



RESEARCH CENTER
Rennes - Bretagne-Atlantique

FIELD

Activity Report 2017

Section Partnerships and Coopera- tions

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ASAP Project-Team

7. Partnerships and Cooperations

7.1. National Initiatives

7.1.1. ANR project *SocioPlug*

Participants: Davide Frey, Anne-Marie Kermarrec, Pierre-Louis Roman, Francois Taiani.

SocioPlug is a collaborative ANR project involving Inria (ASAP team), the Univ. Nantes, and LIRIS (INSA Lyon and Univ. Claude Bernard Lyon). The project emerges from the observation that the features offered by the Web 2.0 or by social media do not come for free. Rather they bring the implicit cost of privacy. Users are more or less consciously selling personal data for services. SocioPlug aims to provide an alternative for this model by proposing a novel architecture for large-scale, user centric applications. Instead of concentrating information of cloud platforms owned by a few economic players, we envision services made possible by cheap low-end plug computers available in every home or workplace. This will make it possible to provide a high amount of transparency to users, who will be able to decide their own optimal balance between data sharing and privacy.

7.1.2. *DeSceNt CominLabs*

Participants: Resmi Ariyattu Chandrasekharannair, Davide Frey, Michel Raynal, Francois Taiani.

The DeSceNt project aims to ease the writing of distributed programs on a federation of plug computers. Plug computers are a new generation of low-cost computers, such as Raspberry pi (25\$), VIA- APC (49\$), and ZERO Devices Z802 (75\$), which offer a cheap and readily available infrastructure to deploy domestic on-line software. Plug computers open the opportunity for everyone to create cheap nano-clusters of domestic servers, host data and services and federate these resources with their friends, colleagues, and families based on social links. More particularly we will seek in this project to develop novel decentralized protocols than can encapsulate the notion of privacy-preserving federation in plug-based infrastructures. The vision is to use these protocols to provide a programming toolkit that can support the convergent data types being developed by our partner GDD (Gestion de Données Distribuées) at Univ. Nantes.

7.1.3. ANR *Blanc* project *Displexity*

Participants: George Giakkoupis, Anne-Marie Kermarrec, Michel Raynal.

The Displexity project started in 2011. The aim of this ANR project that also involves researchers from Paris and Bordeaux is to establish the scientific foundations for building up a consistent theory of computability and complexity for distributed computing. One difficulty to be faced by DISPLEXITY is to reconcile two non necessarily disjoint sub-communities, one focusing on the impact of temporal issues, while the other focusing on the impact of spatial issues on distributed algorithms.

7.1.4. ANR project *PAMELA*

Participants: Davide Frey, George Giakkoupis, Francois Taiani.

PAMELA is a collaborative ANR project involving ASAP, Inria Lille, UMPC, Mediego and Snips. The project aims at developing machine learning theories and algorithms in order to learn local and personalized models from data distributed over networked infrastructures. This project seeks to provide first answers to modern information systems built by interconnecting many personal devices holding private user data in the search of personalized suggestions and recommendations. More precisely, we will focus on learning in a collaborative way with the help of neighbors in a network. We aim to lay the first blocks of a scientific foundation for these new types of systems, in effect moving from graphs of data to graphs of data and learned models. We argue that this shift is necessary in order to address the new constraints arising from the decentralization of information that is inherent to the emergence of big data. We will in particular focus on the question of learning under communication and privacy constraints. A significant asset of the project is the quality of its industrial partners, SNIPS and MEDIEGO, who bring in their expertise in privacy protection and distributed computing as well as use cases and datasets. They will contribute to translate this fundamental research effort into concrete outcomes by developing personalized and privacy-aware assistants able to provide contextualized recommendations on small devices and smartphones.

7.1.5. ANR project *OBrowser*

Participants: David Bromberg, Davide Frey, Francois Taiani.

OBrowser is a collaborative ANR project involving Inria (ASAP team), the Univ. Nantes, the Bretagne Sud. University, and Orange. The project emerges from the vision of designing and deploying distributed application on millions of machines using web-enabled technologies without relying on a cloud or a central authority. OBrowser proposes to build collaborative applications through a decentralized execution environment composed of users' browsers that autonomously manages issues such as communication, naming, heterogeneity, and scalability. The introduction of browser-to-browser communication with WebRTC's Datachannel has made these scenarios closer, but today only experts can afford to tackle the technical challenges associated with large-scale browser-based deployments such as decentralized instant-messaging (Firechat) and Infrastructure-less Mission Critical Push To Talk. O'Browser aims to solve these challenges by means of a novel programming framework.

7.1.6. ANR project *DESCARTES*

Participants: George Giakkoupis, Michel Raynal, Francois Taiani.

DESCARTES is a collaborative ANR project involving ASAP, Labri (U. Bordeaux), Lafia (U. Paris Diderot), Vérimag (Grenoble), LIF (Marseilles), and LINA (Nantes). 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. In this project, 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.

7.1.7. ANR-ERC *Tremplin* project *NDFUSION*

Participant: George Giakkoupis.

NDFUSION is an 18-month ANR project awarded to the PI to support his preparation for his upcoming ERC grant application. The idea of intervening in a network diffusion process to enhance or retard its spread has been studied in various contexts, e.g., to increase the spread or speed of diffusion by choosing an appropriate set of seed nodes (a standard goal in viral marketing by word-of-mouth), or achieve the opposite effect either by choosing a small set of nodes to remove (a goal in immunization against diseases), or by seeding a competing diffusion (e.g., to limit the spread of misinformation in a social network). The aim of this project is to consolidate existing work under a single, comprehensive framework, and using this framework to develop

new, efficient algorithms for optimizing (maximizing or minimizing) the spread of diffusion processes. Novel aspects of the project involve issues of scalability, multiple concurrent diffusions, and the use of multistage online strategies to optimize diffusions. Results from this project are likely to be relevant to many different disciplines, from network optimization in computing to disease containment in medicine.

7.2. International Initiatives

7.2.1. Inria International Labs

- Anne-Marie Kermarrec is the scientific co-chair (with Willy Zwaenepoel) of the EPFL/Inria International Lab

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

7.2.2.1. LiDiCo

Title: Aux limites du calcul réparti

International Partner (Institution - Laboratory - Researcher):

UNAM (Mexico) - Instituto de Matematicas - Sergio Rajsbaum

Start year: 2017

See also: <https://sites.google.com/site/lidicoequipeassociee/>

Today distributed applications are pervasive, some very successful (e.g., Internet, P2P, social networks, cloud computing), and benefit everyone, but the design and the implementation of many of them still rely on ad-hoc techniques instead of on a solid theory. The next generation of distributed applications and services will be more and more complex and demands research efforts in establishing sound theoretical foundations to be able to master their design, their properties and their implementation. This proposal is a step in this inescapable direction.

7.3. International Research Visitors

7.3.1. Visits of International Scientists

- Peter Kling (U of Hamburg) visited ASAP (hosted by G Giakkoupis), Jan 19–25.
- Emanuele Natale (Max Planck, Saarbrücken) visited ASAP (hosted by G Giakkoupis), Apr 23–29.
- Thomas Sauerwald (U of Cambridge) visited ASAP (hosted by G Giakkoupis), Aug 21–24.
- Robert Elsässer (Salzburg U) visited ASAP (hosted by G Giakkoupis), Sep 25–29.

7.3.1.1. Internships

- Jodi Spacek from University of British Columbia, Research internship from May 2017 until Aug 2017, supervised by David Bromberg.
- Stewart Grant from University of British Columbia, Research internship from May 2017 until Aug 2017, supervised by David Bromberg.
- Hayk Saribekyan from MIT, research Internship from June 2017 to August 2017.

7.3.2. Visits to International Teams

7.3.2.1. Research Stays Abroad

- Michel Raynal was at the Hong Kong Polytechnic University from 15 September to 14 October 2017,
- David Bromberg did a visit at USP - Department of Computer Science University of São Paulo, Sao Paulo, Brazil from February 22, 2017 to March 24, 2017

ASCOLA Project-Team

9. Partnerships and Cooperations

9.1. Regional Initiatives

9.1.1. RFI Atlanstic 2020

9.1.1.1. CoMe4ACloud

Participants: Thomas Ledoux [coordinator], Frederico Alvares de Oliveira Junior, Zakarea Al Shara.

The high-level objective of the 1-year CoMe4ACloud (Constraints and Model Engineering for Autonomic Clouds) project is to provide an end-to-end solution for autonomic Cloud services. To that end, we rely on techniques of Constraint Programming so as a decision-making tool and Model-driven Engineering to ease the automatic generation of the so-called autonomic managers as well as their synchronization with the managed system (i.e., the Cloud layers).

This year, we got the best paper award of CLOSER 2017 (the 7th International Conference on Cloud Computing and Services Science) [27]. We have also submitted two publications and provided two video-demonstrations of the early results.

CoMe4ACloud is an Atlanstic2020 funded project and supports a post-doc position. The project is led by Ascola research team and involves also AtlanModels and TASC, all of them from the LS2N and situated at IMT Atlantique. See <https://come4acloud.github.io> for more information.

9.1.1.2. SyMeTRIC

Participant: Jean-Marc Menaud [coordinator].

SyMeTRIC is a regional federated project in Systems Medicine funded by the Pays de la Loire french region. Systems Medicine approaches can be compared to Systems Biology. They aim at integrating several information sources to design and validate bio-models and biomarkers to anticipate and enhance patients follow-up (diagnosis, treatment response prediction, prognosis).

9.2. National Initiatives

9.2.1. CominLabs laboratory of excellence

9.2.1.1. EPOC

Participants: Jean-Marc Menaud [coordinator], Thomas Ledoux, Md Sabbir Hasan, Yunbo Li.

The project EPOC (Energy Proportional and Opportunistic Computing system) is a project running for 4 years. Four other partners collaborate within the project that is coordinated by ASCOLA: Myriads team, and the three institutions ENIB, ENSTB and University of Nantes. In this project, the partners focus on energy-aware task execution from the hardware to application components in the context of a *mono-site* data center (all resources are in the same physical location) which is connected to the *regular electric Grid and to renewable energy sources* (such as windmills or solar cells). Three major challenges are addressed in this context: optimize the energy consumption of distributed infrastructures and service compositions in the presence of ever more dynamic service applications and ever more stringent availability requirements for services; design a clever cloud's resource management which takes advantage of renewable energy availability to perform opportunistic tasks, then exploring the trade-off between energy saving and performance aspects in large-scale distributed system; investigate energy-aware optical ultra high-speed interconnection networks to exchange large volumes of data (VM memory and storage) over very short periods of time.

One of the strengths of the project is to provide a systematic approach, and use a single model for the system (from hard to soft) by mixing constraint programming and behavioral models to manage energy consumption in data centers.

9.2.1.2. *PrivGen*

Participants: Fatima-Zahra Boujdad, Mario Südholt [coordinator].

PrivGen (“Privacy-preserving sharing and processing of genetic data”) is a three-year project that has been started in Oct. 2016 and is conducted by three partners: a team of computer scientists from the LATIM Inserm institute in Brest mainly working on data watermarking techniques, a team of geneticists from an Inserm institute in Rennes working on the gathering and interpretation of genetic data, and the Ascola team. The project provides funding of 330 KEUR altogether with an Ascola share of 120 KEUR.

The project considers challenges related to the outsourcing of genetic data that is in the Cloud by different stakeholders (researchers, organizations, providers, etc.). It tackles several limitations of current security solutions in the cloud, notably the lack of support for different security and privacy properties at once and computations executed at different sites that are executed on behalf of multiple stakeholders.

The partners are working on three main challenges:

- Mechanisms for a continuous digital content protection
- Composition of security and privacy-protection mechanisms
- Distributed processing and sharing of genetic data

The Ascola team is mainly involved in providing solutions for the second and third challenges.

9.2.2. *ANR*

9.2.2.1. *GRECO (ANR)*

Participant: Adrien Lebre [Contact point].

The GRECO project (Resource manager for cloud of Things) is an ANR project (ANR-16-CE25-0016) running for 42 months (starting in January 2017 with an allocated budget of 522KEuros, 90KEuro for ASCOLA).

The consortium is composed of 4 partners: Qarnot Computing (coordinator) and 3 academic research group (DATAMOVE and AMA from the LIG in Grenoble and ASCOLA from Inria Rennes Bretagne Atlantique).

The goal of the GRECO project (<https://anr-greco.net>) is to design a manager for cloud of things. The manager should act at the IaaS, PaaS and SaaS layer of the cloud. One of the principal challenges will consist in handling the execution context of the environment in which the cloud of things operates. Indeed, unlike classical resource managers, connected devices imply to consider new types of networks, execution supports, sensors and new constraints like human interactions. The great mobility and variability of these contexts complexify the modelling of the quality of service. To face this challenge, we intend to innovate in designing scheduling and data management systems that will use machine learning techniques to automatically adapt their behaviour to the execution context. Adaptation here requires a modelling of the recurrent cloud of things usages, the modelling of the dynamics of physical cloud architecture.

9.2.2.2. *KerStream (ANR)*

Participant: Shadi Ibrahim [Coordinator].

The KerStream project (Big Data Processing: Beyond Hadoop!) is an ANR JCJC (Young Researcher) project (ANR-16-CE25-0014-1) running for 48 months (starting in January 2017 with an allocated budget of 238KEuros).

The goal of the KerStream project is to address the limitations of Hadoop when running Big Data stream applications on large-scale clouds and do a step beyond Hadoop by proposing a new approach, called KerStream, for scalable and resilient Big Data stream processing on clouds. The KerStream project can be seen as the first step towards developing the first French middleware that handles Stream Data processing at Scale.

9.2.3. *FSN*

9.2.3.1. *Hosanna (FSN)*

Participants: Jean-Marc Menaud [coordinator], Remy Pottier.

By deploying and using a Fog/Edge OS on backbones, our ultimate vision is to enable large parts of the Internet to be hosted and operated by its internal structure itself: a scalable set of resources delivered by any computing facilities forming the Internet, starting from the larger hubs operated by ISPs, governments and academic institutions, to any idle resources that may be provided by end users.

ASCOLA leads the DISCOVERY IPL and contributes mainly around two axes: VM life cycle management and security concerns.

9.2.6. InriaHub

9.2.6.1. MERCURY

Participants: Ronan-Alexandre Cherrueau, Adrien Lebre [coordinator].

ASCOLA, in particular within the framework of the DISCOVERY initiative has been working on the massively distributed use case since 2013. With the development of several proof-of-concepts around OpenStack, the team has had the opportunity to start an InriaHub action. Named MERCURY, the goal of this action is twofold: (i) support the research development made within the context of DISCOVERY and (ii) favor the transfer toward the OpenStack community.

Further information available at: <http://beyondtheClouds.github.io>.

9.2.7. Fond d'amorçage IMT Industrie du Futur 2017

9.2.7.1. aLIFE

Participants: Hélène Coullon [coordinator], Jacques Noyé.

The French engineering school IMT Atlantique is organizing the aLIFE workshop between industry and academia, in Nantes during two days on January, 30-31 2018. The objective of this workshop is to share various experiences and success stories, as well as open challenges related to the contribution of software-related research to Factories of the Future, in French apport de l'industrie du Logiciel à l'Industrie du Futur Européenne (aLIFE). To this end, big multinational companies, as well as SMEs and academics will exchange through plenary sessions and discussion panels.

9.2.8. Connect Talent

9.2.8.1. Apollo (Connect Talent)

Participant: Shadi Ibrahim [Coordinator].

The Apollo project (Fast, efficient and privacy-aware Workflow executions in massively distributed Data-centers) is an individual research project “Connect Talent” running for 36 months (starting in November 2017 with an allocated budget of 201KEuros).

The goal of the Apollo project is to investigate novel scheduling policies and mechanisms for fast, efficient and privacy-aware data-intensive workflow executions in massively distributed data-centers.

9.3. European Initiatives

9.3.1. FP7 & H2020 Projects

9.3.1.1. CoqHoTT

Title: Coq for Homotopy Type Theory

Programm: H2020

Type: ERC

Duration: June 2015 - May 2020

Coordinator: Inria

Inria contact: Nicolas TABAREAU

Every year, software bugs cost hundreds of millions of euros to companies and administrations. Hence, software quality is a prevalent notion and interactive theorem provers based on type theory have shown their efficiency to prove correctness of important pieces of software like the C compiler of the CompCert project. One main interest of such theorem provers is the ability to extract directly the code from the proof. Unfortunately, their democratization suffers from a major drawback, the mismatch between equality in mathematics and in type theory. Thus, significant Coq developments have only been done by virtuosos playing with advanced concepts of computer science and mathematics. Recently, an extension of type theory with homotopical concepts such as univalence is gaining traction because it allows for the first time to marry together expected principles of equality. But the univalence principle has been treated so far as a new axiom which breaks one fundamental property of mechanized proofs: the ability to compute with programs that make use of this axiom. The main goal of the CoqHoTT project is to provide a new generation of proof assistants with a computational version of univalence and use them as a base to implement effective logical model transformation so that the power of the internal logic of the proof assistant needed to prove the correctness of a program can be decided and changed at compile time—according to a trade-off between efficiency and logical expressivity. Our approach is based on a radically new compilation phase technique into a core type theory to modularize the difficulty of finding a decidable type checking algorithm for homotopy type theory. The impact of the CoqHoTT project will be very strong. Even if Coq is already a success, this project will promote it as a major proof assistant, for both computer scientists and mathematicians. CoqHoTT will become an essential tool for program certification and formalization of mathematics.

9.3.1.2. *BigStorage*

Title: BigStorage: Storage-based Convergence between HPC and Cloud to handle Big Data

Programm: H2020

Duration: January 2015 - December 2018

Coordinator: Universidad politecnica de Madrid

Partners:

Barcelona Supercomputing Center - Centro Nacional de Supercomputacion (Spain)

Ca Technologies Development Spain (Spain)

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

Deutsches Klimarechenzentrum (Germany)

Foundation for Research and Technology Hellas (Greece)

Fujitsu Technology Solutions (Germany)

Johannes Gutenberg Universitaet Mainz (Germany)

Universidad Politecnica de Madrid (Spain)

Seagate Systems Uk (United Kingdom)

Inria contact: G. Antoniu & A. Lebre

The consortium of this European Training Network (ETN) 'BigStorage: Storage-based Convergence between HPC and Cloud to handle Big Data' will train future data scientists in order to enable them and us to apply holistic and interdisciplinary approaches for taking advantage of a data-overwhelmed world, which requires HPC and Cloud infrastructures with a redefinition of storage architectures underpinning them - focusing on meeting highly ambitious performance and energy usage objectives. There has been an explosion of digital data, which is changing our knowledge about the world. This huge data collection, which cannot be managed by current data management systems, is known as Big Data. Techniques to address it are gradually combining with what has been traditionally known as High Performance Computing. Therefore, this ETN will focus on the convergence of Big Data, HPC, and Cloud data storage, its management and analysis. To gain value from Big Data it must be addressed from many different angles: (i) applications, which

can exploit this data, (ii) middleware, operating in the cloud and HPC environments, and (iii) infrastructure, which provides the Storage, and Computing capable of handling it. Big Data can only be effectively exploited if techniques and algorithms are available, which help to understand its content, so that it can be processed by decision-making models. This is the main goal of Data Science. We claim that this ETN project will be the ideal means to educate new researchers on the different facets of Data Science (across storage hardware and software architectures, large-scale distributed systems, data management services, data analysis, machine learning, decision making). Such a multifaceted expertise is mandatory to enable researchers to propose appropriate answers to applications requirements, while leveraging advanced data storage solutions unifying cloud and HPC storage facilities.'

9.4. International Initiatives

9.4.1. Inria International Partners

9.4.1.1. Informal International Partners

National University of Singapore (NUS): We collaborate on resource management for workflows in the cloud and optimizing graph processing in geo-distributed data-centers.

9.5. International Research Visitors

9.5.1. Visits to International Teams

9.5.1.1. Research Stays Abroad

HUST and ShenZhen University, China: From October 28 to November 11, S. Ibrahim visited the Services Computing Technology and System Lab at Huazhong university of Science and Technology and the National High Performance Computing Center at Shenzhen University.

ASPI Team

7. Partnerships and Cooperations

7.1. Regional initiatives

7.1.1. *Stochastic Model-Data Coupled Representations for the Upper Ocean Dynamics (SEACS) — inter labex project*

Participants: François Le Gland, Valérie Monbet.

January 2015 to December 2017.

This is a joint research initiative supported by the three labex active in Brittany, **CominLabs (Communication and Information Sciences Laboratory)**, **Lebesgue (Centre de Mathématiques Henri Lebesgue)** and **LabexMER (Frontiers in Marine Research)**.

This project aims at exploring novel statistical and stochastic methods to address the emulation, reconstruction and forecast of fine-scale upper ocean dynamics. The key objective is to investigate new tools and methods for the calibration and implementation of novel sound and efficient oceanic dynamical models, combining

- recent advances in the theoretical understanding, modeling and simulation of upper ocean dynamics,
- and mass of data routinely available to observe the ocean evolution.

In this respect, the emphasis will be given to stochastic frameworks to encompass multi-scale/multi-source approaches and benefit from the available observation and simulation massive data. The addressed scientific questions constitute basic research issues at the frontiers of several disciplines. It crosses in particular advanced data analysis approaches, physical oceanography and stochastic representations. To develop such an interdisciplinary initiative, the project gathers a set of research groups associated with these different scientific domains, which have already proven for several years their capacities to interact and collaborate on topics related to oceanic data and models. This project will place Brittany with an innovative and leading expertise at the frontiers of computer science, statistics and oceanography. This transdisciplinary research initiative is expected to resort to significant advances challenging the current thinking in computational oceanography.

7.2. National initiatives

7.2.1. *Computational Statistics and Molecular Simulation (COSMOS) — ANR challenge Information and Communication Society*

Participant: Frédéric Cérou.

Inria contract ALLOC 9452 — January 2015 to December 2017.

The COSMOS project aims at developing numerical techniques dedicated to the sampling of high-dimensional probability measures describing a system of interest. There are two application fields of interest: computational statistical physics (a field also known as molecular simulation), and computational statistics. These two fields share some common history, but it seems that, in view of the quite recent specialization of the scientists and the techniques used in these respective fields, the communication between molecular simulation and computational statistics is not as intense as it should be.

We believe that there are therefore many opportunities in considering both fields at the same time: in particular, the adaption of a successful simulation technique from one field to the other requires first some abstraction process where the features specific to the original field of application are discarded and only the heart of the method is kept. Such a cross-fertilization is however only possible if the techniques developed in a specific field are sufficiently mature: this is why some fundamental studies specific to one of the application fields are still required. Our belief is that the embedding in a more general framework of specific developments in a given field will accelerate and facilitate the diffusion to the other field.

