the final model will be analyzed with symbolic model checking techniques and abstract interpretation combined with causality analysis. Candidates will be classified with semantic-based approaches and symbolic bi-clustering technics. All efforts must ultimately converge to experimental validations of hypotheses and we will use our hepatic cellular models (HCC cell lines and hepatic stellate cells) to screen inhibitors on the behaviors of TGF-β signal.

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

9.2. European Initiatives

9.2.1. FP7 & H2020 Projects

ASSUME, ITEA 3 project (Affordable Safe & Secure Mobility Evolution). Affordable Safe & Secure Mobility Evolution

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

9.2.2. MemCad

Type: IDEAS

Defi: Design Composite Memory Abstract Domains

Instrument: ERC Starting Grant

Objectif: Design Composite Memory Abstract Domains

Duration: October 2011 - September 2016

Coordinator: Inria (France)

Partner: None

Inria contact: Xavier Rival

Abstract: The MemCAD project aims at setting up a library of abstract domains in order to express and infer complex memory properties. It is based on the abstract interpretation frameworks, which allows to combine simple abstract domains into complex, composite abstract domains and static analyzers. While other families of abstract domains (such as numeric abstract domains) can be easily combined (making the design of very powerful static analyses for numeric intensive applications possible), current tools for the analysis of programs manipulating complex abstract domains usually rely on a monolithic design, which makes their design harder, and limits their efficiency. The purpose of the MemCAD project is to overcome this limitation.

Our proposal is based on the observation that the complex memory properties that need to be reasoned about should be decomposed in combinations of simpler properties. Therefore, in static analysis, a complex memory abstract domain could be designed by combining many simpler domains, specific to common memory usage patterns. The benefit of this approach is twofold: first it would make it possible to simplify drastically the design of complex abstract domains required to reason about complex softwares, hereby allowing certification of complex memory intensive softwares by automatic static analysis; second, it would enable to split down and better control the cost of the analyses, thus significantly helping scalability. As part of this project, we propose to build a static analysis framework for reasoning about memory properties, and put it to work on important classes of applications, including large softwares.

9.3. International Initiatives

9.3.1. Participation in Other International Programs

9.3.1.1. EXEcutable Knowledge

Title: EXEcutable Knowledge

Type: DARPA

Instrument: DARPA Program

Program: Big Mechanism

Duration: July 2014 - December 2017

Coordinator: Harvard Medical School (Boston, USA)

Partner: Inria Paris-Rocquencourt, École normale supérieure de Lyon Université Paris-Diderot,

Inria contact: Jerome Feret

Abstract: Our overarching objective is Executable Knowledge: to make modeling and knowledge representation twin sides of biological reasoning. This requires the definition of a formal language with a clear operational semantics for representing proteins and their interaction capabilities in terms of agents and rules informed by, but not exposing, biochemical and biophysical detail. Yet, to achieve Executable Knowledge we need to go further:

- Bridge the gap between rich data and their formal representation as executable model elements. Specifically, we seek an intermediate, but already formal, knowledge representation (meta-language) to express granular data germane to interaction mechanisms; a protocol defining which and how data are to be expressed in that language; and a translation procedure from it into the executable format.
- Implement mathematically sound, fast, and scalable tools for analyzing and executing arbitrary collections of rules.
- Develop a theory of causality and attendant tools to extract and analyze the unfolding of causal lineages to observations in model simulations.

We drive these technical goals with the biological objective of assembling rule-based models germane to Wnt signaling in order to understand the role of combinatorial complexity in robustness and control.

9.3.1.2. Active Context

Title: Active Context

Type: DARPA

Instrument: DARPA Program

Program: Communicating with Computers

Duration: July 2015 - December 2018

Coordinator: Harvard Medical School (Boston, USA)

Partner: University of California, (San Diego, USA), Inria Paris-Rocquencourt, École normale supérieure de Lyon Université Paris-Diderot,

Inria contact: Jerome Feret

Abstract: The traditional approach to the curation of biological information follows a philatelic paradigm, in which epistemic units based on raw or processed data are sorted, compared and catalogued in a slow and all too often insufficiently coordinated process aimed at capturing the meaning of each specimen in isolation. The swelling bounty of data generated by a systematic approach to biology founded on high-throughput technologies appears to have only intensified a sense of disconnected facts, despite their rendering as networks. This is all the more frustrating as the tide of static data (sequences, structures) is giving way to a tide of dynamic data about (protein-protein) interaction that want to be interconnected and understood (think annotated) in terms of process, i.e. a systemic approach.

The barrier is the complexity of studying systems of numerous heterogeneously interacting components in a rapidly evolving field of science. The complexity comes from two kinds of dynamically changing context: the internal dynamics of a biological system, which provide the context for assessing the meaning of a protein-protein interaction datum, and the external dynamics of the very fact base used to define the system in the first place. We propose the integration of dynamic modeling into the practice of bioinformatics to address these two dynamics by coupling them. The external dynamics is at first handled by a novel kind of two-layered knowledge representation (KR). One layer

contextualizes proteins and their interactions in a structure that incrementally constructs, in an open-ended dialogue with the user, its own semantics by piecing together fragments of knowledge from a variety of sources tapped by the Big Mechanism program. The other layer is a model representation (MR) that handles and prioritizes the many executable abstractions compatible with the KR. The internal dynamics is handled not only by execution but also by addressing the impedance mismatch between the unwieldy formal language(s) required for execution and the more heuristic, high-level concepts that structure the modeling discourse with which biologists reason about molecular signaling systems. To the extent that we are successful on both ends, users will be able to effectively deploy modeling for curating the very fact base it rests upon, hopefully achieving self-consistency.

9.4. International Research Visitors

9.4.1. Visits of International Scientists

9.4.1.1. Internships

Xavier Rival supervised the internship of Guillaume Cluzel (L3, École Normale Supérieure de Lyon), on the implementation of array abstract domains.

Xavier Rival supervised the internship of Sixiao Zhu (M1, École Polytechnique), on the integration of a three valued abstraction in MemCAD.

9.4.2. Visits to International Teams

9.4.2.1. Research Stays Abroad

Xavier Rival visited KAIST (Korean Advanced Institute for Science and Technology) as an Invited Professor in November/December 2017.

AOSTE2 Team

9. Partnerships and Cooperations

9.1. National Initiatives

9.1.1. FUI

9.1.1.1. CEOS

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

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

9.1.1.2. WARUNA

Participants: Antoine Bertout, Liliana Cucu, Adriana Gogonel, Tomasz Kloda, Yves Sorel, Walid Talaboulma.

This project was started on September 2015. It targets the creation of a framework allowing to connect different existing methods while enriching the description with Waruna results. This framework allows timing analyses for different application domains like avionics, railways, medical, aerospace, automotive, etc.

9.1.2. PIA

9.1.2.1. CAPACITES

Participants: Liliana Cucu, Cristian Maxim, Dumitru Potop-Butucaru, Yves Sorel, Walid Talaboulma.

This project is funded by the LEOC Call (Logiciel Embarqué et Objets Connectés) of the national support programme Investissements d'Avenir. It was started on November 1st, 2014 with the kick-off meeting held on November, 12th 2014. The project cordinator is Kalray, and the objective of the project is to study the relevance of Kalray-style MPPA processor array for real-time computation in the avionic domain (with partners such as Airbus for instance). The PhD of Walid Talaboulma is funded on this contract.

9.1.2.2. DEPARTS

Participants: Liliana Cucu, Adriana Gogonel, Walid Talaboulma.

This project is funded by the BGLE Call (Briques Logicielles pour le Logiciel Embarqué) of the national support programme Investissements d'Avenir. Formally started on October 1st, 2012 with the kick-off meeting held on April, 2013 for administrative reasons. Research will target solutions for probabilistic component-based models, and a Ph.D. thesis should start at latest on September 2015. The goal is to unify in a common framework probabilistic scheduling techniques with compositional assume/guarantee contracts that have different levels of criticality.

9.2. European Initiatives

9.2.1. Collaborations in European Programs, Except FP7 & H2020

9.2.1.1. ASSUME

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

Program: ITEA

Project acronym: ASSUME

Project title: Affordable Safe and Secure Mobility Evolution

Duration: September 2015 - August 2018

Coordinator: Daimler

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

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

9.2.2. Collaborations with Major European Organizations

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

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

9.3. International Research Visitors

9.3.1. Visits of International Scientists

Professor George Lima (University of Baha, Brazil) visited us between May and June. His stay was dedicated the study of the utilization of extreme value theory on the problem of probabilistic estimation of worst case execution time bounds for a program on a processor.

CASCADE Project-Team

7. Partnerships and Cooperations

7.1. National Initiatives with Industry

7.1.1. CryptoComp

Program: FUI

Duration: October 2014 – November 2018

Coordinator: CryptoExperts

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

Local coordinator: David Pointcheval

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

7.1.2. RISQ

Program: GDN

Duration: February 2017 – September 2020

Coordinator: Secure-IC

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

Local coordinator: Michel Abdalla

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

7.2. National Collaborations within Academics

7.2.1. EnBiD

Title: Encryption for Big Data

Program: ANR JCJC

Duration: October 2014 – September 2018

PI: Hoeteck Wee

Partners: Université Paris 2, Université Limoges

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

7.2.2. EfTrEC

Title: Efficient Transferable E-Cash

Program: ANR JCJC

Duration: October 2016 – September 2020

PI: Georg Fuchsbauer

Partners: Université Paris 2

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

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

7.2.3. ALAMBIC

Title: AppLicAtions of MalleaBIlity in Cryptography

Program: ANR PRC

Duration: October 2016 – September 2020

PI: Damien Vergnaud

Partners: ENS Lyon, Université Limoges

The main objectives of the proposal are the following:

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

7.3. European Initiatives

7.3.1. CryptoAction

Title: Cryptography for Secure Digital Interaction

Program: H2020 ICT COST

Duration: April 2014 – April 2018

Local coordinator: Michel Abdalla

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

7.3.2. CryptoCloud

Title: Cryptography for the Cloud

Program: FP7 ERC Advanced Grant

Duration: June 2014 – May 2019

PI: David Pointcheval

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

7.3.3. SAFEcrypto

Title: Secure Architectures of Future Emerging Cryptography

Program: H2020

Duration: January 2015 – January 2019

Coordinator: The Queen's University of Belfast

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

Local coordinator: Michel Abdalla

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

7.3.4. ECRYPT-NET

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

Program: H2020 ITN

Duration: March 2015 – February 2019

Coordinator: KU Leuven (Belgium)

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

Local coordinator: Michel Abdalla

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

7.3.5. aSCEND

Title: Secure Computation on Encrypted Data

Program: H2020 ERC Starting Grant

Duration: June 2015 – May 2020

PI: Hoeteck Wee

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

7.3.6. FENTEC

Title: Functional Encryption Technologies

Program: H2020

Duration: January 2018 – December 2020

Coordinator: ATOS Spain SA

Scientific coordinator: Michel Abdalla

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

Local coordinator: Michel Abdalla

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

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

7.4. International Initiatives with Industry

7.4.1. CryPrivBC

Title: Cryptography for Privacy on the Blockchain

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

Duration: October 2017 – October 2021

PI: Georg Fuchsbauer

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

7.5. International Research Visitors

- Melissa Chase (MSR Redmond)
- Huijia Rachel Lin (UCSB)
- Yuval Ishai (Technion)
- Stefano Tessaro (UCSB)
- Vinod Vaikuntanathan (MIT)

GALLIUM Project-Team

9. Partnerships and Cooperations

9.1. National Initiatives

9.1.1. ANR projects

9.1.1.1. Vocal

Participants: Armaël Guéneau, Xavier Leroy, François Pottier, Naomi Testard.

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

The library will be made available to all OCaml programmers and will be of particular interest to implementors of safety-critical OCaml programs, such as Coq, Astrée, Frama-C, CompCert, Alt-Ergo, as well as new projects. By offering verified program components, our work will provide the essential building blocks that are needed to significantly decrease the cost of developing new formally verified programs.

9.1.2. FUI Projects

9.1.2.1. Secur-OCaml

Participants: Damien Doligez, Fabrice Le Fessant.

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

9.2. European Initiatives

9.2.1. FP7 & H2020 Projects

9.2.1.1. Deepsea

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

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

9.2.2. ITEA3 Projects

9.2.2.1. Assume

Participants: Xavier Leroy, Luc Maranget.

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

9.3. International Initiatives

9.3.1. Informal International Partners

- Princeton University: interactions between the CompCert verified C compiler and the Verified Software Toolchain developed at Princeton.
- Cambridge University and Microsoft Research Cambridge: formal modeling and testing of weak memory models.

PARKAS Project-Team

8. Partnerships and Cooperations

8.1. National Initiatives

8.1.1. ANR

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

8.1.2. Investissements d'avenir

Sys2Soft contract (Briques Génériques du Logiciel Embarqué). Partenaire principal: Dassault-Systèmes, etc. Inria contacts are Benoit Caillaud (HYCOMES, Rennes) and Marc Pouzet (PARKAS, Paris).

8.1.3. Others

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

8.2. European Initiatives

8.2.1. FP7 & H2020 Projects

8.2.1.1. Eurolab-4-HPC

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

Programm: H2020

Duration: September 2015 - September 2017

Coordinator: CHALMERS TEKNISKA HOEGSKOLA AB

Inria contact: Albert Cohen

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 longterm 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 orientated communities in Europe, working across all layers of the system stack and, at the same time, fuelling new industries in HPC.

8.2.1.2. TETRACOM

Title: Technology Transfer in Computing Systems

Programm: FP7

Duration: September 2013 - August 2016

Coordinator: RHEINISCH-WESTFAELISCHE TECHNISCHE HOCHSCHULE AACHEN

Inria contact: Albert Cohen

The mission of the TETRACOM Coordination Action is to boost European academia-to-industry technology transfer (TT) in all domains of Computing Systems. While many other European and national initiatives focus on training of entrepreneurs and support for start-up companies, the key differentiator of TETRACOM is a novel instrument called Technology Transfer Project (TTP). TTPs help to lower the barrier for researchers to make the first steps towards commercialisation of their research results. TTPs are designed to provide incentives for TT at small to medium scale via partial funding of dedicated, well-defined, and short term academia-industry collaborations that bring concrete R&D results into industrial use. This will be implemented via competitive Expressions-of-Interest (EoI) calls for TTPs, whose coordination, prioritization, evaluation, and management are the major actions of TETRACOM. It is expected to fund up to 50 TTPs. The TTP activities will be complemented by Technology Transfer Infrastructures (TTIs) that provide training, service, and dissemination actions. These are designed to encourage a larger fraction of the R&D community to engage in TTPs, possibly even for the first time. Altogether, TETRACOM is conceived as the major pilot project of its kind in the area of Computing Systems, acting as a TT catalyst for the mutual benefit of academia and industry. The projects primary success metrics are the number and value of coordinated TTPs as well as the amount of newly introduced European TT actors. It is expected to acquire around more than 20 new contractors over the project duration. TETRACOM complements and actually precedes the use of existing financial instruments such as venture capital or business angels based funding.

8.2.1.3. EMC2

Title: Embedded Multi-Core Systems for Mixed Criticality Applications in Dynamic and Changeable Real-Time Environments

Programm: FP7

Duration: April 2014 - March 2017

Coordinator: Infineon Technologies

Inria contact: Albert Cohen

'Embedded systems are the key innovation driver to improve almost all mechatronic products with cheaper and even new functionalities. Furthermore, they strongly support today's information society as inter-system communication enabler. Consequently boundaries of application domains are alleviated and ad-hoc connections and interoperability play an increasing role. At the same time, multi-core and many-core computing platforms are becoming available on the market and provide a breakthrough for system (and application) integration. A major industrial challenge arises facing (cost) efficient integration of different applications with different levels of safety and security on a single computing platform in an open context. The objective of the EMC^2 project (Embedded multi-core systems for mixed criticality applications in dynamic and changeable real-time environments) is to foster these changes through an innovative and sustainable service-oriented architecture approach for mixed criticality applications in dynamic and changeable real-time environments. The EMC2 project focuses on the industrialization of European research outcomes and builds on the results of previous ARTEMIS, European and National projects. It provides the paradigm shift to a new and sustainable system architecture which is suitable to handle open dynamic systems. EMC^2 is part of the European Embedded Systems industry strategy to maintain its leading edge position by providing solutions for: . Dynamic Adaptability in Open Systems . Utilization of expensive system features only as Service-on-Demand in order to reduce the overall system cost. . Handling of mixed criticality applications under real-time conditions . Scalability and utmost flexibility . Full scale deployment and management of integrated tool chains, through the entire lifecycle Approved by ARTEMIS-JU on 12/12/2013 for EoN. Minor mistakes and typos corrected by the Coordinator, finally approved by ARTEMIS-JU on 24/01/2014. Amendment 1 changes approved by ECSEL-JU on 31/03/2015.'

8.3. International Initiatives

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

8.3.1.1. POLYFLOW

Title: Polyhedral Compilation for Data-Flow Programming Languages

International Partner (Institution - Laboratory - Researcher):

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

Start year: 2016

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

The objective of the associate team is to foster collaborations on fundamental and applied research. It also supports training sessions, exchange of undergraduate and master students, and highlighting opportunities in the partners' research, education and economic environments.

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

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

8.3.2. Participation in Other International Programs

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

8.4. International Research Visitors

8.4.1. Visits of International Scientists

8.4.1.1. Internships

Alex Susu from Polytechnica di Bucarest spent a 3 months internship in the Fall.

8.4.2. Visits to International Teams

8.4.2.1. Sabbatical programme

Francesco Zappa Nardelli, from Feb. 1st, 2017 to July. 29th, 2017 has been on sabbatical leave at Northeastern University, Boston, USA, invited by Prof. Jan Vitek.

PI.R2 Project-Team

7. Partnerships and Cooperations

7.1. National Initiatives

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

Pierre-Louis Curien (coordinator), Yves Guiraud (local coordinator), Philippe Malbos and Samuel Mimram are members of the four-year Cathre ANR project (January 2014 to December 2017). This project investigates the general theory of higher-dimensional rewriting, the development of a general-purpose library for higher-dimensional rewriting, and applications in the fields of combinatorial linear algebra, combinatorial group theory and theoretical computer science. This project is joint with mathematicians and computer scientists from LAGA (Univ. Paris 13), LIX (École Polytechnique), ICJ (Univ. Lyon 1 and Univ. Saint-Étienne), I2M (Univ. Aix-Marseille) and IMT (Univ. Toulouse 3). The project Cathre provided the funding for the PhD of Maxime Lucas.

Pierre-Louis Curien, Yves Guiraud, Hugo Herbelin, Philippe Malbos, Samuel Mimram and Alexis Saurin are members of the GDR Informatique Mathématique, in the Géocal (Geometry of computation) and LAC (Logic, algebra and computation) working groups.

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

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

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

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

7.2. European Initiatives

7.2.1. Collaborations in European Programs, Except FP7 & H2020

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

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

7.3. International Initiatives

7.3.1. Inria International Labs

7.3.1.1. Other IIL projects

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

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

7.3.2.1. Associate team

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

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

7.3.2.2. Joint Inria-CAS project

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

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

7.3.3. Inria International Partners

7.3.3.1. Informal International Partners

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

7.3.4. Participation in Other International Programs

Pierre-Louis Curien participates to the ANR International French-Chinese project LOCALI (Logical Approach to Novel Computational Paradigms), coordinated by Gilles Dowek (Deducteam). This project ended in July 2017.

7.4. International Research Visitors

7.4.1. Visits of International Scientists

John Baez (University of California River Side) visited the team for a week in November 2017.

Marcelo Fiore (University of Cambridge) visited the team for two weeks in February 2017.

Jovana Obradović (now a postdoc at Charles University, Prague) visited the team from December 1 to December 10 2017.

Amin Timany (KU Leuven, Belgium) visited the team for two months in March-April 2017 and collaborated with Matthieu Sozeau on the design and implementation of cumulative inductive types in Coq.

7.4.2. Visits to International Teams

7.4.2.1. Research Stays Abroad

Pierre-Louis Curien visited East China Normal University for a month in June 2017 (collaborations with Yuxin Deng and Min Zhang). Pierre-Louis Curien and Jovana Obradović visited the Institute of Mathematics of the Serbian Academy of Sciences in Belgrade in July 2017 (collaboration with Zoran Petrić).

Jean-Jacques Lévy visited the Institute of Software of Chinese Academy of Sciences (ISCAS) in December 2017 (project VIP and on-going work with Ran Chen) during 2 weeks. He gave talks at ISCAS hosted by Ying Jiang, and during a third week at ECNU Shanghai hosted by Min Zhang, USTC Suzhou (University of Science and Technology of China) hosted by Xinyu Feng, Nankai University in Tianjin hosted by Chunfu Jia.

POLSYS Project-Team

8. Partnerships and Cooperations

8.1. Regional Initiatives

- **French Ministry of Armies**

  POLSYS has a collaboration with the French Ministry of Armies.

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

  GLOBAL ALGEBRAIC SHOOTING METHOD IN OPTIMAL CONTROL AND APPLICATIONS

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

8.2. National Initiatives

8.2.1. ANR

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

  `Duration:` 2018–2022

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

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

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

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

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

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

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

8.3. European Initiatives

8.3.1. FP7 & H2020 Projects

8.3.1.1. A3

Type: PEOPLE

Instrument: Career Integration Grant

Duration: May 2013 - Apr. 2017

Coordinator: Jean-Charles Faugère

Partner: Institut National de Recherche en Informatique et en Automatique (Inria), France

Inria contact: Elias Tsigaridas

Abstract: The project Algebraic Algorithms and Applications (A3) is an interdisciplinary and multidisciplinary project, with strong international synergy. It consists of four work packages The first (Algebraic Algorithms) focuses on fundamental problems of computational (real) algebraic geometry: effective zero bounds, that is estimations for the minimum distance of the roots of a polynomial system from zero, algorithms for solving polynomials and polynomial systems, derivation of non-asymptotic bounds for basic algorithms of real algebraic geometry and application of polynomial system solving techniques in optimization. We propose a novel approach that exploits structure and symmetry, combinatorial properties of high dimensional polytopes and tools from mathematical physics. Despite the great potential of the modern tools from algebraic algorithms, their use requires a combined effort to transfer this technology to specific problems. In the second package (Stochastic Games) we aim to derive optimal algorithms for computing the values of stochastic games, using techniques from real algebraic geometry, and to introduce a whole new arsenal of algebraic tools to computational game theory. The third work package (Non-linear Computational Geometry), we focus on exact computations with implicitly defined plane and space curves. These are challenging problems that commonly arise in geometric modeling and computer aided design, but they also have applications in polynomial optimization. The final work package (Efficient Implementations) describes our plans for complete, robust and efficient implementations of algebraic algorithms.

8.3.2. Collaborations in European Programs, Except FP7 & H2020

Program: COST

Project acronym: CryptoAction

Project title: Cryptography for Secure Digital Interaction

Duration: Apr. 2014 - Apr. 2018

Coordinator: Claudio ORLANDI

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

Program: COST

Project acronym: CRYPTACUS

Project title: Cryptanalysis of ubiquitous computing systems

Duration: Dec. 2014 - Dec. 2018

Coordinator: Gildas AVOINE

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

8.4. International Initiatives

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

8.4.1.1. GOAL

Title: Geometry and Optimization with ALgebraic methods.

International Partner (Institution - Laboratory - Researcher):

University of California Berkeley (United States) - Dept. of Mathematics - Bernd Sturmfels

Start year: 2015

See also: http://www-polsys.lip6.fr/GOAL/index.html

Polynomial optimization problems form a subclass of general global optimization problems, which have received a lot of attention from the research community recently; various solution techniques have been designed. One reason for the spectacular success of these methods is the potential impact in many fields: data mining, big data, energy savings, etc. More generally, many areas in mathematics, as well as applications in engineering, biology, statistics, robotics etc. require a deeper understanding of the algebraic structure of their underlying objects.

A new trend in the polynomial optimization community is the combination of algebraic and numerical methods. Understanding and characterizing the algebraic properties of the objects occurring in numerical algorithms can play an important role in improving the efficiency of exact methods. Moreover, this knowledge can be used to estimate the quality (for example the number of significant digits) of numerical algorithms. In many situations each coordinate of the optimum is an algebraic number. The degree of the minimal polynomials of these algebraic numbers is the Algebraic Degree of the problem. From a methodological point of view, this notion of Algebraic Degree emerges as an important complexity parameter for both numerical and the exact algorithms. However, algebraic systems occurring in applications often have special algebraic structures that deeply influence the geometry of the solution set. Therefore, the (true) algebraic degree could be much less than what is predicted by general worst case bounds (using Bézout bounds, mixed volume, etc.), and would be very worthwhile to understand it more precisely.

The goal of this proposal is to develop algorithms and mathematical tools to solve geometric and optimization problems through algebraic techniques. As a long-term goal, we plan to develop new software to solve these problems more efficiently. These objectives encompass the challenge of identifying instances of these problems that can be solved in polynomial time with respect to the number of solutions and modeling these problems with polynomial equations.

8.5. International Research Visitors

8.5.1. Visits of International Scientists

- May – July 2017, Delaram Kahrobaei, Professor, CUNY, NYC, USA

8.5.1.1. Internships

- May – July 2017, Kelsey Horan, PhD student, CUNY, NYC, USA.
- Apr. – Nov. 2017, Eliane Koussa, Université de Versailles
- Apr. – Aug. 2017, Pascal Fong, Université de Versailles

PROSECCO Project-Team

8. Partnerships and Cooperations

8.1. National Initiatives

8.1.1. ANR

8.1.1.1. AnaStaSec

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

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

Duration: January 2015 - December 2018.

Coordinator: Jérôme Féret, Inria Antique (France)

Participant: Bruno Blanchet

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

8.1.1.2. AJACS

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

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

Duration: October 2014 - March 2019.

Coordinator: Alan Schmitt, Inria (France)

Participants: Karthikeyan Bhargavan, Bruno Blanchet, Nadim Kobeissi

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

8.1.1.3. SafeTLS

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

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

Duration: October 2016 - September 2020

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

Participants: Karthikeyan Bhargavan

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

8.2. European Initiatives

8.2.1. FP7 & H2020 Projects

8.2.1.1. ERC Consolidator Grant: CIRCUS

Title: CIRCUS: An end-to-end verification architecture for building Certified Implementations of Robust, Cryptographically Secure web applications
Duration: April 2016 - March 2021
Coordinator: Karthikeyan Bhargavn, Inria
Abstract: The security of modern web applications depends on a variety of critical components including cryptographic libraries, Transport Layer Security (TLS), browser security mechanisms, and single sign-on protocols. Although these components are widely used, their security guarantees remain poorly understood, leading to subtle bugs and frequent attacks. Rather than fixing one attack at a time, we advocate the use of formal security verification to identify and eliminate entire classes of vulnerabilities in one go.

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

8.2.1.2. ERC Starting Grant: SECOMP

Title: SECOMP: Efficient Formally Secure Compilers to a Tagged Architecture
Duration: Jan 2017 - December 2021
Coordinator: Catalin Hritcu, Inria
Abstract: This new ERC-funded project called SECOMP1 is aimed at leveraging emerging hardware capabilities for fine-grained protection to build the first, efficient secure compilers for realistic programming languages, both low-level (the C language) and high-level (F*, a dependently-typed ML variant). These compilers will provide a secure semantics for all programs and will ensure that high-level abstractions cannot be violated even when interacting with untrusted low-level code. To achieve this level of security without sacrificing efficiency, our secure compilers will target a tagged architecture, which associates a metadata tag to each word and efficiently propagates and checks tags according to software-defined rules. We will use property-based testing and formal verification to provide high confidence that our compilers are indeed secure.

8.2.1.3. NEXTLEAP

Title: NEXTLEAP: NEXT generation Legal Encryption And Privacy
Programme: H2020
Duration: January 2016 - December 2018
Coordinator: Harry Halpin, Inria
Other partners: IMDEA, University College London, CNRS, IRI, and Merlinux
Abstract: NEXTLEAP aims to create, validate, and deploy protocols that can serve as pillars for a secure, trust-worthy, and privacy-respecting Internet. For this purpose NEXTLEAP will develop an interdisciplinary study of decentralisation that provides the basis on which these protocols can be designed, working with sociologists to understand user needs. The modular specification of decentralized protocols, implemented as verified open-source software modules, will be done for both privacy-preserving secure federated identity as well as decentralized secure messaging services that hide metadata (e.g., who, when, how often, etc.).

8.3. International Initiatives

8.3.1. Inria International Labs

8.3.1.1. Informal International Partners

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

- **F***: Microsoft Research (Cambdridge, Redmond), IMDEA (Madrid)
- **TLS analysis**: Microsoft Research (Cambridge), Mozilla, University of Rennes
- **Web Security**: Microsoft Research (Cambridge, Redmond), Imperial College (London), University of Stuttgart
- **Micro-Policies**: University of Pennsylvania, Portland State University

8.3.2. Participation in Other International Programs

8.3.2.1. International Initiatives

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

Program: DARPA SSITH

Duration: January 2016 - December 2018

Coordinator: Charles Stark, Draper Laboratory

Participants: Catalin Hritcu

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

8.4. International Research Visitors

8.4.1. Visits of International Scientists

- Claudia Diaz from KUL visited the group from 1-2 March and gave a seminar "Designing Mixnets"
- Peter Schwabe visited Inria Paris on 11 April; he gave a seminar: From NewHope to Kyber.
- Joseph Bonneau (Stanford University) visited Inria on 20 April 2017, he gave a seminar: Public randomness, blockchains and proofs-of-delay
- Stefan Ciobaca (Alexandru Ioan Cuza University of Iai, Romania) visited Inria Paris on 15 May 2017; he gave a seminar: The RMT Tool for Rewriting Modulo Theories.
- Ana Nora Evans (University of Virginia) joined Inria as a Visiting Scientist Apr–Aug 2017; she gave a seminar: Using Verified Software Fault Isolation for a Formally Secure Compiler.
- David Evans (University of Virginia) joined Inria as a Visiting Scientist Apr–Aug 2017; he gave a seminar: Can Machine Learning Work in the Presence of Adversaries?

- Jean Yang (CMU) visited Inria Paris on 6 June 2017; she gave a seminar: Policy-Agnostic Programming for Database-Backed Applications.
- Amal Ahmed (Northeastern University) joined Inria as a Visiting Professor from September 2017; she gave a seminar: Prosecco Seminars: Compositional Compiler Verification for a Multi-Language World.
- Aaron Weiss (Northeastern University) joined Inria as a Visiting Scientist from September 2017.
- Amin Timany (KU Leuven) visited Inria Paris 6-8 December 2017; he gave a seminar: A Logical Relation for Monadic Encapsulation of State: Proving contextual equivalences in the presence of runST.
- Eric Rescorla visited Prosecco to discuss the design of TLS 1.3.

8.4.1.1. Internships

- Benjamin Lipp: Dec 2017 until May 2018, supervised by B. Blanchet, K. Bhargavan, and H. Halpin
- Iness Ben Guirat: Masters student 2017, supervised by H. Halpin
- Carmine Abate (University of Trento): Dec 2017 until May 2018
- William Bowman (Northeastern University): Oct 2017 until Dec 2017
- Keith Cannon (American University Paris): Mar 2017 until Sep 2017
- Théo Laurent (ENS Paris): Mar 2017 until Aug 2017
- Clément Pit-Claudel (MIT): Jul 2017 until Oct 2017

8.4.2. Visits to International Teams

- Catalin Hritcu, October 8-13, 2017, Aarhus University, Denmark.
- Catalin Hritcu, October 16-17, 2017, MPI-SWS, Saarbrucken, Germany.
- Catalin Hritcu, December 18, 2017, University of Iasi, Romania.

SECRET Project-Team

9. Partnerships and Cooperations

9.1. National Initiatives

9.1.1. ANR

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

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

9.2. European Initiatives

9.2.1. FP7 & H2020 Projects

9.2.1.1. PQCRYPTO

Title: Post-quantum cryptography for long-term security

Programm: H2020

Duration: March 2015 - March 2018

Coordinator: TECHNISCHE UNIVERSITEIT EINDHOVEN

Partners:

Academia Sinica (Taiwan)

Bundesdruckerei (Germany)

Danmarks Tekniske Universitet (Denmark)

Katholieke Universiteit Leuven (Belgium)

NXP Semiconductors Belgium Nv (Belgium)

Ruhr-Universitaet Bochum (Germany)

Stichting Katholieke Universiteit (Netherlands)

Technische Universiteit Eindhoven (Netherlands)

Technische Universitaet Darmstadt (Germany)

University of Haifa (Israel)

Inria contact: Nicolas Sendrier

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

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

9.2.1.2. QCALL

Title: Quantum Communications for ALL

Programm: H2020-MSCA-ITN-2015

Duration: December 2016 - November 2020

Coordinator: University of Leeds (UK)

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

Inria contact: Anthony Leverrier

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

9.2.1.3. ERC QUASYModo

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

Program: ERC starting grant

Duration: September 2017 - August 2022

PI: María Naya Plasencia

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

9.2.2. Collaborations in European Programs, Except FP7 & H2020

9.2.2.1. COST Action IC1306

Program: COST

Project acronym: ICT COST Action IC1306

Project title: Cryptography for Secure Digital Interaction

Duration: January 2014 - November 2017

Coordinator: Claudio Orlandi, Aarhus University, Denmark

Other partners: see http://www.cost.eu/domains_actions/ict/Actions/IC1306

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

Anne Canteaut is co-leader of the working group on cryptographic primitives. She co-organized a 2-day workshop for PhD students and early-career researchers in symmetric cryptography, DISC 2016 (Bochum, Germany, March 23-24 2016) and a winter school dedicated to Symmetric Cryptography and Blockchain (Torremolinos, Spain, February 19-23, 2018). She also serves on the program committee of the CryptoAction Symposium organized every year.

9.2.2.2. QCDA

Program: QuantERA ERA-NET Cofund in Quantum Technologies

Project acronym: QCDA

Project title: Quantum Code Design and Architecture

Duration: February 2018 - January 2021

Coordinator: Earl Campbell, University of Sheffield, UK

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

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

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

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

9.3. International Initiatives

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

9.3.1.1. CHOCOLAT

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

International Partner (Institution - Laboratory - Researcher):

NTU (Singapore) - SYLLAB - Peyrin Thomas

Start year: 2017

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

The hash function SHA-1 is one of the most widely used hash functions in the industry, but it has been shown to not be collision-resistant by a team of Chinese researchers led by Prof. Wang in 2005. However, a real pair of colliding messages was only published recently by a team from CWI and Google, because the estimated attack complexity is around 2^{63} SHA-1 computations (this represents about 70000 years of computation on a normal PC).

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

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

9.3.2. Inria International Partners

9.3.2.1. Declared Inria International Partners

Title: Discrete Mathematics, Codes and Cryptography

International Partner (Institution - Laboratory - Researcher):

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

Duration: 2014 - 2018

Start year: 2014

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

9.3.2.2. Informal International Partners

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

9.3.3. Participation in Other International Programs

Anirudh Krishna, PhD student at Sherbroke University (Canada) spends six months in our team within the MITACS program.

9.4. International Research Visitors

9.4.1. Visits of International Scientists

- Giannicola Scarpa, Universidad Complutense de Madrid, Spain, April 2017.
- Thomas Peyrin, NTU Singapore, May 2017, July 2017 and January 2018.
- Kaisa Nyberg, University of Helsinki, Finlande, May 2017.
- Adi Shamir, The Weizmann Institute of Science, Rehovot, Israel, May 2017.
- Christof Beierle, Bochum University, Germany, visiting PhD student, April-June 2017.
- Özgül Küçük, Bilgi University, Turkey, July-August 2017 (Bourse SSHN du Gouvernement Français).

9.4.1.1. Internships

- Sristy Agrawal, Kolkata, India, June-Aug. 2017
- Tim Beyne, Univ. Leuven, Belgium, Aug.-Sept. 2017
- Mathilde De La Morinerie, École Polytechnique, April-July 2017
- Matthieu Lequesne, MPRI, March-Aug. 2017
- André Schrottenloher, MPRI and Telecom ParisTech, March-Aug. 2017
- Ferdinand Sibleyras, MPRI, March-Aug. 2017
- Valentin Vasseur, Univ. Grenoble, March-Aug. 2017
- Matthieu Vieira, ENS Lyon, May-July 2017

9.4.2. Visits to International Teams

9.4.2.1. Research Stays Abroad

- NTU, Singapore, October 16 - November 3, joint work within the CHOCOLAT Associate Team (G. Leurent).

MATHERIALS Project-Team

9. Partnerships and Cooperations

9.1. National Initiatives

The project-team is involved in several ANR projects:

- S. Boyaval is the PI of the ANR JCJC project SEDIFLO (2016-2020) to investigate new numerical models of solid transport in rivers.
- G. Stoltz is the PI of the ANR project COSMOS (2014-2018) which focuses on the development of efficient numerical techniques to simulate high-dimensional systems in molecular dynamics and computational statistics. It includes research teams from Institut Mines-Telecom, Inria Rennes and IBPC Paris.
- E. Cancès is a member of the ANR project BECASIM (2013-2017), PI: I. Danaila (Université de Rouen). This project is concerned with the numerical simulation of Bose-Einstein condensates.
- F. Legoll is a member of the ANR project CINE-PARA (2015-2019), PI: Y. Maday, UPMC. This project is concerned with parallel-in-time algorithms.

Members of the project-team are participating in the following GdR:

- CORREL (correlated methods in electronic structure computations),
- EGRIN (gravity flows),
- MANU (MAthematics for NUclear applications)
- MASCOT-NUM (stochastic methods for the analysis of numerical codes),
- MEPHY (multiphase flows)
- DYNQUA (time evolution of quantum systems, with applications to transport problems, nonequilibrium systems, etc.),
- REST (theoretical spectroscopy),
- CHOCOLAS (experimental and numerical study of shock waves).

The project-team is involved in two Labex, namely the Labex Bezout (started in 2011) and the Labex MMCD (started in 2012).

9.2. European Initiatives

The ERC consolidator Grant MSMATH (ERC Grant Agreement number 614492, PI T. Lelièvre) is running (it started in June 2014).

9.3. International Initiatives

The *Germaine de Staël* grant awarded to S. Boyaval (from CampusFrance Hubert-Curien program) has been used in 2017 to pursue the collaboration with A. Caboussat (Lausanne) about 3D numerical simulations of free-surface flows.

T. Lelièvre, G. Stoltz and F. Legoll participate in the Laboratoire International Associé (LIA) CNRS / University of Illinois at Urbana-Champaign on complex biological systems and their simulation by high performance computers. This LIA involves French research teams from Université de Nancy, Université de Lyon and Université Aix-Marseille. The LIA is renewed for 4 years, starting January 1st, 2018.

MATHRISK Project-Team

8. Partnerships and Cooperations

8.1. National Initiatives

8.1.1. ANR

- ANR Cosmos 2015-2018, Participant: B. Jourdain ; Partners : Ecole des Ponts, Telecom, Inria Rennes and IBPC

8.1.2. Competitivity Clusters

Pôle Finance Innovation.

8.2. International Initiatives

8.2.1. Informal International Partners

- Center of Excellence program in Mathematics and Life Sciences at the Department of Mathematics, University of Oslo, Norway, (B. Øksendal).
- Kings College, London (R. Dumitrescu)
- Department of Mathematics, University of Manchester (Tusheng Zhang, currently in charge of an EU-ITN program on BSDEs and Applications).
- Kensas University (Yaozhong Hu)
- Cornell University, ORIE department (Andreea Minca)
- Mannheim University (Alexander Schied, Chair of Mathematics in Business and Economics, Department of Mathematics)
- Roma Tor Vergata University (Lucia Caramellino)
- Ritsumeikan University (A. Kohatsu-Higa).

8.3. International Research Visitors

- Oleg Kudryavtsev, Rostov University (Russia)
- Martino Grasselli, Padova University,

8.3.1. Visits of International Scientists

8.3.1.1. Internships

- Adel Cherchali (June to August 2017): Multilevel Monte-Carlo methods for nested expectations. Supervisor: A. Alfonsi.

- Zeqi Chen (ENSTA), May -July , Supervisor: A. Zanette

- Mohamed Homed, April-September, Supervisor: A. Zanette

- Xinglong Tian (ENSTA), May-July 2017, Supervisor: A. Zanette

- Sebastien Villette, April-October, Supervisor: A. Zanette

MOKAPLAN Project-Team

8. Partnerships and Cooperations

8.1. National Initiatives

8.1.1. ANR

J-D. Benamou is the coordinator of the ANR ISOTACE (Interacting Systems and Optimal Transportation, Applications to Computational Economics) ANR-12-MONU-0013 (2012-2016). The consortium explores new numerical methods in Optimal Transportation AND Mean Field Game theory with applications in Economics and congested crowd motion. Check https://project.inria.fr/isotace/.
J-D. Benamou and G. Carlier are members of the ANR MFG (ANR-16-CE40-0015-01). Scientific topics of the project: Mean field analysis Analysis of the MFG systems and of the Master equation Numerical analysis Models and applications
J-D. Benamou G. Carlier F-X. Vialard and T. Gallouët are members of ANR MAGA (ANR-13-JS01-0007-01). The Monge-Ampère equation is a fully nonlinear elliptic equation, which plays a central role in geometry and in the theory of optimal transport. However, the singular and non-linear nature of the equation is a serious obstruction to its efficient numerical resolution. The first aim of the MAGA project is to study and to implement discretizations of optimal transport and Monge-Ampère equations which rely on tools from computational geometry (Laguerre diagrams). In a second step, these solvers will be applied to concrete problems from various fields involving optimal transport or Monge-Ampère equations such as computational physics: early universe reconstruction problem, congestion/incompressibility constraints economics: principal agent problems, geometry: variational problems over convex bodies, reflector and refractor design for non-imaging optics
T. Gallouët is member of the ANR GEOPOR Scientific topic: geometrical approach, based on Wasserstein gradient flow, for multiphase flows in porous media. Theory and Numerics.

8.2. European Initiatives

8.2.1. FP7 & H2020 Projects

- J-D. Benamou is a member of the ITN ROMSOC (Nov. 2017-Nov.2021).
- Andrea Natale has a PRESTIGE Post-Doc Fellowship.

8.3. International Research Visitors

8.3.1. Visits of International Scientists

The following people visited MOKAPLAN during 2016.

- Alfred Galichon (Courant), Teresa Radice (Naples), Gaoyue Guo (Oxford) visited G. Carlier at inria in 2017
- Simone di Marino (Pisa)

QUANTIC Project-Team

7. Partnerships and Cooperations

7.1. Regional Initiatives

7.1.1. Emergences-Ville de Paris program, ENDURANCE project

In the framework of the Ville de Paris program “EMERGENCES”, Zaki Leghtas has received a funding for his research program "Multi-photon processes in superconducting circuits for quantum error correction". This grant of 232k euros over 4 years will complement the ANR project of the same name obtained last year. Using this funding, we will purchase all the microwave and nano-fabrication equipment and consumables for the experiment based at ENS.

7.1.2. DIM SIRTEQ, PhD fellowship

In the framework of the project “DIM SIRTEQ Domaine d’intérêt Majeur: Science et Ingénierie Quantique” of Ile de France Region, we have received 18 months of PhD fellowship. This completes the funding from ANR GEARED of the PhD thesis of J. Guillaud, who has started his PhD under the supervision of M. Mirrahimi and P. Rouchon in September 2017.

7.1.3. Programme Math-PSL, Postdoctoral fellowship

In the framework of the programme Math-PSL of PSL Research University, we have resceived a 12 month postdoctoral fellowship. Paolo Forni has been hired as a postdoc on this funding.

7.2. National Initiatives

7.2.1. ANR project GEARED

This four-year collaborative ANR project, entitled “Reservoir engineering quantum entanglement in the microwave domain” and coordinated by Mazyar Mirrahimi, started on October 2014. The participants of the project are Mazyar Mirrahimi, François Mallet (QUANTIC project-team), Benjamin Huard (ENS Lyon), Daniel Esteve and Fabien Portier (Quantronics group, CEA Saclay), Nicolas Roch and Olivier Buisson (Institut Neel, Grenoble). This project deals with robust generation of entanglement as a key resource for quantum information processing (quantum simulation, computation and communication). The entangled states are difficult to generate and sustain as interaction with a noisy environment leads to rapid loss of their unique quantum properties. Through Geared we intend to investigate different complementary approaches to master the entanglement of microwave photons coupled to quantum superconducting circuits.

7.2.2. ANR project ENDURANCE

In the framework of the ANR program “Accueil de chercheur de haut niveau”, Zaki Leghtas has received a funding for his research program "Multi-photon processes in superconducting circuits for quantum error correction". This grant of 400k euros has allowed us to purchase the experimental equipment to build a new experiment based at ENS.

7.3. European Initiatives

7.3.1. Collaborations with Major European Organizations

Partner 1: ENS Lyon

We are pursuing our interdisciplinary work about quantum control from theoretical aspects in direct collaboration with existing experiments (ENS Lyon) with the group of Benjamin Huard, former member of the QUANTIC team. Joint papers are published and underway. We are in particular working on the proper combination of two model reduction techniques in their experimental context: adiabatic elimination and Rotating-Wave Approximation. An ANR-JCJC project has been deposited by Alain Sarlette on this subject, with Benjamin Huard as external supporting collaborator.

Partner 2: University of Padova

Alain Sarlette has been pursuing a fruitful collaboration with the group of Francesco Ticozzi on dynamical systems aspects of quantum systems. Common work on the theory of quantum random walks is being finalized and we are working out a concrete plan about next possible steps.

Partner 3: Ghent University.

A. Sarlette is collaborating with applied mathematicians interested in quantum control at his former institution UGent (Dirk Aeyels, Lode Wylleman, Gert De Cooman) in the framework of thesis co-supervisions. Two students are in their last year PhD, in particular Simon Apers is finalizing a thesis centered around Quantum Walks, also in collaboration with Partner 2. A master student in applied physics has started an internship in 2017.

7.4. International Initiatives

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

TAQUILLA is an Inria associate team (between Quantic team and Yale university) with principal Inria investigator, Mazyar Mirrahimi, and principal Yale investigator Michel Devoret. In this framework, L. Verney, J. Guillaud and M. Mirrahimi visited Yale for respectively, 2, 3 and 4 months.

7.5. International Research Visitors

7.5.1. Visits of International Scientists

P. S. Pereira da Silva (Escola Politécnica, PTC, University of SaoPaulo, Brazil) made a 2-week visit (July 3 to July 14) to investigate with Pierre Rouchon motion planning issues based on Lyapunov tracking for quantum gate generations.

7.5.2. Visits to International Teams

7.5.2.1. Research Stays Abroad

In the framework of TAQUILLA associate team, Mazyar Mirrahimi spent four months in the Quantronics Laboratory of Michel H. Devoret and in the Rob Schoelkopf Lab at Yale University. Also, in this same framework Jérémie Guillaud and Lucas Verney spent respectively three months and two months in the same group.

SIERRA Project-Team

8. Partnerships and Cooperations

8.1. National Initiatives

- A. d'Aspremont: IRIS, PSL "Science des données, données de la science".

8.2. European Initiatives

8.2.1. FP7 & H2020 Projects

- **ITN Spartan**
  Title: Sparse Representations and Compressed Sensing Training Network
  Type: FP7
  Instrument: Initial Training Network
  Duration: October 2014 to October 2018
  Coordinator: Mark Plumbley (University of Surrey)
  Inria contact: Francis Bach
  Abstract: The SpaRTaN Initial Training Network will train a new generation of interdisciplinary researchers in sparse representations and compressed sensing, contributing to Europe's leading role in scientific innovation. By bringing together leading academic and industry groups with expertise in sparse representations, compressed sensing, machine learning and optimisation, and with an interest in applications such as hyperspectral imaging, audio signal processing and video analytics, this project will create an interdisciplinary, trans-national and inter-sectorial training network to enhance mobility and training of researchers in this area. SpaRTaN is funded under the FP7-PEOPLE-2013-ITN call and is part of the Marie Curie Actions — Initial Training Networks (ITN) funding scheme: Project number - 607290
- **ITN Macsenet**
  Title: Machine Sensing Training Network
  Type: H2020
  Instrument: Initial Training Network
  Duration: January 2015 - January 2019
  Coordinator: Mark Plumbley (University of Surrey)
  Inria contact: Francis Bach
  Abstract: The aim of this Innovative Training Network is to train a new generation of creative, entrepreneurial and innovative early stage researchers (ESRs) in the research area of measurement and estimation of signals using knowledge or data about the underlying structure. We will develop new robust and efficient Machine Sensing theory and algorithms, together methods for a wide range of signals, including: advanced brain imaging; inverse imaging problems; audio and music signals; and non-traditional signals such as signals on graphs. We will apply these methods to real-world problems, through work with non-Academic partners, and disseminate the results of this research to a wide range of academic and non-academic audiences, including through publications, data, software and public engagement events. MacSeNet is funded under the H2020-MSCA-ITN-2014 call and is part of the Marie Sklodowska- Curie Actions — Innovative Training Networks (ITN) funding scheme.

- **ERC Sequoia**
  Title: Robust algorithms for learning from modern data
  Programm: H2020
  Type: ERC
  Duration: 2017-2022
  Coordinator: Inria
  Inria contact: Francis BACH
  Abstract: Machine learning is needed and used everywhere, from science to industry, with a growing impact on many disciplines. While first successes were due at least in part to simple supervised learning algorithms used primarily as black boxes on medium-scale problems, modern data pose new challenges. Scalability is an important issue of course: with large amounts of data, many current problems far exceed the capabilities of existing algorithms despite sophisticated computing architectures. But beyond this, the core classical model of supervised machine learning, with the usual assumptions of independent and identically distributed data, or well-defined features, outputs and loss functions, has reached its theoretical and practical limits. Given this new setting, existing optimization-based algorithms are not adapted. The main objective of this project is to push the frontiers of supervised machine learning, in terms of (a) scalability to data with massive numbers of observations, features, and tasks, (b) adaptability to modern computing environments, in particular for parallel and distributed processing, (c) provable adaptivity and robustness to problem and hardware specifications, and (d) robustness to non-convexities inherent in machine learning problems. To achieve the expected breakthroughs, we will design a novel generation of learning algorithms amenable to a tight convergence analysis with realistic assumptions and efficient implementations. They will help transition machine learning algorithms towards the same widespread robust use as numerical linear algebra libraries. Outcomes of the research described in this proposal will include algorithms that come with strong convergence guarantees and are well-tested on real-life benchmarks coming from computer vision, bioin- formatics, audio processing and natural language processing. For both distributed and non-distributed settings, we will release open-source software, adapted to widely available computing platforms.

8.3. International Initiatives

8.3.1. BigFOKS2

Title: Learning from Big Data: First-Order methods for Kernels and Submodular functions
International Partner (Institution - Laboratory - Researcher):
IISc Bangalore (India) - Computer Science Department - Chiranjib Bhattacharyya
Start year: 2016
See also: http://mllab.csa.iisc.ernet.in/indo-french.html
Recent advances in sensor technologies have resulted in large amounts of data being generated in a wide array of scientific disciplines. Deriving models from such large datasets, often known as “Big Data”, is one of the important challenges facing many engineering and scientific disciplines. In this proposal we investigate the problem of learning supervised models from Big Data, which has immediate applications in Computational Biology, Computer vision, Natural language processing, Web, E-commerce, etc., where specific structure is often present and hard to take into account with current algorithms. Our focus will be on the algorithmic aspects. Often supervised learning problems can be cast as convex programs. The goal of this proposal will be to derive first-order methods which can be effective for solving such convex programs arising in the Big-Data setting. Keeping this broad goal in mind we investigate two foundational problems which are not well addressed in existing literature. The first problem investigates Stochastic Gradient Descent Algorithms in the context of First-order methods for designing algorithms for Kernel based prediction functions on Large Datasets. The second problem involves solving discrete optimization problems arising in Submodular formulations in Machine Learning, for which first-order methods have not reached the level of speed required for practical applications (notably in computer vision).