7.2.2. Advanced Geophysical Reduced–Order Model Construction from Image Observations (GERONIMO) — ANR programme Jeunes Chercheuses et Jeunes Chercheurs

Participant: Patrick Héas.

Inria contract ALLOC 8102 — March 2014 to February 2018.

The GERONIMO project aims at devising new efficient and effective techniques for the design of geophysical reduced–order models (ROMs) from image data. The project both arises from the crucial need of accurate low–order descriptions of highly–complex geophysical phenomena and the recent numerical revolution which has supplied the geophysical scientists with an unprecedented volume of image data. Our research activities are concerned by the exploitation of the huge amount of information contained in image data in order to reduce the uncertainty on the unknown parameters of the models and improve the reduced–model accuracy. In other words, the objective of our researches is to process the large amount of incomplete and noisy image data daily captured by satellites sensors to devise new advanced model reduction techniques. The construction of ROMs is placed into a probabilistic Bayesian inference context, allowing for the handling of uncertainties associated to image measurements and the characterization of parameters of the reduced dynamical system.

7.3. European initiatives

7.3.1. Molecular Simulation: Modeling, Algorithms and Mathematical Analysis (MSMaths) — ERC Consolidator Grant

Participant: Mathias Rousset.

January 2014 to December 2019.

PI: Tony Lelièvre, Civil Engineer in Chief, Ecole des Ponts Paris-Tech.

Note that 1/3 of Mathias Rousset research activities are held within the MSMATH ERC project.

With the development of large–scale computing facilities, simulations of materials at the molecular scale are now performed on a daily basis. The aim of these simulations is to understand the macroscopic properties of matter from a microscopic description, for example, its atomistic configuration.

In order to make these simulations efficient and precise, mathematics have a crucial role to play. Indeed, specific algorithms have to be used in order to bridge the time and space scales between the atomistic level and the macroscopic level. The objective of the **MSMath** ERC project is thus to develop and study efficient algorithms to simulate high–dimensional systems over very long times. These developments are done in collaboration with physicists, chemists and biologists who are using these numerical methods in an academic or industrial context.

In particular, we are developing mathematical tools at the interface between the analysis of partial differential equations and stochastic analysis in order to characterize and to quantify the metastability of stochastic processes. Metastability is a fundamental concept to understand the timescale separation between the microscopic model and the macroscopic world. Many algorithms which aim at bridging the timescales are built using this timescale separation.

7.3.2. Design of Desalination Systems Based on Optimal Usage of Multiple Renewable Energy Sources (DESIREs) — ERANETMED NEXUS–14–049

Participant: Valérie Monbet.

January 2016 to December 2018.

This project is funded by the ERA–NET Initiative ERANETMED (Euro–Mediterranean Cooperation through ERA–NET Joint Activities and Beyond). It is a collaboration with Greece, Tunisia and Morocco, coordinated by Technical University of Crete (TUC). The French staff includes: Pierre Ailliot (Université de Bretagne Occidentale, Brest), Denis Allard (INRA Avignon), Anne Cuzol (Université de Bretagne Sud, Vannes), Christophe Maisondieu (IFREMER Brest) and Valérie Monbet.

The aim of **DESIRES** is to develop an Internet-based, multi-parametric electronic platform for optimum design of desalination plants, supplied by renewable energy sources (RES). The platform will rely upon (i) a solar, wind and wave energy potential database, (ii) existing statistical algorithms for processing energy-related data, (iii) information regarding the inter-annual water needs, (iv) a database with the technical characteristics of desalination plant units and the RES components, and (v) existing algorithms for cost effective design, optimal sizing and location selection of desalination plants.

7.4. International initiatives

7.4.1. *Rare event simulation in epidemiology — PhD project at université de Ziguinchor*

Participants: Ramatoulaye Dabo, François Le Gland.

This is the subject of the PhD project of Ramatoulaye Dabo (université Assane Seck de Ziguinchor and université de Rennes 1).

The question here is to develop adaptive multilevel splitting algorithms for models that are commonly used in epidemiology, such as SIR (susceptible, infectious, recovered) models [26], or more complex compartmental models. A significant advantage of adaptive multilevel splitting is its robustness, since it does not require too much knowledge about the behavior of the system under study. An interesting challenge would be to understand how to couple the algorithm with numerically efficient simulation methods such as τ -leaping [35]. Complexity bounds and estimation error bounds could also be studied.

7.5. International research visitors

7.5.1. *Visits to international teams*

Patrick Héas has been invited to present his work on 3D wind field reconstruction by infrared sounding, at EUMETSAT (European Organisation for the Exploitation of Meteorological Satellites) in Darmstadt in February 2017.

CAIRN Project-Team

8. Partnerships and Cooperations

8.1. National Initiatives

8.1.1. *Labex CominLabs - 3DCORE (2014-2018)*

Participants: Olivier Sentieys, Daniel Chillet, Cédric Killian, Jiating Luo, Van Dung Pham, Ashraf El-Antably.

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

8.1.2. *Labex CominLabs - RELIASIC (2014-2018)*

Participants: Emmanuel Casseau, Imran Wali.

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

8.1.3. *Labex CominLabs & Lebesgue - H-A-H (2014-2017)*

Participants: Arnaud Tisserand, Gabriel Gallin, Audrey Lucas.

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

8.1.4. *Labex CominLabs - BBC (2016-2020)*

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

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

8.1.5. *Labex CominLabs - SHERPAM (2014-2018)*

Participant: Patrice Quinton.

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

8.1.6. DGA RAPID - FLODAM (2017–2021)

Participants: Olivier Sentieys, Angeliki Kritikakou.

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

8.2. European Initiatives

8.2.1. H2020 ARGO

Participants: Steven Derrien, Olivier Sentieys, Imen Fassi, Ali Hassan El Moussawi.

Program: H2020-ICT-04-2015

Project acronym: ARGO

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

Duration: Feb. 2016 - Feb. 2019

Coordinator: KIT

Other partners: KIT (DE), UR1/Inria/CAIRN (FR), Recore Systems (NL), TEI-WG (GR), Scilab Ent. (FR), Absint (DE), DLR (DE), Fraunhofer (DE)

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

8.2.2. ANR International ARTEFaCT

Participants: Olivier Sentieys, Benjamin Barrois, Tara Petric, Tomofumi Yuki.

Program: ANR International France-Switzerland

Project acronym: ARTEFaCT

Project title: AppRoximaTivE Flexible Circuits and Computing for IoT

Duration: Feb. 2016 - Dec. 2019

Coordinator: CEA

Other partners: CEA-LETI (FR), CAIRN (FR), EPFL (SW)

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

8.3. International Initiatives

8.3.1. Inria Associate Teams

8.3.1.1. IoTA

Title: Ultra-Low Power Computing Platform for IoT leveraging Controlled Approximation

International Partner (Institution - Laboratory - Researcher):

Ecole Polytechnique Fédérale de Lausanne (Switzerland) - Christian Enz

Start year: 2017

See also: <https://team.inria.fr/cairn/IOTA>

Energy issues are central to the evolution of the Internet of Things (IoT), and more generally to the ICT industry. Current low-power design techniques cannot support the estimated growth in number of IoT objects and at the same time keep the energy consumption within sustainable bounds, both on the IoT node side and on cloud/edge-cloud side. This project aims to build on the preliminary results on inexact and exact sub/near-threshold circuit design to achieve major energy consumption reductions by enabling adaptive accuracy control of applications. Advanced ultra low-power hardware design methods utilize very low supply voltage, such as in near-threshold and sub-threshold designs. These emerging technologies are very promising avenues to decrease active and stand-by-power in electronic devices. To move another step forward, recently, approximate computing has become a major field of research in the past few years. IoTA proposes to address, in a consistent fashion, the entire design stack, from hardware design, up to software application analysis, compiler optimizations, and dynamic energy management. We do believe that combining sub-near-threshold with inexact circuits on the hardware side and, in addition, extending this with intelligent and adaptive power management on the software side will produce outstanding results in terms of energy reduction, i.e., at least one order of magnitude, in IoT. The main scientific challenge is twofold: (1) to add adaptive accuracy to hardware blocks built in near/sub threshold technology and (2) to provide the tools and methods to program and make efficient use of these hardware blocks for applications in the IoT domain. This entails developing approximate computing units, on one side, and methods and tools, on the other side, to rigorously explore trade-offs between accuracy and energy consumption in IoT systems. The expertise of the members of the two teams

is complementary and covers all required technical knowledge necessary to reach our objectives, i.e., ultra low power hardware design (EPFL), approximate operators and functions (Inria, EPFL), formal analysis of precision in algorithms (Inria), and static and dynamic energy management (Inria, EPFL). Finally, the proof of concept will consist of results on (1) an adaptive, inexact or exact, ultra-low power microprocessor in 28 nm process and (2) a real prototype implemented in an FPGA platform combining processors and hardware accelerators. Several software use-cases relevant for the IoT domain will be considered, e.g., embedded vision, IoT sensors data fusion, to practically demonstrate the benefits of our approach.

8.3.2. *Inria International Partners*

8.3.2.1. *LRS*

Title: Loop unRolling Stones: compiling in the polyhedral model

International Partner (Institution - Laboratory - Researcher):

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

8.3.2.2. *HARAMCOP*

Title: Hardware accelerators modeling using constraint-based programming

International Partner (Institution - Laboratory - Researcher):

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

8.3.2.3. *SPINACH*

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

International Partner (Institution - Laboratory - Researcher):

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

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

8.3.2.4. *DARE*

Title: Design space exploration Approaches for Reliable Embedded systems

International Partner (Institution - Laboratory - Researcher):

IMEC (Belgium) - Francky Catthoor

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

8.3.2.5. *Informal International Partners*

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

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

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

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

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

8.4. International Research Visitors

8.4.1. *Visits of International Scientists*

Mattia Cacciotti, Ecole Polytechnique Fédérale de Lausanne (Switzerland), from May 2017 until June 2017.

Emna Hammami, University of Tunis, from April 2017 until June 2017.

Prof. Stanislaw Piestrak, Univ de Lorraine, June 2017.

8.4.2. Visits to International Teams

P. Quinton was invited in Passau University (Passau, Germany) by Prof. Chris Lengauer during one week in June 2017, and gave an invited seminar on the synthesis of parallel architectures.

P. Quinton was invited by Prof. Daniel Massicotte of Université de Trois-Rivières (Québec) in October 2017 to cooperate on the design of FPGA hardware accelerators for electric simulation. His stay was supported by a grant of the RESMIQ (regroupement stratégique en microsystemes du Québec). He gave an invited seminar on the synthesis of data-flow parallel systems.

8.4.3. Sabbatical programme

Casseau Emmanuel

Date: Aug 2016 - Jul 2017

Institution: **University of Auckland** (New Zealand), Parallel and Reconfigurable Research Lab. of the Electrical and Computer Engineering department.

The goal of the project was to propose dynamic mapping and scheduling algorithms dedicated to unreliable heterogeneous platforms, enabling self-adaptive and resource-aware computing.

CELTIQUE Project-Team

5. Partnerships and Cooperations

5.1. National Initiatives

5.1.1. *The ANR AnaStaSec project*

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

Static program analysis, Security, Secure compilation

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

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

5.1.2. *The ANR Binsec project*

Participants: Frédéric Besson, Sandrine Blazy, Pierre Wilke, Julien Lepiller.

Binary code, Static program analysis

The **Binsec** project (2013–2017) is funded by the call ISN 2012, a program of the Agence Nationale de la Recherche. The goal of the BINSEC project is to develop static analysis techniques and tools for performing automatic security analyses of binary code. We target two main applicative domains: vulnerability analysis and virus detection.

Binsec is a joint project with the Inria CARTE team, CEA LIS, VERIMAG and EADS IW.

5.1.3. *The ANR MALTHY project*

Participant: David Cachera.

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

5.1.4. *The ANR AJACS project*

Participants: Martin Bodin, Gurvan Cabon, Thomas Jensen, Alan Schmitt.

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

The project partners include the following Inria teams: Celtique, Indes, Prosecco, and Toccata; it also involves researchers from Imperial College as external collaborators. The project runs from December 2014 to November 2018.

5.1.5. The ANR DISCOVER project

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

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

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

The project runs from October 2014 to September 2019.

5.2. European Initiatives

5.2.1. Collaborations in European Programs, Except FP7 & H2020

Program: CA COST Action CA15123

Project acronym: EUTYPES

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

Duration: 03/2016 to 03/2020

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

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

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

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

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

5.3. International Initiatives

5.3.1. Inria International Partners

5.3.1.1. Declared Inria International Partners

WEBCERT

Title: Verified Trustworthy web Applications

International Partner (Institution - Laboratory - Researcher):

Imperial College London - Department of Computing - Philippa Gardner

Duration: 2015 - 2019

Start year: 2015

See also: [JSCert web page](#)

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

CIDRE Project-Team

9. Partnerships and Cooperations

9.1. Regional Initiatives

- **Region Bretagne ARED Grant** : the PhD of Mourad Leslous on malicious codes in Android applications is supported by a grant from the Région Bretagne.
- **Labex COMINLABS contract (2014-2017): "Kharon-Security"** - <http://kharon.gforge.inria.fr>

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

In the project we have already developed GroddDroid a tool dedicated to automatic identification and execution of suspicious code. We have also built a dataset of Android malware. In this dataset, all malware are entirely manually reverse and documented. We have also developed an analysis platform. This platform is been deployed at the High Research Laboratory.

- **Labex COMINLABS contract (2015-2018): "HardBlare-Security"** - <http://www.hardblare.cominlabs.ueb.eu/>

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

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

- **Labex COMINLABS contract (2016-2019): "BigClin"** - <http://www.bigclin.cominlabs.ueb.eu/>

Health Big Data (HBD) is more than just a very large amount of data or a large number of data sources. The data collected or produced during the clinical care process can be exploited at different levels and across different domains, especially concerning questions related to clinical and translational research. To leverage these big, heterogeneous, sensitive and multi-domain clinical data,

new infrastructures are arising in most of the academic hospitals, which are intended to integrate, reuse and share data for research.

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

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

9.2. National Initiatives

9.2.1. ANR

- **ANR INFRA Project: SOCIOPLUG (2013-2017)** - http://socioplug.univ-nantes.fr/index.php/SocioPlug_Project

SocioPlug is a collaborative ANR project involving Inria (ASAP and CIDRE teams), the Nantes University, and LIRIS (INSA Lyon and Université Claude Bernard Lyon). The project emerges from the observation that the features offered by the Web 2.0 or by social media do not come for free. Rather they bring the implicit cost of privacy. Users are more or less consciously selling personal data for services. SocioPlug aims to provide an alternative for this model by proposing a novel architecture for large-scale, user centric applications. Instead of concentrating information of cloud platforms owned by a few economic players, we envision services made possible by cheap low-end plug computers available in every home or workplace. This will make it possible to provide a high amount of transparency to users, who will be able to decide their own optimal balance between data sharing and privacy.

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

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

9.3. International Initiatives

9.3.1. Inria International Partners

9.3.1.1. Informal International Partners

Emmanuelle Anceaume is actively working with Leonardo Querzoni from the University La Sapienza, Italy, on data streams algorithms and engines. Their cooperation gave rise to one publication in *Algotel* 2017 [25].

Valérie Viet Triem Tong has shortly visited Prof Alexander Pretchner at TU Munchen in June 2017. She has participated to a workshop about Android Malware analysis.

9.4. International Research Visitors

9.4.1. Research Stays Abroad

In the context of the project with HP Inc Labs, Ronny Chevalier and Guillaume Hiet collaborate with the security team of HP Labs in Bristol. They are working more specifically with David Plaquin and Maugan Villatel, who are co-authors of the article published at ASCAC. Ronny Chevalier has spent 3 months at HP Labs at Bristol.

Mounir Nasr Allah is currently visiting ARM R&D labs at Cambridge for 6 months in the context of the HardBlare project. This visit has been funded by the EIT Digital Doctoral School Program. He is working with **Alastair Reid** on the use of formal methods to prove that some hardware security mechanisms of ARM embedded processors effectively enforce information flow policies.

Mourad Leslous did an international mobility of three months at the Technical University of Munich, in the team of Professor Alexander Pretschner. This mobility was part of the program of EIT Digital Doctoral School, a European institute that promotes entrepreneurship and innovation among PhD students. During this mobility, he worked on control flow and data flow dependencies in order to detect the malicious code inside Android applications.

DIONYSOS Project-Team

9. Partnerships and Cooperations

9.1. National Initiatives

9.1.1. ANR

- Sofiène Jelassi is participating at 20% of his time to the IRT BCOM granted by the ANR.
- Yassine Hadjadj-Aoul is participating at 20% of his time to the IRT BCOM granted by the ANR.
- Yann Busnel is a member of the three following projects: SocioPlug granted by the ANR (ANR-13-INFR-0003), INSHARE granted by the ANR (ANR-15-CE19-0024) and BigClin granted by the LabEx CominLabs (ANR-10-LABX-07-01).

9.1.2. IPL (Inria Project Lab) BetterNet

Yassine Hadjadj-Aoul, Gerardo Rubino and Bruno Tuffin are members of the IPL (Inria Project Lab) BetterNet: An Observatory to Measure and Improve Internet Service Access from User Experience, 2016-2020.

BetterNet aims at building and delivering a scientific and technical collaborative observatory to measure and improve the Internet service access as perceived by users. In this Inria Project Lab, we will propose new original user-centered measurement methods, which will associate social sciences to better understand Internet usage and the quality of services and networks. Our observatory can be defined as a vantage point, where: 1) tools, models and algorithms/heuristics will be provided to collect data, 2) acquired data will be analyzed, and shared appropriately with scientists, stakeholders and civil society, and 3) new value-added services will be proposed to end-users.

9.2. European Initiatives

9.2.1. Eurostars Camion Project

Participants: Yassine Hadjadj-Aoul

We were involved in a 30 months Eurostars European Project named Camion, which started on October 2014, aiming at offering cost-efficient, QoE-optimized content delivery, allowing for faster content access, as well as offline operation, while improving wireless network capacity and coverage. Camion is leaded by JCP-Connect, and the partners are a SME (FON) and our team. The project ended by June 2017.

9.2.2. Collaborations in European Programs

9.2.2.1. FINTEROP

Program: H2020-ICT-12-2015

Project acronym: F-Interop

Project title: FIRE+ online interoperability and performance test tools to support emerging technologies from research to standardization and market launch

Duration: November 2015 – October 2018

Coordinator: UPMC-LIP6

Other partners: 9 partners including (F. Sismondi and C. Viho (Dionysos); T. Watteyne (Eva))

Abstract: The goal of F-Interop is to extend FIRE+ with online interoperability and performance test tools supporting emerging IoT-related technologies from research to standardization and to market launch for the benefit of researchers, product development by SME, and standardization processes.

9.2.3. Collaborations with Major European Organizations

Partner 1: Sapienza University of Rome, Italy.

We work with Nicolás Rivetti and Leonardo Querzoni on the analysis of stream processing systems.

9.3. International Initiatives

9.3.1. Inria International Partners

9.3.1.1. Informal International Partners

- We maintain a strong line of collaborations with the Technical University Federico Santa María (UTFSM), Valparaíso, Chile. Over the years, this has taken different forms (associated team Manap, Stic AmSud project “AMMA”, Stic AmSud project “DAT”). In 2017, we had a joint PhD work running (PhD of Nicolás Jara, to be defended at the beginning of next year), and a new joint PhD to be started in 2018 (PhD of Jonathan Olavarría). The first one is on optical network analysis and design, the second one on modeling evaluation techniques, with focus on Stochastic Activity Networks.
- We started a collaboration with the Faculty of Sciences of the university of the Republic, in Uruguay, on the application of mathematical modeling tools to a better understanding of a cognitive disease called semantic dementia. This involves Prof. Eduardo Mizraji and Jorge Graneri, PhD student, whose co-advisors are Prof. Mizraji and G. Rubino from Dionysos. Our contribution to this project is around the use of mathematical models, in particular around neural structures.

9.3.2. Participation in Other International Programs

9.3.2.1. International Initiatives

SM-HCD-HDD

Title: Statistical methods for highly complex and/or high dimensional data

International Partner (Institution - Laboratory - Researcher):

Universidad de la Republica Uruguay (Uruguay), Faculty of Sciences; Resp.: Ricardo Fraiman, Department of Mathematics

CNRS (France); Resp.: Catherine Aaron

Universidad Nacional del Litoral (Argentina); Resp.: Liliana Forzani

Duration: 3 years

Start year: 2016

In this project we work on specific statistical tools, mainly concerning predicting the behavior of time series. Our goal is to improve our tools for Perceptual Quality evaluation.

9.3.2.2. International Initiatives

MOCQUASIN

Title: Monte Carlo and Quasi- Monte Carlo for rare event simulation

International Partner (Institution - Laboratory - Researcher):

Université de Montréal (Canada) - DIRO - Pierre L'Ecuyer

Duration: 3 years

Start year: 2013

See also: http://www.irisa.fr/dionysos/pages_perso/tuffin/MOCQUASIN/

The goal of this team is to compute integrals, sums or to solve equations or optimization problems by means of Monte Carlo methods, which are statistical tools used when the models have a high complexity (for instance a large dimension). They are unavoidable tools in areas such as finance, electronics, seismology, computer science, engineering, physics, transport, biology, social sciences... Nonetheless, they have the reputation of being slow, i.e. to require a large computational time to reach a given precision. The goal of the project is to work on acceleration techniques, meaning methods allowing to reach the targeted precision in a shorter computational time. A typical framework is that of rare event simulation for which getting even only one occurrence of the event of interest could require a very long time. In this case, there are two main acceleration techniques: importance sampling and splitting, on which we work.

9.4. International Research Visitors

9.4.1. Visits of International Scientists

- Pierre L'Ecuyer holds an Inria International Chair, Nov. 2013- Oct. 2018.
- Marvin Nakayama (New Jersey Institute of Technology, NJ, USA) visited us 3 days in October to work on the estimation of quantiles in the case of rare events.
- Jonathan Olavarría, from UTFSM, Chile, from January to March (for two months), to work on stochastic models.
- Prof. Leslie Murray, from University of Rosario, Argentina (one month, February) to work on Monte Carlo techniques for rare event analysis.
- Jorge Graneri, from UDELAR, Uruguay (two months in the last quarter of the year, to work on biological applications).
- Prof. Claudio Risso, from UDELAR, Uruguay (two weeks in the last quarter of the year, to work on time series predictions).
- Prof. Gustavo Guerberoff, from UDELAR, Uruguay (two weeks in the last quarter of the year, to work on time series predictions).

DIVERSE Project-Team

9. Partnerships and Cooperations

9.1. National Initiatives

9.1.1. ANR

9.1.1.1. SOPRANO

- Coordinator: CEA
- CEA, University of Paris-Sud, Inria Rennes, OcamlPro, Adacore
- Dates: 2014-2017
- Abstract: Today most major verification approaches rely on automatic external solvers. However these solvers do not fill the current and future needs for verification: lack of satisfying model generation, lack of reasoning on difficult theories (e.g. floating-point arithmetic), lack of extensibility for specific or new needs. The SOPRANO project aims at solving these problems and prepare the next generation of verification-oriented solvers by gathering experts from academia and industry. We will design a new framework for the cooperation of solvers, focused on model generation and borrowing principles from SMT (current standard) and CP (well-known in optimisation). These ideas will be implemented in an open-source platform, with regular evaluations from the industrial partners.

9.1.1.2. VaryVary ANR JCJC

- Coordinator: Mathieu Acher
- DiverSE, Inria/IRISA Rennes
- Dates: 2017-2021
- Abstract: Most modern software systems (operating systems like Linux, Web browsers like Firefox or Chrome, video encoders like x264 or ffmpeg, servers, mobile applications, etc.) are subject to variation or come in many variants. Hundreds of configuration options, features, or plugins can be combined, each potentially with distinct functionality and effects on execution time, memory footprint, etc. Among configurations, some of them are chosen and do not compile, crash at runtime, do not pass a test suite, or do not reach a certain performance quality (e.g., energy consumption, security). In this JCJC ANR project, we follow a thought-provocative and unexplored direction: We consider that the variability boundary of a software system can be specialized and should vary when needs be. The goal of this project is to provide theories, methods and techniques to make vary variability. Specifically, we consider machine learning and software engineering techniques for narrowing the space of possible configurations to a good approximation of those satisfying the needs of users. Based on an oracle (e.g., a runtime test) that tells us whether a given configuration meets the requirements (e.g. speed or memory footprint), we leverage machine learning to retrofit the acquired constraints into a variability that can be used to automatically specialize the configurable system. Based on a relative small number of configuration samples, we expect to reach high accuracy for many different kinds of oracles and subject systems. Our preliminary experiments suggest that varying variability can be practically useful and effective. However, much more work is needed to investigate sampling, testing, and learning techniques within a variety of cases and application scenarios. We plan to further collect large experimental data and apply our techniques on popular, open-source, configurable software (like Linux, Firefox, ffmpeg, VLC, Apache or JHipster) and generators for media content (like videos, models for 3D printing, or technical papers written in LaTeX).

9.1.1.3. CLARITY

- Coordinator: Obéo
- Other partners: AIRBUS, Airbus Defence and Space, All4tec, ALTRAN Technologies, AREVA, Artal, C.E.S.A.M.E.S., Eclipse Foundation Europe, Inria Sophia Antipolis Méditerranée, PRFC, Scilab Enterprises, Thales Global Services, Thales Alenia Space, Thales Research & Technology, Thales Systèmes Aéroportés, Université de Rennes 1.
- Dates: 2014-2017
- Abstract: The CLARITY project aims to establish an international dimension ecosystem around Melody/Capella modeling workbench for systems engineering (MBSE) and engineering architectures (system, software, hardware).

9.1.1.4. Occiware

- Coordinator: Open Wide
- Open Wide, ActiveEon SA, CSRT - Cloud Systèmes Réseaux et Télécoms, Institut Mines-Télécom/Télécom SudParis, Inria, Linagora, Obeo, OW2 Consortium, Pôle Numérique, Université Joseph Fourier,
- Dates: 2014-2017
- Abstract: The Occiware project aims to establish a formal and equipped framework for the management of all cloud resource based on the OCCI standard.

9.1.2. DGA

9.1.2.1. FPML (CYBERDEFENSE)

- Coordinator: DGA
- Partners: DGA MI, Inria
- Dates: 2014-2017
- Abstract: in the context of this project, DGA-MI and the Inria team DiverSE explore the existing approaches to ease the development of formal specifications of domain-Specific Languages (DSLs) dedicated to paquet filtering, while guaranteeing expressiveness, precision and safety. In the long term, this work is part of the trend to provide to DGA-MI and its partners a tooling to design and develop formal DSLs which ease the use while ensuring a high level of reasoning.

9.1.3. Cominlabs

9.1.3.1. PROFILE

- Coordinator: Université de Rennes 1
- Partners: Inria, Université de Rennes 2
- Dates: 2016-2019
- Abstract: The PROFILE project brings together experts from law, computer science and sociology to address the challenges raised by online profiling, following a multidisciplinary approach. More precisely, the project will pursue two complementary and mutually informed lines of research: (i) Investigate, design, and introduce a new right of opposition into the legal framework of data protection to better regulate profiling and to modify the behavior of commercial companies towards being more respectful of the privacy of their users; (ii) Provide users with the technical means they need to detect stealthy profiling techniques as well as to control the extent of the digital traces they routinely produce. As a case study, we focus on browser fingerprinting, a new profiling technique for targeted advertisement. The project will develop a generic framework to reason on the data collected by profiling algorithms, to uncover their inner working, and make them more accountable to users. PROFILE will also propose an innovative protection to mitigate browser fingerprinting, based on the collaborative reconfiguration of browsers.

9.2. European Initiatives

9.2.1. FP7 & H2020 Projects

9.2.1.1. FP7 STREP HEADS

- Coordinator: SINTEF
- Other partners: Inria, Software AG, ATC, Tellu, eZmonitoring
- Dates: 2013-2017
- Abstract: The idea of the HEADS project is to leverage model-driven software engineering and generative programming techniques to provide a new integrated software engineering approach which allow advanced exploitation the full range of diversity and specificity of the future computing continuum. The goal is to empower the software and services industry to better take advantage of the opportunities of the future computing continuum and to effectively provide new innovative services that are seamlessly integrated to the physical world making them more pervasive, more robust, more reactive and closer (physically, socially, emotionally, etc.) to their users. We denote such services HD-services. HD-services (Heterogeneous and Distributed services) characterize the class of services or applications within the Future Internet whose logic and value emerges from a set of communicating software components distributed on a heterogeneous computing continuum from clouds to mobile devices, sensors and/or smart-objects.

9.2.1.2. H2020 ICT-10-2016 STAMP

- Coordinator: Inria Rennes
- Other partners: ATOS, ActiveEon, OW2, TellU, Engineering, XWiki, TU Delft, SINTEF
- Dates: 2016-2019
- Abstract: Leveraging advanced research in automatic test generation, STAMP aims at pushing automation in DevOps one step further through innovative methods of test amplification. It will reuse existing assets (test cases, API descriptions, dependency models), in order to generate more test cases and test configurations each time the application is updated. Acting at all steps of development cycle, STAMP techniques aim at reducing the number and cost of regression bugs at unit level, configuration level and production stage.

STAMP will raise confidence and foster adoption of DevOps by the European IT industry. The project gathers 3 academic partners with strong software testing expertise, 5 software companies (in: e-Health, Content Management, Smart Cities and Public Administration), and an open source consortium. This industry-near research addresses concrete, business-oriented objectives. All solutions are open source and developed as microservices to facilitate exploitation, with a target at TRL 6.

9.2.2. Collaborations with Major European Organizations

- SINTEF, ICT (Norway): Model-driven systems development for the construction of distributed, heterogeneous applications. We collaborate since 2008 and are currently in two FP7 projects together.
- Université du Luxembourg, (Luxembourg): Models runtime for dynamic adaptation and multi-objective elasticity in cloud management; model-driven development.
- KTH, the Royal Institute of Technology (Sweden): continuous software testing, perturbation and diversification.

9.3. International Initiatives

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

9.3.1.1. ALE

- Title: Agile Language Engineering

- International Partner (Institution - Laboratory - Researcher):
 - CWI (Netherlands)
- Start year: 2017
- See also: <http://gemoc.org/ale/>
- Software engineering faces new challenges with the advent of modern software-intensive systems such as complex critical embedded systems, cyber-physical systems and the Internet of things. Application domains range from robotics, transportation systems, defense to home automation, smart cities, and energy management, among others. Software is more and more pervasive, integrated into large and distributed systems, and dynamically adaptable in response to a complex and open environment. As a major consequence, the engineering of such systems involves multiple stakeholders, each with some form of domain-specific knowledge, and with an increasingly use of software as an integration layer. Hence more and more organizations are adopting Domain Specific Languages (DSLs) to allow domain experts to express solutions directly in terms of relevant domain concepts. This new trend raises new challenges about designing DSLs, evolving a set of DSLs and coordinating the use of multiple DSLs for both DSL designers and DSL users. ALE will contribute to the field of Software Language Engineering, aiming to provide more agility to both language designers and language users. The main objective is twofold. First, we aim to help language designers to leverage previous DSL implementation efforts by reusing and combining existing language modules. Second, we aim to provide more flexibility to language users by ensuring interoperability between different DSLs and offering live feedback about how the model or program behaves while it is being edited (aka. live programming/modeling).

9.3.2. *Inria International Partners*

9.3.2.1. *Informal International Partners*

- Université de Montréal (Canada)
- McGill University (Canada)
- University of Alabama (USA)
- TU Wien (Austria)
- Michigan State University (MSU)
- Aachen University (Germany)
- KTH (Sweden)

9.3.3. *Participation in Other International Programs*

The GEMOC studio has been sustained through the creation of a Research Consortium at the Eclipse Foundation.

9.3.4. *International initiative GEMOC*

The GEMOC initiative (cf. <http://www.gemoc.org>) is an open and international initiative launched in 2013 that coordinate research partners worldwide to develop breakthrough software language engineering (SLE) approaches that support global software engineering through the use of multiple domain-specific languages. GEMOC members aim to provide effective SLE solutions to problems associated with the design and implementation of collaborative, interoperable and composable modeling languages.

The GEMOC initiative aims to provide a framework that facilitates collaborative work on the challenges of using of multiple domain-specific languages in software development projects. The framework consists of mechanisms for coordinating the work of members, and for disseminating research results and other related information on GEMOC activities. The framework also provides the required infrastructure for sharing artifacts produced by members, including publications, case studies, and tools.

The governance of the GEMOC initiative is ensured by the Advisory Board. The role of the Advisory Board is to coordinate the GEMOC work and to ensure proper dissemination of work products and information about GEMOC events (e.g., meetings, workshops).

Benoit Combemale is the co-founder and currently acts as principal coordinator of the GEMOC initiative. Benoit Combemale and Jean-Marc Jézéquel are part of the Advisory Board, and 9 DIVERSE members are part of the GEMOC initiative.

9.4. International Research Visitors

9.4.1. Visits of International Scientists

Yves Le Traon, Professor at the University of Luxembourg, visited the team in June and July 2017.

Tanja Mayerhofer, Junior Researcher at the TU Wien, visited the team in March 2017.

François Fouquet, Junior Researcher at the SnT (Lux), visited the team in November 2017.

9.4.1.1. Internships

Koko armando Nguepi kenfack, Master interns at the University of Namur, visited the team from September 2017 to January 2018.

9.4.2. Visits to International Teams

Manuel Leduc visited CWI for 3 weeks in September 2017

Benoit Combemale visited Professor Jorg Kienzle at McGill University (Canada) for 3 months in 2017; and made several short visits at CWI (The Netherlands).

9.4.2.1. Research Stays Abroad

Marcelino Rodriguez-Cancio visited Vanderbilt University from November 2016 to September 2017.

DYLISS Project-Team

9. Partnerships and Cooperations

9.1. Regional Initiatives

9.1.1. Regional initiative: the Ecosyst project

Participants: Damien Eveillard, Marie Chevallier, Clémence Frioux, Anne Siegel, Camille Trottier.

EcoSyst is a Biogenouest inter-regional federating project (Brittany & Pays de la Loire) aiming at the emergence of Systems Ecology at the level of western France regions. Drawing on the strengths and skills involved, EcoSyst targets the incubation of new ideas and new projects at disciplinary interfaces. Thanks to this community project, we want to develop the skills of Ecology, Environment, Modeling, Bioinformatics and Systems Biology and their application to organisms and ecosystems of interest in agronomy, sea and health. EcoSyst includes also the identification of the major issues and concerns, the fundamental and essential methods and the very real needs of the community (training, tools, ...); this in order to consider the construction of a community platform (or an offer of service within an existing platform) on complex systems modeling, meeting expectations of the community as fully as possible.

9.1.2. Regional partnership with computer science laboratories in Nantes

Participants: Anne Siegel, Jérémie Bourdon, Damien Eveillard, François Coste, Maxime Folschette, Jacques Nicolas.

Methodologies are developed in close collaboration with the LS2N (fusion of LINA and IRCCyN) located at University of Nantes and École centrale de Nantes. This is acted through the Biotempo and Idealg ANR projects and co-development of common software toolboxes within the Renabi-GO platform support. C. Trottier is a co-supervised bioanalysis and software development engineer within the Idealg project. M. Chevallier is a co-supervised development and animation engineer within the regional initiative "Ecosyst". In addition, the ongoing Ph-D student J. Laniau is co-supervised with a member of the LS2N laboratory. Finally, M. Folschette is a PostDoc working on a project aiming at analyzing TGF-beta-related pathways evolutions after epithelial-mesenchymal transition in liver cancer, which is a recognized biological process leading to metastasis. This project is based on a topic shared with the LS2N: the use of graph coloring and reconstruction to witness expression changes, and is funded by the Université Bretagne Loire.

9.1.3. Regional partnership in Marine Biology

Participants: Meziane Aite, Arnaud Belcour, Catherine Belleannée, Jérémie Bourdon, Jean Coquet, François Coste, Damien Eveillard, Olivier Dameron, Clémence Frioux, Jeanne Got, Julie Laniau, Jacques Nicolas, Camille Trottier, Anne Siegel.

A strong application domain of the Dyliss project is marine Biology. This application domain is co-developed with the station biologique de Roscoff and their three UMR and involves several contracts. Our approach based on parcimonious modelling allowed an in silico characterization of processes required within sea urchin translation [83], [95]. We are also strongly involved in the IDEALG consortium, a long term project (10 years, ANR Investissement avenir) aiming at the development of macro-algae biotechnology. Among the research activities, we are particularly interested in the analysis and reconstruction of metabolism and the characterization of key enzymes. Our methods based on combinatorial optimization for the reconstruction of genome-scale metabolic networks and on classification of enzyme families based on local and partial alignments allowed the *E. Siliculosus* seaweed metabolism to be deciphered [97], [67]. As a further study, we reconstructed the metabolic network of a symbiot bacterium *Ca. P. ectocarpi* [69] and used this reconstructed network to decipher interactions within the **algal-bacteria holobiont** [21].

9.1.4. Regional partnership in agriculture and environmental sciences

Participants: Catherine Belleannée, François Coste, Olivier Dameron, Xavier Garnier, François Moreews, Jacques Nicolas, Anne Siegel, Denis Tagu.

We have a strong and long term collaboration with biologists of INRA in Rennes : PEGASE and IGEPP units. F. Moreews is a permanent engineer from PEGASE center hosted in the team to develop methods for integrative biology applied to species of interest in agriculture. D. Tagu is a research director at INRA/IGEPP who spends 20% of his time in the team to develop collaborative projects. This partnership has been supported by the co-supervision of PhDs, post-docs and engineers. This collaboration was also reinforced by collaboration within ANR contracts (MirNadapt, FatInteger).

In collaboration with researchers from the PEGASE center (INRA) focused on breeding animals, we have contributed to several studies aiming at better integrating and investigating data in order to facilitate animal selection and alimentation. The *NutritionAnalyzer* prototype was developed to understand better the impact of several diaries or treatments for lactary cows over the composition of milk [37]. Our work on the identification of upstream regulators within large-scale knowledge databases (prototype *KeyRegulatorFinder*) [59] and on semantic-based analysis of metabolic networks [54] was also very valuable for interpreting differences of gene expression in pork meat [79] and figure out the main gene-regulators of the response of porks to several diets (see [74], [76] and [18]).

In addition, constraints-based programming also allows us to decipher regulators of reproduction for the pea aphid, an insect that is a pest on plants in the framework of the *MirNAdapt* project. In terms of biological output of the network studies on the pea aphid microRNAs, we have identified one new microRNA (apmir-3019, not present in any known species other than the pea aphid) who has more than 900 putative mRNA targets. All these targets, as well as apmir3019, are differentially expressed between sexual and asexual embryos [85], [119].

9.1.5. Regional partnership in health

Participants: Jean Coquet, Olivier Dameron, Victorien Delannée, Marine Louarn, Anne Siegel, Nathalie Théret, Pierre Vignet.

We also have a strong and long term collaboration in health, namely with the IRSET laboratory at Univ. Rennes 1. N. Théret, research director at INSERM, is hosted in the team to strengthen our collaborative projects. Our collaborations are acted by the co-supervised Ph-D theses of V. Delannée [14], M. Conan (Metagenotox project, funded by Anses) and J. Coquet [12]. This partnership was reinforced by the ANR contract Biotempo ended at the end of 2014. In 2015, the project of combining semantic web technologies and bi-clustering classification based on formal concept analysis was applied to systems biology within the PEPS CONFOCAL project. This scientific project has been recently pushed forward in the recent TGFSYSBio project funded by Plan Cancer on the modelling of the microenvironment of TGFbeta signaling network (P. Vignet has been recruited on this contract at the end of 2016).

A new application was initiated in 2017 through a collaboration with Rennes hospital, supported by a Inria-INSERM Ph-D thesis (M. Louarn).

9.2. National Initiatives

9.2.1. ANR Idealg

Participants: Meziane Aite, Arnaud Belcour, Jérémie Bourdon, Marie Chevallier, François Coste, Damien Eveillard, Clémence Frioux, Jeanne Got, Julie Laniau, Jacques Nicolas, Anne Siegel.

IDEALG is one of the five laureates from the national call 2010 for Biotechnology and Bioresource and will run until 2020. It gathers 18 different partners from the academic field (CNRS, IFREMER, UEB, UBO, UBS, ENSCR, University of Nantes, INRA, AgroCampus), the industrial field (C-WEED, Bezhin Rosko, Aleor, France Haliotis, DuPont) as well as a technical center specialized in seaweeds (CEVA) in order to foster biotechnology applications within the seaweed field. We are participating to the tasks related to the establishment of a virtual platform for integrating omics studies on seaweeds and the integrative analysis of seaweed metabolism, in cooperation with SBR Roscoff. Major objectives are the building of brown algae metabolic maps, flux analysis and the selection of symbiotic bacteria to brown algae. We will also contribute to the prediction of specific enzymes (sulfatases) [\[More details\]](#).

9.2.2. Programs funded by research institutions

9.2.2.1. PEPS PEPS: a platform for supporting studies in pharmaco-epidemiology using medico-administrative databases

Participants: Olivier Dameron, Yann Rivault.

As a partner of the PEPS platform, several teams at Inria Rennes develop generic methods supporting efficient and semantically-rich queries for pharmaco-epidemiology studies on medico-administrative databases. The leader is Thomas Guyet (Inria team Lacodam). We showed that Semantic Web technologies are technically suited for representing patients' data from medico-administrative databases as RDF and querying them using SPARQL. We also demonstrated that this approach is relevant as it supports the combination of patients' data with hierarchical knowledge in order to address the problem of reconciling precise patients data with more general query criteria [\[45\]](#), [\[99\]](#), [\[98\]](#). This work is mostly conducted by Yann Rivault, whose PhD thesis is supervised by Olivier Dameron and Nolwenn LeMeur (Ecole des Hautes Etudes en Santé Publique).

9.2.2.2. Cancer Plan: TGFSysBio

Participants: Jean Coquet, Olivier Dameron, Maxime Folschette, Vijay Ingalalli, Jacques Nicolas, Anne Siegel, Nathalie Théret, Pierre Vignet.

The TGFSYSBIO project aims to develop the first model of extracellular and intracellular TGF-beta system that might permit to analyze the behaviors of TGF-beta activity during the course of liver tumor progression and to identify new biomarkers and potential therapeutic targets. Based on collaboration with Jérôme Feret from ENS, Paris, 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-beta-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-beta. 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. The project is funded by the national program "Plan Cancer - Systems biology" from 2015 to 2018.

9.2.2.3. ANR Samosa

Participants: Mael Conan, Damien Eveillard, Jeanne Got, Anne Siegel.

Oceans are particularly affected by global change, which can cause e.g. increases in average sea temperature and in UV radiation fluxes onto ocean surface or a shrinkage of nutrient-rich areas. This raises the question of the capacity of marine photosynthetic microorganisms to cope with these environmental changes both at short term (physiological plasticity) and long term (e.g. gene alterations or acquisitions causing changes in fitness in a specific niche). *Synechococcus* cyanobacteria are among the most pertinent biological models to tackle this question, because of their ubiquity and wide abundance in the field, which allows them to be studied at all levels of organization from genes to the global ocean.

The SAMOSA project is funded by ANR from 2014 to 2018, coordinated by F. Gaczarek at the Station Biologique de Roscoff/UPMC/CNRS. The goal of the project is to develop a systems biology approach to characterize and model the main acclimation (i.e., physiological) and adaptation (i.e. evolutionary) mechanisms involved in the differential responses of *Synechococcus* clades/ecotypes to environmental fluctuations, with the goal to better predict their respective adaptability, and hence dynamics and distribution, in the context of global change. For this purpose, following intensive omics experimental protocol driven by our colleagues from — Station Biologique de Roscoff —, we aim at constructing a gene network model sufficiently flexible to allow the integration of transcriptomic and physiological data.

9.2.2.4. ANSES Mecagenotox

Participants: Victorien Delannée, Mael Conan, Anne Siegel, Nathalie Théret.

The objective of Mecagenotox project is to characterize and model the human liver ability to bioactivate environmental contaminants during liver chronic diseases in order to assess individual susceptibility to xenobiotics. Indeed, liver pathologies which result in the development of fibrosis are associated with a severe dysfunction of liver functions that may lead to increased susceptibility against contaminants. In this project funded by ANSES and coordinated by S. Langouet at IRSET/inserm (Univ. Rennes 1), we will combine cell biology approaches, biochemistry, biophysics, analytical chemistry and bioinformatics to 1) understand how the tension forces induced by the development of liver fibrosis alter the susceptibility of hepatocytes to certain genotoxic chemicals (especially Heterocyclic Aromatic Amines) and 2) model the behavior of xenobiotic metabolism during the liver fibrosis. Our main goal is to identify "sensitive" biomolecules in the network and to understand more comprehensively bioactivation of environmental contaminants involved in the onset of hepatocellular carcinoma.