8.4. International Research Visitors

8.4.1. Internships

- Marwa El Halabi, from Jan. until Apr. 2017, EPFL, Lausanne, Switzerland
- Jonathan Weed, from Mar. 2017 until May 2017, MIT, US
- Alfredo Zermini, from Mar 2017 until June 2017, University of Surrey, UK
- Billy Tang, visited from Sept. 2017 until Dec. 2017, University of Edimburgh, UK

ANGE Project-Team

9. Partnerships and Cooperations

9.1. National Initiatives

9.1.1. ANR SEDIFLO (2015-2019)

Participants: Emmanuel Audusse, Martin Parisot.

Program: ANR Défi 1 “Gestion sobre des ressources et adaptation au changement climatique” (JCJC)

Project acronym: SEDIFLO

Project title: Modelling and simulation of solid transport in rivers

Coordinator: Sébastien Boyaval (LHSV/ENPC)

Based on recent theoretical and experimental results, this project is aimed at modelling transport of sediments within rivers. It will rely on innovations from the point of view of rheology as well as advanced mathematical tools (asymptotic model reduction, PDE discretisation).

9.1.2. ANR Hyflo-Eflu (2016-2020)

Participants: Jérémy Ledoux, Martin Parisot, Jacques Sainte-Marie, Julien Salomon.

ANR project call: Energies marines renouvelables

Project acronym: Hyflo-Eflu

Project title: Hydroliennes flottantes et énergie fluviale

Coordinator: Julien Salomon

The project is a collaboration between the Inria-team ANGE, specialist of free surface flow and optimisation, and the industrial developers of the turbine, HYDROTUBE ENERGIE. The objective of the project HyFlo-EFlu is to deliver a numerical software able to simulate the dynamic of a floating water turbine in real context. For the academic partner, the main challenge is in the simulation of the floating structure at the scale of the river, and the modelling of the vertical and horisontal axis turbine. For the industrial partner, the objective is the validation of the stability of the structure and the performance in term of energy production.

9.1.3. ANR MIMOSA (2014–2017)

Participants: Marie-Odile Bristeau, Anne Mangeney, Bernard Di Martino, Jacques Sainte-Marie.

Program: ANR Défi 1 “Gestion sobre des ressources et adaptation au changement climatique”

Project acronym: MIMOSA

Project title: MIcroseism modelling and Seismic Applications

Coordinator: Eleonore Stutzmann (IPGP)

Seismic noise is recorded by broadband seismometers in the absence of earthquakes. It is generated by the atmosphere-ocean system with different mechanisms in the different frequency bands. Even though some mechanisms have been known for decades, an integrated understanding of the noise in the broadband period band 1-300sec is still missing. Using novel theoretical, numerical and signal processing methods, this project will provide a unified understanding of the noise sources and quantitative models for broadband noise. Conversely, we will be able to interpret seismic noise in terms of ocean wave properties. This first analysis step will lead to the identification and characterisation of source events, which we will use to improve noise tomography, and seismic monitoring.

9.1.4. ANR CHARMS (2016-2020)

Participant: Cindy Guichard.

ANR project call: Transformations et inter-conversions énergétiques

Project acronym: CHARMS

Project title: Modèles de réservoirs quantitatifs pour les systèmes hydrothermaux complexes

Coordinator: Simon Lopez (BRGM)

Funding: 73k euros for LJLL (in 767k euros for the whole project)

CHARMS ANR project is focused on the mathematical methods and software tools dedicated to the simulation of the physical models issued from geothermal engineering. The final objective is the achievement of a highly parallel code, validated on realistic cases.

9.1.5. CNRS Moset (2016-2017)

Participants: Emmanuel Audusse, Martin Parisot.

CNRS project call: INSU Tellus

Project acronym: Moset

Project title: Modélisation des suspensions concentrées naturelles

Coordinator: Emmanuel Audusse

In collaboration with G. Antoine (EDF), S. Boyaval (LHSV), C. Le Bouteiller (Irstea), M. Jodeau (EDF).

Gathering mathematicians (numerical analysis) and geophysicists, this project focuses on the quantitative prediction of solid transport. This issue raises several questions about rheology when the sediment concentration is high enough. It is crucial for modelling the dynamics of suspension. The collaboration aims at assessing models by means of experimental data and at providing preliminary numerical results to evaluate the order of magnitude of constraints.

9.1.6. CNRS Simulations of free-surface flows (2017)

Participants: Cindy Guichard, Martin Parisot, Yohan Penel, Jacques Sainte-Marie.

CNRS project call: PEPS JC

Project title: modélisation avancée et simulation d'écoulements à surface libre

Coordinator: Yohan Penel

Funding: 2.5k euros

In collaboration with E. Fernaández-Nieto.

Free-surface flows are extensively studied in the literature by means of simplified models (like the Shallow Water equations) due to the theoretical and numerical issues related to the Euler system. Intermediate models have then been derived to improve the accuracy and the physical relevance (e.g. taking into account hydrodynamic pressure or multilayer approaches). This collaboration aims at designing a hierarchy of multilayer models with a non-hydrostatic pressure as a discretisation along the vertical axis of the Euler equations. The hierarchy relies on the degree of approximation of the variables discretised with a Discontinuous Galerkin method for the vertical direction. These innovative models will imply a theoretical study and the development of numerical tools in dimensions 1 and 2 before the modelling of other physical phenomena (viscosity effects, ...).

9.1.7. CNRS Mocha (2017-2018)

Participant: Martin Parisot.

CNRS project call: LEFE

Project acronym: MOCHA

Project title: Multi-dimensiOnal Coupling in Hydraulics and data Assimilation

Coordinator: Martin Parisot

Funding: 14k euros

In collaboration with S. Barthélémy, N. Goutal, S. Ricci, M. Hoang Le.

Multi-dimensionnal coupling in river hydrodynamics offers a conveninent solution to properly model complex flow while limiting the computational cost and making the most of pre-exsiting models. The project aims to adapt the lateral interface coupling proposed in [39] to the implicit version and test it on real data for the Garonne River.

9.1.8. Inria Project Lab "Algae in Silico" (2015-2018)

Participants: Marie-Odile Bristeau, Yohan Penel, Jacques Sainte-Marie, Fabien Souillé.

In the aftermath of the ADT In@lgae (2013–2015), we developed a simulation tool for microalgae culture. An Inria Project Lab "Algae in Silico" has started in collaboration with Inria teams BIOCORE and DYLISS. It concerns microalgae culture for biofuel production and the aim is to provide an integrated platform for numerical simulation "from genes to industrial processes".

9.1.9. Inria Project Lab "CityLab" (2015-2018)

Participants: Vivien Mallet, Raphaël Ventura.

CityLab@Inria studies ICT solutions toward smart cities that promote both social and environmental sustainability.

9.1.10. GdR EGRIN (2013–2017)

Participants: Emmanuel Audusse, Bernard Di Martino, Nicole Goutal, Cindy Guichard, Anne Mangeney, Martin Parisot, Jacques Sainte-Marie.

EGRIN stands for Gravity-driven flows and natural hazards. J. Sainte-Marie is the head of the scientific committee of this CNRS research group and A. Mangeney is a member of the committee. Other members of the team involved in the project are local correspondents. The scientific goals of this project are the modelling, analysis and simulation of complex fluids by means of reduced-complexity models in the framework of geophysical flows.

9.1.11. ANR ESTIMAIR (2013-2017)

Participant: Vivien Mallet.

ANR project call: Modèles numériques

Project acronym: ESTIMAIR

Project title: Estimation d'incertitudes en simulation de la qualité de l'air à l'échelle urbaine

Coordinator: Vivien Mallet

Funding: 415k euros

The project aims to propagate uncertainties in a complete air quality modelling chain at urban scale, from road traffic assignment to air pollutant dispersion.

9.1.12. ANR FireCaster (2017-2020)

Participants: Frédéric Allaire, Vivien Mallet.

ANR project call: DS0104

Project acronym: FireCaster

Project title: Plateforme de prévision incendie et de réponse d'urgence

Coordinator: Jean-Baptiste Filippi (Univ. Corse)

Funding: 442k euros

The goal of the FireCaster project is to prototype a fire decision support system at the national scale to estimate upcoming fire risk (H+24 to H+48) and in case of crisis, to predict fire front position and local pollution (H+1 to H+12).

9.1.13. ANR CENSE (2017-2020)

Participants: Antoine Lesieur, Vivien Mallet.

ANR project call: DS0601

Project acronym: CENSE

Project title: Caractérisation des environnements sonores urbains : vers une approche globale associant données libres, mesures et modélisations

Coordinator: Judicaël Picaut (IFSTTAR)

Funding: 856k euros

The CENSE project aims at proposing a new methodology for the production of more realistic noise maps, based on an assimilation of simulated and measured data through a dense network of low-cost sensors.

9.1.14. ANR RAVEX (2017-2020)

Participant: Anne Mangeney.

ANR project call: DS0106

Project acronym: RAVEX

Project title: Développement d'une approche intégrée pour la réduction des Risques Associés au Volcanisme EXplosif, de la recherche sur l'aléa aux outils de gestion de crise : le cas de la Martinique

Coordinator: Olivier Roche (IRD)

Funding: 619k euros

9.1.15. ANR CARIB (2014-2017)

Participant: Anne Mangeney.

ANR project call: Simi6

Project acronym: CARIB

Project title: Fréquence et processus de mise en place des avalanches de débris tsunamigènes de l'arc des Petites Antilles : apport des forages de l'Expédition IODP 340 et impact en termes de risque

Coordinator: Anne Le Friant (IPGP)

Funding: 274k euros

9.1.16. ANR CINE-PARA (2015-2019)

Participant: Julien Salomon.

ANR project call: DS0708

Project acronym: CINE-PARA

Project title: Méthodes de parallélisation pour cinétiques complexes

Coordinator: Yvon Maday (LJLL)

9.2. European Initiatives

9.2.1. FP7 & H2020 Projects

9.2.1.1. ERC Consolidator Grant (2013-2018)

Participants: Anne Mangeney, Hugo Martin.

The project SLIDEQUAKES is about detection and understanding of landslides by observing and modelling gravitational flows and generated earthquakes and is funded by the European Research Council (2 million euros). More precisely, it deals with the mathematical, numerical and experimental modelling of gravitational flows and generated seismic waves coupled with field measurements to better understand and predict these natural hazards and their link with volcanic, seismic and climatic activities.

9.2.1.2. EoCoE (2015-2018)

Title: Energy oriented Centre of Excellence for computer applications

Program: H2020

Duration: October 2015 - October 2018

Coordinator: Édouard Audit (CEA)

Partners: CEA (Commissariat à l'Énergie Atomique et aux Énergies Alternatives, France), Forschungszentrum Julich (Germany), Max Planck Gesellschaft (Germany), ENEA (Agenzia Nazionale Per le Nuove Tecnologie, l'energia E Lo Sviluppo Economico Sostenibile, Italy), CERFACS (European Centre for Research and Advanced Training in Scientific Computing, France), Instytut Chemii Bioorganicznej Polskiej Akademii Nauk (Poland), Universita Degli Studi di Trento (Italy), Fraunhofer Gesellschaft (Germany), University of Bath (United Kingdom), CYL (The Cyprus Institute, Cyprus), CNR (National Research Council of Italy), Université Libre de Bruxelles (Belgium), BSC (Centro Nacional de Supercomputacion, Spain)

Inria contact: Michel Kern (Serena team)

Participants: Vivien Mallet

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

9.2.1.3. Env&You (2017)

Title: Env&You

Program: EIT Digital

Duration: January 2016 - December 2016

Coordinator: Inria (MiMove)

Partners: NUMTECH, Ambiciti, ForumVirium, TheCivicEngine

Inria contact: Valérie Issarny (Mimove project-team)

Participants: Vivien Mallet, Raphaël Ventura

Env&You aims at delivering the whole picture of urban pollution, from the individual exposure to neighborhood-by-neighborhood and day-to-day variation, to citisens and governments, informing their decisions for healthy urban living.

9.2.2. Collaborations with Major European Organisations

9.2.2.1. CNRS PICS NHML (2017-2019)

Program: CNRS PICS (projet international de collaboration scientifique)

Project acronym: NHML

Project title: non-hydrostatic multilayer models

Duration: 01/17-12/19

Coordinator: Yohan Penel (CEREMA)

Other partners: IMUS (Sevilla, Spain)

Participants: Martin Parisot (Inria), Jacques Sainte-Marie (CEREMA), Enrique Fernández-Nieto (Sevilla), Tomas Morales de Luna (Cordoba)

Funding: 12k euros

Abstract: This collaboration aims at designing a hierarchy of multilayer models with a non-hydrostatic pressure as a discretisation along the vertical axis of the Euler equations. The hierarchy relies on the degree of approximation of the variables discretised with a Discontinuous Galerkin method for the vertical direction. These innovative models will imply a theoretical study and the development of numerical tools in dimensions 1 and 2 before the modelling of other physical phenomena (viscosity effects, ...).

9.3. International Initiatives

9.3.1. Inria International Partners

9.3.1.1. Informal International Partners

Two collaborations with foreign colleagues are to be mentioned:

- A collaboration with spanish researchers has been initiated in 2016 to derive accurate models and effecient algorithms for free surface flows including non-hydrostatic effects.
- A joint work with R. LeVeque (Univ. Seattle) and M. Berger (New York Univ.) consists in modelling the impact of asteroids on the generation of tsunamis.

9.3.2. Participation in Other International Programs

9.3.2.1. PROCORE Hong-Kong (2016-2017)

Program: Hubert Curien PROCORE

Project title: time-parallelisation methods for control

Duration: 01/16-12/17

Coordinator: Felix Kwok (Univ. Hong-Kong)

Other partners: HKBU (Hong-Kong)

Funding: 5k euros

9.4. International Research Visitors

9.4.1. Visits to International Teams

9.4.1.1. Research Stays Abroad

- Y. Penel spent one month and a half (Mar.-Apr.) at the university of Sevilla (Spain) to collaborate with E. Fernández-Nieto.
- M. Parisot spent a week to Sevilla in April.

We also mention that M. Parisot spent four separate weeks at the university of Toulouse (CERFACS).

ARAMIS Project-Team

9. Partnerships and Cooperations

9.1. National Initiatives

9.1.1. ANR

9.1.1.1. ANR-NIH-NSF NETBCI

Participants: Fabrizio de Vico Fallani [Correspondant], Mario Chavez, Denis Schwartz.

Project acronym: NETBCI

Project title: Modeling and predicting brain-computer interface learning from dynamic networks

Duration: Avr 2016 - Avr 2020

Amount: 322k€

Coordinator: Fabrizio De Vico Fallani

Other partners: Complex system group, UPenn, USA

Abstract: This project will bring together expertise in computational and experimental neuroscience, signal processing and network science, statistics, modeling and simulation, to establish innovative methods to model and analyze temporally dynamic brain networks, and to apply these tools to develop predictive models of brain-computer interface (BCI) skill acquisition that can be used to improve performance. Leveraging experimental data and interdisciplinary theoretical techniques, this project will characterize brain networks at multiple temporal and spatial scales, and will develop models to predict the ability to control the BCI as well as methods to engineer BCI frameworks for adapting to neural plasticity. This project will enable a comprehensive understanding of the neural mechanisms of BCI learning, and will foster the design of viable BCI frameworks that improve usability and performance.

9.1.1.2. ANR-NIH-NSF HIPLAY7

Participants: Olivier Colliot [Correspondant], Marie Chupin, Stanley Durrleman, Anne Bertrand.

Project acronym: HIPLAY7

Project title: Hippocampal layers: advanced computational anatomy using very high resolution MRI at 7 Tesla in humans

Duration: Jan 2017 - Jan 2020

Amount: 770k€

Coordinator: Olivier Colliot and Pierre-François Van de Moortele

Other partners: University of Minnesota, Neurospin

Abstract: The overall goal of this proposal is to develop a coherent mathematical framework for computational anatomy of the internal structures of the hippocampus based on cutting edge MRI acquisition techniques at 7 Tesla. These mathematical and computational approaches are expected to significantly advance the field of computational anatomy of the human brain, breaking down the millimeter barrier of conventional brain morphometry and providing a coherent analysis framework for anatomical data at ultra-high spatial resolution.

9.1.1.3. ANR PREV-DEMALS

Participants: Olivier Colliot [Correspondant], Marie Chupin, Stanley Durrleman, Anne Bertrand.

Project acronym: PREV-DEMALS

Project title: Predict to prevent frontotemporal lobar degeneration (FTLD) and amyotrophic lateral sclerosis (ALS)

Duration: Avr 2015 - Avr 2019

Amount: 487k€

Coordinator: Isabelle Le Ber

Other partners: ICM, AP-HP, CHR de Lille, CHU Limoges, CHU Rouen, Laboratory of Biomedical Imaging

Abstract: The project focuses on C9ORF72, the most frequent genetic form of frontotemporal lobar degeneration (FTLD) and amyotrophic lateral sclerosis (ALS). Since 2006, major discoveries have helped elucidate the pathological bases and linked FTLD and ALS: 1) TDP-43 aggregates in neurons and 2) C9ORF72 mutations in both disorders. Two major pathological subtypes are now defined in FTLD, FTLD-TDP and FTLD-TAU. C9ORF72 mutations (associated to FTLD-TDP) are the most frequent genetic causes of FTLD (15%), FTLD-ALS (65%) and ALS (40%). No curative treatment actually exists, but therapeutics emerged against tau aggregation. The objectives of the project are to develop appropriate cognitive, brain imaging markers and peripheral biomarkers of the early phase of FTLD, to follow disease progression and to guide future targeted therapeutic trials. To address this questions, we will conduct a multimodal study (cognition, brain structural MRI, brain metabolism - FDG-PET) in C9ORF72 families. The cohort will be followed at 3-time points (M0, M18, M36). Longitudinal analyses will aim at characterizing the trajectory of decline across time. Brain structural changes will be evaluated by 1) morphometric analysis to assess global brain atrophy, cortical thickness and study of the cortical sulci; 2) functional connectivity analysis of resting-state MR data; 3) structural connectivity analysis of diffusion-weighted MRI. Brain metabolism will be evaluated with FDG-PET. We will use the most recent RNA sequencing technology to detect gene expression and RNA splicing alterations in lymphocytes of patients and presymptomatic carriers. The discovery of new markers involved in FTLD will have practical consequences for early and accurate diagnosis of FLD and ALS disease.

9.1.1.4. ANR IVMRS

Participants: Anne Bertrand [Correspondant], Alexandra Petiet, Mathieu Santin, Francesca Branzoli, Benoit Delatour, Marc Sanson.

Project acronym: IVMRS

Project title: Implantable miniaturized probe for In-vivo Magnetic Resonance Spectroscopy: Application to Murine models of Alzheimer's disease and Gliomas.

Duration: Oct 2016 - Oct 2020

Amount: 633k€

Coordinator: Luc Hebrard

Other partners: ICube - Unistra, Strasbourg; ISA Laboratory, Lyon; NYU School of Medicine, NY, USA.

Abstract: During the development of new therapeutics against brain diseases, the pre-clinical phase, i.e. the validation of treatment delivery, safety and efficacy in animal models of the disease, represents a crucial step. Magnetic Resonance Imaging (MRI) is a method of particular interest at this stage, as it provides non-invasive surrogate endpoints that can help selecting appropriate candidates during the process of drug development. Single Voxel Magnetic Resonance Spectroscopy (SVS) provides non-invasive, in-vivo quantitative measurements of brain metabolites, which reflects functional changes at the cellular and subcellular levels, and can be repeated longitudinally. As high-field MRI has become the benchmark in preclinical research on animal models, it appears possible

to investigate the cerebral metabolomics changes in animals, and to use it as a surrogate marker in preclinical therapeutic trials. However, the number of relevant metabolites is much higher than the low number of measurable metabolites with conventional in-vivo high-field SVS. Moreover, considering also the subtle changes of these metabolites at the early stage of the disease, the use of conventional high-field SVS in preclinical studies remains strongly limited. The high volume of the Voxel-of-Interest (VOI), ranging from 10 to 30mm3, which is required to have a usable signal in conventional SVS, and the inherent variability of longitudinal SVS measurement due to the variable position of the VOI in the successive experiments, remain the two major issues when looking during time for small changes in metabolic concentrations and metabolites ratios in a specific small region of the animal brain. The IvMRS project aims at filling this gap by developing the first chronic implantable MRS micro-probe (μ- probe), minimally invasive, exhibiting very high signal sensitivity, and sharp spectral peaks, from sub-millimetric VOI. Such a probe will allow detecting a much higher number of metabolites than conventional in-vivo SVS. The μ-probe will work at frequencies ranging from 300MHz to 500MHz in ultra-high field Magnetic Resonance Imaging scanners, 7T and 11.7T. It will embed a specific micro-coil antenna, a low-noise signal conditioning circuit designed in CMOS microelectronics technology, as well as an accurate on-chip positioning sensor. It will be dedicated to the study of changes in brain metabolite markers of two major diseases, Alzheimer's disease and cerebral gliomas, and to the assessment of effective therapeutic strategies.

9.1.2. Inria Project Labs

9.1.2.1. IPL Neuromarkers

Participants: Stanley Durrleman [Correspondant], Olivier Colliot [Correspondant], Fabrizio de Vico Fallani, Anne Bertrand, Stéphane Epelbaum.

Project acronym: Neuromarkers

Project title: Design of imaging biomarkers of neurodegenerative diseases for clinical trials and study of their genetic associations

Duration: 2017-2021

Amount: 633k€

Coordinators: Stanley Durrleman and Olivier Colliot

Other partners: Inria GENSCALE, Inria BONSAI, Inria DYLISS, Inria XPOP, ICM, IHU/ICM iConics

Abstract: The Inria Project Lab Neuromarkers to develop new statistical and computational approaches to integrate multimodal imaging and omics data and to demonstrate their potential to identify early alterations and predict progression of neurodegenerative diseases. To tackle this challenge, the project brings together multidisciplinary expertise from Inria and ICM (Brain and Spine Institute) in the fields of statistical learning, brain imaging, bioinformatics, knowledge modeling, genomics and neurodegenerative diseases.

9.1.3. IHU

9.1.3.1. General program

Participants: Olivier Colliot, Mario Chavez, Stanley Durrleman, Marie Chupin, Didier Dormont, Dominique Hasboun, Damien Galanaud, Fabrizio de Vico Fallani.

Project acronym: IHU-A-ICM

Project title: Institute of Translational Neuroscience

Founded in 2011

General Director: Bertrand Fontaine

The IHU-A-ICM program was selected, in 2011, in a highly competitive national call for projects. A 10-year, 55M€ program, has been implemented by a recently created foundation for scientific cooperation. Based on the clinical and scientific strenghts of the ICM and the hospital Department of Nervous System Diseases, it mainly supports neuroscience research, but is also invested in improving care and teaching. ARAMIS is strongly involved in the IHU-A-ICM project, in particular in WP6 (neuroimaging and electrophysiology), WP7 (biostatistics), WP2 (Alzheimer) and WP5 (epilepsy). We have started collaborations with the new bioinformatics/biostatistics platform (IHU WP7, head: Ivan Moszer), in particular through a joint project on the integration of imaging and genomics data.

9.1.3.2. ICM-Internal Research projects

Participants: Anne Bertrand [Correspondant], Takoua Kaaouana, Benoit Delatour, Alexandra Petiet.

Project title: The Histo-MRI project: targeting MR signature of tauopathy from micro- to macroscopy

Started in 2014

Coordinator: Anne Bertrand

Identifying morphological MR signatures of brain diseases usually follows a top-down process, which starts by describing a pattern of MR signal changes in patients, hypothesizes an underlying pathological mechanism, and confirms this mechanism by correlating the observed MR signal changes with histological lesions on post-mortem examination. This top-down process, relevant for large, centimetric brain lesions, becomes inappropriate when targeting the MR signal intensity changes associated with microscopic lesions. Our project aims at developing an MR biomarker of NFT using a new bottom-up approach. We will start by identifying the MR signal changes associated with the presence of NFT at the level of the histological slice, and utilize these findings to develop a method of NFT quantification on clinical, millimetric 3D MR images. To achieve this goal, we will develop and implement a 11.7T histological coil dedicated to the scanning of histological slices, which allows both ultra-high resolution MR imaging (up to 33 microns in-plane) and perfect co-registration with histological staining, performed subsequently on the same slice. This method has the potential to provide a novel biomarker of tauopathy that could not have been identified using the usual top-down approach. It also envisions the possibility to describe and understand new MRI contrasts in other neurodegenerative diseases associated with microscopic deposition of various proteins.

9.1.3.3. ICM-Internal Research projects

Participants: Mario Chavez [Correspondant], Fabrizio de Vico Fallani [Correspondant].

Project title: Non-invasive manipulation of brain synchrony to enhance brain function and rehabilitate faulty cognition in humans: A proof of concept

Started in 2014

Coordinator: Antoni Valero Cabre (ICM-team “Dynamiques Cérébrales, Plasticité et Rééducation”)

Other partners: Service des Urgences Cérébro-Vasculaires de l’Hôpital Pitié-Salpêtrière, Paris.

The long-term goal of this project is to develop the use of non-invasive manipulation of abnormal cerebral oscillations underlying cognitive activity to restore brain function in neurological patients. Cognitive functions emerge from large distributed networks organized in space and time. The short-term goal of this application is to study the causal role played by oscillatory activity in visual awareness and test whether their manipulation by non-invasive brain stimulation has the potential to restore its function in stroke patients.

9.1.3.4. ICM Big Brain Theory Program

Participants: Stanley Durrleman [Correspondant], Harald Hampel [Correspondant], Sabrina Fontanella, Simone Lista, Olivier Colliot, Stephanie Allassonniere, Jean-Baptiste Schiratti, Bruno Dubois, Hovagim Bakardjian, Remi Genthon, Enrica Cavedo, Katrine Rojkowa.

Project title: Dynamic models of disease progression across Alzheimer's disease stages informed by multimodal neuroimaging and biological data

Founded in 2016-2017

Coordinator: Stanley Durrleman and Harald Hampel

Other partners: Institut de la Mémoire et de la maladie d'Alzheimer

The estimation of data-driven models of disease progression for neurodegenerative diseases, including Alzheimer's disease (AD), is crucial to confirm, refine and extend the current hypothetical models. The estimation of such quantitative models from longitudinal data sets is notably difficult because of the lack of principled methodological frameworks for the analysis of spatiotemporal data.