9.2.3. Programs funded by Inria

9.2.3.1. ADT Complex-biomarkers and ADT Proof of concept

Participants: Jeanne Got, Marie Chevallier, Meziane Aite, Anne Siegel.

These projects started in Oct. 2014 and aims at designing a working environment based on workflows to assist molecular biologists to integrate large-scale omics data on non-classical species. The main goal of the workflows will be to facilitate the identification of set of regulators involved in the response of a species when challenged by an environmental stress. Applications target extremophile biotechnologies (biomining) and marine biology (micro-algae).

9.2.3.2. IPL Algae in silico

Participants: Meziane Aite, Jeanne Got, Julie Laniau, Anne Siegel.

Microalgae are recognized for the extraordinary diversity of molecules they can contain: proteins, lipids (for biofuel or long chain polyunsaturated fatty acids for human health), vitamins, antioxidants, pigments. The project aims at predicting and optimizing the productivity of microalgae. It involves mainly the inria teams BIOCORE (PI), ANGE and DYLISS. Dyliss is in charge of the identification of physiological functions for microalgae based on their proteomes, which is undergone through the reconstruction of the metabolic network of the *T. lutea* microalgae.

9.2.3.3. IPL Neuromarkers

Participants: Olivier Dameron, Anne Siegel.

The project aims at identifying the main markers of pathologies through the production and the integration of imaging and bioinformatics data. It involves mainly the inria teams Aramis (PI) Dyliss, Genscale and Bonsai. Dyliss is in charge of facilitating the interoperability of imaging and bioinformatics data.

9.2.3.4. FederatedQueryScaler (Exploratory Research Action)

Participants: Olivier Dameron, Xavier Garnier, Vijay Ingalalli.

This project aims at developing automatic generation of abstractions for biological data and knowledge in order to scale federated queries in the context of semantic web technologies. It is a common project with the WIMMICS Inria team.

9.3. European Initiatives

9.3.1. Collaborations with Major European Organizations

Partner: Aachen university (Germany)

Title: Modeling the logical response of a signalling network with constraints-programming.

9.4. International Initiatives

9.4.1. Inria International Labs

9.4.1.1. Other IIL projects

We have a cooperation with Univ. of Chile (MATHomics, A. Maass) on methods for the identification of biomarkers and software for biochip design. It aims at combining automatic reasoning on biological sequences and networks with probabilistic approaches to manage, explore and integrate large sets of heterogeneous omics data into networks of interactions allowing to produce biomarkers, with a main application to biomining bacteria. The program is co-funded by Inria and CORFO-chile from 2012 to 2016. In this context, Integrative-BioChile was an Associate Team between Dyliss and the Laboratory of Bioinformatics and Mathematics of the Genome hosted at Univ. of Chile funded from 2011 to 2016. The collaboration is now supported by Chilean programs.

9.5. International Research Visitors

9.5.1. Visits of International Scientists

- **Niger.** University of Maradi [O. Abdou-Arbi]
- **Poland.** Politechnika Wroclawska [W. Dyrka]
- **India.** VIT University, Vellore [K. Lakshmanan]

9.5.2. Visits to International Labs

- **Chile.** University of Chile [A. Siegel, C. Frioux]

9.5.2.1. Research Stays Abroad

- **Germany.** University of Potsdam [L. Bourneuf, 3 months (nov 2017 - jan 2018)]

FLUMINANCE Project-Team**9. Partnerships and Cooperations****9.1. National Initiatives****9.1.1. Comins'lab: SEACS : Stochastic modEl-dAta-Coupled representationS for the analysis, simulation and reconstruction of upper ocean dynamics****Participants:** Pierre Derian, Cédric Herzet, Etienne Mémin.

duration 48 months. The SEACS project whose acronym stands for: "Stochastic modEl-dAta-Coupled representationS for the analysis, simulation and reconstruction of upper ocean dynamics" is a Joint Research Initiative between the three Brittany clusters of excellence of the "Laboratoires d'Excellence" program: Cominlabs, Lebesgue and LabexMer centered on numerical sciences, mathematics and oceanography respectively. Within this project we aim at studying the potential of large-scale oceanic dynamics modeling under uncertainty for ensemble forecasting and satellite image data assimilation.

9.1.2. ANR JCJC GERONIMO : Advanced GEophysical Reduced-Order Model construction from IMage Observations**Participants:** Mamadou Diallo, Cédric Herzet.

duration 48 months. The GERONIMO project which started in March 2014 aims at devising new efficient and effective techniques for the design of geophysical reduced-order models from image data. The project both arises from the crucial need of accurate low-order descriptions of highly-complex geophysical phenomena and the recent numerical revolution which has supplied the geophysical scientists with an unprecedented volume of image data. The project is placed at the intersection of several fields of expertise (Bayesian inference, matrix factorization, sparse representations, etc.) which will be combined to handle the uncertainties associated to image measurements and to characterize the accurate reduced dynamical systems.

9.1.3. ANR BECOSE : Beyond Compressive Sensing: Sparse approximation algorithms for ill-conditioned inverse problems.**Participants:** Dominique Heitz, Cédric Herzet.

duration 48 months. The BECOSE project aims to extend the scope of sparsity techniques much beyond the academic setting of random and well-conditioned dictionaries. In particular, one goal of the project is to step back from the popular L1-convexification of the sparse representation problem and consider more involved nonconvex formulations, both from a methodological and theoretical point of view. The algorithms will be assessed in the context of tomographic Particle Image Velocimetry (PIV), a rapidly growing imaging technique in fluid mechanics that will have strong impact in several industrial sectors including environment, automotive and aeronautical industries. The consortium gathers the Fluminance and Panama Inria research teams, the Research Center for Automatic Control of Nancy (CRAN), The Research Institute of Communication and Cybernetics of Nantes (IRCCyN), and ONERA, the French Aerospace Lab.

9.1.4. ANR-MN: H2MNO4 project**Participants:** Yvan Crenner, Benjamin Delfino, Jean-Raynald de Dreuz, Jocelyne Erhel, Lionel Lenôtre.

Contract with ANR, program Modèles Numériques

Duration: four years from November 2012 until April 2017.

Title: Original Optimized Object Oriented Numerical Model for Heterogeneous Hydrogeology.

Coordination: Jocelyne Erhel and Géraldine Pichot, with Fabienne Cuyollaa.

Partners: Geosciences Rennes, University of Poitiers, University of Lyon 1, Andra, Itasca.

International collaborations: University of San Diego (USA), UPC, Barcelona (Spain)

Web page: <http://h2mno4.inria.fr/>

Abstract: The project H2MNO4 develops numerical models for reactive transport in heterogeneous media. It defines six mathematical and computational challenges and three applications for environmental problems with societal impact.

9.1.5. GDR MANU

Participants: Yvan Crenner, Jocelyne Erhel, Bastien Hamlat.

Title: Mathematics for Nuclear industry

Duration: From 2016 to 2019

Coordination: C. Cancès

Webpage: <http://gdr-manu.math.cnrs.fr/>

Abstract: The working group MANU is a follow-up to the group MOMAS. It covers many subjects related to mathematical modeling and numerical simulations for problems arising from nuclear industry and nuclear waste disposal. The team organizes a workshop on reactive transport, Paris, February 2018.

9.2. International Initiatives

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

9.2.1.1. LFD-FLU

Title: Large-scale Fluid Dynamics analysis from FLOW Uncertainty

International Partner (Institution - Laboratory - Researcher):

Universidad de Buenos Aires (Argentina) - Department of Computer Science and Electrical Engineering - Guillermo Artana

Start year: 2016

See also: <http://www.irisa.fr/prive/memin/LFD-FLU/>

The first objective of this associate team is primarily concerned with the establishment of efficient fluid flow image data analysis procedures. This concerns for instance data assimilation issues to reconstruct meaningful numerical representation of experimental fluid flows for analysis purpose. The second objective focuses on the incorporation of uncertainties in the flow dynamical evolution models

9.2.1.2. Informal International Partners

Imperial College, London (UK), Collaboration with Dan Crisan and Darryl Holm on Stochastic transport for the upper ocean dynamics

Chico California State University (USA), We have pursued our collaboration with the group of Shane Mayor on the GPU implementation of wavelet based motion estimator for Lidar data. This code is developed in coproperty between Inria and Chico.

9.2.2. Participation in Other International Programs

Royal Society funding, collaboration between Dominique Heitz, Etienne Mémin and Sylvain Laizet (Imperial College) on Stochastic large-eddies simulation and data assimilation for the reconstruction of 3D turbulent flows.

China Scholarship Council funding, Collaboration between Etienne Memin, Shengze Cai and Chao Xu (Zhejiang University, College of Control Science & Engineering), on turbulent motion estimation and modeling under uncertainty.

9.3. International Research Visitors

- 3 weeks visit of Alejandro Gronskis (Researcher Conicet Argentina) to work with Dominique Heitz, Etienne Mémin and Pranav Chandramouli within the associate team LFD
- Sojourn of 12 month of Shengze Cai PhD student in the College of Control Science & Engineering, Zhejiang University to work with Etienne Mémin

GENSCALE Project-Team

9. Partnerships and Cooperations

9.1. Regional Initiatives

9.1.1. Rennes Hospital, Hematology service

Participants: Dominique Lavenier, Patrick Durand.

The collaboration with the Hematology service of the Rennes hospital aims to set up advanced bioinformatics pipelines for cancer diagnosis. More precisely, we evaluated a new method of predictions of small cancer-related mutations (such as SNPs and small insertions/deletions) from raw DNA sequencing data.

9.1.2. Partnership with INRA in Rennes

Participants: Susete Alves Carvalho, Cervin Guyomar, Dominique Lavenier, Fabrice Legeai, Claire Lemaitre, Sebastien Letort, Pierre Peterlongo.

The GenScale team has a strong and long term collaboration with biologists of INRA in Rennes: IGEPP and PEGASE units. This partnership concerns both service and research activities and is acted by the hosting of two INRA engineer (F. Legeai, S. Alves Carvalho) and one PhD student (C. Guyomar).

9.2. National Initiatives

9.2.1. ANR

9.2.1.1. Project HydroGen: Metagenomic applied to ocean life study

Participants: Dominique Lavenier, Pierre Peterlongo, Claire Lemaitre, Guillaume Rizk, Gaetan Benoit.

Coordinator: P. Peterlongo (Inria/Irisa, GenScale, Rennes)

Duration: 42 months (Nov. 2014 – Apr. 2018)

Partners: CEA (GenoScope, Evry), INRA (AgroParisTech, Paris – MIG, Jouy-en-Jossas).

The HydroGen project aims to design new statistical and computational tools to measure and analyze biodiversity through comparative metagenomic approaches. The support application is the study of ocean biodiversity based on the analysis of seawater samples available from the Tara Oceans expedition.

9.2.1.2. Project SpeCrep: speciation processes in butterflies

Participants: Dominique Lavenier, Jeremy Gauthier, Fabrice Legeai, Claire Lemaitre, Pierre Peterlongo.

Coordinator: M. Elias (Museum National d'Histoire Naturelle, Institut de Systematique et d'Evolution de la Biodiversite, Paris)

Duration: 48 months (Jan. 2015 – Dec. 2018)

Partners: MNHN (Paris), INRA (Versailles-Grignon), Genscale Inria/IRISA Rennes.

The SpeCrep project aims at better understanding the speciation processes, in particular by comparing natural replicates from several butterfly species in a suture zone system. GenScale's task is to develop new efficient methods for the assembly of reference genomes and the evaluation of the genetic diversity in several butterfly populations.

9.2.2. PIA: Programme Investissement d'Avenir

9.2.2.1. RAPSODYN: Optimization of the rapeseed oil content under low nitrogen

Participants: Dominique Lavenier, Claire Lemaitre, Sebastien Letort, Pierre Peterlongo.

Coordinator: N. Nesi (Inra, IGEPP, Rennes)

Duration: 7.5 year (2012-2019)

Partners: 5 companies, 9 academic research labs.

The objective of the Rapsodyn project is the optimization of the rapeseed oil content and yield under low nitrogen input. GenScale is involved in the bioinformatics work package to elaborate advanced tools dedicated to polymorphism and application to the rapeseed plant. (<http://www.rapsodyn.fr>)

9.2.2.2. *Institut Français de Bioinformatique: Plant node*

Participant: Fabrice Legeai.

Coordinator: Hadi Quesneville (INRA, Versailles)

The aim of the Institut Francais de Bioinformatique (IFB) offers resources for a large community of French biologist. With INRA and CIRAD, we were part of the plant node of IFB, and focused on delivering efficient tools for sharing agronomical data, such as Askomics.

9.2.3. *Programs from research institutions*

9.2.3.1. *Inria ADT DiagCancer*

Participants: Dominique Lavenier, Patrick Durand.

Since October 1st, 2016, Genscale started a one-year Inria ADT called DiagCancer. It aims at: (1) including the DiscoSnp++ tool within the current data production pipeline at Pontchaillou Hospital (Rennes), (2) providing a new prediction tool applied to the calling of cancer related mutations from DNA sequencing data and (3) creating new analysis tools to facilitate the interpretation of results by end-users (biologists, doctors). The project is done in close collaboration with Haematology Service, CHU Pontchaillou, Rennes.

9.2.3.2. *CNRS Mastodons program: C3G*

Participants: Dominique Lavenier, Pierre Peterlongo, Claire Lemaitre, Camille Marchet, Lolita Lecompte.

High-throughput sequencing applications now cover all life sciences: from medicine to agronomy. The 3rd generation sequencing produces very long reads, but the reads are extremely noisy, which has a strong impact on the quality of bioinformatics analyses. The challenge of the C3G project is to bring this type of data to a high level of quality through the development of new correction strategies.

9.2.3.3. *Inria Project Lab: Neuromarkers*

Participants: Dominique Lavenier, Pierre Peterlongo, Claire Lemaitre.

The IPL Neuromarkers aims to design imaging biomarkers of neurodegenerative diseases for clinical trials and study of their genetic associations. In this project, GenScale bring its expertise in the genomic field.

9.3. International Initiatives

9.3.1. *Inria Associate Team: HipcoGen*

- Title: High-Performance Combinatorial Optimization for Computational Genomics
- International Partner (Institution - Laboratory - Researcher):
 - Los Alamos National Laboratory (LANL)-NM, United States, CCS-3, Hristo Djidjev
- Start year: 2017
- Teams' web site: <https://team.inria.fr/genscale/presentation/associated-team/>

Genome sequencing and assembly, the determination of the DNA sequences of a genome, is a core experiment in computational biology. During the last decade, the cost of sequencing has decreased dramatically and a huge amount of new genomes have been sequenced. Nevertheless, most of recent genome projects stay unfinished and nowadays the databases contain much more incompletely assembled genomes than whole stable reference genomes. The main reason is that producing a complete genome, or an as-complete-as-possible-genome, is an extremely difficult computational task (an NP-hard problem) and, in spite of the efforts and the progress done by the bioinformatics community, no satisfactory solution is available today. New sequencing technologies (such as PacBio or Oxford Nanopore) are being developed that tend to produce longer DNA sequences and offer new opportunities, but also bring significant new challenges. The goal of this joint project—a cooperation between Los Alamos National Laboratory, US and Inria, is to develop a new methodology and tools based on novel optimization techniques and massive parallelism suited to these emerging technologies and able to tackle the complete assembly of large genomes.

9.3.2. Informal International Partners

- Free University of Brussels, Belgium: Genome assembly [P. Perterlongo, A. Limasset]

9.4. International Research Visitors

9.4.1. Visits of International Scientists

- Visit of Hristo Djidjev from Los Alamos National Laboratory, June 5 to July 4, 2017

9.4.2. Visits to International Teams

- Visit of R. Andonov at LANL from May 4th to May 30th. Work on Task 2 from HipcoGen project.
- Visit of S. Francois at LANL from May 4th to May 30th and from August 2 to August 23. Work on Task 2 from HipcoGen project.
- Visit of Pierre Peterlongo at LANL, May 2017 (one week). Talk to SFAF conference: "Assembly of heterozygous genomes".

HYBRID Project-Team

9. Partnerships and Cooperations

9.1. Regional Initiatives

9.1.1. Labex Cominlabs SUNSET

Participants: Bruno Arnaldi, Guillaume Claude, Gautier Picard, Valérie Gouranton [contact].

SUNSET is a 4-year Labex Cominlabs project (2016-2020). SUNSET partners are MediCIS-LTSI (coordinator), Hybrid, Hycomes (IRISA/Inria), and CHU Rennes. SUNSET aims at developing an innovative training software suite based on immersive and collaborative virtual reality technology for training and evaluating non-technical skills. This approach will be implemented and evaluated in the context of training neurosurgical scrub nurses. We will notably integrate methods and systems developed in the S3PM project (see below). By relying on Human Factors approaches, the project also addresses training and evaluation of interpersonal skills. Whereas the developed technologies and approaches will be generic and adaptable to any surgical specialty, the project will evaluate the developed system within training sessions performed with scrub nurses. We ambition to propose novel approaches for surgical non-technical skill learning and assessment, and to install the developed training factory at the University Hospital of Rennes, and evaluate it with real-scale user studies.

9.1.2. Labex Cominlabs S3PM

Participants: Bruno Arnaldi, Guillaume Claude, Valérie Gouranton [contact].

S3PM ("Synthesis and Simulation of Surgical Process Models") is a 4-year Labex Cominlabs project (2013-2017). S3PM partners are MediCIS-LTSI (coordinator), Hybrid, Hycomes (IRISA/Inria), and CHU Rennes. The objective of S3PM is to propose a solution for the computation of surgical procedural knowledge models from recordings of individual procedures, and their execution. The goal of the Hybrid team is to propose and use new models for collaborative and interactive virtual environments for procedural training. The Hybrid team also works on the creation of a surgical training application in virtual reality, exposing the different contributions.

9.1.3. Labex Cominlabs HEMISFER

Participants: Anatole Lécuyer [contact], Marsel Mano, Lorraine Perronnet.

HEMISFER is a 4-year project (2013-2017) funded by Labex CominLabs. It involves 4 Inria/IRISA teams (Hybrid, Visages (lead), Panama, Athena) and 2 medical centers: the Rennes Psychiatric Hospital (CHGR) and the Reeducation Department of Rennes Hospital (CHU Pontchaillou). The goal of HEMISFER is to make full use of neurofeedback paradigm in the context of rehabilitation and psychiatric disorders. The major breakthrough will come from the use of a coupling model associating functional and metabolic information from Magnetic Resonance Imaging (fMRI) to Electro-encephalography (EEG) to "enhance" the neurofeedback protocol. Clinical applications concern motor, neurological and psychiatric disorders (stroke, attention-deficit disorder, treatment-resistant mood disorders, etc).

9.1.4. Labex Cominlabs SABRE

Participants: Anatole Lécuyer [contact], Jussi Tapio Lindgren, Nataliya Kos'Myna.

SABRE is a 3-year project (2014-2017) funded by Labex CominLabs. It involves 1 Inria/IRISA team (Hybrid) and 2 groups from TELECOM BREST engineering school. The goal of SABRE is to improve computational functionalities and power of current real-time EEG processing pipelines. The project will investigate innovative EEG solution methods empowered and speeded-up by ad-hoc, transistor-level, implementations of their key algorithmic operations. A completely new family of fully-hardware-integrated, new computational EEG imaging methods will be developed that are expected to speed up the imaging process of an EEG device of several orders of magnitude in real case scenarios.

9.1.5. IRT b<>com

Participants: Bruno Arnaldi [contact], Valérie Gouranton, Maud Marchal.

b<>com is a French Institute of Research and Technology (IRT). The main goal of this IRT is to fasten the development and marketing of tools, products and services in the field of digital technologies. Our team has already collaborated with b<>com within two 3-year projects: ImData (on "Immersive Interaction") and GestChir (on "Augmented Healthcare") which both ended in 2016. A new 3-year project called NeedleWare (on "Augmented Healthcare") has started on October 2016.

9.1.6. CNPAO Project

Participants: Valérie Gouranton [contact], Jean-Baptiste Barreau, Ronan Gaugne.

CNPAO ("Conservatoire Numérique du Patrimoine Archéologique de l'Ouest") is an on-going research project partially funded by the Université Européenne de Bretagne (UEB) and Université de Rennes 1. It involves IRISA/Hybrid and CReAAH. The main objectives are: (i) a sustainable and centralized archiving of 2D/3D data produced by the archaeological community, (ii) a free access to metadata, (iii) a secure access to data for the different actors involved in scientific projects, and (iv) the support and advice for these actors in the 3D data production and exploration through the latest digital technologies, modeling tools and virtual reality systems. This project involves a collaboration with Quentin Petit (SED Inria Rennes).

9.1.7. Imag'In CNRS IRMA

Participants: Bruno Arnaldi, Jean-Baptiste Barreau, Ronan Gaugne, Valérie Gouranton [contact], Théophane Nicolas.

The IRMA project is an Imag'In project funded by CNRS which aims at developing innovative methodologies for research in the field of cultural heritage based on the combination of medical imaging technologies and interactive 3D technologies (virtual reality, augmented reality, haptics, additive manufacturing). It relies on close collaborations with the National Institute of Preventive Archaeological Research (Inrap), the Research Center Archaeology, and History Archéosciences (CReAAH UMR 6566) and the company Image ET. The developed tools are intended for cultural heritage professionals such as museums, curators, restorers, and archaeologists. We focus on a large number of archeological artefacts of different nature, and various time periods (Paleolithic, Mesolithic, and Iron Age Medieval) from all over France. We can notably mention the oldest human bones found in Brittany (clavicle Beg Er Vil), a funeral urn from Trebeurden (22), or a Bronze Cauldron from a burial of the Merovingian necropolis "Crassés Saint-Dizier" (51). This project involves a collaboration with Quentin Petit (SED Inria Rennes) and Grégor Marchand (CNRS/UMR CReAAH).

9.2. National Initiatives

9.2.1. ANR-FRQSC INTROSPECT

Participants: Valérie Gouranton [contact], Bruno Arnaldi, Ronan Gaugne, Jean-Baptiste Barreau, Flavien Lecuyer.

INTROSPECT is a 3-year project funded by French ANR and "Fonds de Recherche Société et Culture" (FRQSC) from Quebec region, Canada. The collaboration involves researchers in computer science and archeology from France and Canada : Hybrid (Inria-IRISA), CReAAH, Inrap, company Image ET, University Laval and INRS-ETE. INTROSPECT aims to develop new uses and tools for archaeologists that facilitate access to knowledge through interactive numerical introspection methods that combine computed tomography with 3D visualization technologies, such as Virtual Reality, tangible interactions and 3D printing. The scientific core of the project is the systematization of the relationship between the artefact, the archaeological context, the digital object and the virtual reconstruction of the archaeological context that represents it and its tangible double resulting from the 3D printing. This axiomatization of its innovative methods makes it possible to enhance our research on our heritage and to make use of accessible digital means of dissemination. This approach changes from traditional methods and applies to specific archaeological problems. Several case studies will be studied in various archaeological contexts on both sides of the Atlantic. Quebec museums are partners in the project to spread our results among the general public.

9.2.2. *Ilab CertiViBE*

Participants: Anatole Lécuyer [contact], Jussi Tapio Lindgren, Thierry Gaugry, Cédric Riou.

CertiViBE is a 2-year "Inria Innovation Lab" (2015-2017) funded by Inria for supporting the development of OpenViBE software, and notably its evolution in order to enable and fasten the medical transfer and the medical certification of products based on OpenViBE. This joint lab involves two partners: Hybrid and Mensia Technologies startup company. The project aims at setting up a quality environment, and developing a novel version of the software which should comply with medical certification rules.

9.2.3. *IPL BCI-LIFT*

Participants: Anatole Lécuyer [contact], Jussi Tapio Lindgren, Hakim Si Mohammed, Lorraine Perronnet, Nataliya Kos'Myna.

BCI-LIFT is a 4-year "Inria Project Lab" initiative (2015-2019) funded by Inria for supporting a national research effort on Brain-Computer Interfaces. This joint lab involves several Inria teams: Hybrid, Potioc, Athena, Neurosys, Mjolnir, Demar; as well as external partners: INSERM-Lyon, and INSA Rouen. This project aims at improving several aspects of Brain-Computer Interfaces: learning and adaptation of BCI systems, user interfaces and feedback, training protocols, etc.

9.2.4. *ATT CONSORVIBE*

Participants: Anatole Lécuyer [contact], Jussi Tapio Lindgren [contact].

CONSORVIBE is a 6-month ATT Inria Project funded by Inria for supporting a prospective effort and the feasibility study of building a consortium of partners dedicated to the sustainability and promotion of the OpenViBE software.

9.3. European Initiatives

9.3.1. *FP7 & H2020 Projects*

9.3.1.1. *HAPPINESS*

Title: Haptic Printed Patterned INtErfaces for Sensitive Surface

Programm: H2020

Duration: January 2015 - December 2017

Coordinator: CEA (France)

Partners:

Arkema France (France)

Robert Bosch (Germany)

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

Fundacion Gaiker (Spain)

Integrated Systems Development S.A. (Greece)

University of Glasgow (United Kingdom)

Walter Pak SL (Spain)

Inria contact: Nicolas Roussel and Anatole Lécuyer

The Automotive HMI (Human Machine Interface) will soon undergo dramatic changes, with large plastic dashboards moving from the ‘push-buttons’ era to the ‘tactile’ era. User demand for aesthetically pleasing and seamless interfaces is ever increasing, with touch sensitive interfaces now commonplace. However, these touch interfaces come at the cost of haptic feedback, which raises concerns regarding the safety of eyeless interaction during driving. The **HAPPINESS** project intends to address these concerns through technological solutions, introducing new capabilities for haptic feedback on these interfaces. The main goal of the HAPPINESS project is to develop a smart conformable surface able to offer different tactile sensations via the development of a Haptic Thin and Organic Large Area Electronic technology (TOLAE), integrating sensing and feedback capabilities, focusing on user requirements and ergonomic designs. To this aim, by gathering all the value chain actors (materials, technology manufacturing, OEM integrator) for application within the automotive market, the HAPPINESS project will offer a new haptic Human-Machine Interface technology, integrating touch sensing and disruptive feedback capabilities directly into an automotive dashboard. Based on the consortium skills, the HAPPINESS project will demonstrate the integration of Electro-Active Polymers (EAP) in a matrix of mechanical actuators on plastic foils. The objectives are to fabricate these actuators with large area and cost effective printing technologies and to integrate them through plastic molding injection into a small-scale dashboard prototype. We will design, implement and evaluate new approaches to Human-Computer Interaction on a fully functional prototype that combines in packaging both sensors and actuator foils, driven by custom electronics, and accessible to end-users via software libraries, allowing for the reproduction of common and accepted sensations such as Roughness, Vibration and Relief. In this project, the role of Hybrid team is to design user studies on tactile perception, and study innovative usages of the technologies developed in HAPPINESS.

9.3.1.2. IMAGINE

Title: IMAGINE - Robots Understanding Their Actions by Imagining Their Effects

Programm: H2020

Duration: January 2017 - December 2020

Coordinator: Univ. Innsbruck (Austria)

Partners:

Univ. Innsbruck (Austria)

Univ. Göttingen (Germany)

Karlsruhe Institute of Technology (Germany)

INSA Rennes (France)

Institute of Robotics and Industrial Informatics (Spain)

Univ. Bogazici (Turkey)

Electro Cycling (Germany)

Inria contact: Maud Marchal

Today’s robots are good at executing programmed motions, but they do not understand their actions in the sense that they could automatically generalize them to novel situations or recover from failures. **IMAGINE** seeks to enable robots to understand the structure of their environment and how it is affected by its actions. “Understanding” here means the ability of the robot (a) to determine the applicability of an action along with parameters to achieve the desired effect, and (b) to discern to what extent an action succeeded, and to infer possible causes of failure and generate recovery actions. The core functional element is a generative model based on an association engine and a physics simulator. “Understanding” is given by the robot’s ability to predict the effects of its actions, before and during their execution. This allows the robot to choose actions and parameters based on their simulated performance, and to monitor their progress by comparing observed to simulated behavior. This scientific objective is pursued in the context of recycling of electromechanical appliances.

Current recycling practices do not automate disassembly, which exposes humans to hazardous materials, encourages illegal disposal, and creates significant threats to environment and health, often in third countries. IMAGINE will develop a TRL-5 prototype that can autonomously disassemble prototypical classes of devices, generate and execute disassembly actions for unseen instances of similar devices, and recover from certain failures. For robotic disassembly, IMAGINE will develop a multi-functional gripper capable of multiple types of manipulation without tool changes. IMAGINE raises the ability level of robotic systems in core areas of the work programme, including adaptability, manipulation, perception, decisional autonomy, and cognitive ability. Since only one-third of EU e-waste is currently recovered, IMAGINE addresses an area of high economical and ecological impact.

9.4. International Research Visitors

9.4.1. Visits of International Scientists

This year, Hybrid team has welcomed for short periods:

- Gabriel Cirio, Universidad Rey Juan Carlos Madrid (Spain), May 2017
- Victoria Interrante, University of Minnesota (US), December 2017
- Geneviève Treyvaud and Pierre Francus, INRS (Canada), November 2017

9.4.2. Visits to International Teams

Ronan Gaugne and Valérie Gouranton made a short stay at University Laval (Canada) in August 2017

HYCOMES Project-Team

7. Partnerships and Cooperations

7.1. Regional Initiatives

- Ayman Aljarbough's PhD (see Section 5.1.3) was partially funded by an ARED grant of the Brittany Regional Council. His doctoral work took place in the context of the Modrio (completed in 2016) and Sys2Soft (completed in 2015) projects on hybrid systems modeling. Ayman Aljarbough is working on accelerated simulation techniques for hybrid systems. In particular, he is focusing on the regularisation, at runtime, of chattering behaviour and the approximation of Zeno behaviour.
- Benoît Caillaud and Aurélien Lamercurie are participating to the S3PM and SUNSET projects of the CominLabs excellence laboratory⁰. This project focuses on the computation of surgical procedural knowledge models from recordings of individual procedures, and their execution [28]. The objective is to develop an enabling technology for procedural knowledge based computer assistance of surgery. In this project, we demonstrate its potential added value in nurse and surgeon training [36], [35]. In 2017, Benoît Caillaud and Aurélien Lamercurie have released Demodocos, a software synthesizing surgical process models from instances of surgical procedures.

7.2. National Initiatives

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

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

Name	Team	Inria Center or Laboratory
Vincent Acary	Bipop	Inria Grenoble Rhône Alpes
Albert Benveniste Benoît Caillaud Khalil Ghorbal	Hycomes	Inria Rennes Bretagne Atlantique
Marc Pouzet Tim Bourke	Parkas	ENS Inria Paris
Goran Frehse	Tempo	Verimag-univ. Grenoble Alpes
Antoine Girard		L2S-CNRS, Saclay
Eric Goubault Sylvie Putot	Cosynus	LIX, École Polytechnique, Saclay

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

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

⁰<http://www.s3pm.cominlabs.ueb.eu/>

I4S Project-Team

9. Partnerships and Cooperations

9.1. Regional Initiatives

9.1.1. MONEOL

Participants: Ivan Guéguen, Guillaume Gautier, Laurent Mevel.

Type: CEAtch PDL

Objectif: Modal analysis of wind turbines using new sensors

Duration: 09/2015 to 11/2017.

Coordinator: Louis Marie Cotineau (IFSTTAR)

Inria contact: Guillaume Gautier

Abstract: The MONEOL project aims to demonstrate the feasibility of using Morphosense as a vibration monitoring system for wind turbines. It is proposed to set up a demonstrator consisting of a monitoring system placed in the mast of the wind turbine, a vibration analysis system and a visualization of the vibratory state at the CEA-Tech premises, located on the Technocampus Ocean of Nantes allowing to visualize in real time (quasi) the modal deformations of the mast of the wind turbine.

The MONEOL (Wind turbine monitoring) project was concluded in September 2017. Morphosense ribbon was deployed on the mast of a wind turbine. Morphosense validation was conducted through the comparison with a classical vibration monitoring system. The relevance regarding the use of such a system was highlighted, especially due to reduced installation time. SSI algorithms, including modal parameters and damage identification, were implemented inside the Morphosense. Actually, wind turbine health condition is displayed in real time through a web page.

9.1.2. *Interactive Communication (InterCom): Massive random access to subsets of compressed correlated data*

Participants: Jean Dumoulin, Antoine Crinière, Frederic Gillot.

Type: Labex COMINLABS

Objectif: Massive random access to large-scale sensor network (Smart Cities)

Duration: Since November 2016 to Nov. 2019.

Coordinator :Aline Roumy, Thomas Maugey (Sirocco), Jean Dumoulin (I4S)

Partners: Elsa Dupraz (Lab-STICC), Aline Roumy (IRISA, Sirocco team), Michel Kieffer (L2S), Thomas Maugey (IRISA, Sirocco team), CentraleSupélec, Univ. Paris Sud.

Inria contact: Jean Dumoulin

Abstract: This project aims to develop novel compression techniques allowing massive random access to large databases. Indeed, we consider a database that is so large that, to be stored on a single server, the data have to be compressed efficiently, meaning that the redundancy/correlation between the data have to be exploited. The dataset is then stored on a server and made available to users that may want to access only a subset of the data. Such a request for a subset of the data is indeed random, since the choice of the subset is user-dependent. Finally, massive requests are made, meaning that, upon request, the server can only perform low complexity operations (such as bit extraction but no decompression/compression).

Algorithms for two emerging applications of this problem will be developed: Free-viewpoint Television (FTV) and massive requests to a database collecting data from a large-scale sensor network (such as Smart Cities) in which I4S is involved.

9.1.3. *MAG2C-Pont Tabarly*

Participants: Ivan Guéguen, Jean Dumoulin.

Type: GIS

Objectif: bridge instrumentation

Duration: Since 2014

Coordinator: LIRGEC

Partners: IFSTTAR, CSTB, Nantes Métropole, Université de Nantes

Inria contact: Ivan Guéguen

Abstract: The project deals with the instrumentation of the Tabarly Bridge. In collaboration with Nantes Métropole, CSTB, and Université de Nantes, instrumentation of both dynamical and InfraRed properties of an operational bridge are investigated. These measures coupled with a wireless data transmission system will allow remote monitoring of the evolution of the structure. Objective is to couple different kind of measurement to achieve thermo-vibration monitoring of the structure. This is a big milestone for the team and our objective to mix thermo-vibration data.

9.1.4. *MAG2C-MOSIWIND (MONitoring of Structural Integrity of an onshore WIND turbine slab foundation and tower)*

Participants: Xavier Chapeleau, Ivan Guéguen.

Type: GIS

Objectif: MONitoring of Structural Integrity of an onshore WIND turbine slab foundation and tower

Duration: Since 2015

Coordinator : LIRGEC

Partners: IFSTTAR, CSTB, Nantes Métropole, Université de Nantes, ECN, Valorem, Valréa and Valémo

Inria contact: Xavier Chapeleau

Abstract: The project deals with the instrumentation of an onshore WIND turbine's slab foundation and tower. The aim is to experiment sensors and methods for structural integrity monitoring of an onshore wind turbine under real conditions and to qualify them over long term. Before casting, the concrete slab foundation (20m in diameter, 3.85m high, 450m³ of concrete, 48T of reinforcement) was first instrumented with continuous optical fibers, optical strain gauges, temperature sensors and accelerometers. Afterwards, accelerometers were placed in the mast. Data obtained by these different sensors will help, on the one hand, to monitor changes in the dynamic behavior of the structure in order to verify that they remain within the limits fixed during the design and, on the other hand, to detect any damage that could be critical for the safety of the structure. For this, SSI methods under ambient vibration will be applied. Since July 2017, only the data of accelerometers measurements are logged periodically. The installation of systems of measurements for distributed fiber optics sensors and optical strains gauges remains to be done as soon as it can be possible to access to the wind turbine .

9.1.5. *Collaboration with GeM*

Participants: Laurent Mevel, Michael Doehler, Md Delwar Hossain Bhuyan.

Md Delwar Hossain Bhuyan has done his PhD on damage localisation on civil structures in collaboration with GeM (Institute of Civil and Mechanical Engineering), Université de Nantes. The thesis is co-directed by L. Mevel, and F. Schoefs from GeM, with supervision shared with M. Doehler and Y. Lecieux from GeM. It is funded by the Brittany region for 3 years and has been successfully defended in November 2017.

9.1.6. Collaboration with IETR

Participants: Vincent Le Cam, David Pallier.

The thesis is directed by Sébastien Pillement at IETR. It is funded by RFI WISE Electronique Professionnelle within the SENTAUR project.

The subject of the thesis is to study, implement and propose a deterministic and reliable dating solution for wireless sensor networks. This solution must take into account both the risks of loss of synchronization signals, environmental hazards and the desire to achieve the most sober possible solution in energy.

9.2. National Initiatives

9.2.1. High speed rail track instrumentation

Participant: Ivan Guéguen.

Type: IRT

Objective: rail track SHM

Duration: 11/2014 to 11/2018

Coordinator: RAILENIUM

Partners: IFSTTAR, EIFFAGE, RFF, LGCgE

Inria contact: Ivan Guéguen

Abstract: This project aims to orchestrate multiple sections of a high-speed route (classical section with granular layer, transition zone). The proposed instrumentation concerns all the different layers of the structure, and is designed to allow monitoring of the overall track behavior. Using accelerometers and weather station, this instrumentation will estimate the fatigue life and temperature changes in the track.

9.2.2. ANR Resbati

Participants: Ludovic Gaverina, Jean Dumoulin.

Type: ANR

Objectif: In-situ measurements of thermal wall resistance

Duration: 10/2016 to 10/2019

Coordinator: Laurent Ibos

Partners : IFSTTAR, CERTES, CEREMA, CSTB, LNE, THEMACS, AFNOR

Inria contact: Jean Dumoulin

Abstract: RESBATI is an applied research project whose objective is to develop a field measurement device that meets precise specifications to systematically measure the level of thermal insulation of building walls. The preferred metrological tool is infrared thermography.

9.2.3. Equipex Sense-City

Participants: Jean Dumoulin, Laurent Mevel, Antoine Crinière.

Through the ADT Cloud2SM, participation of I4S in SenseCity was possible. IFSTTAR's SensorBox developed by Jean Dumoulin was installed and presented at SENSECITY Kick off and is installed on-site. Cloud2IR and Cloud2SM software have been deployed within the ADT of A. Crinière. (<http://sense-city.ifsttar.fr/>)

9.3. European Initiatives

9.3.1. FP7 & H2020 Projects

9.3.1.1. Built to Specifications (Built2Spec)

Participant: Jean Dumoulin.

Type: Horizon 2020

Defi: Model Driven Physical Systems Operation

Objectif: Reduce the gap between a building's designed and as-built energy performance.

Duration: January 2015 to January 2019

Coordinator: Manager and project head : NOBATEK, Germain Adell. For CERMA : Marjorie Musy
Inria teams I4S

Inria contact: J. Dumoulin

Partners: Consortium of 20 Public and Industrial actors

Website: <http://built2spec-project.eu/>

Abstract: Built to Specifications (Built2Spec) is involving 20 European partners that seeks to reduce the gap between a building designed and as-built energy performance. To do this, the project put a new set of breakthrough technological advances for self-inspection checks and quality assurance measures into the hands of construction professionals. The project aims to deliver Building Information Modelling (BIM) and Thermal and 3D Imaging Tools among others.

The project is in collaboration with formers members of the team, Alexandre Nassiopoulos and Jordan Brouns, now working at Ecotropy, SME.

9.3.1.2. INFRASTAR(Innovation and Networking for Fatigue and Reliability Analysis of Structures – Training for Assessment of Risk)

Participants: Xavier Chapeleau, Antoine Bassil.

Call: H2020-MSCA-ITN-2015 (Horizon 2020 â Marie-Sklodowska Curie Actions â Innovative Training Networks)

Type of Action: MSCA-ITN-ETN

Objectif: Reduce the gap between a building's designed and as-built energy performance.

Duration: 48 months since 2016 May 1st

Coordinator: Odile Abraham (IFSTTAR)

Academic and industrial Partners: IFSTTAR, UNIVERSITY OF AALBORG, BAM, EPFL, GuD Consult GmbH, COWI A/S, NeoStrain, PHIMECA

Inria contact: X. Chapeleau

Website: <http://infrastar.eu/>

Abstract: The aim of INFRASTAR project is to develop tools combining modeling and measurements for the prediction of the fatigue behavior of concrete structures (bridges and foundations of wind turbines) with the ultimate objective of establishing an efficient strategy for inspection and reinforcement operations. In the second half of 2016, 12 young researchers were recruited to carry out and cross-examine research on monitoring and auscultation (WP 1), structural models (WP 2) and reliability of approaches for decision-making (WP 3). In this project, a phd student (Antoine Bassil) was recruited (Nov. 2016) on the fatigue monitoring of concrete structure by fibre-optic sensors. During the first 6 months of the thesis, a State of the Art on the use of fiber optic sensors for structural health monitoring in civil engineering was done and mostly by focusing on distributed optical fiber sensor's technology (DOFS) for crack detection in concrete. This State of the Art shows that distributed optical fiber sensor can localize accurately cracks in concrete if they propagate across the sensor. However, the quantification of the crack widths by distributed optical fiber sensor remains a scientific challenge. Indeed, it is necessary to take into account of the mechanical strain transfer of the fiber sensor. Now, the second part of the phd student work is to develop a theoretical model for the mechanical strain transfer function and to validate it by experimental tests. The main milestone of the modelling to overcome is to take into account of slippage and elasto-plastic effects

9.3.2. Collaborations in European Programs, Except FP7 & H2020

9.3.2.1. COST Action TU 1402

Participants: Michael Doehler, Laurent Mevel.

L. Mevel is member of the management committee of the COST Action.

M. Doehler is co-leader of working group 2 “SHM strategies and structural performance” and member of the steering committee.

Type: COST

Objectif: Quantifying the value of structural health monitoring

Duration: 11/2014 - 11/2018

Coordinator: S. Thoens (DTU Denmark)

Partner: 23 countries, see http://www.cost.eu/COST_Actions/tud/Actions/TU1402

Inria contact: Laurent Mevel

Abstract: Since 2014, until 2018, the COST Action has altogether around 120 participants from over 25 countries. This Action aims to develop and describe a theoretical framework, together with methods, tools, guidelines, examples and educational activities, for the quantification of the value of SHM. Progress of the action is presented in [40].

9.3.2.2. PROCOPE 37826QE

Participants: Michael Doehler, Laurent Mevel, Eva Viefhues.

Type: PHC PROCOPE

Objectif: Statistical damage localization for civil structures

Duration: 01/2017 - 12/2018

Coordinator: M. Doehler

Partner: BAM German Federal Institute for Materials Research and Testing

Inria contact: M. Doehler

Abstract: Our main objective is the development of a theoretically solid damage localization method that does not only work in simulations and lab experiments, but on structures in the field under real operational conditions. This German-French mobility grant is in support of Eva Viefhues' PhD thesis.

9.3.3. Collaborations with Major European Organizations

9.3.3.1. European Research Network on System Identification (ERNSI)

Participants: Qinghua Zhang, Michael Doehler, Laurent Mevel.

The I4S project-team is involved in the activities of the European Research Network on System Identification (ERNSI) federating major European research teams on system identification. Modeling of dynamical systems is fundamental in almost all disciplines of science and engineering, ranging from life science to process control. System identification concerns the construction, estimation and validation of mathematical models of dynamical physical or engineering phenomena from experimental data.

9.3.4. Other European Programs

9.3.4.1. Innobooster

Participants: Michael Doehler, Laurent Mevel.

Together with SVS, we got the Danish Innobooster innovation grant for industrial research and transfer. In 2017, the grant was awarded to transfer methods for the identification of mode shapes and their uncertainty [30] to SVS' ARTeMIS software.

9.4. International Initiatives

9.4.1. Informal International Partners

9.4.1.1. Collaboration with CNR, Italy

Participants: Jean Dumoulin, Nicolas Le Touz.

Non destructive testing on outdoor structures by coupling infrared thermography with ground penetrating radar is one of the topic addressed in this collaboration. A new one about TerHertz is starting. A proposal for associated lab is currently drafted.

9.4.1.2. Collaboration with British Columbia University, Canada

Participants: Laurent Mevel, Michael Doehler, Saeid Allahdadian.

Saeid Allahdadian was PhD student of professor Carlos Ventura in Vancouver. Following our recent papers, Michael Doehler has been invited to co-supervise the PhD of Saeid Allahdadian. The thesis has been defended this year.

9.4.1.3. Collaboration with BAM, Germany

Participants: Laurent Mevel, Michael Doehler, Eva Viefhues.

Eva Viefhues is currently PhD student of Laurent Mevel and Michel Doehler in Berlin, financed by BAM. M. Doehler is also associate researcher of the BAM institut since 2016.

9.4.1.4. Collaboration with Politecnico di Milano, Italy

Participants: Michael Doehler, Francesco Giordano.