The project builds on an innovative mathematical, statistical, and computational framework to automatically align the dynamics and the direction of individual trajectories of the evolving pathology, and then to infer a normative scenario of disease progression across different disease stages. The estimated scenario will combine spatiotemporal maps of lesion propagation, such as maps of amyloid deposition or cortical atrophy, and global measurements such as levels of CSF biomarkers. It will be possible to estimate not only a normative scenario but also the inter-individual variability in the values, dynamics and direction of both topographical and pathophysiological biomarkers changes during the course of the disease.

The application of this technology to publicly available and in-house longitudinal data sets of individuals from the asymptomatic at risk to the prodromal and dementia stages will yield new insights into the pathophysiology of AD from the preclinical to the AD dementia stages. This quantitative data-driven approach will be exploited to assess and refine the current qualitative hypothetical models of AD progression. Notably, it will complement these models with typical pathways of lesion propagation in the brain during disease progression. It will also highlight the effect of the known risk factors of AD such as apolipoprotein E genotype on the disease progression profile.

The project will open up the concrete possibility to derive a computer-aided diagnosis, staging, and prognosis tool for a better recruitment of patients in clinical studies and to assist clinicians in the diagnosis and the monitoring of both disease progression and treatment efficacy.

9.1.3.5. IFR49-Internal Research projects

Participants: Mario Chavez [Correspondant], Fabrizio de Vico Fallani [Correspondant].

Project title: Exploring the impact and time frequency signature of rhythmic patterns of Transcranial Magnetic Stimulation (TMS) on network activity by Magneto-Encephalography (MEG)

Founded in 2014

Coordinator: Antoni Valero Cabre (ICM-team "Dynamiques Cérébrales, Plasticité et Rééducation")

Other partners: TMS, EEG and MEG technical platforms of the ICM at the Hopital Pitié-Salptrière; and Service des Urgences Cérébro-Vasculaires de l'Hôpital Pitié-Salpêtrière, Paris.

The long-term goal of this project is to better understand the ability of non invasive neurostimulation to induce lasting local and distributed reorganization effects in the human brain to better plan and document therapies for patients. The short-term goal of this application is to develop a new mapping procedure to be able to capture and characterize in terms of oscillatory activity the lasting impact of repetitive Transcranial Magnetic Stimulation (TMS) on specific brain regions and associated networks.

9.1.4. National Networks

- GdR Statistics and Medicine - http://gdr-stat-sante.math.cnrs.fr/spip/
- GdR (MaDICS) Masses de Données, Informations et Connaissances en Sciences Big Data - Data ScienceStatistics and Medicine - http://www.madics.fr/reseaux/

9.1.5. Other National Programs

9.1.5.1. Programme Hospitalier de Recherche Clinique (PHRC)

Participants: Olivier Colliot, Marie Chupin, Stanley Durrleman, Didier Dormont, Damien Galanaud.

- PHRC PredictPGRN, co-funding by Alzheimer Plan, *Caractérisation multimodale prospective de la démence frontotemporale dûe à des mutations du gène PGRN à un stade symptomatique et présymptomatique*. (Coordinator : A. Brice)
- PHRC ImaBio3, co-funding by Roche (pharmaceutical industry), *Rôle des réactions cellulaires sanguines, inflammatoires et immunitaires anti-amyloïde centrales et périphériques dans la maladie d'Alzheimer débutante*. (Coordinator : M. Sarazin)
- PHRC CAPP, *Caractérisation linguistique, anatomique/métabolique et biologique des différentes formes d'aphasie primaire progressive : vers le rationnel pour des essais pharmacologiques et des rééducations du langage ciblées*. (Coordinator: M. Teichmann)

9.1.5.2. Institut Universitaire d'Ingénierie pour la Santé (IUIS)

Participants: Mario Chavez, Xavier Navarro.

Project acronym: DYSPEV

Project title: Dépistage de la dyspnée par potentiels évoqués visuels

Funded in 2014

Amount: 38K€

Coordinator: Thomas Similowski

Other partners: UPMC, Inserm UMR 1158

Abstract: Steady state visual evoked potentials (SSVEP) have been widely utilized in brain computer interfacing (BCI) in last years. In this project, we explore the possibilities of SSVEP to manage the communication between patients suffering from respiratory disorders and health care providers. By imposing different breathing constraints, we use a SSVEP-based brain computer interface to help those subjects to communicate their breathing sensations (breathing well/breathing bad).

9.2. European Initiatives

9.2.1. FP7 & H2020 Projects

9.2.1.1. H2020 - Project EuroPOND

Participants: Olivier Colliot, Stanley Durrleman, Manon Ansart, Igor Koval, Alexandre Bône.

Project acronym: EuroPOND

Project title: Data-driven models for Progression Of Neurological Disease

Duration: Jan 2016 - Dec 2019

Amount: 6M€

Coordinator: Daniel Alexander

Other partners: University College London (UK), EMC Rotterdam (The Netherlands), VUMC (The Netherlands), Fate Bene Fratelli (Italy), Carol Besta Institute (Italy), Université de Genève (Switzerland), Icometrix (Belgium)

Abstract: EuroPOND will develop a data-driven statistical and computational modeling framework for neurological disease progression. This will enable major advances in differential and personalized diagnosis, prognosis, monitoring, and treatment and care decisions, positioning Europe as world leaders in one of the biggest societal challenges of 21st century healthcare. The inherent complexity of neurological disease, the overlap of symptoms and pathologies, and the high comorbidity rate suggests a systems medicine approach, which matches the specific challenge of this call. We take a uniquely holistic approach that, in the spirit of systems medicine, integrates a variety of clinical and biomedical research data including risk factors, biomarkers, and interactions. Our consortium has a multidisciplinary balance of essential expertise in mathematical/statistical/computational modelling; clinical, biomedical and epidemiological expertise; and access to a diverse range of datasets for sporadic and well-phenotyped disease types.The project will devise and implement, as open-source software tools, advanced statistical and computational techniques for reconstructing long-term temporal evolution of disease markers from cross-sectional or short-term longitudinal data. We will apply the techniques to generate new and uniquely detailed pictures of a range of important diseases. This will support the development of new evidence-based treatments in Europe through deeper disease understanding, better patient stratification for clinical trials, and improved accuracy of diagnosis and prognosis. For example, Alzheimer's disease alone costs European citizens around €200B every year in care and loss of productivity. No disease modifying treatments are yet available. Clinical trials repeatedly fail because disease heterogeneity prevents bulk response. Our models enable fine stratification into phenotypes enabling more focussed analysis to identify subgroups that respond to putative treatments.

9.2.1.2. FET Flagship - Human Brain Project

Participants: Olivier Colliot, Stanley Durrleman.

Project acronym: HBP

Project title: Human Brain Project

Sub-project: SP8 - Medical Informatics Platform

Duration (for this phase): 2016-2018

Abstract: The Human Brain Project (HBP) is a European Commission Future and Emerging Technologies Flagship. The HBP aims to put in place a cutting-edge, ICT-based scientific Research Infrastructure for brain research, cognitive neuroscience and brain-inspired computing. The Project promotes collaboration across the globe, and is committed to driving forward European industry. Our team is involved in the Subproject SP8 (Medical Informatics Platform). The Medical Informatics Platform (MIP) is an innovative data management system that gives researchers the means to access and analyse large amounts of anonymized clinical neuroscience data. Within that framework, we will develop and implement a method to construct disease progression models from longitudinal biomarkers. The method will use statistical learning techniques to infer a long-term disease progression model from multiple short term data from a series of individuals. The model will account for variability in age at disease onset, pace of disease progression and trajectories of biomarkers changes across individuals in the observed population.

9.2.1.3. ERC - LEASP

Participants: Stanley Durrleman, Raphael Couronné.

Project acronym: LEASP

Project title: Learning Spatiotemporal Patterns in Longitudinal Image Data Sets of the Aging Brain

Duration: 2016-2021

Abstract: Time-series of multimodal medical images offer a unique opportunity to track anatomical and functional alterations of the brain in aging individuals. A collection of such time series for several individuals forms a longitudinal data set, each data being a rich iconic-geometric representation of the brain anatomy and function. These data are already extraordinary complex and variable across individuals. Taking the temporal component into account further adds difficulty, in that each individual follows a different trajectory of changes, and at a different pace. Furthermore, a disease is here a progressive departure from an otherwise normal scenario of aging, so that one could not think of normal and pathologic brain aging as distinct categories, as in the standard case-control paradigm.

Bio-statisticians lack a suitable methodological framework to exhibit from these data the typical trajectories and dynamics of brain alterations, and the effects of a disease on these trajectories, thus limiting the investigation of essential clinical questions. To change this situation, we propose to construct virtual dynamical models of brain aging by learning typical spatiotemporal patterns of alterations propagation from longitudinal iconic-geometric data sets.

By including concepts of the Riemannian geometry into Bayesian mixed effect models, the project will introduce general principles to average complex individual trajectories of iconic-geometric changes and align the pace at which these trajectories are followed. It will estimate a set of elementary spatiotemporal patterns, which combine to yield a personal aging scenario for each individual. Disease-specific patterns will be detected with an increasing likelihood.

This new generation of statistical and computational tools will unveil clusters of patients sharing similar lesion propagation profiles, paving the way to design more specific treatments, and care patients when treatments have the highest chance of success.

9.3. International Initiatives

9.3.1. Inria International Partners

9.3.1.1. Informal International Partners

F. De Vico Fallani has a collaboration with the University Penn, Philadelphia, US (Prof. Danielle Bassett).

M. Chavez has different collaborations with the Mathematics Departement of the Queen Mary University of London, UK (Prof. V. Latora); and the Physics Department of the Universitat de Barcelona, Spain (Prof. Albert Diaz-Guilera)

F. De Vico Fallani has an enduring collaboration with the University Sapienza, Rome, Italy (Profs. Fabio and Claudio Babiloni) and with the IRCCS Fondazione Santa Lucia, Rome, Italy (M. Molinari and D. Mattia).

S. Durrleman has an enduring collaboration with professor Guido Gerig, Tandon School of Engineering, NYU. He is consultant for NIH Grant "4D shape analysis for modeling spatiotemporal change trajectories in Huntington's Disease "predict-HD".

O. Colliot has an enduring collaboration with the Center for Magnetic Resonance Research, University of Minnesota, USA (P-F Van de Moortele, T. Henry, M. Marjanska, K. Ugurbil) a leading center in 7T MRI.

S. Durrleman and O. Colliot have a collaboration with the Center for Medical Image Computing (CMIC) at University College London (UCL), London, UK (S. Ourselin, D. Alexander, M. Modat).

S. Durrleman has a collaboration with the department of Computer Science at New York University (NYU) (G. Gerig and J. Fishbaugh)

A. Bertrand has an enduring collaboration with professor Youssef Z. Wadghiri, head of the Preclinical Imaging Core, Center for Biomedical Imaging, NYU School of Medicine, New York, NY, USA.

9.4. International Research Visitors

9.4.1. Visits of International Scientists

- Professor Tom Fletcher from the University of Utah visited ARAMIS from January 23 to January 27.

9.4.1.1. Internships

Kuldeep Kumar (Ecole de Technologie Supérieure, Montréal, Canada) is visiting ARAMIS from October 2016 to March 2017 under the MITACS programme.

9.4.2. Visits to International Teams

9.4.2.1. Research Stays Abroad

Junhao Wen, PhD candidate, did a 3-month internship in the team of Hui Zhang, UCL, to develop pipelines of analysis for advanced diffusion MRI acquisitions (Neurite Orientation Dispersion and Density Imaging). This internship was funded by the ICM Carnot Program.

MAMBA Project-Team

8. Partnerships and Cooperations

8.1. National Initiatives

8.1.1. ANR

8.1.1.1. ANR Blanc 2014-2018 "Kibord"

This project gathers several members of the MAMBA team together with the ENS Cachan and Université Paris-Dauphine on the mathematical study of PDE models with application to biology.

8.1.1.2. ANR 2014-2017 IFLOW

Eric Vibert, Hopital Paul Brousse (coordinator). Partners: Inria REO, Hopital Toulouse, Dirk Drasdo. Objectives are simulation of liver perfusion after partial hepatectomy with and without therapeutic manipulations to improve patients survival after PHx.

8.1.1.3. ANR iLITE 2016 - 2020

Jean-Charles Duclos-Vallée, Paul Brousse Hospital, Villejuif. Partners are several departments in Paul Brousse Hospital, ENS Cachan, University of Compiègne and several companies all over France, and REO team, Inria Paris. The pursued objective is the bioengineering design of an artificial liver intended for liver replacement.

8.1.1.4. ANR InTelo 2017-2020

Telomere dynamics, headed by Teresa Teixeira (IBPC, Paris).

8.1.2. ITMO Cancer 2016 - 2020, HTE call (heterogeneity of tumours in their ecosystems)

8.1.2.1. ITMO Cancer EcoAML

Early leukaemogenesis in Acute Myelogenous Leukaemia (AML), 8 teams headed by François Delhommeau (CDR St Antoine, Paris).

8.1.2.2. ITMO Cancer MoGlImaging

Treatment-induced treatment resistance and heterogeneity in glioblastoma, 8 teams headed by Elizabeth Moyal (INSERM, Toulouse).

8.2. European Initiatives

8.2.1. FP7 & H2020 Projects

Research axis 1 (population dynamics): The ERC Starting Grant SKIPPER^{AD} (Marie Doumic, 2014-2018) supported and was the guideline for the study of nucleation, growth and fragmentation equations.

Benoît Perthame has obtained in April 2017 the ERC Advanced Grant ADORA (Asymptotic approach to spatial and dynamical organisations)

8.2.2. Collaborations with Major European Organisdations

German BMBF: LiverSimulator (Dirk Drasdo, 2014 - 2017)

8.3. International Initiatives

8.3.1. Participation in International Programs

CAPES/COFECUB project "Modelling innovative control methods for dengue fever" (Bliman)

STIC AmSud project “MOSTICAW- MOdelling the Spread and (opTImal) Control of Arboviroses by Wolbachia" (2016-2017) (Bliman)..

ECOS-Nord project “New methods for controlling epidemics of dengue fever and arboviroses" (2017-2019) (Bliman)

(See below)

8.3.1.1. International Initiatives

MOSTICAW

Title: MOdelling the Spread and (opTImal) Control of Arboviroses by Wolbachia

International Partners (Institution - Laboratory - Researcher):

Universidad de Buenos Aires (Argentina) - Hernán G. Solari

Universidad de Chile (Chile) - Carlos Conca

Universidade Federal Fluminense (Brazil) - Max Souza

Duration: 2016 - 2017

Start year: 2016

The spread of certain strains of the intracellular parasitic bacterium Wolbachia in populations of mosquitoes Aedes aegypti drastically reduces their competence as vector of dengue and other severe mosquito-borne viral diseases known as arboviral infections. In absence of vaccine, or of preventive or curative treatment, the release of mosquitoes infected by the bacterium has been recently considered a promising tool to control these diseases, and experimental introductions in wild populations are currently under way in Brazil and Colombia. A key question about this method concerns the effective strategies of release of the infected mosquitoes in the field that can be applied with limited cost to reach the desired state of complete exclusion of Wolbachia-free mosquitoes. The mathematical study of central topics is the core of this project. The scientific questions to be addressed during this project are related to the study of the dynamic and control of the key invasion mechanism on finite-dimensional compartmental models; and to specific focus on the spatial aspects, achieved through more elaborate models (PDE, models on interaction graphs, stochastic models). We further propose to elaborate on the risks involved in the spreading of Wolbachia, implementing in mathematical models critical analysis, complex systems (R. García) and a complexity aware epistemology (E. Morin) in contrast with the instrumental reason (Horkheimer).

8.3.1.2. International Initiatives

C17M01

Title: New methods for the control of epidemics of dengue and arboviroses

International Partner (Institution - Laboratory - Researcher):

Universidad del Valle (Colombia) - Olga Vasilieva

Duration: 2017 - 2019

Start year: 2017

8.4. International Research Visitors

8.4.1. Internships

September 2016-January 2017: Julie Favre, M1 student at EPFL (Zürich), research internship report [39]

8.4.2. Visits to International Teams

8.4.2.1. Sabbatical programme

Doumic Marie

Date: Sep 2016 - Jul 2018

Institution: Wolfgang Pauli Institute, Vienna (Austria)

8.4.2.2. Research Stays Abroad

P.-A. Bliman is still a professor at Funadação Getulio Vargas, Rio de Janeiro, Brazil, and makes frequent stays there.

MYCENAE Project-Team

8. Partnerships and Cooperations

8.1. European Initiatives

Together with our BIOS INRA partner, we have participated in a synergistic way in the proposal EVE (*In-Silico Safety and Efficacy Assessment of Reproductive Endocrinology Treatments*) submitted to the H2020-SC1-2016-2017 call (Personalised Medicine), whose PI was Enrico Tronci (Sapienza, Roma).

8.2. National Initiatives

8.2.1. ANR

Jonathan Touboul is member of the Kibord (KInetic models in Biology Or Related Domains) project obtained in 2014.

He is also PI of the projects "Mathematical modeling of synaptic plasticity" (with Laurent Venance, CIRB) funded as an interdisciplinary structuring project of INSB (Institut des Sciences Biologiques in CNRS) and "Altering Fear Memory" (with Sidney Wiener, CIRB and Karim Benchenane, ESPCI) funded by the PSL Labex MemoLife.

8.2.2. National Networks

- GdR REPRO (F. Clément is member of the direction board)
- MIA REM network: Réduction de modèles (PI Béatrice Laroche, INRA Jouy)

8.2.3. National Collaborations

- UMR Physiologie de la Reproduction et des Comportements, INRA Centre- Val de Loire (Bios and Bingo teams)
- Université Pierre & Marie Curie (UPMC)
  - Jacques-Louis Lions Laboratory, Pierre & Marie Curie University (Jean-Pierre Françoise, Marie Postel)
  - Developmental Biology Laboratory, Institut de Biologie Paris Seine (IBPS), Pierre & Marie Curie University (Alice Karam, Sylvie Schneider Maunoury), in the framework of the NeuroMathMod, Sorbonne-Universités Émergence call
- Center for Interdisciplinary Research in Biology (CIRB), Collège de France (Alain Prochiantz, Marie Manceau, Laurent Venance)

REO Project-Team

9. Partnerships and Cooperations

9.1. National Initiatives

9.1.1. ANR

9.1.1.1. ANR Project "iFLOW"

Participants: Chloé Audebert, Jean-Frédéric Gerbeau, Florian Joly, Irene Vignon Clementel [co-Principal Investigator].

Period: 2013-2017.
This ANR-TecSan, co-managed by Eric Vibert (Paul Brousse Hospital) and Irene Vignon Clementel, aims at developing an Intraoperative Fluorescent Liver Optimization Workflow to better understand the relationship between architecture, perfusion and function in hepatectomy.

Other partners: DHU Hepatinov - Hôpital Paul Brousse, Inria Mamba, Fluoptics, IfADo, MID.

9.1.1.2. ANR Project "IFSMACS"

Participants: Muriel Boulakia, Céline Grandmont [local coordinator].

Period: 2015-2019.
The objective of this project, coordinated by Takéo Takahashi (Inria Nancy Grand-Est), is the mathematical analysis of systems involving structures immersed in a fluid. This includes the asymptotic analysis, the study of the controllability and stabilization of fluid-structure interaction systems, the understanding of the motion of self-propelled structures and the analysis and development of numerical methods to simulate fluid-structure systems.

9.1.1.3. Participation to other ANR projects

- Laurent Boudin is a member of the ANR Blanc project Kibord on kinetic models in biology and related domains
- Laurent Boudin is a member of the ANR TecSan Oxhelease
- Céline Grandmont is a member of the ANR TecSan Oxhelease
- Marina Vidrascu is a member of the ANR ARAMIS
- Irene Vignon Clementel is a member of the project iLite (09/16-), RHU-santé grant, a large French hospital-medical research consortium that aims at developing innovations for liver and tissue engineering (Inria PI: Dirk Drasdo).

9.1.2. Inria initiatives

9.1.2.1. ADT Project "PARASOL"

Participants: Miguel Ángel Fernández Varela [Principal Investigator], Axel Fourmont, Marina Vidrascu.

Period: 2016-2017
The aim of this project, coordinated by Miguel Ángel Fernández Varela, is to implement in the FELiScE library several balancing domain decomposition methods (BDD) for solid-mechanics.

9.2. European Initiatives

9.2.1. FP7 & H2020 Projects

9.2.1.1. REVAMMAD

Title: "Retinal Vascular Modeling, Measurement and Diagnosis"

Programm: FP7

Duration: April 2013 - March 2017

Coordinator: University of Lincoln

Partners: : See the web site http://revammad.blogs.lincoln.ac.uk/partners/

Inria contact: J-F Gerbeau

REVAMMAD is a European Union project aimed at combatting some of the EU's most prevalent chronic medical conditions using retinal imaging. The project aims to train a new generation of interdisciplinary scientists for the academic, clinical and industrial sectors, and to trigger a new wave of biomedical interventions. The role of REO team within this consortium is to propose a mathematical model and a simulation tool for the retina hemodynamics. See http://revammad.blogs.lincoln.ac.uk for more details.

9.2.2. Collaborations in European Programs, Except FP7 & H2020

9.2.2.1. SimInhale COST

Participant: Irene Vignon Clementel.

Action MP1404, a pan-European network of experts in the field of inhaled medicine

9.3. International Research Visitors

9.3.1. Internships

- Gonzalo Castineira Veiga, Visiting PhD student, Universidade da Coruña, Apr 2017–Jun 2017

SERENA Project-Team

9. Partnerships and Cooperations

9.1. Regional Initiatives

GiS: scientific collaboration network between ten public institutions from the Paris (Ile-de-France) region, focused on natural resources and environment. The project-team SERENA is a member.

9.2. National Initiatives

9.2.1. ANR

ANR DEDALES: "Algebraic and geometric domain decomposition for subsurface flow". The project aims at developing high performance software for the simulation of two phase flow in porous media. It specifically targets parallel computers where each node is itself composed of a large number of processing cores, such as are found in new generation many-core architectures. The project had its intermediate review in December 2016, and received excellent marks from the expert panel.

The partners are HIEPACS, Laboratoire Analyse, Géométrie et Application, University Paris 13, Maison de la Simulation, and ANDRA. SERENA representants are M. Kern (grant leader) and M. Vohralík, period 2014–2017.

ANR GEOPOR: "Geometrical approach for porous media flows: theory and numerics". A new approach to numerical methods for multiphase simulations based on the concept of gradient flows is investigated. With Laboratoire Jacques-Louis Lions, University Pierre and Marie Curie. SERENA representant is M. Vohralík, period 2013–2017.

ANR H2MNO4: "Original optimized object-oriented numerical model for heterogeneous hydrogeology". The project H2MNO4 develops numerical models for reactive transport in heterogeneous media. The objective is to design both Eulerian and Lagrangian models. Three applications are concerned: freshwater supply, remediation of mine drainage, and waste geological disposal. The project relies on a consortium of six partners, involving four public research laboratories (Inria, Geosciences Rennes, University of Lyon 1, University of Poitiers, Pprime Institute), one public institution (ANDRA), and one enterprise (ITASCA). International collaborations are pursued with University of San Diego (USA) and UPC (Spain). SERENA representant is G. Pichot, period 2012–2016.

ANR HHOMM: "Hybrid high-order methods on polyhedral meshes", Theoretical foundations and applications (up to software development) for the recently-devised Hybrid high-order methods. Coordinated by D. Di Pietro, University of Montpellier. SERENA representant is A. Ern, period 2015–2019.

9.3. European Initiatives

9.3.1. FP7 & H2020 Projects

ERC GATIPOR: "Guaranteed fully adaptive algorithms with tailored inexact solvers for complex porous media flows". The subject of this project are new approaches to porous media multiphase flows: inexact Newton-multigrid solvers, local stopping criteria, adaptivity, and a posteriori error control. The goal is to guarantee the overall simulation error and to speed-up importantly the present-day simulations. SERENA representant is M. Vohralík (grant leader), period 2015–2020.

EoCoE: "Energy Oriented Center of Excellence" This project is coordinated by Maison de la Simulation and gathers 23 partners from 13 countries to use the tremendous potential offered by the ever-growing computing infrastructure to foster and accelerate the European transition to a reliable low carbon energy supply using HPC (High Performance Computing). SERENA representant M. Kern, period 2015–2018.

9.3.2. Collaborations in European Programs, Except FP7 & H2020

OPENCPS

Program: ITEA 3

Project acronym: OPENCPS

Project title: Open cyber-physical system model-driven certified development

Duration: Dec 2015–Dec 2018

Coordinator: Magnus Eek

Other partners: AB SKF, CEA, ELTE-Soft Kft., ESI Group, EDF, Wqua Simulation AB, Ericsson, IncQuery Labs Kft., KTH, Linköping University, RTE, SICS, SIREHNA, Saab AB, Sherpa Engineering, Siemens Industrial Torbumachinery AB, VTT Technical Research Center of Finland Ltd.

Abstract: Cyber-physical systems put increasing demands on reliability, usability, and flexibility while, at the same time, lead time and cost efficiency are essential for industry competitiveness. Tools and environments for model-based development of cyber-physical systems are becoming increasingly complex and critical for the industry: tool interoperability, vendor lock-ins, and tool life-cycle support are some of the challenges. The project focuses on interoperability between the standards Modelica/UML/FMI, improved execution speed of (co-)simulation, and certified code generation.

MoRe

Program: Research, Development and Innovation Council of the Czech Republic

Project acronym: MoRe

Project title: Implicitly constituted material models: from theory through model reduction to efficient numerical methods

Duration: September 2012 – September 2017

Coordinator: Josef MÁLEK, Charles University in Prague. SERENA representant is M. Vohralík.

Other partners: Institute of Mathematics, Czech Academy of Sciences; University of Oxford

Abstract: A multidisciplinary project on nonlinear Navier–Stokes flows with implicit constitutive laws. It focuses on development of accurate, efficient, and robust numerical methods for simulations of the new class of implicit models.

9.4. International Initiatives

9.4.1. Inria International Partners

9.4.1.1. Informal International Partners

Erik Burman, Professor at University College London, UK, unfitted methods.