During COST Action TU 1402 and professor M.P. Limongelli's research stay at IFSTTAR, collaboration with Politecnico di Milano has started, resulting in several joint publications in 2016 and 2017. PhD student F. Giordano has started at Politecnico Milano in November 2017 under the direction of M.P. Limongelli, M. Doehler is co-supervising.

9.4.1.5. Collaboration with Technical University of Denmark (DTU)

Participant: Michael Doehler.

During COST Action TU 1402 and previously at BAM, collaboration with Sebastian Thöns from DTU in Denmark started on risk analysis and SHM based reliability updating. Also, DTU's PhD student Lijia Long is involved [36].

9.4.1.6. Collaboration with Aalborg University, Denmark

Participant: Michael Doehler.

Together with Structural Vibration Solutions, collaboration with Aalborg University (professor Lars Damkilde, Department of Civil Engineering) has started during the PhD of Szymon Gres on damage detection methods [32].

9.5. International Research Visitors

9.5.1. Visits of International Scientists

Within the PROCOPE mobility grant, E. Viefhues and F. Hille from BAM, Germany, visited Inria for one week each.

Prof. Xingwen Liu from Southwest University of China visited the I4S team for one week.

9.5.2. Visits to International Teams

Within the PROCOPE mobility grant and the collaboration in L. Long's PhD thesis with S. Thöns, M. Doehler spent 4 weeks at BAM, Germany.

Within the IFSTTAR foreign affair department grant and the existing collaboration, J. Dumoulin spent 2 weeks at Laval University, Canada.

Within the H2020 INFRASTAR Project A. Bassil spent 3 months at BAM.

IPSO Project-Team

5. Partnerships and Cooperations

5.1. Regional Initiatives

- A. Crestetto is member of the project "Pari Scientifique Régional Exprodil".
- M. Lemou is member of the project "Défis" of the University of Rennes 1, leader Nicolas Seguin.

5.2. National Initiatives

5.2.1. ANR MOONRISE: 2015-2019

Participants: Francois Castella, Philippe Chartier, Nicolas Crouseilles, Mohammed Lemou, Florian Mehats.

The project *Moonrise* submitted by Florian Méhats has been funded by the ANR for 4 years, for the period 2015-2019. This project aims at exploring modeling, mathematical and numerical issues originating from the presence of high-oscillations in nonlinear PDEs from the physics of nanotechnologies (quantum transport) and from the physics of plasmas (magnetized transport in tokamaks). The partners of the project are the IRMAR (Rennes), the IMT (Toulouse) and the CEA Cadarache. In the IPSO team, François Castella, Philippe Chartier, Nicolas Crouseilles and Mohammed Lemou are members of the project Moonrise.

Postdocs

- Loïc Le Treust has been hired as a Postdoc, under the supervision of Philippe Chartier and Florian Méhats. His contract started in september 2015 and ended in august 2016. Loïc Le Treust is now assistant professor at the university of Marseille.
- Xiaofei Zhao has been hired as a Postdoc from september 2015 to september 2016 under the supervision of Florian Méhats.

5.2.2. ANR MFG: 2016-2020

Participant: Arnaud Debussche.

Mean Field Games (MFG) theory is a new and challenging mathematical topic which analyzes the dynamics of a very large number of interacting rational agents. Introduced ten years ago, the MFG models have been used in many areas such as, e.g., economics (heterogeneous agent models, growth modeling,...), finance (formation of volatility, models of bank runs,...), social sciences (crowd models, models of segregation) and engineering (data networks, energy systems...). Their importance comes from the fact that they are the simplest ("stochastic control"-type) models taking into account interactions between rational agents (thus getting beyond optimization), yet without entering into the issues of strategic interactions. MFG theory lies at the intersection of mean field theories (it studies systems with a very large number of agents), game theory, optimal control and stochastic analysis (the agents optimize a payoff in a possibly noisy setting), calculus of variations (MFG equilibria may arise as minima of suitable functionals) and partial differential equations (PDE): In the simplest cases, the value of each agent is found by solving a backward Hamilton-Jacobi equation whereas the distribution of the agents' states evolves according to a forward Fokker-Planck equation. The "Master" equation (stated in the space of probability measures) subsumes the individual and collective behaviors. Finally, modeling, numerical analysis and scientific computing are crucial for the applications. French mathematicians play a world-leading role in the research on MFG: The terminology itself comes from a series of pioneering works by J.-M. Lasry and P.-L. Lions who introduced most of the key ideas for the mathematical analysis of MFG; the last conference on MFG was held last June in Paris and organized by Y. Achdou, P. Cardaliaguet and J.-M. Lasry. As testifies the proposal, the number of researchers working on MFG in France (and also abroad) is extremely fast-growing, not only because the theoretical aspects are exciting and challenging, but also because MFG models find more and more applications. The aim of the project is to better coordinate the French mathematical research on MFG and to achieve significant progress in the theory and its applications.

The partners of the project are the CEREMADE laboratory (Paris Dauphine), the IRMAR laboratory (Rennes I), the university of Nice and of Tours.

5.2.3. ANR ACHYLLES: 2014-2018

Participant: Anais Crestetto.

The ACHYLLES project focuses on Long-Time Asymptotic-Preserving (LTAP) numerical schemes for hyperbolic systems of conservation laws supplemented by potentially stiff source terms. It ambitions to perform a breakthrough in the understanding and efficiency of LTAP scheme.

The partners are IMB (Bordeaux), LMV (Versailles) and LMJL (Nantes).

5.2.4. IPL FRATRES

IPSO is associated to IPL FRATRES which started in june 2015. The aim of this project is to organize Inria teams activities which develop mathematical and numerical tools in magnetically confined nuclear fusion. The ambition is to prepare the next generation of numerical modeling methodologies able to use in an optimal way the processing capabilities of modern massively parallel architectures. This objective requires close collaboration between a) applied mathematicians and physicists that develop and study mathematical models of PDE; b) numerical analysts developing approximation schemes; c) specialists of algorithmics proposing solvers and libraries using the many levels of parallelism offered by the modern architecture and d) computer scientists. The project road map ambitions to contribute in close connection with National and European initiatives devoted to nuclear Fusion to the improvement and design of numerical simulation technologies applied to plasma physics and in particular to the ITER project for magnetic confinement fusion.

Postdoc

- Xiaofei Zhao has been hired as a Postdoc, under the supervision of Nicolas Crouseilles and Sever Hirstoaga (Inria-Nancy). His contract started in october 2016 and ended in september 2017.

5.3. European Initiatives

5.3.1. Collaborations in European Programs, Except FP7 & H2020

Program: EUROfusion Enabling Research

Project acronym: WPENR

Project title: Verification and development of new algorithms for gyrokinetic codes

Duration: january 2015 - december 2017.

Coordinator: E. Sonnendrücker (Max-Planck IPP, Germany)

Other partners: IPP, EPFL, CEA-Cadarache, university of Strasbourg, Toulouse, Marseille, Paris 6.

Abstract: Gyrokinetic codes play a major role in understanding the development and saturation of micro-turbulence in a magnetic fusion plasma and its influence on energy confinement time. The first aim of this proposal is to assess the reliability of gyrokinetic codes by extensive verification and benchmarking. All the major european gyrokinetic codes are involved in the proposal and this will enable them to define comparison elements, which ultimately will also facilitate the cross-validation of new physics. On the other hand we will develop new algorithms for extending the physics capabilities or the computational efficiency of different gyrokinetic codes. Finally we will also perform a prospective investigation of models and numerical methods that could help in the future to address physics where kinetic effects might play an important role but that cannot be handled with today's gyrokinetic codes, like L-H (low to high confinement) transition, edge physics or MHD time scales simulations.

5.4. International Initiatives

5.4.1. Informal International Partners

Members of the IPSO team have several international collaborations

- the group of S. Jin (university of Wisconsin, US).
- the group of W. Bao (university of Singapore).
- G. Vimart (university of Geneva, Switzerland).
- the group of A. Ostermann (university of Innsbruck).
- the SNS of Pisa (G. Da Prato).
- several US universities: Maryland (S. Cerrai), Chicago (C. Sparber), Colorado (O. Pinaud), ...
- ...

5.4.2. Participation in Other International Programs

- A. Crestetto is involved in the project PHC PROCOPE "Hétérogénéités Fortes dans les Modèles d'Ecoulement Fluide".

5.5. International Research Visitors

5.5.1. Visits to International Teams

- P. Chartier was invited by Fernando Casas, University of Castellon, Spain, July 6-9 2017.
- A. Crestetto was invited by Christian Klingenberg, Institute of Mathematics, Würzburg University, July 10-14 2017.
- M. Lemou was invited by Shi Jin, Jiao Tong university Shanghai, China, July 5-15 2017.
- M. Lemou was invited by Hao Wu, Tsinghua university Beijing, China, July 15-20 2017.

KERDATA Project-Team

8. Partnerships and Cooperations

8.1. National Initiatives

8.1.1. ANR

8.1.1.1. OverFlow (2015–2019)

Participants: Alexandru Costan, Paul Le Noac’h.

- Project Acronym: OverFlow.
- Project Title: Workflow Data Management as a Service for Multisite Applications.
- Coordinator: Alexandru Costan.
- Duration: Octobre 2015–October 2019.
- Other Partners: None (Young Researcher Project).
- External collaborators: **Kate Keahey** (University of Chicago and Argonne National Laboratory), **Bogdan Nicolae** (Huawei Research) and **Christophe Blanchet** (Institut Français de Bioinformatique).
- Abstract: This JCJC project led by Alexandru Costan investigates approaches to data management enabling an efficient execution of geographically distributed workflows running on multi-site clouds.
- Progress: In 2017, we have reviewed in depth the technical and architectural needs of data storage for the use cases that drive OverFlow, in order to consolidate a set of requirements for its future architecture. Based on these workflow traces, in a second step, we have investigated the suitable benchmarks that reasonably represent them. In this direction, we have first focused on ingestion and storage optimisations for such complex deployments, in particular the novel support for concurrent writes. The project was successfully reviewed at T0+18.

8.1.1.2. KerStream (2017–2021)

Participant: Shadi Ibrahim.

- Project Acronym: KerStream.
- Project Title: Big Data Processing: Beyond Hadoop!
- Coordinator: Shadi Ibrahim .
- Duration: January 2017–January 2021.
- Other Partners: None (Young Researcher Project).
- Abstract: This JCJC project led by Shadi Ibrahim aims to address the limitations of Hadoop when running stream Big Data applications on large-scale clouds and to do a step beyond Hadoop by proposing a new approach, called KerStream, for scalable and resilient stream Big Data processing on clouds. The KerStream project can be seen as the first step towards developing the first French middleware that handles Stream Data processing at Scale.
- Note: Shadi Ibrahim left the KerData team in April 2017, so that this contract is no longer managed within the KerData team.

8.1.2. Other National Projects

8.1.2.1. ADT Damaris

Participants: Hadi Salimi, Alexandru Costan, Luc Bougé.

- Project Acronym: ADT Damaris
- Project Title: Technology development action for the Damaris environment.
- Coordinator: Alexandru Costan.
- Duration: 2016–2018.
- Abstract: This action aims to support the development of the Damaris software. Inria's *Technological Development Office* (D2T, *Direction du Développement Technologique*) provided 2 years of funding support for a senior engineer.

Hadi Salimi is funded through this project to document, test and extend the **Damaris** software and make it a safely distributable product.

8.1.2.2. Grid'5000

We are members of Grid'5000 community and run experiments on the Grid'5000 platform on a daily basis.

8.2. European Initiatives

8.2.1. FP7 & H2020 Projects

8.2.1.1. BigStorage

Title: BigStorage: Storage-based Convergence between HPC and Cloud to handle Big Data.

Programme: H2020.

Duration: January 2015–December 2018.

Coordinator: Universidad Politécnica de Madrid (UPM).

Partners:

- Barcelona Supercomputing Center — Centro Nacional de Supercomputacion (Spain)
- CA Technologies Development Spain (Spain)
- CEA — Commissariat à l'énergie atomique et aux énergies alternatives (France)
- Deutsches Klimarechenzentrum (Germany)
- Foundation for Research and Technology Hellas (Greece)
- Fujitsu Technology Solutions (Germany)
- Johannes Gutenberg Universität Mainz (Germany)
- Universidad Politécnica de Madrid (Spain)
- Seagate Systems UK (United Kingdom)

Inria contact: **Gabriel Antoniu** and **Adrien Lèbre**.

URL: <http://www.bigstorage-project.eu/>.

Description: BigStorage is a European Training Network (ETN) whose main goal is to train future *data scientists*. It aims at enabling them and us to apply holistic and interdisciplinary approaches to take advantage of a data-overwhelmed world. This world requires *HPC* and *Cloud* infrastructures with a redefinition of *storage* architectures underpinning them — focusing on meeting highly ambitious performance and *energy* usage objectives. The KerData team is hosting 2 *Early Stage Researchers* in this framework and co-advises an extra PhD student.

8.2.2. Collaborations with Major European Organizations

Gabriel Antoniu and Alexandru Costan are serving as Inria representatives in the working groups dedicated to *HPC-Big Data* convergence within the **Big Data Value Association** (BDVA) and the **European Technology Platform in the area of High-Performance Computing** (ETP4HPC). They are contributing to the respective Strategic Research Agendas of BDVA and ETP4HPC.

8.3. International Initiatives

8.3.1. Inria International Labs

8.3.1.1. JLESC: Joint Laboratory on Extreme-Scale Computing

The **Joint Laboratory on Extreme-Scale Computing** is jointly run by Inria, UIUC, ANL, BSC, JSC and RIKEN/AICS. It has been created in 2014 as a follow-up of the Inria-UIUC JLPC, the *Joint Laboratory for Petascale Computing*.

The KerData team is collaborating with teams from ANL and UIUC within this lab since 2009 on several topics in the areas of I/O, storage and in situ processing and cloud computing. This collaboration has been initially formalized as the *Data@Exascale* Associate Team with ANL and UIUC (2013–2015) followed by *Data@Exascale 2* Associate Team with ANL (2016–2018). Our activities in this framework are described here: <http://www.irisa.fr/kerdata/data-at-exascale/>

Since 2015, Gabriel Antoniu serves as a topic leader for Inria for the *I/O, Storage and In Situ Processing* topic. Ongoing lab research directions and projects he is co-supervising in this area are described here: <https://jlesc.github.io/projects/> in the *I/O, Storage and In-Situ Processing* section.

Since 2017, Gabriel Antoniu is serving as *Vice-Executive Director of JLESC for Inria*.

8.3.1.1.1. Associate Team involved in the International Lab: Data@Exascale 2

Project Acronym: Data@Exascale 2.

Project Title: Convergent Data Storage and Processing Approaches for Exascale Computing and Big Data Analytics.

International Partner: Argonne National Laboratory (United States) — Mathematics and Computer Science Division (MCS) — **Rob Ross**.

Start year: 2013.

URL: <http://www.irisa.fr/kerdata/data-at-exascale/>.

Description: In the past few years, countries including United States, the European Union, Japan and China have set up aggressive plans to get closer to what appears to be the next goal in terms of high-performance computing (HPC): Exaflop computing, a target which is now considered reachable by the next-generation supercomputers in 2020-2023. While these government-led initiatives have naturally focused on the big challenges of Exascale for the development of new hardware and software architectures, the quite recent emergence of the Big Data phenomenon introduces what could be called a tectonic shift that is impacting the entire research landscape for Exascale computing. As data generation capabilities in most science domains are now growing substantially faster than computational capabilities, causing these domains to become data-intensive, new challenges appeared in terms of volumes and velocity for data to be stored, processed and analyzed on the future Exascale machines.

To face the challenges generated by the exponential data growth (a general phenomenon in many fields), a certain progress has already been made in the recent years in the rapidly-developing, industry-led field of cloud-based Big Data analytics, where advanced tools emerged, relying on machine-learning techniques and predictive analytics.

Unfortunately, these advances cannot be immediately applied to Exascale computing: the tools and cultures of the two worlds, HPC (High-Performance Computing) and BDA (Big Data Analytics) have developed in a divergent fashion (in terms of major focus and technical approaches), to the detriment of both. The two worlds share however multiple similar challenges and unification now appears as essential in order to address the future challenges of major application domains that can benefit from both.

The scientific program we propose for the Data@Exascale 2 Associate Team is defined from this new, highly-strategic perspective and builds on the idea that the design of innovative approaches

to data I/O, storage and processing allowing Big Data analytics techniques and the newest HPC architectures to leverage each other clearly appears as a key catalyst factor for the convergence process.

Activities in 2017 are described on the web site of the Associate Team.

8.3.2. *Inria International Partners*

8.3.2.1. *Declared Inria International Partners*

8.3.2.2. *DataCloud@Work*

Title: DataCloud@Work.

International Partner:

- Polytechnic University of Bucharest (Romania), Computer Science Department, Nicolae Tapus and Valentin Cristea.

Duration: 5 years.

Start year: 2013. The status of IIP was established right after the end of our former *DataCloud@work* Associate Team (2010–2012).

URL: https://www.irisa.fr/kerdata/doku.php?id=cloud_at_work:start.

Description: Our research topics address the area of distributed data management for cloud services, focusing on autonomic storage. The goal is explore how to build an efficient, secure and reliable storage IaaS for data-intensive distributed applications running in cloud environments by enabling an autonomic behavior.

8.3.2.3. *Informal International Partners*

Instituto Politécnico Nacional, IPN, Ciudad de México: We continued our informal collaboration in the area of stream processing. A PhD student from IPN (José Aguilar Canepa) was hosted by the KerData team for a 1-month internship, during which he identified optimization problems that can be subject to joint work (see Internships section below).

National University of Singapore (NUS): We collaborate on resource management for workflows in the cloud and optimizing graph processing in geo-distributed data-centers.

8.3.3. *Participation in Other International Programs*

8.3.3.1. *International Initiatives*

8.3.3.1.1. BDEC: Big Data and Extreme Computing

Since 2015, Gabriel Antoniu has been invited to participate to the yearly workshops of the international **Big Data and Extreme-scale Computing** (BDEC) working group, focused on the convergence of Extreme Computing (the latest incarnation of High-Performance Computing - HPC) and Big Data. BDEC is organized as an yearly series of invitation-based international workshops. In 2017 Gabriel Antoniu was solicited to co-lead the BDEC working group dedicated to exploring convergence-related challenges for hybrid architectures combining HPC systems, clouds and fog/edge computing infrastructures with **Geoffrey Fox** and **Ewa Deelman**. The contributions are reflected in the final report on convergence available on the BDEC web page.

8.4. *International Research Visitors*

8.4.1. *Visits of International Scientists*

José Aguilar Canepa (Instituto Politécnico Nacional, IPN, Mexico) visited the KerData team for one month (November 2017) in order to setup a common topic of research for the future proposal of an Associate Team Kerdata-IPN.

8.4.1.1. *Internships*

Mukrram Rahman (M1, University of Rennes 1) has done a 3-month internship within the team, working with Ovidiu Marcu and Alexandru Costan on HDFS extensions for dedicated stream storage.

8.4.2. *Visits to International Teams*

8.4.2.1. *Research Stays Abroad*

Pierre Matri has done a 3-month internship at Argonne National Lab, to work on extreme-scale logging through application-defined storage under the supervision of Phil Carns and Rob Ross. See Section *New Results* for details.

LACODAM Project-Team

9. Partnerships and Cooperations

9.1. Regional Initiatives

9.1.1. *SePaDec: Declarative approaches for Sequential Pattern mining*

Participants: Benjamin Negrevergne, Thomas Guyet, Ahmed Samet, Alexandre Termier.

The SEPADEC project is funded by the Region Bretagne. During the execution of this project we explored the application of declarative pattern mining (specifically ASP) in the field of care pathway analysis. The goal was to model domain knowledge to enrich raw data with medical expert knowledge and to develop a toolbox that smoothly integrates both expert knowledge and declarative pattern mining.

We developed a new approach for mining rare sequential mining with ASP [20] and we also proposed a general framework based on ASP for flexibly mine care pathways [12].

9.2. National Initiatives

9.2.1. ANR

9.2.1.1. *#DigitAg: Digital agriculture*

Participants: Alexandre Termier, Véronique Masson, Christine Largouët, Anne-Isabelle Graux.

#DigitAg is a “Convergence Institute” dedicated to the increasing importance of digital techniques in agriculture. Its goal is twofold: First, make innovative research on the use of digital techniques in agriculture in order to improve competitiveness, preserve the environment, and offer correct living conditions to farmers. Second, prepare future farmers and agricultural policy makers to successfully exploit such technologies.

While #DigitAg is based on Montpellier, Rennes is a satellite of the institute focused on cattle farming. LACODAM is involved in the “data mining” challenge of the institute, that A. Termier co-leads. He is also the representative of Inria in the steering committee of the institute.

The interest for the team is to design novel methods to analyze and represent agricultural data, which are challenging because they are both heterogeneous and multi-scale (both spatial and temporal).

9.2.2. National Platforms

9.2.2.1. *PEPS: Pharmaco-epidemiology for Health Products*

Participants: Yann Dauxais, Thomas Guyet, Véronique Masson, René Quiniou, Ahmed Samet.

The PEPS project (Pharmaco-epidemiology des Produits de Santé) is funded by the ANSM (National Agency for Health Security). The project leader is E. Oger from the clinical investigation center CIC-1414 INSERM/CHU Rennes. The other partners located in Rennes are the Institute of Research and Technology (IRT), B<>Com, EHESP and the LTSI. The project started in January 2015 and is funded for 4 years.

The PEPS project consists of two parts: a set of clinical studies and a research program dedicated to the development of innovative tools for pharmaco-epidemiological studies with medico-administrative databases.

Our contribution to this project will be to propose pattern mining algorithms and reasoning techniques to analyse the typical care pathways of specific groups of insured patients. This year we worked on the design and development of the DCM algorithm [8], [7] to mine patterns on care pathways.

9.3. International Research Visitors

9.3.1. Internships

This year, we hosted Scarlett Kelly, a student of Dalhousie University (Canada) from May to the end of August. Her internship was funded by a joint Mitacs Globalink (Canada) / Inria grant. Scarlett Kelly is a student of social sciences, thus she has a different profile than the computer science students who usually do internships at LACODAM. We were interested in such profile in order to gain a critical view on the current approaches of *interactive data mining*. Scarlett quickly picked up the literature of the domain, and could write a report and make interesting propositions that were unexpected from a computer science point of view, i.e., introduce a specially trained "data liaison" person between practitioners and data scientists. Her proposition led to a paper [14] accepted at the HICSS conference (an IT conference ranked "A" at CORE2017).

LAGADIC Project-Team

9. Partnerships and Cooperations

9.1. Regional Initiatives

9.1.1. *ARED DeSweep*

Participants: Lesley-Ann Duflot, Alexandre Krupa.

no Inria Rennes 8033, duration: 36 months.

This project funded by the Brittany council started in October 2014. It supports in part Lesley-Ann Duflot's Ph.D. about visual servoing based on the shearlet transform (see Section 7.3.1).

9.1.2. *ARED Locoflot*

Participants: Ide Flore Kenmogne Fokam, Vincent Drevelle, Eric Marchand.

no Inria Rennes 9944, duration: 36 months.

This project funded by the Brittany council started in October 2015. It supports in part Ide Flore Kenmogne Fokam's Ph.D. about cooperative localization in multi-robot fleets using interval analysis (see Section 7.6.2).

9.1.3. *ARED Mod4Nav*

Participants: Aline Baudry, Marie Babel.

no INSA Rennes 2016/01, duration: 36 months.

This project funded by the Brittany council started in October 2016. It supports in part Aline Baudry's Ph.D. about wheelchair modeling.

9.1.4. *“Equipement mi-lourd Rennes Métropole”*

Participant: Paolo Robuffo Giordano.

no CNRS Rennes 14C0481, duration: 36 months.

This grant from “Rennes Métropole” has been obtained in June 2014 and supported the activities related to the use of drones (quadrotor UAVs). The platform described in Section 6.8.5 has been purchased in part thanks to this grant.

9.1.5. *“Allocation d'installation scientifique”*

Participant: Claudio Pacchierotti.

no CNRS Rennes 17C0487, duration: 36 months.

This grant from “Rennes Métropole” has been obtained in July 2017 and supported the activities related to the teleoperation of drones (quadrotor UAVs) using wearable haptics interfaces.

9.1.6. *IRT Jules Verne Mascot*

Participant: François Chaumette.

no Inria Rennes 10361, duration: 36 months.

This project started in October 2015. It is managed by IRT Jules Verne in Nantes and achieved in cooperation with LS2N, Airbus, Renault, Faurecia and Alstom. Its goal is to perform screwing for various industrial applications.

9.1.7. *IRT b<>com NeedleWare*

Participants: Hadrien Gurnel, Alexandre Krupa.

no Inria Rennes 9072, duration: 36 months.

This project started in October 2016. It supports Hadrien Gurnel's Ph.D. about the study of a shared control strategy fusing haptic and ultrasound visual control for assisting manual steering of needles for biopsy or therapy purposes in a synergetic way (see Section 7.3.4).

9.1.8. *Prisme*

Participants: Solenne Fortun, Marie Babel.

no Insa Rennes 9072, duration: 24 months.

This project started in January 2017 and is supported by Brittany region/BPI. This project aims at designing a fall prevention strategy based on the sensing collaboration of a smart wheelchair and a smart medical bed. Fall detection and automatic positioning of the wheelchair next to the bed issues are planned to be addressed (see Section 7.5.5).

9.2. National Initiatives

9.2.1. *France Life Imaging WP3-FLI ANFEET*

Participant: Alexandre Krupa.

duration: 24 months.

This project started in January 2016. Its objective is to initiate collaborative research with the ICube laboratory (Strasbourg) on the control and supervision of flexible endoscopes in the digestive tube using ultrasound images.

9.2.2. *ANR Contint Visioland*

Participants: Noël Mériaux, Pierre-Marie Kerzerho, Patrick Rives, François Chaumette.

no Inria Rennes 8304, duration: 48 months.

This project ended in October 2017. It involved a consortium managed by Onera in Toulouse with Airbus, Spikenet Technology, LS2N, and Lagadic. Its aim was to develop vision-based localization and navigation techniques for autonomous landing on a runway (see Section 7.1.4).

9.2.3. *ANR Contint Entracte*

Participant: Julien Pettré.

no Inria Rennes 8013, duration: 42 months.

This project ended in April 2017. It was realized in collaboration with the Gepetto group at Laas, Toulouse, and the Mimetic group at Irisa and Inria Rennes Bretagne Atlantique. It addressed the problem of motion planning for anthropomorphic systems, and more generally, the problem of manipulation path planning. Entracte proposed to study in parallel both the mathematical foundations of artificial motion and the neurocognitive structures used by humans to quickly solve motion problems.

9.2.4. *ANR JCJC Percolation*

Participant: Julien Pettré.

no Inria Rennes 7991, duration: 42 months.

The ANR "Jeune Chercheur" Percolation project ended on June 2017. It aimed at designing perception-based crowd simulation algorithms. We developed agents able of perceiving their virtual environment through virtual sensors, and able to navigate in it, as well as to interact with the other agents.

9.2.5. *ANR JCJC SenseFly*

Participants: Thomas Bellavoire, Muhammad Usman, Paolo Robuffo Giordano.

no Irisa CNRS 50476, duration: 36 months.

The ANR “Jeune Chercheur” SenseFly project started in August 2015. Its goal is to advance the state-of-the-art in multi-UAV in the design and implementation of fully decentralized and sensor-based group behaviors by only resorting to onboard sensing (mainly cameras and IMU) and local communication (e.g., Bluetooth communication, wireless networks). Topics such as individual flight control, formation control robust against sensor limitations (e.g., limited field of view, occlusions), distributed estimation of relative positions/bearings from local sensing, maintenance of architectural properties of a multi-UAV formation are studied in the project. Part of the platforms described in Section 6.8.5 has been purchased thanks to this grant.

9.2.6. ANR PLaTINUM

Participants: Eduardo Fernandez Moral, Vincent Drevelle, Patrick Rives.

no Inria Sophia 10204, duration: 42 months.

This project started in November 2015. It involves a consortium managed by Litis in Rouen with IGN Matis (Paris), Le2i (Le Creusot) and Lagadic group. It aims at proposing novel solutions to robust long-term mapping of urban environments.

9.2.7. BPI Romeo 2

Participants: Giovanni Claudio, Fabien Spindler, François Chaumette.

no Inria Rennes 7114, duration: 60 months.

This project ended in October 2017. It involved a large consortium managed by Softbank Robotics (ex Aldebaran Robotics) with Laas in Toulouse, Isir in Paris, Lirmm in Montpellier, Inria groups Lagadic, Bipop (Pierre-Brice Wieber), Flowers (Pierre-Yves Oudeyer), etc. It aimed at developing advanced control and perception functionalities to a humanoid robot. In this project, we developed visual manipulation and navigation tasks with Romeo and Pepper.

9.2.8. Equipex Robotex

Participants: Fabien Spindler, François Chaumette.

no Inria Rennes 6388, duration: 9 years.

Lagadic is one of the 15 French academic partners involved in the Equipex Robotex network that started in February 2011. It is devoted to get and manage significant equipment in the main robotics labs in France. In the scope of this project, we have got the humanoid robot Romeo (see Section 6.8.4).

9.3. European Initiatives

9.3.1. FP7 & H2020 Projects

9.3.1.1. FP7 Space RemoveDEBRIS

Participants: Eric Marchand, François Chaumette.

Instrument: Specific Targeted Research Project

Duration: October 2013 - September 2018

Coordinator: University of Surrey (United Kingdom)

Partners: Surrey Satellite Technology (United Kingdom), Airbus (Toulouse, France and Bremen, Germany), Isis (Delft, The Netherlands), CSEM (Neuchâtel, Switzerland), Stellenbosch University (South Africa).

Inria contact: François Chaumette

Abstract: The goal of this project is to validate model-based tracking algorithms on images acquired during an actual space debris removal mission [22], [47].

9.3.1.2. H2020 ICT Comanoid

Participants: Giovanni Claudio, Souriya Trinh, Fabien Spindler, François Chaumette.

Title: Multi-contact Collaborative Humanoids in Aircraft Manufacturing

Programme: H2020

Duration: January 2015 - December 2018

Coordinator: CNRS (Lirmm)

Partners: Airbus Group (France), DLR (Germany), Università Degli Studi di Roma La Sapienza (Italy), CNRS (I3S)

Inria contact: Francois Chaumette

Comanoid investigates the deployment of robotic solutions in well-identified Airbus airliner assembly operations that are laborious or tedious for human workers and for which access is impossible for wheeled or rail-ported robotic platforms. As a solution to these constraints a humanoid robot is proposed to achieve the described tasks in real-use cases provided by Airbus Group. At a first glance, a humanoid robotic solution appears extremely risky, since the operations to be conducted are in highly constrained aircraft cavities with non-uniform (cargo) structures. Furthermore, these tight spaces are to be shared with human workers. Recent developments, however, in multi-contact planning and control suggest that this is a much more plausible solution than current alternatives such as a manipulator mounted on multi-legged base. Indeed, if humanoid robots can efficiently exploit their surroundings in order to support themselves during motion and manipulation, they can ensure balance and stability, move in non-gaited (acyclic) ways through narrow passages, and also increase operational forces by creating closed-kinematic chains. Bipedal robots are well suited to narrow environments specifically because they are able to perform manipulation using only small support areas. Moreover, the stability benefits of multi-legged robots that have larger support areas are largely lost when the manipulator must be brought close, or even beyond, the support borders. COMANOID aims at assessing clearly how far the state-of-the-art stands from such novel technologies. In particular the project focuses on implementing a real-world humanoid robotics solution using the best of research and innovation. The main challenge are to integrate current scientific and technological advances including multi-contact planning and control; advanced visual-haptic servoing; perception and localization; human-robot safety, and the operational efficiency of cobotics solutions in airliner manufacturing.

9.3.1.3. H2020 ICT Romans

Participants: Firas Abi Farraj, Fabien Spindler, François Chaumette, Claudio Pacchierotti, Paolo Robuffo Giordano.

Title: Robotic Manipulation for Nuclear Sort and Segregation

Programme: H2020

Duration: May 2015 - April 2018

Coordinator: University of Birmingham

Partners: NLL (UK), CEA (France), Univ. Darmstadt (Germany)

CNRS contact: Paolo Robuffo Giordano

The RoMaNS (Robotic Manipulation for Nuclear Sort and Segregation) project will advance the state of the art in mixed autonomy for tele-manipulation, to solve a challenging and safety-critical “sort and segregate” industrial problem, driven by urgent market and societal needs. Cleaning up the past half century of nuclear waste, in the UK alone (mostly at the Sellafield site), represents the largest environmental remediation project in the whole of Europe. Most EU countries face related challenges. Nuclear waste must be “sorted and segregated”, so that low-level waste is placed in low-level storage containers, rather than occupying extremely expensive and resource intensive high-level storage containers and facilities. Many older nuclear sites (>60 years in UK) contain large

numbers of legacy storage containers, some of which have contents of mixed contamination levels, and sometimes unknown contents. Several million of these legacy waste containers must now be cut open, investigated, and their contents sorted. This can only be done remotely using robots, because of the high levels of radioactive material. Current state-of-the-art practice in the industry, consists of simple tele-operation (e.g. by joystick or teach-pendant). Such an approach is not viable in the long-term, because it is prohibitively slow for processing the vast quantity of material required. The project aims at: 1) Develop novel hardware and software solutions for advanced bi-lateral master-slave tele-operation. 2) Develop advanced autonomy methods for highly adaptive automatic grasping and manipulation actions. 3) Combine autonomy and tele-operation methods using state-of-the-art understanding of mixed initiative planning, variable autonomy and shared control approaches. 4) Deliver a TRL 6 demonstration in an industrial plant-representative environment at the UK National Nuclear Lab Workington test facility.

9.3.2. Collaborations in European Programs, Except FP7 & H2020

9.3.2.1. Interreg Adapt

Participants: Nicolas Le Borgne, Marie Babel.

Programme: Interreg VA France (Channel) England

Project acronym: Adapt

Project title: Assistive Devices for empowering disAbled People through robotic Technologies

Duration: 01/2017 - 06/2021

Coordinator: ESIGELEC/IRSEEM Rouen

Other partners: INSA Rennes - IRISA, LGCGM, IETR (France), Université de Picardie Jules Verne - MIS (France), Pôle Saint Héliier (France), CHU Rouen (France), Réseau Breizh PC (France), Ergovie (France), Pôle TES (France), University College of London - Aspire CREATE (UK), University of Kent (UK), East Kent Hospitals Univ NHS Found. Trust (UK), Health and Europe Centre (UK), Plymouth Hospitals NHS Trust (UK), Canterbury Christ Church University (UK), Kent Surrey Sussex Academic Health Science Network (UK), Cornwall Mobility Center (UK).

Abstract: This project aims to develop innovative assistive technologies in order to support the autonomy and to enhance the mobility of power wheelchair users with severe physical/cognitive disabilities. In particular, the objective is to design and evaluate a power wheelchair simulator as well as to design a multi-layer driving assistance system.

9.3.3. Collaborations with European Partners

9.3.3.1. ANR Opmops

Participants: Florian Berton, Julien Pettré.

Programme: ANR

Project acronym: Opmops

Project title: Organized Pedestrian Movement in Public Spaces: Preparation and Crisis Management of Urban Parades and Demonstration Marches with High Conflict Potential

Duration: June 2017 - June 2020

Coordinator: Université de Haute Alsace (for France), Technische Universität Kaiserslautern (for Germany)

Other partners: Gendarmerie Nationale, Hochschule München, ONHYS S.A.S, Polizei Rheinland-Pfalz, Universität Koblenz-Landau, VdS GmbH

Abstract: This project is about parades of highly controversial groups or of political demonstration marches are considered as a major threat to urban security. Due to the movement of the urban parades and demonstration marches (in the following abbreviated by UPM) through large parts of cities and the resulting space and time dynamics, it is particularly difficult for forces of civil security (abbreviated in the following by FCS) to guarantee safety at these types of urban events without endangering one of the most important indicators of a free society. In this proposal, partners representing the FCS (police and industry) will cooperate with researchers from academic institutions to develop a decision support tool which can help them both in the preparation phase and crisis management situations of UPMs. Specific technical issues which the French-German consortium will have to tackle include the following: Optimization methods to plan UPM routes, transportation to and from the UPM, location and personnel planning of FCS, control of UPMs using stationary and moving cameras, and simulation methods, including their visualization, with specific emphasis on social behavior.

9.3.3.2. *iProcess*

Participants: Agniva Sengupta, Fabien Spindler, Eric Marchand, Alexandre Krupa, François Chaumette.

Project acronym: i-Process

Project title: Innovative and Flexible Food Processing Technology in Norway

Duration: January 2016 - December 2019

Coordinator: Sintef (Norway)

Other partners: Nofima, Univ. of Stavanger, NMBU, NTNU (Norway), DTU (Denmark), KU Leuven (Belgium), and about 10 Norwegian companies.

Abstract: This project is granted by the Norwegian Government. Its main objective is to develop novel concepts and methods for flexible and sustainable food processing in Norway. In the scope of this project, the Lagadic group is involved for visual tracking and visual servoing of generic and potentially deformable objects (see Section 7.1.2). Prof. Ekrem Misimi from Sintef spent a 4-month visit from May 2017 and a 1-week visit in November 2017. François Chaumette and Alexandre Krupa spent a short period at Sintef in Trondheim in February and June 2017 respectively.

9.4. International Initiatives

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

9.4.1.1. *SIMS*

Title: Realistic and Efficient Simulation of Complex Systems

International Partners:

University of North Carolina at Chapel Hill (USA) - GAMMA Group - Ming C. Lin, Dinesh Manocha

University of Minnesota (USA) - Motion Lab - Stephen Guy

Brown University (USA) - VenLab - William Warren

Start year: 2012

See <http://people.rennes.inria.fr/Julien.Pettre/EASIMS/easims.html>

The general goal of SIMS is to make significant progress toward realistic and efficient simulation of highly complex systems, which raise combinatory explosive problems. This proposal is focused on human motion and interaction, and covers 3 active topics with wide application range:

1. Crowd simulation: virtual human interacting with other virtual humans,
2. Autonomous virtual humans interacting with their environment,
3. Physical simulation: real humans interacting with virtual environments.

SIMS is orthogonally structured by transversal questions: the evaluation of the level of realism reached by a simulation (which is a problem by itself in the considered topics), considering complex systems at various scales (micro, meso and macroscopic ones), and facing combinatory explosion of simulation algorithms.

9.4.1.2. ISI4NAVE

Title: Innovative Sensors and adapted Interfaces for assistive NAVigation and pathology Evaluation
International Partner (Institution - Laboratory - Researcher):

University College London (United Kingdom) - Aspire CREATE - Tom Carlson

Start year: 2016

See also: <http://www.irisa.fr/lagadic/team/MarieBabel/ISI4NAVE/ISI4NAVE.html>

The global ageing population, along with disability compensation constitutes major challenging societal and economic issues. In particular, achieving autonomy remains a fundamental need that contributes to the individual's wellness and well-being. In this context, innovative and smart technologies are designed to achieve independence while matching user's individual needs and desires.

Hence, designing a robotic assistive solution related to wheelchair navigation remains of major importance as soon as it compensates partial incapacities. This project then addresses the following two issues. First, the idea is to design an indoor / outdoor efficient obstacle avoidance system that respects the user intention, and does not alter user perception. This involves embedding innovative sensors to tackle the outdoor wheelchair navigation problem. The second objective is to take advantage of the proposed assistive tool to enhance the user Quality of Experience by means of biofeedback. Indeed, adapted interfaces should improve the understanding of people that suffer from cognitive and/or visual impairments.

The originality of the project is to continuously integrate medical validation as well as clinical trials during the scientific research work in order to match user needs and acceptance.

9.4.2. Participation in International Programs

9.4.2.1. ACRV

The Lagadic group is one of the five external partners of the Australian Center for Robotic Vision (see <http://roboticvision.org>). This center groups QUT in Brisbane, ANU in Canberra, Monash University and Adelaide University. In the scope of this project, Quentin Bateux received a grant to participate to the 2017 Robotic Vision Summer School in Kioloa (New South Wales) and spent a 1-week visit at QUT in March 2017.

9.5. International Research Visitors

9.5.1. Visits of International Scientists

- Prof. Denis Wolf, Associate Professor at Univ. Sao Paulo, Brazil, spent a sabbatical year in Sophia Antipolis from July 2016 to August 2017. He worked on semantic learning applied to intelligent vehicles.
- Prof. Dan Zelazo (Technion) and Prof. Antonio Bicchi (Univ. Pisa) spent a short visit in the group in Rennes in 2017.

9.5.1.1. Internships

- Giuseppe Sirignano (Univ. Salerno), from October 2017 to March 2018
- Mario Selvaggio (Univ. Naples), from November 2017 till end of December 2017

9.5.2. Visits to International Teams

9.5.2.1. Research Stays Abroad

- Jason Chevie spent a 3-month visit in Sarthak Misra's lab at the Surgical Robotics Laboratory (SRL) of University of Twente (Netherlands) where he performed robotic experiments in the scope of his Ph.D (see Section 7.3.2).
- François Chaumette was invited for a 1-week visit at Zhejiang University in November 2017.

LINKMEDIA Project-Team

9. Partnerships and Cooperations

9.1. Regional Initiatives

9.1.1. *CominLabs Project Linking Media in Acceptable Hypergraphs (LIMAH)*

Participants: Rémi Bois, Vincent Claveau, Guillaume Gravier, Pascale Sébillot, Arnaud Touboullic.

Duration: 4 years, started in April 2014

Partners: Telecom Bretagne (IODE), Univ. Rennes II (CRPCC, PREFics), Univ. Nantes (LINA/TAL)

URL: <http://limah.irisa.fr>

LIMAH aims at exploring hypergraph structures for multimedia collections, instantiating actual links reflecting particular content-based proximity—similar content, thematic proximity, opinion expressed, answer to a question, etc. Exploiting and developing further techniques targeting pairwise comparison of multimedia contents from an NLP perspective, LIMAH addresses two key issues: How to automatically build from a collection of documents an hypergraph, i.e., a graph combining edges of different natures, which provides exploitable links in selected use cases? How collections with explicit links modify usage of multimedia data in all aspects, from a technology point of view as well as from a user point of view? LIMAH studies hypergraph authoring and acceptability taking a multidisciplinary approach mixing ICT, law, information and communication science as well as cognitive and ergonomics psychology.

9.1.2. *CominLabs Project BigCLIN*

Participants: Vincent Claveau, Ewa Kijak, Clément Dalloux.

Duration: 3 years, started in September 2016

Partners: STL-CNRS, Inserm/CHU Rennes, Inria

URL: <http://www.bigclin.cominlabs.ueb.eu>

Data collected or produced during clinical care process can be exploited at different levels and across different domains. Yet, a well-known challenge for secondary use of health big data is that much of detailed patient information is embedded in narrative text, mostly stored as unstructured data. The project proposes to address the essential needs when reusing unstructured clinical data at a large scale. We propose to develop new clinical records representation relying on fine-grained semantic annotation thanks to new NLP tools dedicated to French clinical narratives. To efficiently map this added semantic information to existing structured data for further analysis at big scale, the project also addresses distributed systems issues: scalability, management of uncertain data and privacy, stream processing at runtime, etc.

9.2. National Initiatives

9.2.1. *ANR Project IDFRAud*

Participant: Teddy Furon.

Duration: 3 years, started in Feb. 2015

Partners: AriadNext, IRCGN, École Nationale Supérieure de Police

The IDFRAud project consists in proposing an automatic solution for ID analysis and integrity verification. Our ID analysis goes through three processes: classification, text extraction and ID verification. The three processes rely on a set of rules that are externalized in formal manner in order to allow easy management and evolving capabilities. This leads us to the ID knowledge management module. Finally, IDFRAud addresses the forensic link detection problem and to propose an automatic analysis engine that can be continuously applied on the detected fraud ID database. Cluster analysis methods are used to discover relations between false IDs in their multidimensional feature space. This pattern extraction module will be coupled with a suitable visualization mechanism in order to facilitate the comprehension and the analysis of extracted groups of inter-linked fraud cases.

9.2.2. *FUI 19 NexGenTV*

Participants: Vincent Claveau, Guillaume Gravier, Ewa Kijak, Gabriel Sargent, Ronan Sicre.

Duration: 2.5 years, started in May 2015

Partners: Eurecom, Avisto Telecom, Wildmoka, Envivio-Ericsson

Television is undergoing a revolution, moving from the TV screen to multiple screens. Today's user watches TV and, at the same time, browses the web on a tablet, sends SMS, posts comments on social networks, searches for complementary information on the program, etc. Facing this situation, NexGen-TV aims at developing a generic solution for the enrichment, the linking and the retrieval of video content targeting the cost-cutting edition of second screen and multiscreen applications for broadcast TV. The main outcome of the project will be a software platform to aggregate and distribute video content via a second-screen edition interface connected to social media. The curation interface will primarily make use of multimedia and social media content segmentation, description, linking and retrieval. Multiscreen applications will be developed on various domains, e.g., sports, news.