Jean-Luc Guermond, Professor at Texas A&M University, USA, finite element methods.

Ulrich Rüde, Professor at Friedrich-Alexander-Universität Erlangen-Nürnberg, Germany, multigrid methods.

Mary Wheeler, professor, University of Texas at Austin, USA, porous medial applications.

Barbara Wohlmuth, Professor at Technical University of München, Germany, mixed finite element methods.

9.5. International Research Visitors

9.5.1. Visits of International Scientists

Lars Diening, Professor at University of Bielefeld, Germany, February 17–23, 2017.

Christian Kreuzer, Professor at University of Dortmund, Germany, February 19–25, 2017.

Joscha Gedicke, post-doc at University Vienna, Austria, May 29–June 2, 2017.

Martin Eigel, post-doc at Weierstrass Institute Berlin, Germany, May 29–June 2, 2017.

Carsten Carstensen, Professor at Humboldt University Berlin, Germany, August 15–September 15, 2017.

Peter Minev, Professor at the University of Alberta, Canada, September 15–October 15, 2017.

Hend Ben Ameur, Professor at IPEST and member of ENIT-Lamsin, Tunis, Tunisia, October 23–November 3, 2017.

9.5.1.1. Internships

K. Talali, université de Fez, Morocco, April 1–August 31 (Master degree).

9.5.2. Visits to International Teams

9.5.2.1. Research Stays Abroad

Alexandre Ern participated as Invited Professor to the HIM Program on Multiscale Problems: Algorithms, Numerical Analysis and Computation, in Bonn, Germany, January 2017.

Martin Vohralík was invited for two weeks stay to Charles University in Prague collaboration with J. Málek, April 2017.

TAPDANCE Team

6. Partnerships and Cooperations

6.1. European Initiatives

6.1.1. FP7 & H2020 Projects

Woods applied for an ERC Consolidator award. The application was successful and begins in 2018.

6.2. International Research Visitors

6.2.1. Visits of International Scientists

David Doty (UC Davis) visited the team several times in 2017.

ALPINES Project-Team

9. Partnerships and Cooperations

9.1. National Initiatives

9.1.1. ANR

9.1.1.1. B3DCMB

ANR Decembre 2017 - Novembre 2021 This project is in the area of data analysis of cosmological data sets as collected by contemporary and forthcoming observatories. This is one of the most dynamic areas of modern cosmology. Our special target are data sets of Cosmic Microwave Background (CMB) anisotropies, measurements of which have been one of the most fruitful of cosmological probes. CMB photons are remnants of the very early evolution of the Universe and carry information about its physical state at the time when the Universe was much younger, hotter and denser, and simpler to model mathematically. The CMB has been, and continue to be, a unique source of information for modern cosmology and fundamental physics. The main objective of this project is to empower the CMB data analysis with novel high performance tools and algorithms superior to those available today and which are capable of overcoming the existing performance gap. Partners: AstroParticules et Cosmologie Paris 7 (PI R. Stompor), ENSAE Paris Saclay.

9.1.1.2. Medimax

ANR-MN (Modèles Numériques) October 2013 - September 2017

The main goal is the methodological and numerical development of a new robust inversion tool, associated with the numerical solution of the electromagnetic forward problem, including the benchmarking of different other existing approaches (Time Reverse Absorbing Condition, Method of Small-Volume Expansions, Level Set Method). This project involves the development of a general parallel open source simulation code, based on the high-level integrated development environment of FreeFem++, for modeling an electromagnetic direct problem, the scattering of arbitrary electromagnetic waves in highly heterogeneous media, over a wide frequency range in the microwave domain. The first applications considered here will be medical applications: microwave tomographic images of brain stroke, brain injuries, from both synthetic and experimental data in collaboration with EMTensor GmbH, Vienna (Austria), an Electromagnetic Medical Imaging company.

9.1.1.3. ANR Cine-Para

October 2015 - September 2019, Laura Grigori is Principal Coordinator for Inria Paris. Funding for Inria Paris is 145 Keuros. The funding for Inria is to combine Krylov subspace methods with parallel in time methods. Partners: University Pierre and Marie Curie, J. L. Lions Laboratory (PI Y. Maday), CEA, Paris Dauphine University, Paris 13 University.

9.1.1.4. Non-local DD

ANR appel à projet générique October 2015 - September 2020

This project in scientific computing aims at developing new domain decomposition methods for massively parallel simulation of electromagnetic waves in harmonic regime. The specificity of the approach that we propose lies in the use of integral operators not only for solutions local to each subdomain, but for coupling subdomains as well. The novelty of this project consists, on the one hand, in exploiting multi-trace formalism for domain decomposition and, on the other hand, considering optimized Schwarz methods relying on Robin type transmission conditions involving quasi-local integral operators.

9.1.1.5. Soilμ-3D

ANR appel à projet générique October 2015 - September 2020

In spite of decades of work on the modeling of greenhouse gas emission such as CO2 and N2O and on the feedback effects of temperature and water content on soil carbon and nitrogen transformations, there is no agreement on how these processes should be described, and models are widely conflicting in their predictions. Models need improvements to obtain more accurate and robust predictions, especially in the context of climate change, which will affect soil moisture regime.

The goal of this new project is now to go further using the models developed in MEPSOM to upscale heterogeneities identified at the scale of microbial habitats and to produce macroscopic factors for biogeochemical models running at the field scale.

To achieve this aim, it will be necessary to work at different scales: the micro-scale of pores (μm) where the microbial habitats are localized, the meso-scale of cores at which laboratory measurements on CO2 and N2O fluxes can be performed, and the macro-scale of the soil profile at which outputs are expected to predict greenhouse gas emission. The aims of the project are to (i) develop new descriptors of the micro-scale 3D soil architecture that explain the fluxes measured at the macro-scale, (ii) Improve the performance of our 3D pore scale models to simulate both micro-and meso- scales at the same time. Upscaling methods like "homogeneization" would help to simulate centimeter samples which cannot be achieved now. The reduction of the computational time used to solve the diffusion equations and increase the number of computational units, (iii) develop new macro-functions describing the soil micro-heterogeneity and integrate these features into the field scale models.

9.2. European Initiatives

9.2.1. FP7 & H2020 Projects

9.2.1.1. NLAFET

Title: Parallel Numerical Linear Algebra for Future Extreme-Scale Systems

Programm: H2020

Duration: November 2015 - November 2018

Coordinator: UMEÅUniversitet

Partners:

Science and Technology Facilities Council (United Kingdom)

Computer Science Department, UmeåUniversitet (Sweden)

Mathematics Department, The University of Manchester (United Kingdom)

Inria contact: Laura Grigori

The NLAFET proposal is a direct response to the demands for new mathematical and algorithmic approaches for applications on extreme scale systems, as identified in the FETHPC work programme and call. This project will enable a radical improvement in the performance and scalability of a wide range of real-world applications relying on linear algebra software, by developing novel architecture-aware algorithms and software libraries, and the supporting runtime capabilities to achieve scalable performance and resilience on heterogeneous architectures. The focus is on a critical set of fundamental linear algebra operations including direct and iterative solvers for dense and sparse linear systems of equations and eigenvalue problems. Achieving this requires a co-design effort due to the characteristics and overwhelming complexity and immense scale of such systems. Recognized experts in algorithm design and theory, parallelism, and auto-tuning will work together to explore and negotiate the necessary tradeoffs. The main research objectives are: (i) development of novel algorithms that expose as much parallelism as possible, exploit heterogeneity, avoid communication bottlenecks, respond to escalating fault rates, and help meet emerging power constraints; (ii) exploration of advanced scheduling strategies and runtime systems focusing on the extreme scale and strong scalability in multi/many-core and hybrid environments; (iii) design and evaluation of novel strategies and software support for both offline and online auto-tuning. The

validation and dissemination of results will be done by integrating new software solutions into challenging scientific applications in materials science, power systems, study of energy solutions, and data analysis in astrophysics. The deliverables also include a sustainable set of methods and tools for cross-cutting issues such as scheduling, auto-tuning, and algorithm-based fault tolerance packaged into open-source library modules.

9.2.1.2. EXA2CT

Title: EXascale Algorithms and Advanced Computational Techniques

Programm: FP7

Duration: September 2013 - August 2016

Coordinator: IMEC

Partners:

Fraunhofer-Gesellschaft Zur Foerderung Der Angewandten Forschung E.V (Germany)

Interuniversitair Micro-Electronica Centrum Vzw (Belgium)

Intel Corporations (France)

Numerical Algorithms Group Ltd (United Kingdom)

T-Systems Solutions for Research (Germany)

Universiteit Antwerpen (Belgium)

Universita della Svizzera italiana (Switzerland)

Université de Versailles Saint-Quentin-En-Yvelines. (France)

Vysoka Skola Banska - Technicka Univerzita Ostrava (Czech Republic)

Inria contact: Luc Giraud

Numerical simulation is a crucial part of science and industry in Europe. The advancement of simulation as a discipline relies on increasingly computing intensive models that require more computational resources to run. This is the driver for the evolution to exascale. Due to limits in the increase in single processor performance, exascale machines will rely on massive parallelism on and off chip, with a complex hierarchy of resources. The large number of components and the machine complexity introduce severe problems for reliability and programmability. The former of these will require novel fault-aware algorithms and support software. In addition, the scale of the numerical models exacerbates the difficulties by making the use of more complex simulation algorithms necessary, for numerical stability reasons. A key example of this is increased reliance on solvers. Such solvers require global communication, which impacts scalability, and are often used with preconditioners, increasing complexity again. Unless there is a major rethink of the design of solver algorithms, their components and software structure, a large class of important numerical simulations will not scale beyond petascale. This in turn will hold back the development of European science and industry which will fail to reap the benefits from exascale. The EXA2CT project brings together experts at the cutting edge of the development of solvers, related algorithmic techniques, and HPC software architects for programming models and communication. It will take a revolutionary approach to exascale solvers and programming models, rather than the incremental approach of other projects. We will produce modular open source proto-applications that demonstrate the algorithms and programming techniques developed in the project, to help boot-strap the creation of genuine exascale codes.

9.3. International Initiatives

9.3.1. Inria International Partners

9.3.1.1. Informal International Partners

- J. Demmel, UC Berkeley, USA

- R. Hipmair, ETH Zurich
- M. Grote (Université de Bâle, Suisse)
- F. Assous (Israel)

9.4. International Research Visitors

9.4.1. Visits of International Scientists

- Ralf Hiptmair (ETH Zürich) came to visit Xavier Claeys for a sabbatical semester, from January to June 2017.
- Mahadevan Ganesh (Colorado School of Mines) came to visit Xavier Claeys from the 4th of July 2017 to 18th of July 2017.
- Carlos Jerez-Hanckes (Pontificia Universidad Catholica, Santiago, Chile) came to visit Xavier Claeys from the 3rd of December to the 16th of December 2017.

9.4.2. Visits to International Teams

9.4.2.1. Research Stays Abroad

- Laura Grigori has spent 3 weeks at UC Berkeley, from July 21, 2016 to August 13, 2016.
- Xavier Claeys visited Catalin Turc (New Jersey Institute of Technology) from the 5th of November to the 14th of November 2017.

DYOGENE Project-Team

9. Partnerships and Cooperations

9.1. Regional Initiatives

DYOGENE is associated to the Laboratory of Information, Networking and Communication Sciences (LINCS) http://www.lincs.fr/ co-founded in 2010 by Inria, Institut Mines-Télécom and UPMC, with Bell Labs Nokia (formerly Alcatel-Lucent) and SystemX joining it as strategic partners in 2011 and 2014, respectively. The LINCS is dedicated to research and innovation in the domains of future information and communication networks, systems and services.

9.2. National Initiatives

9.2.1. GdR GeoSto

Members of Dyogene participate in Research Group GeoSto (Groupement de recherche, GdR 3477) http://gdr-geostoch.math.cnrs.fr/ on Stochastic Geometry led by Pierre Calka [Université de Rouen], Viet Chi Tran [Université de Lille] and David Coupier [Université de Valenciennes].

This is a collaboration framework for all French research teams working in the domain of spatial stochastic modeling, both on theory development and in applications.

9.2.2. GdR IM

Members of Dyogene participate in GdR-IM (Informatique-Mathématiques), https://www.gdr-im.fr/, working groups ALEA and SDA2 (Systèmes dynamiques, Automates et Algorithmique).

9.2.3. GdR RO

Members of Dyogene participate in GdR-RO (Recherche Opérationelle; GdR CNRS 3002), http://gdrro.lip6.fr/, working group COSMOS (Stochastic optimization and control, modeling and simulation), lead by A. Busic and E. Hyon (LIP 6); http://gdrro.lip6.fr/?q=node/78

9.2.4. PGMO

Gaspard Monge Program for Optimization and Operations Research project Decentralized control for renewable integration in smart-grids (2015-17). PI: A. Busic.

9.2.5. ANR MARMOTE

Markovian Modeling Tools and Environments - coordinator: Alain Jean-Marie (Inria Maestro); local coordinator (for partner Inria Paris-Rocquencourt): A. Bušić; Started: January 2013; Duration: 48 months; partners: Inria Paris-Rocquencourt (EPI DYOGENE), Inria Sophia Antipolis Méditerranée (EPI MAESTRO), Inria Grenoble Rhône-Alpes (EPI MESCAL), Université Versaillese-St Quentin, Telecom SudParis, Université Paris-Est Creteil, Université Pierre et Marie Curie.

The aim of the project was to realize a modeling environment dedicated to Markov models. One part developed the Perfect Simulation techniques, which allow one to sample from the stationary distribution of the process. A second one developed parallelization techniques for Monte Carlo simulation. A third one developed numerical computation techniques for a wide class of Markov models. All these developments were integrated into a programming environment allowing the specification of models and their solution strategy. Several applications have been studied in various scientific disciplines: physics, biology, economics, network engineering.

The project terminated in October 2017.

9.2.6. ANR JCJC PARI

Probabilistic Approach for Renewable Energy Integration: Virtual Storage from Flexible Loads. The project started in January 2017. PI — A. Bušić. This project is motivated by current and projected needs of a power grid with significant renewable energy integration. Renewable energy sources such as wind and solar have a high degree of unpredictability and time variation, which makes balancing demand and supply challenging. There is an increased need for ancillary services to smooth the volatility of renewable power. In the absence of large, expensive batteries, we may have to increase our inventory of responsive fossil-fuel generators, negating the environmental benefits of renewable energy. The proposed approach addresses this challenge by harnessing the inherent flexibility in demand of many types of loads. The objective of the project is to develop decentralized control for automated demand dispatch, that can be used by grid operators as ancillary service to regulate demand-supply balance at low cost. We call the resource obtained from these techniques virtual energy storage (VES). Our goal is to create the necessary ancillary services for the grid that are environmentally friendly, that have low cost and that do not impact the quality of service (QoS) for the consumers. Besides respecting the needs of the loads, the aim of the project is to design local control solutions that require minimal communications from the loads to the centralized entity. This is possible through a systems architecture that includes the following elements: i) local control at each load based on local measurements combined with a grid-level signal; ii) frequency decomposition of the regulation signal based on QoS and physical constraints for each class of loads.

9.3. International Initiatives

9.3.1. PARIS

Title: Probabilistic Algorithms for Renewable Integration in Smart Grid

International Partner (Institution - Laboratory - Researcher):

University of Florida (United States) - Laboratory for Cognition & Control in Complex Systems - Sean Meyn.

Start year: 2015

See also: http://www.di.ens.fr/~busic/PARIS/

The importance of statistical modeling and probabilistic control techniques in the power systems area is now evident to practitioners in both the U.S. and Europe. Renewable generation has brought unforeseen volatility to the grid that require new techniques in distributed and probabilistic control. In a series of recent papers the two PIs have brought together their complementary skills in optimization, Markov modeling, simulation, and stochastic networks that may help to solve some pressing open problems in this area. This new research also opens many exciting new scientific questions.

9.3.2. Inria International Partners

9.3.2.1. Informal International Partners

- O. Mirsadeghi [Sharif University, Tehran],
- V. Anantharam [UC Berkeley],
- D. Yogeshwaran [Indian Statistical Institute].

9.4. International Research Visitors

9.4.1. Visits of International Scientists

- Venkat Anantharam [UC Berkeley, from Jun 2017 until Jul 2017]
- Prabir Barooah [University of Florida, from May 2017 until Jun 2017]
- Milan Bradonjic [Nokia, until Jan 2017]

- Adithya Munegowda Devraj [University of Florida, from Aug 2017 until Sep 2017]
- Christian Hirsch [LMU Munich, Sep 2017]
- Yuting Ji [Stanford, Oct 2017]
- Marc Olivier Buob [Bell Labs (Alcatel)]
- Josu Doncel [University of the Basque Country, Jul 2017]
- Mir Omid Haji Mirsadeghi [Sharif University, Tehran]

9.4.2. Visits to International Teams

9.4.2.1. Research Stays Abroad

- B. Blaszczyszyn, October 1st – December 15th, Specially Appointed Professor at The School of Computing, Tokyo Institute of Technology.

EVA Project-Team

9. Partnerships and Cooperations

9.1. National Initiatives

- EVA has a collaboration with Vedecom. **Paul Muhlethaler** supervises Younes Bouchaala's PhD funded by Vedecom. This PhD aims at studying vehicle-to-vehicle communication to improve roads safety.
- EVA has an ongoing collaboration with SODEAL company, which exploits the Cap d'Agde marina, as part of the SmartMarina project.

9.2. European Initiatives

9.2.1. FP7 & H2020 Projects

The H2020 following projects are ongoing:

- H2020 F-Interop, http://f-interop.eu/, Nov 2015 – Oct 2018.
- H2020 ARMOUR, https://www.armour-project.eu/, Feb 2016 – Jan 2018.

9.2.2. Collaborations in European Programs, Except FP7 & H2020

9.2.2.1. Collaborations with Major European Organizations

Inria-EVA has collaboration in 2017 with ETSI (the European Telecommunications Standards Institute) to organize the F-Interop 6TiSCH Interop Event in July 2017 in Prague.

9.3. International Initiatives

9.3.1. Inria International Labs

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

9.3.2.1. REALMS

- Title: Real-Time Real-World Monitoring Systems
- International Partner (Institution - Laboratory - Researcher):
  - University of California Berkeley (United States) - Civil and Environmental Engineering - Steven Glaser
  - University of Michigan (United States) - Civil and Environmental Engineering - Branko Kerkez
- Start year: 2015
- See also: http://glaser.berkeley.edu et http://www-personal.umich.edu/~bkerkez/
- The Internet of Things revolution prompted the development of new products and standards; The IEEE802.15.4e (2012) standard introduced the Time Synchronized Channel Hoping (TSCH) which can provide end-to-end reliability of 99.999 % and an energy autonomy of many years. This exceptional performance prompted the IETF to create the 6TISCH working group to standardize the integration of TSCH networks in the Internet. While the first experimental data have highlighted the great robustness of these networks, there is no data of a real network, accessible in real time, on a large scale and over a long period. Such data is needed to better model network performance and produce better products and standards. Teams of Professors Glaser and Kerkez are successfully deploying such networks to study mountain hydrology, monitor water quality and manage rainwater in urban environments. A model is missing to assist in the deployment and operation of these networks, as well as to monitor an operational network.

9.3.2.2. DIVERSITY

- Title: Measuring and Exploiting Diversity in Low-Power Wireless Networks
- International Partner (Institution - Laboratory - Researcher):
  - University of Southern California (United States) - Autonomous Networks Research Group (ANRG) - Bhaskar Krishnamachari
- Start year: 2016
- The goal of the DIVERSITY associate team is to develop the networking technology for tomorrow's Smart Factory. The two teams comes with a perfectly complementary background on standardization and experimentation (Inria-EVA) and scheduling techniques (USC-ANRG). The key topic addressed by the joint team will be networking solutions for the Industrial Internet of Things (IIoT), with a particular focus on reliability and determinism.

9.3.3. Inria International Partners

9.3.3.1. Declared Inria International Partners

Inria-EVA has a long-standing Memorandum of Understanding with the OpenMote company (http://www.openmote.com/), which runs until 2020. OpenMote emerged as a spin-off of the OpenWSN project, co-lead by **Thomas Watteyne** and Prof. Xavier Vilajosana, Professor at the Open University of Catalonia and Chief Technical Officer at OpenMote.

The collaboration has been ongoing since 2012 and at the time of writing has resulted in:

- Joint academic publications, including 7 journal articles, 1 letter, 1 book chapter, 5 conference papers, 2 tutorials and invited talks.
- Joint standardization activities, in particular in the IETF 6TiSCH working group, co-chaired by **Thomas Watteyne** and for which Prof. Xavier Vilajosana is a key contributor. This activity has resulted in the joint participation in 12 IETF face-to-face meetings, joint participation in over 100 audioconferences, co-authorship of 3 Internet-Drafts and joint organization of 2 interop events.
- Joint software development, as both institutions closely collaborate in the maintenance, development, promotion and research along the OpenWSN project, including the development of the protocol stack, the integration of novel hardware technologies, the support to the community and the participation in standardization activities and interoperability events.

This MOU is NOT a commitment of funds by any part.

9.3.3.2. Informal International Partners

The Inria-EVA collaborates extensively with Prof. Pister's group at UC Berkeley on the OpenWSN and Smart Dust projects. This activity translated into several members of the Pister team visiting Inria-EVA and vice-versa in 2017.

9.3.4. Participation in Other International Programs

9.3.4.1. International Initiatives

- **PEACH**
- Title: PrEcision Agriculture through Climate researcH
- International Partners (Institution - Laboratory - Researcher):
  - Universidad Diego Portales (Chile) - Diego Dujovne
  - Universidad Tecnológica de Mendoza (Argentina) - Gustavo Mercado
- Duration: 2016 - 2017

- In 2013, 85% of the peach production in the Mendoza region (Argentina) was lost because of frost. Because less fruit was produced in the region, 600.000 less work days were needed to process the harvest between November 2013 and March 2014, a reduction in work force of 10.600 people. Across the Mendoza region, frost has caused a loss of revenue of 950 million Argentine pesos - roughly 100 million USD - in the peach business alone. A frost event happens when the temperature is so low that the crops cannot recover their tissue or internal structure from the effects of water freezing inside or outside the plant. For the peach production, a critical period is when the trees are in bloom and fruit set (Aug./Sept. in Mendoza), during which the temperature needs to be kept above -3 C. Even a few hours below that temperature causes flowers to fall, preventing fruits to grow. Because of the huge economic impact, countermeasures exist and are used extensively. Today, virtually all industrial peach orchards are equipped with a small number of meteorological stations which monitor temperature and humidity. If the temperature drops dangerously low, the most effective countermeasures is to install a number of furnaces in the orchard (typically coal-fueled) and fly helicopters above the orchard to distribute the heat and avoid cold spots. This countermeasure is effective, but suffers from false negatives (the helicopters are called in, but there is no frost event) and false positives (the meteorological stations don't pick up a frost event happening in some part of the orchard). What is missing is a dense real-time monitoring solution deployed in the orchard, and feeding a frost prediction model. For this, having a couple of meteorological stations doesn't provide the measurement density needed. Frost events are micro-climatic: cold and hot air have a different density, wind blows irregularly between the trees, so different parts of an orchard are affected very differently by frost. What is needed are a large number of sensing points (humidity, temperature, wind speed), at different elevations, throughout the orchard. Low-power wireless mesh networking technology has evolved significantly over recent years. With this technology, a node is the size of a deck of cards, is self-contained and battery-operated. When switched on, nodes form a multi-hop low-power wireless network, automatically. Off-the-shelf commercial solutions are available today which offer >99.999% end-to-end data reliability and a decade of battery lifetime. Rather than being installed at a fixed location, these nodes can be hung directly in the trees. A network is deployed in an orchard in a matter of hours, and if needed, sensing points can be moved to improve the accuracy of the prediction model in minutes. And this solution is cheap, too: for the price one meteorological station, one can build 10 low-power wireless mesh sensing nodes. We use machine learning and pattern recognition to build an micro-climate predictive model by continuously analyzing the gathered sensor data in real time. This model generates early frost warnings. If successful, the solution can be extended to other crops, and other regions. The goal of this project is to dramatically increase the predictability of frost events in peach orchards by using dense monitoring using low-power wireless mesh networking technology. The project is designed to be completed in 24-month, and involves: (1) building a dense sensing solution based on off-the-shelf networking and sensing products, (2) developing accurate frost prediction models based on the sensing data gathered, (3) conducting real-world deployments on peach orchards in the Mendoza region. This project brings together world experts in agronomic and networking fields in a symbiotic manner. Perfectly in line with the philosophy of STIC-AmSud, the teams are already conducting cutting-edge research in their respective fields the funding we are applying for would enable the teams to collaborate together in a cross-disciplinary manner.

9.4. International Research Visitors

9.4.1. Visits of International Scientists

1. *David Burnett* (*UC Berkeley*), Micro-Motes, collaboration with **Thomas Watteyne**, 30 November 2017.
2. *Prof. Xavi Vilajosana* (*UOC/OpenMote*), OpenMote B, 6TiSCH, collaboration with **Thomas Watteyne** and Tengfei Chang, 20 November – 19 December 2017.
3. *Pablo Modernell* (*UOC*), F-Interop, collaboration with Remy Leone and **Thomas Watteyne**, 20–27 November 2017.

4. *Malisa Vucinic* (*U Montenegro*), 6TiSCH Security, collaboration with **Thomas Watteyne**, 06-24 November 2017.
5. *Carlos Oroza* (*UC Berkeley*), Machine-Learning Based Placement Strategy, collaboration with **Thomas Watteyne**, 18 October – 06 November 2017.
6. *Prof. Xavi Vilajosana* (*UOC/OpenMote*), OpenMote B, the greatest thing since sliced bread, collaboration with **Thomas Watteyne** and Tengfei Chang, 19–20 September 2017.
7. *Felipe Lallane* (*Inria Chile*), Exploiring collaboration opportunities with Inria-Chile around IoT, collaboration with **Thomas Watteyne**, 19–20 June 2017.
8. *Cristina Cano* (*UOC, Barcelona*), Wireless Coexistence, collaboration with **Thomas Watteyne**, 16 May 2017.
9. *Ryan Grammenos* (*Univ. College London*), Machine Learning for 6TiSCH networks, collaboration with Keoma Brun-Laguna and **Thomas Watteyne**, 15–19 May 2017.
10. *Craig Schindler* (*UC Berkeley*), Industrial Process Control with 6TiSCH, collaboration with Tengfei Chang and **Thomas Watteyne**, 9–19 May 2017.
11. *Pedro Henrique Gomez* (*USC*), Exploiting Diversity in 6TiSCH Networks, collaboration with Tengfei Chang and **Thomas Watteyne**, 5 June – 9 July 2017.
12. *Prof. Diego Dujovne* (*UDP, Chile*), Advanced Scheduling in 6TiSCH networks, collaboration with **Thomas Watteyne**, 5–22 July 2017.
13. *Prof. Steven Glaser* (*UC Berkeley*), Real-time real-world remote sensing, collaboration with Ziran Zhang, Keoma Brun-Laguna, **Thomas Watteyne**, 27 May – 3 June 2017.
14. *Prof. Xavi Vilajosana* (*UOC/OpenMote*), OpenWSN core-team meet-up, collaboration with **Thomas Watteyne** and Tengfei Chang, 3–7 April 2017.

9.4.2. Internships

1. **Felipe Moran Correa Meyer**, sub-100 μs synchronization and sub-m RTLS with SmartMesh IP (ENSTA), September 2017 – August 2018.
2. **Fatima Adda**, simulation of active signaling in TDMA networks (Paris VI), March-August 2017.
3. **Nasr Khouaja Mohamed Hassine**, positioning with wireless networks (ENSTA), April-June 2017.

9.4.3. Visits to International Teams

9.4.3.1. Research Stays Abroad

- **Thomas Watteyne** spent the month of August 2017 at UC Berkeley, working with Prof. Glaser on the SnowHow project, and with Prof. Pister on Smart Dust and OpenWSN.
- Keoma Brun-Laguna spent summer 2017 with the Dust Networks product team at Analog Devices in Silicon Valley as part of an internship.

GANG Project-Team

8. Partnerships and Cooperations

8.1. Regional Initiatives

8.1.1. Laboratory of Information, Networking and Communication Sciences (LINCS)

Gang is participating to the LINCS, a research centre co-founded by Inria, Institut Mines-Télécom, UPMC and Alcatel-Lucent Bell Labs, dedicated to research and innovation in the domains of future information and communication networks, systems and services. Gang contributes to work on online social networks, content centric networking and forwarding information verification.

8.2. National Initiatives

8.2.1. ANR DESCARTES

Participants: Carole Delporte-Gallet, Hugues Fauconnier, Pierre Fraigniaud, Adrian Kosowski, Laurent Viennot.

Cyril Gavoille (U. Bordeaux) leads this project that grants 1 Post-Doc. H. Fauconnier is the local coordinator (This project began in October 2016).

Despite the practical interests of reusable frameworks for implementing specific distributed services, many of these frameworks still lack solid theoretical bases, and only provide partial solutions for a narrow range of services. We argue that this is mainly due to the lack of a generic framework that is able to unify the large body of fundamental knowledge on distributed computation that has been acquired over the last 40 years. The DESCARTES project aims at bridging this gap, by developing a systematic model of distributed computation that organizes the functionalities of a distributed computing system into reusable modular constructs assembled via well-defined mechanisms that maintain sound theoretical guarantees on the resulting system. DESCARTES arises from the strong belief that distributed computing is now mature enough to resolve the tension between the social needs for distributed computing systems, and the lack of a fundamentally sound and systematic way to realize these systems.

8.2.2. ANR MultiMod

Participants: Adrian Kosowski, Laurent Viennot.

David Coudert (Sophia Antipolis) leads this project. L. Viennot coordinates locally. The project begins in 2018.

The MultiMod project aims at enhancing the mobility of citizens in urban areas by providing them, through a unique interface enabling to express their preferences, the most convenient transportation means to reach their destinations. Indeed, the increasing involvement of actors and authorities in the deployment of more responsible and cost-effective logistics and the progress made in the field of digital technology have made possible to create synergies in the creation of innovative services for improving the mobility in cities. However, users are faced with a number of solutions that coexist at different scales, providing complementary information for the mobility of users, but that make very complex to find the most convenient itinerary at a given time for a specific user. In this context, MultiMod aims at improving the mobility of citizens in urban areas by proposing contextualized services, linking users, to facilitate multimodal transport by combining, with flexibility, all available modes (planned/dynamic carpooling, public transport (PT), car-sharing, bicycle, etc.).

We consider the use of carpooling in metropolitan areas, and so for short journeys. Such usage enables itineraries that are not possible with PT, allows for opening up areas with low PT coverage by bringing users near PT (last miles), and for faster travel-time when existing PT itineraries are too complex or with too low frequency (e.g., one bus per hour). In this context, the application must help the driver and the passenger as much as possible. In particular, the application must propose the meeting-point, indicate the driver the detour duration, and indicate the passenger how to reach this meeting-point using PT. Here, the time taken by drivers and passengers to agree becomes a critical issue and so the application must provide all needed information to quickly take a decision (i.e., in one click).

In addition, the era of Smart City gathers many emerging concepts, driven by innovative technological players, which enables the exploitation of real-time data (e.g., delay of a bus, traffic jam) made available by the various actors (e.g., communities in the framework of Open Data projects, users via their mobile terminals, traffic supervision authorities). In the MultiMod project, we will use these rich sources of data to propose itineraries that are feasible at query-time. Our findings will enable the design of a mobility companion able not only to guide the user along her journey, including when and how to change of transportation mean, but also to propose itinerary changes when the current one exceeds a threshold delay. The main originality of this project is thus to address the problem of computing itineraries in large-scale networks combining PT, carpooling and real-time data, and to satisfy the preferences of users. We envision that the outcome of this project will significantly improve the daily life of citizens.

The targeted metropolitan area for validating our solutions is Ile-de-France. Indeed, Instant-System is currently developing the new application "Vianavigo lab" which will replace the current "Vianavigo" application for the PT network of Ile-de-France. Our findings will therefore be tested at scale and eventually be integrated and deployed in production servers and mobile applications. The smaller networks of Bordeaux and Nice will be used to perform preliminary evaluations since Instant System already operates applications in these cities (Boogi Nice, Boogi Bordeaux). An important remark is that new features and algorithms can contractually be deployed in production every 4 months, thus enabling Instant System to measure and challenge the results of the MultiMod project in continue. This is a chance for the project to maximize its impact.

8.2.3. ANR FREDDA

Participants: Carole Delporte-Gallet, Hugues Fauconnier, Pierre Fraigniaud.

Arnaud Sangnier (IRIF, Univ Paris Diderot) leads this project that grants 1 PhD. (This project began in October 2017).

Distributed algorithms are nowadays omnipresent in most systems and applications. It is of utmost importance to develop algorithmic solutions that are both robust and flexible, to be used in large scale applications. Currently, distributed algorithms are developed under precise assumptions on their execution context: synchronicity, bounds on the number of failures, etc. The robustness of distributed algorithms is a challenging problem that has not been much considered until now, and there is no systematic way to guarantee or verify the behavior of an algorithm beyond the context for which it has been designed. We propose to develop automated formal method techniques to verify the robustness of distributed algorithms and to support the development of robust applications. Our methods are of two kinds: statically through classical verification, and dynamically, by synthesizing distributed monitors, that check either correctness or the validity of the context hypotheses at runtime.

8.2.4. ANR Distancia

Participants: Pierre Charbit, Michel Habib, Laurent Viennot.

Victor Chepoi (Univ. Marseille) leads this project. P. Charbit coordinates locally. The project begins in early-2018.

The theme of the project is Metric Graph Theory, and we are concerned both on theoretical foundations and applications. Such applications can be found in real world networks. For example, the hub labelling problem in road networks can be directly applied to car navigation applications. Understanding key structural properties of large-scale data networks is crucial for analyzing and optimizing their performance, as well as

improving their reliability and security. In prior empirical and theoretical studies researchers have mainly focused on features such as small world phenomenon, power law degree distribution, navigability, and high clustering coefficients. Although those features are interesting and important, the impact of intrinsic geometric and topological features of large-scale data networks on performance, reliability and security is of much greater importance. Recently, there has been a surge of empirical works measuring and analyzing geometric characteristics of real-world networks, namely the Gromov hyperbolicity (called also the negative curvature) of the network. It has been shown that a number of data networks, including Internet application networks, web networks, collaboration networks, social networks, and others, have small hyperbolicity.

Metric graph theory was also indispensable in solving some open questions in concurrency and learning theory in computer science and geometric group theory in mathematics. Median graphs are exactly the 1–skeletons of CAT(0) cube complexes (which have been characterized by Gromov in a local-to-global combinatorial way). They play a vital role in geometric group theory (for example, in the recent solution of the famous Virtual Haken Conjecture). Median graphs are also the domains of event structures of Winskel, one of the basic abstract models of concurrency. This correspondence is very useful in dealing with questions on event structures.

Many classical algorithmic problems concern distances: shortest path, center and diameter, Voronoi diagrams, TSP, clustering, etc. Algorithmic and combinatorial problems related to distances also occur in data analysis. Low-distortion embeddings into l1-spaces (theorem of Bourgain and its algorithmical use by Linial et al.) were the founding tools in metric methods. Recently, several approximation algorithms for NP-hard problems were designed using metric methods. Other important algorithmic graph problems related to distances concern the construction of sparse subgraphs approximating inter-node distances and the converse, augmentation problems with distance constraints. Finally, in the distributed setting, an important problem is that of designing compact data structures allowing very fast computation of inter- node distances or routing along shortest or almost shortest paths. Besides computer science and mathematics, applications of structures involving distances can be found in archeology, computational biology, statistics, data analysis, etc. The problem of characterizing isometric subgraphs of hypercubes has its origin in communication theory and linguistics. . To take into account the recombination effect in genetic data, the mathematicians Bandelt and Dress developed in 1991 the theory of canonical decompositions of finite metric spaces. Together with geneticists, Bandelt successfully used it over the years to reconstruct phylogenies, in the evolutional analysis of mtDNA data in human genetics. One important step in their method is to build a reduced median network that spans the data but still contains all most parsimonious trees. As mentioned above, the median graphs occurring there constitute a central notion in metric graph theory.

With this project, we aim to participate at the elaboration of this new domain of Metric Graph Theory, which requires experts and knowledge in combinatorics (graphs, matroids), geometry, and algorithms. This expertise is distributed over the members of the consortium and a part of the success of our project it will be to share these knowledges among all the members of the consortium. This way we will create a strong group in France on graphs and metrics.

8.2.5. ANR HOSIGRA

Participants: Pierre Charbit, Michel Habib.

This project starting in early-2018, led by Reza Naserasr, explores the connection between minors and colorings, exploiting the notion of signed graphs. With the four colour theorem playing a central role in development of Graph Theory, the notions of minor and coloring have been branded as two of the most distinguished concepts in this field. The geometric notion of planarity has given birth to the theory of minors among others, and coloring have proven to have an algebraic nature through its extension to the theory of graph homomorphisms. Great many projects have been completed on both subjects, but what remains mostly a mystery is the correlation of the two subjects. The four color theorem itself, in slightly stronger form, claims that if a complete graph on five vertices cannot be formed by minor operation from a given graph, then the graph can be homomorphically mapped into the complete graph on four vertices (thus a 4-coloring). Commonly regarded as the most challenging conjecture on graph theory, the Hadwiger conjecture claims that

five and four in this theorem can be replaced with n and $n-1$ respectively for any value of n. The correlation of these two concepts has been difficult to study, mainly for the following reason: While the coloring or homomorphism problems roots back into intersections of odd-cycles, the minor operation is irrelevant of the parity of cycles. To overcome this barrier, the notion of signed graphs has been used implicitly since 1970s when coloring results on graphs with no odd-K4 is proved, following which a stronger form of the Hadwiger conjecture, known as Odd Hadwiger conjecture, was proposed by P. Seymour and B. Gerards, independently. Being a natural subclass of Matroids and a superclass of graphs, the notion of minor of signed graphs is well studied and many results from graph minor are either already extended to signed graphs or it is considered by experts of the subject. Observing the importance, and guided by some earlier works, in particular that of B. Guenin, we then started the study of algebraic concepts (coloring and homomormphisms) for signed graphs. Several results have been obtained in the past decade, and this project aims at exploring more of this topic.

8.3. European Initiatives

8.3.1. FP7 & H2020 Projects

Amos Korman has an ERC Consolidator Grant entitled "Distributed Biological Algorithms (DBA)", started in May 2015. This project proposes a new application for computational reasoning. More specifically, the purpose of this interdisciplinary project is to demonstrate the usefulness of an algorithmic perspective in studies of complex biological systems. We focus on the domain of collective behavior, and demonstrate the benefits of using techniques from the field of theoretical distributed computing in order to establish algorithmic insights regarding the behavior of biological ensembles. The project includes three related tasks, for which we have already obtained promising preliminary results. Each task contains a purely theoretical algorithmic component as well as one which integrates theoretical algorithmic studies with experiments. Most experiments are strategically designed by the PI based on computational insights, and are physically conducted by experimental biologists that have been carefully chosen by the PI. In turn, experimental outcomes will be theoretically analyzed via an algorithmic perspective. By this integration, we aim at deciphering how a biological individual (such as an ant) "thinks", without having direct access to the neurological process within its brain, and how such limited individuals assemble into ensembles that appear to be far greater than the sum of their parts. The ultimate vision behind this project is to enable the formation of a new scientific field, called algorithmic biology, that bases biological studies on theoretical algorithmic insights.

8.3.2. LIA Struco

Pierre Charbit is director of the LIA STRUCO, which is an Associated International Laboratory of CNRS between IÚUK, Prague, and IRIF, Paris. The director on the Czech side is Pr. Jaroslav Nešetřil. The primary theme of the laboratory is graph theory, more specifically: sparsity of graphs (nowhere dense classes of graphs, bounded expansion classes of graphs), extremal graph theory, graph coloring, Ramsey theory, universality and morphism duality, graph and matroid algorithms and model checking.

STRUCO focuses on high-level study of fundamental combinatorial objects, with a particular emphasis on comprehending and disseminating the state-of-the-art theories and techniques developed. The obtained insights shall be applied to obtain new results on existing problems as well as to identify directions and questions for future work.

One of the main goals of STRUCO is to provide a sustainable and reliable structure to help Czech and French researchers cooperate on long-term projects, disseminate the results to students of both countries and create links between these students more systematically. The chosen themes of the project indeed cover timely and difficult questions, for which a stable and significant cooperation structure is needed. By gathering an important number of excellent researchers and students, the LEA will create the required environment for making advances, which shall be achieved not only by short-term exchanges of researchers, but also by a strong involvement of Ph. D students in the learning of state-of-the-art techniques and in the international collaborations.

STRUCO is a natural place to federate and organize these many isolated collaborations between our two countries. Thus, the project would ensure long-term cooperations and allow young researchers (especially PhD students) to maintain the fruitful exchanges between the two countries in the future years, in a structured and federated way.

8.4. International Initiatives

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

Carole Delporte-Gallet and Hugues Fauconnier are members of the Inria-MEXICO Equipe Associée LiDiCo (At the Limits of Distributed Computability, https://sites.google.com/site/lidicoequipeassociee/).

8.4.2. Inria International Partners

8.4.2.1. Informal International Partners

Ofer Feinerman (Physics department of complex systems, Weizmann Institute of Science, Rehovot, Israel), is a team member in Amos Korman's ERC project DBA. This collaboration has been formally established by signing a contract between the CNRS and the Weizmann Institute of Science, as part of the ERC project.

Rachid Guerraoui (School of Computer and Communication Sciences, EPFL, Switzerland) maintains an active research collaboration with Gang team members (Carole Delporte, Hugues Fauconnier).

Pierluigi Crescenzi (University of Florence, Italy) is a frequent visitor to the team and maintains an active research collaboration with Gang team members (Pierre Fraigniaud).

Sergio Rajsbaum (UNAM, Mexico) is a regular collaborator of the team, also involved formally in a joint French-Mexican research project (see next subsection).

Boaz Patt-Shamir (Tel Aviv University, Israel) is a regular collaborator of the team, also involved formally in a joint French-Israeli research project (see next subsection).

8.5. International Research Visitors

8.5.1. Visits of International Scientists

[chercheurs invités, profs invités (via université), Les internships sont à mettre dans la subsection suivante.]

Sergio Rajsbaum (UNAM-Mexico) was invited for two months (May-June).

Eli Gafni visited the team for one month (mid-June to mid-July).

Lalla Mouatadid visited the group for 2 weeks in 2017. She is finishing her PhD in computer. Science at University of Toronto, under the supervision of prof. Derek Corneil and Alan Borodin.

8.5.2. Visits to International Teams

Carole Delporte-Gallet and Hugues Fauconnier have visited 2x10 days Sergio Rajsbaum at UNAM (Mexico) in September and November 2017.

MIMOVE Team

9. Partnerships and Cooperations

9.1. National Initiatives

"BottleNet: Understanding and Diagnosing End-to-end Communication Bottlenecks of the Internet", project funded by the French research agency (ANR), from Feb 2016 to Sep 2020.

9.1.1. Inria Support

9.1.1.1. Inria IPL CityLab@Inria

Participants: Valérie Issarny [correspondent], Fadwa Rebhi.

- **Name:** CityLab@Inria – *Overcoming the Smart City Challenge – Toward Environmental and Social Sustainability*
- **Period:** [January 2014 – November 2018]
- **Inria teams:** CLIME/ANGE, DICE, FUN, MIMOVE, MYRIADS, SMIS, URBANET, WILLOW
- **URL:** http://citylab.inria.fr

The Inria Project Lab (IPL) CityLab@Inria studies ICT solutions toward smart cities that promote both social and environmental sustainability. A strong emphasis of the Lab is on the undertaking of a multi-disciplinary research program through the integration of relevant scientific and technology studies, from sensing up to analytics and advanced applications, so as to actually enact the foreseen smart city Systems of Systems. Obviously, running experiments is a central concern of the Lab, so that we are able to confront proposed approaches to actual settings.

9.1.1.2. Inria IPL BetterNet

Participants: Renata Teixeira, Vassilis Christophides, Francesco Bronzino.

- **Name:** BetterNet – *An observatory to measure and improve Internet service access from user experience*
- **Period:** [2016 – 2019]
- **Inria teams:** Diana, Dionysos, Inria Chile, Madynes, MiMove, Spirals
- **URL:** https://project.inria.fr/betternet/

BetterNet aims at building and delivering a scientific and technical collaborative observatory to measure and improve the Internet service access as perceived by users. In this Inria Project Lab, we will propose new original user-centered measurement methods, which will associate social sciences to better understand Internet usage and the quality of services and networks. Our observatory can be defined as a vantage point, where:

1. tools, models and algorithms/heuristics will be provided to collect data,
2. acquired data will be analyzed, and shared appropriately with scientists, stakeholders and civil society,
3. and new value-added services will be proposed to end-users.

9.1.1.3. Inria ADT MOSQUITO

Participants: Renata Teixeira, Francesco Bronzino, Romain Rouvoy.

- **Name:** MOSQUITO – *A mobile platform to measure the quality of Internet connectivity*
- **Period:** [November 2016 – October 2018]
- **Partners:** Inria MiMove, Inria SPIRALS.

The ADT MOSQUITO is part of the Inria Project Lab (IPL) initiative BetterNet. This ADT project focuses on the design and the development of a measurement platform for the quality of mobile Internet access by federating the existing mobile platforms identified in the BetterNet IPL. Beyond the priceless value of such a measurement platform for the research community, this ADT also aims to publish live reports on the quality of mobile Internet access through the BetterNet initiative.

9.2. European Initiatives

9.2.1. FP7 & H2020 Projects

9.2.1.1. H2020 ICT CHOReVOLUTION

Participants: Nikolaos Georgantas [correspondent], Valérie Issarny [correspondent].

Name: CHOReVOLUTION – *Automated Synthesis of Dynamic and Secured Choreographies for the Future Internet*

URL: http://www.chorevolution.eu

Type: Research & Innovation Action (ICT)

Topic: Tools and Methods for Software Development

Period: [January 2015 - December 2017]

Partners: CEFRIEL (Italy), Inria MiMove, OW2 Consortium (France), Thales Communications S.A. (France) [**coordinator**], Università degli Studi dell'Aquila (Italy) [**scientific leader**], Softeco Sismat SrL (Italy), Tirasa (Italy), Viktoria Swedish ICT (Sweden).

The Future Internet (FI) represents an age of unprecedented opportunities for social, economic, and business growth thanks to the global scale connectivity of the virtual as well as of the physical world. This indeed opens up a wealth of innovative and revolutionary real-life scenarios, as for instance illustrated by the smarter cities perspectives where envisioned scenarios significantly ease daily human activities and give support for the growth of new markets and employment opportunities. However, leveraging the FI for the development of innovative software applications remain a challenging task even though major enablers are readily available by ways of service-oriented and cloud computing. It is in particular our vision that enabling the choreography of FI services shall play a significant role in the provisioning of innovative applications. However, existing choreography-based service composition approaches are rather static and are poorly suited to the need of the FI that is a highly dynamic networking environment, further bringing together highly heterogeneous services ranging from Thing- to Business-based services that span different security domains. As a result, the technology is not mature enough for market take-up. CHOReVOLUTION elevates the Readiness Level of existing choreography technologies in order to drop the dynamism and cross-organization security barriers via the automated synthesis of dynamic and secured choreographies in the FI. To meet its objectives, CHOReVOLUTION undertakes both research and innovation tasks. The former concentrates on choreography modelling, synthesis, adaptation, service bus, security, and cloud; the latter focus on industrial validation, development support and integration platform, and the establishment of a CHOReVOLUTION community and market take- up. Last but not least CHOReVOLUTION outcomes are assessed by experimenting with new applications in the field of Intelligent Transportation Systems.

9.2.1.2. H2020 ICT FIESTA-IoT

Participants: Valérie Issarny [correspondent], Nikolaos Georgantas [correspondent].

Name: FIESTA-IoT – *Federated Interoperable Semantic IoT/cloud Testbeds and Applications*

URL: http://fiesta-iot.eu

Type: Research & Innovation Action (ICT)

Topic: FIRE+ (Future Internet Research & Experimentation)

Period: [February 2015 - January 2018]

Partners: Fraunhofer FOKUS (Germany) [**coordinator**], INSIGHT @ National University of Galway (Ireland) [**co-coordinator**], University of Southampton IT Innovation Centre (UK), Inria MiMove, University of Surrey (UK), Unparallel Innovation Lda (Portugal), Easy Global Market (France), NEC Europe Ltd (UK), University of Cantabria (Spain), Com4innov (France), Athens Information Technology (Greece), SOCIEDAD PARA EL DESARROLLO REGIONAL DE CANTABRIA (Spain), Ayuntamiento de Santander (Spain), Korea Electronics Technology Institute (Korea).

Despite the proliferation of IoT and smart cities testbeds, there is still no easy way to conduct large scale experiments that leverage data and resources from multiple geographically and administratively distributed IoT platforms. Recent advances in IoT semantic interoperability provide a sound basis for implementing novel cloud-based infrastructures that could allow testbed-agnostic access to IoT data and resources. FIESTA will open new horizons in IoT experimentation at a global scale, based on the interconnection and interoperability of diverse IoT testbeds. FIESTA will produce a first-of-a-kind blueprint experimental infrastructure (tools, techniques and best practices) enabling testbed operators to interconnect their facilities in an interoperable way, while at the same time facilitating researchers in deploying integrated experiments, which seamlessly transcend the boundaries of multiple IoT platforms. FIESTA will be validated and evaluated based on the interconnection of four testbeds (in Spain, UK, France and Korea), as well as based on the execution of novel experiments in the areas of mobile crowd-sensing, IoT applications portability, and dynamic intelligent discovery of IoT resources. In order to achieve global outreach and maximum impact, FIESTA will integrate an additional testbed and experiments from Korea, while it will also collaborate with IoT experts from USA. The participation of a Korean partner (based its own funding) will maximize FIESTA's value for EC money. Moreover, the project will take advantage of open calls processes towards attracting third-parties that will engage in the integration of their platforms within FIESTA or in the conduction of added-value experiments. As part of its sustainability strategy, FIESTA will establish a global market confidence programme for IoT interoperability, which will enable innovative platform providers and solution integrators to ensure/certify the openness and interoperability of their developments.

9.2.2. Collaborations in European Programs, Except FP7 & H2020

9.2.2.1. EIT Digital Env&You

Participant: Valérie Issarny [correspondent].

Name: Env&You – *Personalizing environmental science for your home, your neighborhood and your life*

URL: http://ambiciti.io

Period: [January 2017 - December 2017]

Partners: Ambiciti (F), Forum Virium Helsinki (FI), Inria CLIME/ANGE, Inria MIMOVE [**coordinator**], NumTech (F), TheCivicEngine (USA).

There is a clear, and probably increasing, desire from the citizens to better know their individual exposure to pollution. Partial solutions exist to the exposure data problem but each focuses on one or another domain of information – crowdsourcing exposure, translating government open data to usable consumer information, harnessing social media information, harnessing biometrics – what is unique about Env&You is that we assimilate a multi-dimensional picture of exposure and provide the integrated information to citizen, government, and business use (spanning: B2G, B2B and B2C business cases).

9.2.2.2. EIT Digital CivicBudget

Participants: Valérie Issarny [correspondent], Nikolaos Georgantas [correspondent].

Name: CivicBudget – *Software platform supporting Internet-based participatory budgeting campaigns*

Period: [January 2017 - December 2017]

Partners: CITRIS@UCB (USA), Inria MIMOVE, MissionsPubliques (F) [**coordinator**], Nexus (DE), and TU Berlin (DE).

Many cities in Europe and the U.S.A, and around the world, commit a percentage of their annual budget (often 5%) to implement citizen-proposed projects through a process called Participatory Budgeting (PB). However, supporting urban-scale participatory budgeting campaigns is greatly challenged as it still principally relies on physical meetings. CivicBudget addresses this challenge by leveraging latest ICT so as to promote urban-scale inclusion. CivicBudget fosters a new and inclusive urban public sphere of citizenship. It is especially designed for community groups and activists who want to participate in the PB process. City governments will also be able to promote its use. CivicBudget will facilitate the mobilization of residents both to promote their proposals and to monitor their progress through the PB process to implementation.

9.3. International Initiatives

9.3.1. Inria International Labs

Valérie Issarny acts as scientific manager of the Inria@Silicon Valley program (https://project.inria.fr/inria-siliconvalley/) since summer 2013; she is visiting scholar at the EECS Department of University of California, Berkeley, and hosted by CITRIS.

9.3.2. Inria Associate Teams Not Involved in an Inria International Lab

9.3.2.1. HOMENET

Title: *Home network diagnosis and security*

International Partner: Princeton (United States) - Nick Feamster

Start year: 2017

Website: https://team.inria.fr/homenet/

Modern households connect a multitude of networked devices (ranging from laptops and smartphones to a number of Internet of Things devices) via a home network. Most home networks, however, do not have a technically skilled network administrator for managing the network, for example to identify faulty equipment or take steps to secure end hosts such as applying security patches. Home networks represent a particularly challenging environment due to the diversity of devices, applications, and services users may connect. The goal of HOMENET is to assist users in diagnosing and securing their home networks. Our approach is based on developing new algorithms and mechanisms that will run on the home router (or in-collaboration with the router). The router connects the home network to the rest of the Internet; it is hence the ideal place to secure home devices and to distinguish problems that happen in the home from those happening elsewhere. We will address a number of research challenges for example in device discovery and fingerprinting, anomaly detection in the Internet of Things, home network diagnosis (including wireless diagnosis). HOMENET will bring together two leading research teams in the network measurement arena with successful prior collaboration. Moreover, Princeton brings an existing home router platform and expertise in security, wireless, and software-defined networks; and MiMove brings an existing Web-based measurement platform, and expertise in traffic-based profiling and anomaly detection.

9.3.2.2. ACHOR

Participant: Nikolaos Georgantas [correspondent].

Title: *Adaptive enactment of service choreographies*

International Partner: Universidade Federal de Goiás (UFG), Brazil - Fabio Costa

Start year: 2016

Website: http://www.inf.ufg.br/projects/achor

Service choreographies are distributed compositions of services (e.g., Web services) that coordinate their execution and interactions without centralized control. Due to this decentralized coordination and the ability to compose third-party services, choreographies have shown great potential as an approach to automate the construction of large-scale, on-demand, distributed applications. Technologies to enable this approach are reaching maturity level, such as modeling languages for choreography specification and engines that operate the deployment of services and enactment of choreographies at Future Internet scales. Nevertheless, a number of problems remain open on the way to fully realize the approach, among them: (i) Deployment of multiple choreographies on top of a collection of shared services (considering service sharing as an effective way to increase the utilization of resources); (ii) Dynamic adaptation of functional and non-functional properties due to runtime changes in the environment and user requirements (adapting the set of services and/or the resources used to run the services in order to add/remove/change functions and maintain QoS properties, respectively); and (iii) Seamless and dynamic integration of mobile services (e.g., smartphone apps, sensors and actuators on handhelds and wearables) and cloud- based services (including the need to consider: mobility of both devices and services, resource constraints of mobile devices, temporary disconnection, interoperability between different interaction paradigms (message-passing, event-based, data-sharing) at the middleware layer, and effect of these paradigms on end-to-end QoS). The overall goal of the project is to design an architecture for adaptive middleware to support service choreographies in large-scale scenarios that involve dynamicity and diversity in terms of application requirements, service interaction protocols, and the use of shared local, mobile and cloud resources.

9.3.3. Inria International Partners

9.3.3.1. Informal International Partners

Northeastern University (Prof. David Choffnes and his student Arash Molavi): we are working on monitoring and diagnosing Internet QoE.

9.4. International Research Visitors

9.4.1. Visits of International Scientists

9.4.1.1. Internships

Kushagra Singh (from Jun 2017 until Jul 2017)

Internship funded by H2020 CHOReVOLUTION project.

Subject: *Towards correction of outliers in spatial dataset*

Institution: Indraprastha Institute of Information Technology (IIIT) Delhi (India)

9.4.2. Visits to International Teams

9.4.2.1. Research Stays Abroad

- Valérie Issarny is visiting scholar at the EECS Department at UC Berkeley; she is hosted by CITRIS in the context of which she carries out collaborative research in the area of smart cities and acts as scientific coordinator of the Inria@SiliconValley program.
- Rachit Agarwal was visiting professor at Fundacao Getulio Vargas (FGV), Rio De Janerio, Brazil (from Jun 2017 until Aug 2017). He was hosted at EMAp (Escola de Matematica Aplicada) department within FGV. He taught a Network Science course to Master's students.

RAP2 Team

6. Partnerships and Cooperations

6.1. International Research Visitors

6.1.1. Visits of International Scientists

- Louigi Addario-Berri (McGill)
- Gabor Lugosi (ICREA and Pompeu Fabra)
- Cyril Marzouk (Paris Sud)
- Minmin Wang (Buenos Aires)
- S. Foss (Heriot-Watt University, UK)
- V. Gupta (University of Chicago, USA)

6.1.2. Visits to International Teams

- *Nicolas Broutin* visited the computer science department of McGill University (Canada), the CRM in Montreal, the mathematics institute in Nice and the university Aix-Marseille.
- *Wen Sun* has visited the Division of Applied Mathematics in Brown University to work with Kavita Ramanan, 07-16 Nov. 2017.

REGAL Project-Team

7. Partnerships and Cooperations

7.1. National Initiatives

7.1.1. Labex SMART - (2012–2019)

Members: ISIR (UPMC/CNRS), LIP6 (UPMC/CNRS), LIB (UPMC/INSERM), LJLL (UPMC/CNRS), LTCI (Institut Mines-Télécom/CNRS), CHArt-LUTIN (Univ. Paris 8/EPHE), L2E (UPMC), STMS (IRCAM/CNRS).

Funding: Sorbonne Universités, ANR.

Description: The SMART Labex project aims globally to enhancing the quality of life in our digital societies by building the foundational bases for facilitating the inclusion of intelligent artifacts in our daily life for service and assistance. The project addresses underlying scientific questions raised by the development of Human-centered digital systems and artifacts in a comprehensive way. The research program is organized along five axes and Regal is responsible of the axe "Autonomic Distributed Environments for Mobility."

The project involves a PhD grant of 100 000 euros over 3 years.

7.1.2. ESTATE - (2016–2020)

Members: LIP6 (Regal, project leader), LaBRI (Univ. de Bordeaux); Verimag (Univ. de Grenoble).

Funding: ESTATE is funded by ANR (PRC) for a total of about 544 000 euros, of which 233 376 euros for Regal.

Objectives: The core of ESTATE consists in laying the foundations of a new algorithmic framework for enabling Autonomic Computing in distributed and highly dynamic systems and networks. We plan to design a model that includes the minimal algorithmic basis allowing the emergence of dynamic distributed systems with self-* capabilities, *e.g.*, self-organization, self-healing, self-configuration, self-management, self-optimization, self-adaptiveness, or self-repair. In order to do this, we consider three main research streams:

(i) building the theoretical foundations of autonomic computing in dynamic systems, (ii) enhancing the safety in some cases by establishing the minimum requirements in terms of amount or type of dynamics to allow some strong safety guarantees, (iii) providing additional formal guarantees by proposing a general framework based on the Coq proof assistant to (semi-)automatically construct certified proofs.

The coordinator of ESTATE is Franck Petit.

7.1.3. RainbowFS - (2016–2020)

Members: LIP6 (Regal, project leader), Scality SA, CNRS-LIG, Télécom Sud-Paris, Université Savoie-Mont-Blanc.

Funding: is funded by ANR (PRC) for a total of 919 534 euros, of which 359 554 euros for Regal.

Objectives: RainbowFS proposes a "just-right" approach to storage and consistency, for developing distributed, cloud-scale applications. Existing approaches shoehorn the application design to some predefined consistency model, but no single model is appropriate for all uses. Instead, we propose tools to co-design the application and its consistency protocol. Our approach reconciles the conflicting requirements of availability and performance vs. safety: common-case operations are designed to be asynchronous; synchronisation is used only when strictly necessary to satisfy the application's

integrity invariants. Furthermore, we deconstruct classical consistency models into orthogonal primitives that the developer can compose efficiently, and provide a number of tools for quick, efficient and correct cloud-scale deployment and execution. Using this methodology, we will develop an entreprise-grade, highly-scalable file system, exploring the rainbow of possible semantics, and we demonstrate it in a massive experiment.

The coordinator of RainbowFS is Marc Shapiro.

7.2. European Initiatives

7.2.1. FP7 & H2020 Projects

7.2.1.1. LightKone

Title: Lightweight Computation for Networks at the Edge

Programm: H2020-ICT-2016-2017

Duration: January 2017 - December 2019

Coordinator: Université Catholique de Louvain

Partners:

Université Catholique de Louvain (Belgium)

Technische Universitaet Kaiserslautern (Germany)

INESC TEC - Instituto de Engenharia de Sistemas e Computadores, Tecnologia e Ciencia (Portugal)

Faculdade de Ciencias E Tecnologiada Universidade Nova de Lisboa (Portugal)

Universitat Politecnica De Catalunya (Spain)

Scality (France)

Gluk Advice B.V. (Netherlands)

Inria contact: Marc Shapiro

The goal of LightKone is to develop a scientifically sound and industrially validated model for doing general-purpose computation on edge networks. An edge network consists of a large set of heterogeneous, loosely coupled computing nodes situated at the logical extreme of a network. Common examples are networks of Internet of Things, mobile devices, personal computers, and points of presence including Mobile Edge Computing. Internet applications are increasingly running on edge networks, to reduce latency, increase scalability, resilience, and security, and permit local decision making. However, today's state of the art, the gossip and peer-to-peer models, give no solution for defining general-purpose computations on edge networks, i.e., computation with shared mutable state. LightKone will solve this problem by combining two recent advances in distributed computing, namely synchronisation-free programming and hybrid gossip algorithms, both of which are successfully used separately in industry. Together, they are a natural combination for edge computing. We will cover edge networks both with and without data center nodes, and applications focused on collaboration, computation, and both. Project results will be new programming models and algorithms that advance scientific understanding, implemented in new industrial applications and a startup company, and evaluated in large-scale realistic settings.

7.3. International Initiatives

7.3.1. Participation in Other International Programs

7.3.1.1. STIC Amsud

Title: PaDMetBio - Parallel and Distributed Metaheuristics for Structural Bioinformatics

International Partners (Institution - Laboratory - Researcher):

Universidade Federal do Rio Grande do Sul (Brazil)- Mãrcio Dorn

Universidad Nacional de San Luis (Argentina) - Verõnica Gil-Costa

Universidad de Santiago de Chile (Chile) - Mario Inostroza-Ponta

Duration: 2017 - 2018

Start year: 2017

Structural bioinformatics deals with problems where the rules that govern the biochemical processes and relations are partially known which makes hard to design efficient computational strategies for these problems. There is a wide range of unanswered questions, which cannot be answered neither by experiments nor by classical modeling and simulation approaches. Specifically, there are several problems that still do not have a computational method that can guarantee a minimum quality of solution. Two of the main challenging problems in Structural Bioinformatics are (1) the three-dimensional (3D) protein structure prediction problem (PSP) and (2) the molecular docking problem for drug design. Predicting the folded structure of a protein only from its amino acid sequence is a challenging problem in mathematical optimization. The challenge arises due to the combinatorial explosion of plausible shapes, where a long amino acid chain ends up in one out of a vast number of 3D conformations. The problem becomes harder when we have proteins with complex topologies, in this case, their predictions may be only possible with significant increases in high-performance computing power. In the case of the molecular docking problem for drug design, we need to predict the preferred orientation of a small drug candidate against a protein molecule. With the increasing availability of molecular biological structures, smarter docking approaches have become necessary. These two problems are classified as NP-Complete or NP-Hard, so there is no current computational approach that can guarantee the best solution for them in a polynomial time. Because of the above, there is the need to build smarter approaches that can deliver good solutions to the problem. In this project, we plan to explore a collaborative work for the design and implementation of population based metaheuristics, like genetic and memetic algorithms. Metaheuristics are one of the most common and powerful techniques used in this case. The main goal of this project is to gather the expertise and current work of researchers in the areas of structural bioinformatics, metaheuristics and parallel and distributed computing, in order to build novel and high quality solutions for these hot research area.

7.3.1.2. CNRS-Inria-FAP's

Title: Autonomic and Scalable Algorithms for Building Resilient Distributed Systems

International Partner (Institution - Laboratory - Researcher):

Universida de Federal do Paraná (UFPR), Brazil, Prof. Elias Duarte

Duration: 2015–2017

In the context of autonomic computing systems that detect and diagnose problems, self-adapting themselves, the VCube (Virtual Cube), proposed by Prof. Elias Duarte , is a distributed diagnosis algorithm that organizes the system nodes on a virtual hypercube topology. VCube has logarithmic properties: when all nodes are fault-free, processes are virtually connected to form a perfect hypercube; as soon as one or more failures are detected, links are automatically reconnected to remove the faulty nodes and the resulting topology, connecting only fault-free nodes, keeps the logarithmic properties. The goal of this project is to exploit the autonomic and logarithmic properties of the VCube by proposing self-adapting and self-configurable services.

7.3.1.3. Capes-Cofecub

Title: CHOOSING - Cooperation on Hybrid cOmputing clOuds for energy SavING

French Partners: Paris XI (LRI), Regal, LIG, SUPELEC

International Partners (Institution - Laboratory - Researcher):

Universidade de São Paulo - Instituto de Matemática e Estatística - Brazil, Unicamp - Instituto de Computação - Brazil

Duration: 2014–2018

The cloud computing is an important factor for environmentally sustainable development. If, in the one hand, the increasing demand of users drive the creation of large datacenters, in the other hand, cloud computing's "multitenancy" trait allows the reduction of physical hardware and, therefore, the saving of energy. Thus, it is imperative to optimize the energy consumption corresponding to the datacenter's activities. Three elements are crucial on energy consumption of a cloud platform: computation (processing), storage and network infrastructure. Therefore, the aim of this project is to provide different techniques to reduce energy consumption regarding these three elements. Our work mainly focuses on energy saving aspects based on virtualization, i.e., pursuing the idea of the intensive migration of classical storage/processing systems to virtual ones. We will study how different organizations (whose resources are combined as hybrid clouds) can cooperate with each other in order to minimize the energy consumption without the detriment of client requirements or quality of service. Then, we intend to propose efficient algorithmic solutions and design new coordination mechanisms that incentive cloud providers to collaborate.

7.3.1.4. Spanish research ministry project

Title: BFT-DYNASTIE - Byzantine Fault Tolerance: Dynamic Adaptive Services for Partitionable Systems

French Partners: Labri, Irisa, LIP6

International Partners (Institution - Laboratory - Researcher):

University of the Basque Country UPV - Spain, EPFL - LSD - Switzerland, Friedrich-Alexander-Universitat Erlangen-Nurenberg - Deutschland, University of Sydney - Australia

Duration: 2017–2019

The project BFT-DYNASTIE is aimed at extending the model based on the alternation of periods of stable and unstable behavior to all aspects of fault-tolerant distributed systems, including synchrony models, process and communication channel failure models, system membership, node mobility, and network partitioning. The two main and new challenges of this project are: the consideration of the most general and complex to address failure model, known as Byzantine, arbitrary or malicious, which requires qualified majorities and the use of techniques form the security area; and the operation of the system in partitioned mode, which requires adequate reconciliation mechanisms when two partitions merge.

7.4. International Research Visitors

7.4.1. Visits of International Scientists

7.4.1.1. Internships

Ajay Singh of Indian Institute Of Technology Hyderabad, India, was invited for a six-month internship, on data structures for concurrency and persistent memory. This work is published at the HiPC SRS 2017 workshop [43].

WHISPER Project-Team

9. Partnerships and Cooperations

9.1. Regional Initiatives

- City of Paris, 2016-2019, 100 000 euros. As part of the "Émergence - young team" program the city of Paris is supporting part of our work on domain-specific languages.

9.2. National Initiatives

9.2.1. ANR

ITrans - awarded in 2016, duration 2017 - 2020

Members: LIP6 (Whisper), David Lo (Singapore Management University)

Coordinator: Julia Lawall

Whisper members: Julia Lawall, Gilles Muller, Lucas Serrano, Van-Anh Nguyen

Funding: ANR PRCI, 287,820 euros.

Objectives:

Large, real-world software must continually change, to keep up with evolving requirements, fix bugs, and improve performance, maintainability, and security. This rate of change can pose difficulties for clients, whose code cannot always evolve at the same rate. This project will target the problems of *forward porting*, where one software component has to catch up to a code base with which it needs to interact, and *back porting*, in which it is desired to use a more modern component in a context where it is necessary to continue to use a legacy code base, focusing on the context of Linux device drivers. In this project, we will take a *history-guided source-code transformation-based* approach, which automatically traverses the history of the changes made to a software system, to find where changes in the code to be ported are required, gathers examples of the required changes, and generates change rules to incrementally back port or forward port the code. Our approach will be a success if it is able to automatically back and forward port a large number of drivers for the Linux operating system to various earlier and later versions of the Linux kernel with high accuracy while requiring minimal developer effort. This objective is not achievable by existing techniques.

9.3. International Initiatives

9.3.1. Inria International Labs

- EPFL-Inria Lab Our work on the Ipanema DSL [17] is done as part of the EPFL-Inria Lab. Baptiste Lepers (EPFL) is supported in 2017 as a joint postdoc between the Whisper and the groups of V. Kuncak and W. Zwaenepoel.

9.3.2. Inria International Partners

9.3.2.1. Informal International Partners

- We collaborate with David Lo and Lingxiao Jiang of Singapore Management University, who are experts in software mining, clone detection, and information retrieval techniques. Our work with Lo and/or Jiang has led to 8 joint publications since 2013 [12], [68], [78], [83], [84], [85], [88], [86], at conferences including ASE and ICSME. The ITrans ANR is a joint project with them.
- We collaborate with Christoph Reichenbach of the University of Lund and Krishna Narasimhan of Itemis (Germany) on program transformation [18] and the design of tools for code clone management.

- We collaborate with Wouter Swierstra of the University of Utrecht (Netherlands) on type-directed structured differences [20].
- We collaborate with Eric Tanter of the University of Chile (Chile) on the theoretical and practical aspects of dependent interoperability [38] in type theory.

9.4. International Research Visitors

9.4.1. Visits of International Scientists

As part of the Invited Professor program of LIP6, we have hosted Prof. Éric Tanter (University of Chile) for two weeks (December 2017) who took this opportunity to give an introductory master class as well as a research seminar on the topic of gradual typing.

9.4.1.1. Internships

- Lukas Gnirke, Oberlin College, January 2017, evaluation of our methodology for searching for examples to guide driver porting [16].
- Adina Johnson, Oberlin College, May - August 2017, analysis of the differences between the Linux kernel and the Android kernel.
- Jonathan Carroll, Oberlin College, May - August 2017, use of machine learning to identify stable-kernel relevant patches.
- Bhumika Goyal, October - November 2017, constification of Linux kernel structures, supported by the Linux Foundation's Core Infrastructure Initiative.
- Peio Borthelle, École Normale Supérieure de Lyon, June - July 2017, solving the Oware on a single machine.
- Darius Mercadier, Université Pierre et Marie Curie, January - August 2017, designing and implementing Usuba, a bitslicing compiler.

9.4.1.2. Research Stays Abroad

- Julia Lawall, visit to David Lo and Lingxiao Jiang at Singapore Management University (two weeks in May 2017).

ALMANACH Team

9. Partnerships and Cooperations

9.1. National Initiatives

9.1.1. ANR

- **ANR SoSweet** (2015-2019, PI J.-P. Magué, resp. ALMAnaCH: DS; Other partners: ICAR [ENS Lyon, CRNS], Dante [Inria]). Topic: studying sociolinguistic variability on Twitter, comparing linguistic and graph-based views on tweets
- **ANR ParSiTi** (2016-2021, PI Djamé Seddah, Other partners: LIMSI, LIPN). Topic: context-aware parsing and machine translation of user-generated content
- **ANR PARSE-ME** (2015-2020, PI. Matthieu Constant, resp. Marie Candito [ALPAGE, then LLF], ALMAnaCH members are associated with Paris-Diderot's LLF for this project). Topic: multi-word expressions in parsing
- **ANR Profiterole** (2016-2020, PI Sophie Prévost [LATTICE], resp. Benoit Crabbé [ALPAGE, then LLF], ALMAnaCH members are associated with Paris-Diderot's LLF for this project). Topic: modelling and analysis of Medieval French
- **ANR TIME-US** (2016-2019, PI Manuela Martini [LARHRA], ALMAnaCH members are associated with Paris-Diderot's CEDREF for this project). Topic: Digital study of remuneration and time budget textile trades in XVIIIth and XIXth century France

9.1.2. Competitivity Clusters

- **LabEx EFL** (2010-2019, PI Christian Puech [HTL, Paris 3], Sorbonne Paris Cité). Topic: empirical foundations of linguistics, including computational linguistics and natural language processing. ALPAGE was one of the partner teams of this LabEx, which gathers a dozen of teams within and around Paris whose research interests include one aspects of linguistics or more. BS serves as deputy head (and former head) of one of the scientific strands of the LabEx, namely strand 6 dedicated to language resources. BS and DS are in charge of a number of scientific "operations" within strands 6, 5 ("computational semantic analysis") and 2 ("experimental grammar"). BS, EVdLC and DS are now individual members of the LabEx EFL since 1st January 2017, and BS still serves as the deputy head of strand 6. Main collaborations are on language resource development (strands 5 and 6), syntactic and semantic parsing (strand 5, especially with LIPN [CNRS and U.Paris 13]) and computational morphology (strands 2 and 6, especially with CRLAO [CNRS and Inalco]).
- **PSL project LAKME** (2015-2017, PI Thierry Poibeau [LATTICE]). Topic: language resource development for morphologically rich languages, especially Rabbinic Hebrew (syntactic level), Medieval French (morphological level) and some Finno-Ugric languages (to a lesser extent).
- **PSL Iris project SCRIPTA** This project emanates from the history and philology department of the EPHE (DSBE). It is directed by Andreas Stauder (EPHE) with Philip Huyse (EPHE) and Charlotte Schmid (EFEO). It unites the forces of a great number of researchers in PSL (EPHE, ENS, EHESS, ENC, Collège de France and in addition the IRHT) working on written texts in all its forms, on all kinds of material, from all periods and regions and has important digital and computational ambitions especially with regard to epigraphy, palaeography, digital editions and NLP.

9.1.3. Other National Initiatives

- **TGIR Huma-Num** ALPAGE was a member of the CORLI consortium on "corpora, languages and interactions" (BS is a member of the consortium's board), and ALMAnaCH is in the process of joining this consortium. With a joint funding of Huma-Num and the H2020 project Parthenos (on which see below), ALMAnaCH members have also co-organised a workshop on 3D techniques for Humanities in Bordeaux (December 2016).

- **Institut de Linguistique Française (ILF)**: ALPAGE was a member of this CNRS "federation". ALMAnaCH is in the process of joining this federation if possible, especially as BS is the scientific head of the "Corpus de Référence du Français" initiative, an ILF project whose other head is Franck Neveu and whose goal is to develop a French National Corpus, a resource that has been awaited for a long time.
- **Notary registers project** (2017-2018): An explorative study has been launched in collaboration with the National Archives in France, in the context of the framework agreement between Inria and the Ministry of Culture, to explore the possibility of extracting various components from gigitized 19th Century notary registers.
- **Nénufar (DGLFLF - Délégation générale à la langue française et aux langues de France)**: The projects is intended to digitize and exploit the early editions (beginning of the 20th Century) of the Petit Larousse dictionary. ALMAnaCH is involve to contribute to the automatic extraction of the dictionary content by means of GROBID-dictionaries and define a TEI compliant interchange format for all results.
- **PIA Opaline**: The objective of the project is to provide a better access to published French literature and reference material for visually impaired persons. Financed by the Programme d'Investissement d'Avenir, it will integrate technologies related to document analysis and re-publishing, textual content enrichment and dedicated presentational interfaces. Inria participate to deploy the GROBID tool suite for the automatic structuring of content from books available as plain PDF files.

9.2. European Initiatives

9.2.1. FP7 & H2020 Projects

- **H2020 Parthenos** (2015-2019, PI Franco Niccolucci [University of Florence]; LR is a work package coordinator) Topic: strengthening the cohesion of research in the broad sector of Linguistic Studies, Humanities, Cultural Heritage, History, Archaeology and related fields through a thematic cluster of European Research Infrastructures, integrating initiatives, e-infrastructures and other world-class infrastructures, and building bridges between different, although tightly interrelated, fields.
- **H2020 EHRI** "European Holocaust Research Infrastructure" (2015-2019, PI Conny Kristel [NIOD-KNAW, NL]; LR is task leader) Topic: transform archival research on the Holocaust, by providing methods and tools to integrate and provide access to a wide variety of archival content.
- **H2020 Iperion CH** (2015-2019, PI Luca Pezzati [CNR, IT], LR is task leader) Topic: coordinating infrastructural activities in the cultural heritage domain.
- **H2020 HIRMEOS**: HIRMEOS objective is to improve five important publishing platforms for the open access monographs in the humanities and enhance their technical capacities and services and rendering technologies, while making their content interoperable. Inria is responsable for improving integrating the entity-fishing component deplyed as an infrastructural service for the five platforms.
- **H2020 DESIR**: The DESIR project aims at contributing to the sustainability of the DARIAH infrastructure along all its dimensions: dissemination, growth, technology, robustness, trust and education. Inria is responsable for providing of a portfolio of text analytics services based on GROBID and entity-fishing.

9.2.2. Collaborations in European Programs, Except FP7 & H2020

- **ERIC DARIAH "Digital Research Infrastructure for the Arts and Humanities"** (set up as a consortium of states, 2014-2034; LR is president of the board of director) Topic: coordinating Digital Humanities infrastructure activities in Europe (17 partners, 5 associated partners).
- **COST enCollect** (2017-2020, PI Lionel Nicolas [European Academy of Bozen/Bolzano]) Topic: combining language learning and crowdsourcing for developing language teaching materials and more generic language resources for NLP

9.2.3. Collaborations with Major European Organizations

Informal collaborations with institutions not cited above (for the SPMRL initiative, see below):

- University of Ljubljana (Darja Fišer) [wordnet development]
- University of Zürich, Switzerland (Géraldine Walther) [computational morphology, lexicons]
- Academy of Sciences, Berlin, Germany (Karl-Heinz Moerth) [lexicology]
- University of Fribourg, Switzerland [historical document analysis]
- University of Valencia, Spain [historical document analysis]
- University of Groningen, Netherlands [historical document analysis]
- University of Innsbruck, Austria [historical document analysis]

9.3. International Initiatives

9.3.1. International Partners

- **ANR-NSF project MCM-NL** (2016-2020, PI John Hale [Cornell University, USA], resp. for Inria Paris / ALMAnaCH: EVdLC) Topic: exploring correlations between data from neuro-imagery (fMRI, EEG) and data from NLP tools (mostly parsers). The data will come from "Le Petit Prince" read in French and English, and parsed with different parsers. Other partners: Cornell Univ., Univ. Michigan, Paris Saclay/Neurospin, Univ. Paris 8. Informal collaborations:
- **The SPMRL initiative** (Statistical Parsing of Morphologically Rich Languages): a worldwide network of internationally renowned teams that was initiated during the IWPT'09 conference ALPAGE organised in Paris, DS playing a leading role since then. Other institutions involved include the University of Heidelberg (Germany), Bar Ilan University (Israel), Potsdam University (Germany) and Indiana University (USA). The outcomes of this initiative include the successful SPMRL Workshop and Shared Task series hosted successively by NAACL-HLT (2010), IWPT (2011), ACL (2012), EMNLP (2013), CoLing (2014) and IWPT (2015), in which DS as well as other ALPAGE/ALMAnaCH members played an active role. DS also served as a co-editor of a special issue of Computational Linguistics on this topic.
- **Sofer Mahir ("fast scribe") project**. Joint work on the computational processing of Rabbinic Hebrew manuscripts involving DSBE: Nachum Dershowitz (Tel Aviv University, Israel), Moshe Koppel (DICTA, Bar Ilan University, Israel), Meni Adler (DICTA, Ben Gurion University, Israel), Michael Elhadad (Ben Gurion University, Israel) on the NLP side and Hayim Lapin (University of Maryland, USA), Tal Ilan (FU Berlin, Germany) Shamma Friedmann (Bar Ilan University, Israel) on morphological analysis of Rabbinic Hebrew, alignment of manuscript witnesses (textual criticism), finding parallels, aligning related but different texts (like the Gospels). This work is also connected to the LAKME project mentioned above.

9.4. International Research Visitors

9.4.1. Visits of International Scientists

- Daniel Dakota (Indiana University, 4 months, until Jan 2017)
- Theresa Lynn (Dublin City University, 10 days in January 2017)
- Amir More (Open University of Israel, 10 days in April 2017)

9.4.1.1. Internships

- Basant Agarwal (ERCIM, Aug-Sep 2017)

COML Team

9. Partnerships and Cooperations

9.1. Regional Initiatives

Collaboration with the Willow Team:

- co-advising with J. Sivic and I. Laptev of a PhD student: Ronan Riochet.
- construction of a naive physics benchmark

9.2. National Initiatives

9.2.1. ANR

Transatlantic Platform "Digging into Data". Title: "Analysis of Children's Language Experiences Around the World. (ACLEW)"; (coordinating PI : M. Soderstrom; Leader of tools development and co-PI : E. Dupoux), (2017–2020. 5 countries; Total budget: 1.4M€)

9.3. European Initiatives

9.3.1. FP7 & H2020 Projects

ERC Advanced Grant (BOOTPHON, PI: E. Dupoux, Budget 2.4M€).

9.4. International Initiatives

9.4.1. Informal International Partners

- Johns Hopkins University, Baltimore, USA: S. Kudanpur, H. Hermanksy
- RIKEN Institute, Tokyo, Japan: R. Mazuka

9.5. International Research Visitors

9.5.1. Visits of International Scientists

Valentina Gliozzi (Professor, Univ. di Torino, Visiting Professor Spring 2017)

RITS Project-Team

8. Partnerships and Cooperations

8.1. National Initiatives

8.1.1. ANR

8.1.1.1. COCOVEA

Title: Coopération Conducteur-Véhicule Automatisé

Instrument: ANR

Duration: November 2013 - April 2017

Coordinator: Jean-Christophe Popieul (LAMIH - University of Valenciennes)

Partners: LAMIH, IFSTTAR, Inria, University of Caen, COMETE, PSA, CONTINENTAL, VALEO, AKKA Technologies, SPIROPS

Inria contact: Fawzi Nashashibi

Abstract: CoCoVeA project aims at demonstrating the need to integrate from the design of the system, the problem of interaction with the driver in resolving the problems of sharing the driving process and the degree of freedom, authority, level of automation, prioritizing information and managing the operation of the various systems. This approach requires the ability to know at any moment the state of the driver, the driving situation in which he finds himself, the operating limits of the various assistance systems and from these data, a decision regarding activation or not the arbitration system and the level of response.

8.1.1.2. VALET

Title: Redistribution automatique d'une flotte de véhicules en partage et valet de parking

Instrument: ANR

Duration: January 2016 - December 2018

Coordinator: Fawzi Nashashibi

Partners: Inria, Ecole Centrale de Nantes (IRCCyN), AKKA Technologies

Inria contact: Fawzi Nashashibi

Abstract: The VALET project proposes a novel approach for solving car-sharing vehicles redistribution problem using vehicle platoons guided by professional drivers. An optimal routing algorithm is in charge of defining platoons drivers' routes to the parking areas where the followers are parked in a complete automated mode. The main idea of VALET is to retrieve vehicles parked randomly on the urban parking network by users. These parking spaces may be in electric charging stations, parking for car sharing vehicles or in regular parking places. Once the vehicles are collected and guided in a platooning mode, the objective is then to guide them to their allocated parking area or to their respective parking lots. Then each vehicle is assigned a parking place into which it has to park in an automated mode.

8.1.2. FUI

8.1.2.1. Sinetic

Title: Système Intégré Numérique pour les Transports Intelligents Coopératifs

Instrument: FUI

Duration: December 2014 - May 2017

Coordinator: Thomas Nguyen (Oktal)

Partners: Oktal, ALL4TEC, CIVITEC, Dynalogic, Inria, EURECOM, Renault, Armines, IFSTTAR, VEDECOM

Inria contact: Jean-Marc Lasgouttes

Abstract: The purpose of the project SINETIC is to create a complete simulation environment for designing cooperative intelligent transport systems with two levels of granularity: the system level, integrating all the components of the system (vehicles, infrastructure management centers, etc.) and its realities (terrain, traffic, etc.) and the component-level, modeling the characteristics and behavior of the individual components (vehicles, sensors, communications and positioning systems, etc.) on limited geographical areas, but described in detail.

8.1.2.2. PAC V2X

Title: Perception augmentée par coopération véhicule avec l'infrastructure routière

Instrument: FUI

Duration: September 2016 - August 2019

Coordinator: SIGNATURE Group (SVMS)

Partners: DigiMobee, LOGIROAD, MABEN PRODUCTS, SANEF, SVMS, VICI, Inria, VEDECOM

Inria contact: Raoul de Charette

Abstract: The objective of the project is to integrate two technologies currently being deployed in order to significantly increase the time for an automated vehicle to evolve autonomously on European road networks. It is the integration of technologies for the detection of fixed and mobile objects such as radars, lidars, cameras ... etc. And local telecommunication technologies for the development of ad hoc local networks as used in cooperative systems.

8.1.3. Competitivity Clusters

RITS team is a very active partner in the competitivity clusters, especially MOV'EO and System@tic. We are involved in several technical committees like the DAS SUR of MOV'EO for example.
RITS is also the main Inria contributor in the VEDECOM institute (IEED). VEDECOM is financing the PhD theses of Mr. Fernando Garrido and Mr. Zayed Alsayed.

8.2. European Initiatives

8.2.1. FP7 & H2020 Projects

8.2.1.1. AUTOCITS

Title: AUTOCITS Regulation Study for Interoperability in the Adoption of Autonomous Driving in European Urban Nodes

Program: CEF- TRANSPORT Atlantic corridor

Duration: November 2016 - December 2018

Coordinator: Indra Sistemas S.A. (Spain)

Partners: Indra Sistemas S.A. (Spain); Universidad Politécnica de Madrid (UPM), Spain; Dirección General de Tráfico (DGT), Spain; Inria (France); Instituto Pedro Nunes (IPN), Portugal; Autoridade Nacional de Segurança Rodoviária (ANSR), Portugal; Universidade de Coimbra (UC), Portugal.

Inria contact: Fawzi Nashashibi, Mohammad Abualhoul

Abstract: The aim of the Study is to contribute to the deployment of C-ITS in Europe by enhancing interoperability for autonomous vehicles as well as to boost the role of C-ITS as catalyst for the implementation of autonomous driving. Pilots will be implemented in 3 major Core Urban nodes (Paris, Madrid, Lisbon) located along the Core network Atlantic Corridor in 3 different Member States. The Action consists of Analysis and design, Pilots deployment and assessment, Dissemination and communication as well as Project Management and Coordination.

8.2.2. Collaborations with Major European Organizations

RITS is member of the **euRobotics AISBL** and the Leader of "People transport" Topic. This makes from Inria one of the rare French robotics representatives at the European level. See also: http://www.eu-robotics.net/

RITS is a full partner of **VRA – Vehicle and Road Automation**, a support action funded by the European Union to create a collaboration network of experts and stakeholders working on deployment of automated vehicles and its related infrastructure. VRA project is considered as the cooperation interface between EC funded projects, international relations and national activities on the topic of vehicle and road automation. It is financed by the European Commission DG CONNECT and coordinated by ERTICO – ITS Europe. See also: http://vra-net.eu/

8.3. International Initiatives

8.3.1. Participation in Other International Programs

8.3.1.1. ICT-Asia

SIM-Cities

Title: "Sustainable and Intelligent Mobility for Smart Cities"

International Partner (Institution - Laboratory - Researcher):

- Nanyang Technical University (NTU), School of Electrical and Electronic Engineering – Singapore. Prof. Dan Wei Wang

- National University of Singapore (NUS), Department of Mechanical Engineering – Singapore. Dr. Marcelo Ang

- Kumamotoo University - Japan. Intelligent Transportation Systems Lab, Graduate School of Science and Technology, Prof. James Hu / Prof. Ogata

- Shanghai Jiao-Tong University (SJTU), Department of Automation – China. Prof. Ming Yang

- Hanoi University of Science and Technology, International Center MICA Institute – Vietnam. Prof. Eric Castelli

- Inria, RITS Project-Team – France. Dr. Fawzi Nashashibi

- Inria, e-Motion/CHROMA Project-Team – France. Dr. Christian Laugier

- Ecole Centrale de Nantes, IRCCyN – France. Prof. Philippe Martinet

Duration: Jan. 2015 - May 2017

Start year: 2015

This project aims at conducting common research and development activities in the field of sustainable transportation and advanced mobility of people and goods in order to move in the direction of smart, clean and sustainable cities.

RITS and MICA lab have obtained from the Vietnamese Program 911 the financing of the joint PhD thesis of Dinh-Van Nguyen (co-directed by Eric Castelli from MICA lab and Fawzi Nashashibi).

8.3.1.2. ECOS Nord – Venezuela

ECOS Nord

Title: "Les Techniques de l'Information et de la Communication pour la Conception de Systèmes Avancés de Mobilité durable en Milieu Urbain."

International Partner (Institution - Laboratory - Researcher):

- Simon Bolivar University, Department of Mecatronics – Venezuela. Dr. Gerardo Fernandez

- Inria, RITS Project-Team – France. Dr. Fawzi Nashashibi

Duration: Jan. 2014 - Dec. 2017

Start year: 2014

The main objective of this project is to contribute scientifically and technically to the design of advanced sustainable mobility systems in urban areas, particularly in dense cities where mobility, comfort and safety needs are more important than in other types of cities. In this project, we will focus on the contribution of advanced systems of perception, communication and control for the realization of intelligent transport systems capable of gradually integrating into the urban landscape. These systems require the development of advanced dedicated urban infrastructures as well as the development and integration of on-board intelligence in individual vehicles or mass transport.
This year, a session of courses has been organized at University Simon Bolivar, Caracas (Venezuela). Following several PhDs and interns recruitments from this university, prof G. Fernandez and J. Capeletto invited Raoul de Charette to organize a 32Hr Computer Vision Master Class in December 2017. PhDs Carlos Flores and Luis Roldao were also part of the master class and teached control (10Hr) and point cloud processing (7Hr), respectively.

8.4. International Research Visitors

8.4.1. Visits of International Scientists

8.4.1.1. Internships

Julio Blanco Deniz, Nievsabel Molina from Simon Bolivar University, Venezuela.
They both worked on a cascade control architecture based on PID controllers for a Citroen C1: the longitudinal control was developed by Julio Blanco Deniz , under the supervision of Carlos Flores and the lateral control (for the action on the steering wheel) was done by Nievsabel Molina, under the supervision of Francisco Navas. Using this architecture, a reference trajectory can be smoothly followed by the vehicle at different speeds.

Aitor Gomez, Alfredo Valle, Edgar Talavera Munoz from Universidad Politécnica de Madrid, Spain.

Ziyang Hong from Université de Bourgogne, Dijon, France.

Maradona Rodrigues from University of Warwick, United Kingdom.

Sule Kahraman from MIT, USA.

Arthur Lecert from ESIEE Paris, France. He was supervised by Pierre de Beaucorps.

Valda Team

7. Partnerships and Cooperations

7.1. Regional Initiatives

Valda has obtained a 10k€ budget from ENS in 2017, as a start-up grant from the team (*Action Concertée Incitative*).

Inria established a bilateral contract with the Centre – Val de Loire region, for the expertise and audit of a research project by Pierre Senellart. Because of delays due to the company being audited, the expertise is still in progress.

7.2. National Initiatives

7.2.1. ANR

Valda has been part of one ANR project in 2017 (Headwork, budget managed by Inria), together with IRISA (DRUID team, coordinator), Inria Lille (LINKS & SPIRAL), and Inria Rennes (SUMO), and two application partners: MNHN (Cesco) and FouleFactory. The topic is workflows for crowdsourcing. See http://headwork.gforge.inria.fr/.

In addition, another project (BioQOP, budget managed by ENS) will start in January 2018, with Morpho and GREYC, on the optimization of queries for privacy-aware biometric data management

7.3. International Initiatives

7.3.1. Informal International Partners

Valda has strong collaborations with the following international groups:

Univ. Edinburgh, United Kingdom: Peter Buneman and Leonid Libkin
Univ. Oxford, United Kingdom: Michael Benedikt, Evgeny Kharlamov, and Georg Gottlob
Dortmund University, Germany: Thomas Schwentick
Warsaw University, Poland: Mikołaj Bojańczyk and Szymon Toruńczyk
Tel Aviv University, Israel: Daniel Deutch and Tova Milo
Drexel University, USA: Julia Stoyanovich
Univ. California San Diego, USA: Victor Vianu
National University of Singapore: Stéphane Bressan

7.4. International Research Visitors

7.4.1. Visits of International Scientists

Victor Vianu, Professor at UC San Diego and holder of an Inria international chair, spent 6 months within Valda: three months employed by Inria and three months as an ENS invited professor.

7.4.1.1. Internships

Deabrota Basu, PhD student at National University of Singapore, stayed 2.5 months within Valda, to work with Pierre Senellart.

7.4.2. Visits to International Teams

7.4.2.1. Research Stays Abroad

- Pierre Senellart has spent around two months at the University of Edinburgh, collaborating with Peter Buneman and Leonid Libkin.
- Pierre Senellart has spent a cumulated time of more than one month at National University of Singapore, co-advising Debabrota Basu, PhD student working under the co-supervision of Stéphane Bressan.

WILLOW Project-Team

9. Partnerships and Cooperations

9.1. National Initiatives

9.1.1. Agence Nationale de la Recherche (ANR): SEMAPOLIS

Participants: Mathieu Aubry, Josef Sivic.

The goal of the SEMAPOLIS project is to develop advanced large-scale image analysis and learning techniques to semantize city images and produce semantized 3D reconstructions of urban environments, including proper rendering. Geometric 3D models of existing cities have a wide range of applications, such as navigation in virtual environments and realistic sceneries for video games and movies. A number of players (Google, Microsoft, Apple) have started to produce such data. However, the models feature only plain surfaces, textured from available pictures. This limits their use in urban studies and in the construction industry, excluding in practice applications to diagnosis and simulation. Besides, geometry and texturing are often wrong when there are invisible or discontinuous parts, e.g., with occluding foreground objects such as trees, cars or lampposts, which are pervasive in urban scenes. This project will go beyond the plain geometric models by producing semantized 3D models, i.e., models which are not bare surfaces but which identify architectural elements such as windows, walls, roofs, doors, etc. Semantic information is useful in a larger number of scenarios, including diagnosis and simulation for building renovation projects, accurate shadow impact taking into account actual window location, and more general urban planning and studies such as solar cell deployment. Another line of applications concerns improved virtual cities for navigation, with object-specific rendering, e.g., specular surfaces for windows. Models can also be made more compact, encoding object repetition (e.g., windows) rather than instances and replacing actual textures with more generic ones according to semantics; it allows cheap and fast transmission over low- bandwidth mobile phone networks, and efficient storage in GPS navigation devices.

This is a collaborative effort with LIGM / ENPC (R. Marlet), University of Caen (F. Jurie), Inria Sophia Antipolis (G. Drettakis) and Acute3D (R. Keriven).

9.2. European Initiatives

9.2.1. European Research Council (ERC) Starting Grant: "Activia" - Ivan Laptev

Participant: Ivan Laptev.

WILLOW will be funded in part from 2013 to 2017 by the ERC Starting Grant "Activia" awarded to Ivan Laptev by the European Research Council.

‘Computer vision is concerned with the automated interpretation of images and video streams. Today’s research is (mostly) aimed at answering queries such as ’Is this a picture of a dog?’, (classification) or sometimes ’Find the dog in this photo’ (detection). While categorisation and detection are useful for many tasks, inferring correct class labels is not the final answer to visual recognition. The categories and locations of objects do not provide direct understanding of their function i.e., how things work, what they can be used for, or how they can act and react. Such an understanding, however, would be highly desirable to answer currently unsolvable queries such as ’Am I in danger?’ or ’What can happen in this scene?’. Solving such queries is the aim of this proposal. My goal is to uncover the functional properties of objects and the purpose of actions by addressing visual recognition from a different and yet unexplored perspective. The main novelty of this proposal is to leverage observations of people, i.e., their actions and interactions to automatically learn the use, the purpose and the function of objects and scenes from visual data. The project is timely as it builds upon the two key recent technological advances: (a) the immense progress in visual recognition of objects, scenes and human actions achieved in the last ten years, as well as (b) the emergence of a massive amount of

public image and video data now available to train visual models. ACTIVIA addresses fundamental research issues in automated interpretation of dynamic visual scenes, but its results are expected to serve as a basis for ground-breaking technological advances in practical applications. The recognition of functional properties and intentions as explored in this project will directly support high-impact applications such as detection of abnormal events, which are likely to revolutionise today's approaches to crime protection, hazard prevention, elderly care, and many others.'

9.2.2. European Research Council (ERC) Starting Grant: "Leap" - Josef Sivic

Participant: Josef Sivic.

The contract has begun on Nov 1st 2014. WILLOW will be funded in part from 2014 to 2018 by the ERC Starting Grant "Leap" awarded to Josef Sivic by the European Research Council.

'People constantly draw on past visual experiences to anticipate future events and better understand, navigate, and interact with their environment, for example, when seeing an angry dog or a quickly approaching car. Currently there is no artificial system with a similar level of visual analysis and prediction capabilities. LEAP is a first step in that direction, leveraging the emerging collective visual memory formed by the unprecedented amount of visual data available in public archives, on the Internet and from surveillance or personal cameras - a complex evolving net of dynamic scenes, distributed across many different data sources, and equipped with plentiful but noisy and incomplete metadata. The goal of this project is to analyze dynamic patterns in this shared visual experience in order (i) to find and quantify their trends; and (ii) learn to predict future events in dynamic scenes. With ever expanding computational resources and this extraordinary data, the main scientific challenge is now to invent new and powerful models adapted to its scale and its spatio-temporal, distributed and dynamic nature. To address this challenge, we will first design new models that generalize across different data sources, where scenes are captured under vastly different imaging conditions such as camera viewpoint, temporal sampling, illumination or resolution. Next, we will develop a framework for finding, describing and quantifying trends that involve measuring long-term changes in many related scenes. Finally, we will develop a methodology and tools for synthesizing complex future predictions from aligned past visual experiences. Our models will be automatically learnt from large-scale, distributed, and asynchronous visual data, coming from different sources and with different forms of readily-available but noisy and incomplete metadata such as text, speech, geotags, scene depth (stereo sensors), or gaze and body motion (wearable sensors). Breakthrough progress on these problems would have profound implications on our everyday lives as well as science and commerce, with safer cars that anticipate the behavior of pedestrians on streets; tools that help doctors monitor, diagnose and predict patients' health; and smart glasses that help people react in unfamiliar situations enabled by the advances from this project.'

9.3. International Initiatives

9.3.1. IMPACT: Intelligent machine perception

Participants: Josef Sivic, Jean Ponce, Ivan Laptev.

IMPACT is a 5-year collaborative project with Czech Technical University, Center for Robotics, Informatics and Cybernetics (CIIRC) (2017-2022). The IMPACT project focuses on fundamental and applied research in computer vision, machine learning and robotics to develop machines that learn to perceive, reason, navigate and interact with complex dynamic environments. For example, people easily learn how to change a flat tire of a car or perform resuscitation by observing other people doing the same task. This involves advanced visual intelligence abilities such as interpreting sequences of human actions that manipulate objects to achieve a specific task. Currently, however, there is no artificial system with a similar level of cognitive visual competence. Breakthrough progress in intelligent machine perception will have profound implications on our everyday lives as well as science and commerce, with smart assistive robots that automatically learn new skills from the Internet, safer cars that autonomously navigate in difficult changing conditions, or intelligent glasses that help people navigate never seen before environments.

9.3.2. Inria CityLab initiative

Participants: Josef Sivic, Jean Ponce, Ivan Laptev, Alexei Efros [UC Berkeley].

Willow participates in the ongoing CityLab@Inria initiative (co-ordinated by V. Issarny), which aims to leverage Inria research results towards developing “smart cities" by enabling radically new ways of living in, regulating, operating and managing cities. The activity of Willow focuses on urban-scale quantitative visual analysis and is pursued in collaboration with A. Efros (UC Berkeley).

Currently, map-based street-level imagery, such as Google Street-view provides a comprehensive visual record of many cities worldwide. Additional visual sensors are likely to be wide-spread in near future: cameras will be built in most manufactured cars and (some) people will continuously capture their daily visual experience using wearable mobile devices such as Google Glass. All this data will provide large-scale, comprehensive and dynamically updated visual record of urban environments.

The goal of this project is to develop automatic data analytic tools for large-scale quantitative analysis of such dynamic visual data. The aim is to provide quantitative answers to questions like: What are the typical architectural elements (e.g., different types of windows or balconies) characterizing a visual style of a city district? What is their geo-spatial distribution? How does the visual style of a geo-spatial area evolve over time? What are the boundaries between visually coherent areas in a city? Other types of interesting questions concern distribution of people and their activities: How do the number of people and their activities at particular places evolve during a day, over different seasons or years? Are there tourists sightseeing, urban dwellers shopping, elderly walking dogs, or children playing on the street? What are the major causes for bicycle accidents?

Break-through progress on these goals would open-up completely new ways smart cities are visualized, modeled, planned and simulated, taking into account large-scale dynamic visual input from a range of visual sensors (e.g., cameras on cars, visual data from citizens, or static surveillance cameras).

9.3.3. Associate team GAYA

Participants: Jean Ponce, Matthew Trager.

GAYA is a joint research team bringing together two Inria project-teams (Thoth, Grenoble and WILLOW, Paris) and Carnegie Mellon University, USA. It focuses on two research themes: (i) semantic structured interpretation of videos, and (ii) studying the geometric properties of object shapes to enhance state-of-the-art object recognition approaches.

Interpreting videos semantically in a general setting, involving various types of video content like home video clips, news broadcasts, feature films, which contain a lot of clutter, non-rigid motion, many “actors” performing actions, person-object and person-person interactions, varying viewpoints, is challenging. This task is being examined increasingly over the past decade, with the availability of large video resources, e.g., YouTube. Despite this progress, an effective video representation for recognizing actions is still missing. To address this critical challenge, we propose a joint optimization framework, wherein we learn the video representation and also develop models for action recognition. Specifically, we aim to exploit the spatio-temporal relations among pixels in a video through graphical models and novel deep learning feature representations.

The second research theme explores geometric aspects of computer vision, in particular how to model three-dimensional objects from their two-dimensional projections, and how the appearance of these objects evolves with changes in viewpoint. Beyond its theoretical interest, this work is critical for developing object recognition algorithms that take into account the three-dimensional nature of the visual world and go beyond the template-matching approaches dominant today. Duality is an important concept in this area, and we are investigating its application to the construction of visual hulls as well as the characterization of the topology of image contours using the Gauss map. Existing results are essentially limited to the Euclidean setting, and we are investigating their generalization to the general projective case.

Partners: CMU (Deva Ramanan, Martial Hebert, Abhinav Gupta, Gunnar Sigurdsson), Inria Thoth (Cordelia Schmid, Karteek Alahari, Pavel Tokmakov).

9.4. International Research Visitors

9.4.1. Visits of International Scientists

Prof. Alexei Efros (UC Berkeley, USA) visited Willow during June. Hildegard Kuehne (Universtiy of Bonn) and Jason Corso (University of Michigan) visited Willow during April.

9.4.1.1. Internships

Kai Han has visited Willow from the University of Hong Kong.

9.4.2. Visits to International Teams

9.4.2.1. Research Stays Abroad

Jean Ponce is visiting New York University since September 2017.