9.2.3. *Inria Project Lab Knowledge-driven data and content collaborative analytics (iCODA)*

Participants: Laurent Amsaleg, Vincent Claveau, Cheikh Brahim El Vaigh, Guillaume Gravier, Pascale Sébillot.

Duration: 4.5 years, started in April 2017

Partners: Inria project-teams Linkmedia, CEDAR, GraphIK and ILDA, with Ouest France, Le Monde and AFP

One of today's major issues in data science is the design of algorithms that allow analysts to efficiently infer useful information and knowledge by collaboratively inspecting heterogeneous information sources, from structured data to unstructured content. Taking data journalism as an emblematic use-case, the goal of the project is to develop the scientific and technological foundations for knowledge-mediated user-in-the-loop collaborative data analytics on heterogeneous information sources, and to demonstrate the effectiveness of the approach in realistic, high-visibility use-cases. The project stands at the crossroad of multiple research fields—content analysis, data management, knowledge representation, visualization—that span multiple Inria themes, and counts on a club of major press partners to define usage scenarios, provide data and demonstrate achievements.

9.3. European Initiatives

9.3.1. *CHIST ERA ID_IOT*

Participant: Teddy Furon.

Duration: 3 years, started in Oct. 2016

Partners: Eindhoven Univ. of Technology, Univ. of Geneva

The IoT will contain a huge number of devices and objects that have very low or nonexistent processing and communication resources, coupled to a small number of high-power devices. The weakest devices, which are most ubiquitous, will not be able to authenticate themselves using cryptographic methods. This project addresses these issues using physical unclonable functions (PUFs). PUFs, and especially quantum readout PUFs, are ideally suited to the IoT setting because they allow for the authentication and identification of physical objects without requiring any crypto or storage of secret information.

Furthermore, we foresee that back-end systems will not be able to provide security and privacy via cryptographic primitives due to the sheer number of IoT devices. Our plan is to address these problems using privacy-preserving database structures and algorithms with good scaling behaviour. Approximate nearest neighbour (ANN) search algorithms, which have remarkably good scaling behaviour, have recently become highly efficient, but do not yet have the right security properties and have not yet been applied to PUF data. Summarised in a nutshell, the project aims to improve the theory and practice of technologies such as PUFs and ANN search in the context of generic IoT authentication and identification scenarios.

9.3.2. Collaborations with Major European Organizations

Big Data Value Association (BDVA): LINKMEDIA is a co-founder and co-leader of the media group (TF7) within BDVA

9.4. International Initiatives

9.4.1. Inria International Partners

9.4.1.1. Informal International Partners

- National Institute for Informatics, Japan
- University of Amsterdam, The Netherlands
- Czech Technical University, Czech Republic
- Katholieke Universiteit Leuven, Belgium

9.4.2. Participation in Other International Programs

- CNRS – CONFAP FIGTEM
 - Title: Fine-grained text-mining for clinical trials
 - International Partner (Institution - Laboratory - Researcher): Pontifícia Universidade Católica do Paraná - Health Informatics dept, Claudia Moro

FIGTEM aims at developing natural language processing methods, including information extraction and indexing, dedicated to the clinical trial domain. The goal is to populate a formal representation of patients (via their electronic patient records) and clinical trial data in different languages (French, English, Portuguese).
 - Jan. 2016 – Dec. 2018

9.5. International Research Visitors

9.5.1. Visits of International Scientists

Giorgos Tolias

Date: Sept. 2017 (1 week)

Institution: Czech Technical University, Czech Republic

Vincent Oria

Date: July 2017 (2 weeks)

Institution: New Jersey Institute of Technology, Newark, USA

Michael Houle

Date: July 2017 (2 weeks)

Institution: National Institute of Informatics, Tokyo, Japan

9.5.1.1. Internships

Gabriel B. de Fonseca

Date: Nov. 2016 - Jan. 2017

Institution: PUC Minas, Brazil

9.5.2. Visits to International Teams

Laurent Amsaleg

Date: Oct. 2017 (2 days)

Institution: New Jersey Institute of Technology, Newark, USA

Laurent Amsaleg

Date: May. 2017 (1 week)

Institution: East China Normal University, Shanghai, PRC

Clément Dalloux

Date: Nov.-Dec 2017 (1 month)

Institution: Pontifícia Universidade Católica do Paraná, Brazil

Guillaume Gravier

Date: Nov. 2017 (1 week)

Institution: Universidad de Chile, Santiago, Chile

Guillaume Gravier

Date: May. 2017 (1 week)

Institution: East China Normal University, Shanghai, PRC

MIMETIC Project-Team

9. Partnerships and Cooperations

9.1. Regional Initiatives

- SATT "Ouest valorisation" grant for the maturation of the Kimea software and projet (Franck Multon and Pierre Plantard). 12 months of three full-time people 300K€. Creation of the start-up company planned beginning of 2018.
- SATT "Ouest valorisation" grant for the maturation of the Populate software (Fabrice Lamarche). One full-time engineer (2017-2018).

9.2. National Initiatives

9.2.1. ANR

9.2.1.1. Cineviz

Participants: Marc Christie [contact], Christophe Lino, Quentin Galvane, Hui-Yin Wu.

Cineviz is a 3-year ANR LabCom project (2016-2019). Amount: 300k€. Parnters: SolidAnim, UR1.

The project is a bilateral collaboration with the SolidAnim company. The objective is to jointly progress on the design and implementation of novel tools for the preproduction in the film industry. The project will address the challenges related to (i) proposing expressive framing tools, (ii) integrating the technical aspects of shooting (how to place the cameras, lights, green sets) directly at the design stage), and (iii) novel interaction metaphors for designing and controlling the staging of lights in preproduction, using an example-based approach.

9.2.1.2. Entracte

Participants: Charles Pontonnier [contact], Georges Dumont, Franck Multon, Pierre Plantard, Ana Lucia Cruz Ruiz, Antoine Muller, Anthony Sorel, Nicolas Bideau, Richard Kulpa.

The ANR project ENTRACTE is a collaboration between the Gepetto team in LAAS, Toulouse (head of the project) and the Inria/MimeTIC team. The project started in November 2013 and ended in August 2017. The purpose of the ENTRACTE project is to address the action planning problem, crucial for robots as well as for virtual human avatars, in analyzing human motion at a biomechanical level [16] and in defining from this analysis bio-inspired motor control laws and bio-inspired paradigms for action planning. The project is launched since november 2013 and Ana Lucia Cruz Ruiz, who has been recruited as a PhD student since this date, defended her thesis on muscle-based control based on synergies last year.

9.2.2. National scientific collaborations

9.2.2.1. Cavaletic

Participant: Franck Multon [contact].

The Cavaletic collaborative project is leaded by University Bretagne Sud and also involves University Rennes2 (CREAD Lab.). It has been funded by the National IFCE (Institut Français du Cheval et de l'Equitation) in order to develop and evaluate technological assistance in horse riding learning, thanks to a user-centered approach. MimeTIC is involved in measuring expert and non-expert horse riders' motions in standardized situations in order to develop metrics to measure riders' performance. It will be used to develop a technological system embedded on users to evaluate their performance and provide them with real-time feedback to correct potential errors.

9.2.2.2. FFT

Participants: Richard Kulpa [contact], Benoit Bideau, Pierre Touzard.

An exclusive contract has been signed between the M2S laboratory and the French Federation of Tennis for three years. The goal is to perform biomechanical analyses of 3D tennis serves on a population of 40 players of the Pôle France. The objective is to determine the link between injuries and biomechanical constraints on joints and muscles depending on the age and gender of the players. At the end, the goal is to evaluate their load training.

9.2.2.3. *gDGA*

Participants: Antonio Mucherino [contact], Ludovic Hoyet, Franck Multon.

gDGA (generalization of the Distance Geometry and its Applications) is a INS2I/CNRS PEPS project involving local and national partners. Distance geometry can nowadays be seen as a classical problem in operational research, having a wide range of applications. The main aim of this interdisciplinary project is to extend the definition and the range of applicability of distance geometry. In particular, our main interest is on dynamical problems, motivated by a certain number of applications of interest, including interaction motion adaptation, the simulation of crowd behaviours, and the conception of modern recommender systems. The classical application of distance geometry arising in the biological field is also taken into consideration. The necessity of a strong computational power for the considered applications motivates the need of implementing our algorithms in environments capable of exploiting the resources on GPU cards.

9.2.2.4. *IRMA*

Participants: Ronan Gaugne [contact], Georges Dumont.

The IRMA project is an Imag'In project funded by CNRS which aims at developing innovative methodologies for research in the field of cultural heritage based on the combination of medical imaging technologies and interactive 3D technologies (virtual reality, augmented reality, haptics, additive manufacturing). It relies on close collaborations with the National Institute of Preventive Archaeological Research (Inrap), the Research Center Archaeology, and History Archéosciences (CReAAH UMR 6566) and the company Image ET. The developed tools are intended for cultural heritage professionals such as museums, curators, restorers, and archaeologists. We focus on a large number of archeological artefacts of different nature, and various time periods (Paleolithic, Mesolithic, and Iron Age Medieval) from all over France. We can notably mention the oldest human bones found in Brittany (clavicle Beg Er Vil), a funeral urn from Trebeurden (22), or a Bronze Cauldron from a burial of the Merovingian necropolis "Crassés Saint-Dizier" (51). This project involves a strong collaboration with members of the team Hybrid (Valérie Gouranton, Bruno Arnaldi and Jean-Baptiste Barreau), Théophane Nicolas (Inrap/UMR Trajectoires), Quentin Petit (SED Inria Rennes), and Grégor Marchand (CNRS/UMR CReAAH).

9.2.3. *ADT: Immerstar*

Participants: Franck Multon, Georges Dumont [contact], Ronan Gaugne.

The ADT-Immerstar is driven by the SED and aims at developing new tools and facilities for the scientific community in order to develop demos and use the two immersive rooms in Rennes: Immersia and Immermove. The engineer (Quentin Petit, SED) has the responsibility of homogenizing the software modules and development facilities in each platform, of installing new upgrades and of developing collaborative applications between the two sites.

9.2.4. *PRE*

Participants: Franck Multon [contact], Ludovic Hoyet, Antonio Mucherino.

The Inria PRE projet entitled "Smart sensors and novel motion representation breakthrough for human performance analysis" aims at designing a new description for human motion in order to automatically capture, measure and transfer the intrinsic constraints of human motion. Current approached consisted in manually editing the constraints associated with a motion, to use classical skeleton representation with joint angles based on direct or indirect measurements, and then perform inverse kinematics to fulfill these constraints. We aim at designing a new representation to simplify this process pipeline and make it automatic, together with relevant motion sensors that could provide enough information to automatically extract these intrinsic

constraints. To this end, this project has been jointly proposed with the Inria CAIRN team, which develops sensors based on joint orientations and distances between sensors. We aim at extending this type of device to measure new types of information that would help to simplify the above mentioned pipeline. A postdoc arrived in November 2016 to jointly work with CAIRN. We also involved Hubert Shum from Northumbria University to link this project with the long-term collaboration with Dr. Shum about this type of problem. type of problems.

9.3. International Initiatives

9.3.1. FORMOSA

Title: Fostering Research on Models for Storytelling Applications

International Partner (Institution - Laboratory - Researcher):

NCCU (Taiwan) - Intelligent Media Lab (IML) - Tsai-Yen Li

Start year: 2016

See also: <http://www.irisa.fr/mimetic/GENS/mchristi/EA-FORMOSA/>

Interactive Storytelling is a new media which allows users to alter the content and outcome of narratives through role-playing and specific actions. With the quality, the availability and reasonable costs of display technologies and 3D interaction devices on one side, and the accessibility of 3D content creation tools on the other, this media is taking a significant share in entertainment (as demonstrated by the success of cinematographic games such as Heavy Rain or Beyond: two souls). These advances push us to re-think the way narratives are traditionally structured, explore new interactive modalities and provide new interactive cinematographic experiences. As a sequel of the first associate team FORMOSA 1, we propose to address new challenges pertained to interactive storytelling such as the use of temporal structures in narratives, interaction modalities and their impact in terms of immersion, and the adaptation of cinematographic real data to 3D environments. To achieve these objectives, the associate team will rely on the complementary skills of its partners and on the co-supervision of students.

9.3.2. SIMS

Title: REal data against crowd SIMulation AlgorithMS

International Partner (Institution - Laboratory - Researcher):

University of North Carolina at Chapel Hill (United States) - GAMMA Research Group (GAMMA) - Ming LIN

Start year: 2015

See also: <http://www.irisa.fr/mimetic/GENS/jpettre/EASIMS/easims.html>

RE-SIMS aims at gathering the best international research teams working on crowd simulation to allow significant progresses on the level of realism achieved by crowd simulators. To this end, RE-SIMS aims at improving methods for capturing crowd motion data that describe real crowd behaviors, as well as by improving data assimilation techniques.

In this renewal, RE-SIMS extends the previous SIMS partnership and follows a multidisciplinary direction.

9.3.3. Inria International Partners

9.3.3.1. Informal International Partners

- Dr. Edouard Auvinet, Imperial College London, UK (collaboration with Franck Multon)
- Dr. Huber Shum, Northumbria University, Newcastle, UK (collaboration with Franck Multon and Ludovic Hoyet, with joint papers and supervision)

- Dr. Rachel McDonnell, Trinity College Dublin, Ireland (on-going collaboration with Ludovic Hoyet, including a 6-month internship from one of her PhD student in Rennes)
- Prof. Carol O’Sullivan, Trinity College Dublin, Ireland (on-going collaboration with Ludovic Hoyet)
- Prof. Carlile Lavor, UNICAMP, Campinas, Sao Paulo, Brazil (collaboration with Antonio Mucherino)
- Dr. Douglas S. Gonçalves, Federal University of Santa Catarina, Florianópolis, Brazil (collaboration with Antonio Mucherino)
- Jung-Hsin Lin, Academia Sinica, Taipei, Taiwan (collaboration with Antonio Mucherino)

9.4. International Research Visitors

9.4.1. Visits of International Scientists

9.4.1.1. Professors and associate professors

- Victoria Interrante, Professor, Department of Computer Science and Engineering, University of Minnesota USA, December 8th, 2017
- Michael Cinelli, Associate Professor, Kinesiology and Physical Education, Wilfrid Laurier University, Canada, June 2017

9.4.1.2. Internships

- Emma Carrigan, Trinity College Dublin, Ireland (PhD supervisor: Dr. Rachel McDonnell), 6-month internship in collaboration with Technicolor (Quentin Avril), Jan. to June 2017.

MYRIADS Project-Team

9. Partnerships and Cooperations

9.1. Regional Initiatives

9.1.1. CominLabs EPOC project (2013-2017)

Participants: Sabbir Hasan Rochi, Yunbo Li, Anne-Cécile Orgerie, Jean-Louis Pazat.

In this project, partners aim at focusing on energy-aware task execution from the hardware to application's components in the context of a mono-site data center (all resources are in the same physical location) which is connected to the regular electric Grid and to renewable energy sources (such as windmills or solar cells). In this context, we tackle three major challenges:

- Optimizing the energy consumption of distributed infrastructures and service compositions in the presence of ever more dynamic service applications and ever more stringent availability requirements for services.
- Designing a clever cloud's resource management which takes advantage of renewable energy availability to perform opportunistic tasks, then exploring the trade-off between energy saving and performance aspects in large-scale distributed systems.
- Investigating energy-aware optical ultra high-speed interconnection networks to exchange large volumes of data (VM memory and storage) over very short periods of time.

Sabbir Hasan Rochi has defended his PhD on SLA driven Cloud autoscaling for optimizing energy footprint on May 3rd, 2017. Yunbo Li has defended his PhD on Resource allocation in a Cloud partially powered by renewable sources on June 12th, 2017.

9.1.2. INDIC - Cybersecurity Pole of Excellence (2014-2020)

Participants: Anna Giannakou, Christine Morin, Jean-Louis Pazat, Louis Rilling, Amir Teshome Wonjiga, Clément El Baz.

Our study carried out in the framework of a collaboration with DGA-MI aims at defining and enforcing SLA for security monitoring of virtualized information systems. To this aim we study three topics:

- defining relevant SLA terms for security monitoring,
- enforcing and evaluating SLA terms,
- making the SLA terms enforcement mechanisms self-adaptable to cope with the dynamic nature of clouds.

The considered enforcement and evaluation mechanisms should have a minimal impact on performance. The funding from DGA funds two PhD students: Anna Giannakou and Amir Teshome Wonjiga. Clément El Baz is partially funded by the Brittany Regional Council in the PEC framework.

9.2. National Initiatives

9.2.1. ADEME RennesGrid

Participants: Benjamin Camus, Anne-Cécile Orgerie, Martin Quinson.

The aim of the RennesGrid project is to design and implement a large-scale preindustrial microgrid demonstrator in the territory of Rennes Metropole to organize the shared self-consumption of a group of photovoltaic panels coupled to stationary storage devices. Traditional approaches to power grid management tend to overlook the costs, both energy and economic, of using computers to ensure optimal electricity network management. However, these costs can be significant. It is therefore necessary to take them into account along with the design of IT tools during studies of optimal energy management of smart grids. In addition, telecommunication networks are generally considered to have an ideal functioning, that is to say they can not negatively affect the performance of the electricity network. However, this is not realistic and it is necessary to analyze the impact of phenomena such as congestion, latency, failures related to computer equipment or impact on the batteries of sensors, etc. on strategies for optimal management of the electricity network. In this project, we will closely collaborate with Anne Blavette (CR CNRS in electrical engineering, SATIE, Rennes) and co-supervise a post-doc on evaluating the impact of the IT infrastructure in the management of smart grids.

9.2.2. *Inria ADT SaaP (2016-2018)*

Participants: Toufik Boubehziz, Martin Quinson.

The SaaP technological development action (SimGrid As A Platform) funded by INRIA targets the refactoring of SimGrid to make it ready to use in production and teaching contexts. Our ultimate goal is to sustain the development of the framework by involving 5 to 10 companies that are using it internally. Our target of the teaching context is thus an intermediate goal, as we think that the best solution to ensure the adoption of our tool by the industrial engineers is that they discover the tool during their studies.

The technical actions envisioned for this ADT are the complete re-factoring of the software (to make it easier to script a new model within the tool kernel) and a reorganization of the interfaces (for a better integration in the Java and python language). This work is lead by Toufik Boubehziz in collaboration with the whole SimGrid community, which provide valuable feedback.

9.2.3. *Inria ADT DiFFuSE (2017-2018)*

Participants: Nikos Parlavantzas, Christine Morin, Manh Linh Pham.

The DiFFuSE technological development action (Distributed framework for cloud-based epidemic simulations) funded by INRIA focuses on the DiFFuSE framework developed by Myriads in the context of MIHMES (2012-2017). MIHMES was a 5-year collaborative multidisciplinary project funded by ANR under the Investments for the Future Program, and led by BIOEPAR, INRA, ONIRIS. DiFFuSE is a framework that provides design support, reusable code, and tools for building and executing epidemic simulations in the cloud. The main objectives of this ADT are to improve the usability and robustness of DiFFuSE, to provide support to scientists for applying the framework to a new epidemic simulations as well as to provide a thorough evaluation of the framework using multiple case studies.

9.2.4. *Inria IPL Discovery (2015-2019)*

Participants: Ehsan Ahvar, Anne-Cécile Orgerie, Matthieu Simonin, Genc Tato, Cédric Tedeschi.

The Inria IPL Discovery officially started in September 2015. It targets the design, development and deployment of a distributed Cloud infrastructure within the network's backbone. It will be based upon a set of building blocks whose design will take locality as a primary constraint, so as to minimize distant communications and consequently achieve better network traffic, partition management and improved availability.

Its developments are planned to get integrated within the OpenStack framework. Myriads is involved in the design of new overlay networks for such environments so as to support efficient messaging and routing. Myriads is also involved in the energy/cost benefit analysis of distributed edge-cloud architectures.

9.2.5. *Inria IPL CityLab (2015-2018)*

Participants: Subarna Chatterjee, Christine Morin.

The Inria Project Lab (IPL) CityLab@Inria (<http://citylab.inria.fr>) studies ICT solutions toward smart cities that promote both social and environmental sustainability. A strong emphasis of the Lab is on the undertaking of a multi-disciplinary research program through the integration of relevant scientific and technology studies, from sensing up to analytics and advanced applications, so as to actually enact the foreseen smart city Systems of Systems. City-scale experiments of the proposed platforms and services are planned in cities in California and France, thereby learning lessons from diverse setups.

Myriads investigates advanced cloud solutions for the Future Internet, which are critical for the processing of urban data. It leverages its experience in cloud computing and Internet of services while expanding its research activities to the design and implementation of cloud services to support crowd-Xing applications and mobile social applications.

In 2017, Christine Morin was involved in the preparation of a SPOC entitled "Technological challenges of participatory smart cities", which is proposed in the framework of the EIT Digital professional school. She prepared seven sequences on cloud-based urban data management. This SPOC is the English version of the MOOC entitled "*Défis technologiques des villes intelligentes participatives*" run on the FUN platform in Spring and Fall 2017.

In 2017, we also conducted a comparative experimental evaluation of data stream processing environments executed on clusters and clouds. We compared the performance and energy consumption of Heron, Storm and Flink frameworks with three data streaming representative applications.

9.2.6. Inria IPL Hac Specis (2016-2020)

Participants: Anne-Cécile Orgerie, Martin Quinson, The Anh Pham.

The goal of the HAC SPECIS (High-performance Application and Computers: Studying PERformance and Correctness In Simulation) project (<http://hacspecis.gforge.inria.fr/>) is to answer methodological needs of HPC application and runtime developers and to allow to study real HPC systems both from the correctness and performance point of view. To this end, we gather experts from the HPC, formal verification and performance evaluation community.

During his first year of PhD thesis, The Anh Pham conducted an analysis of the formal methods and algorithms used in SimGrid. This work, co-advised by Martin Quinson with Thierry Jéron (team SUMO, formal methods), was important to bridge the gap between the involved communities. The resulting work has been published in a workshop gathering the intersection between the communities of formal methods and HPC [44].

Another PhD thesis will start in December 2017, co-advised by Laurent Lefèvre (Avalon team, Lyon), Martin Quinson and Anne-Cécile Orgerie. This thesis will focus on simulating the energy consumption of continuum computing between heterogeneous numerical infrastructures for HPC.

9.2.7. COSMIC PRE (2016 - 2018)

Participants: Benjamin Camus, Anne-Cécile Orgerie, Martin Quinson.

The distributed nature of Cloud infrastructures involves that their components are spread across wide areas, interconnected through different networks, and powered by diverse energy sources and providers, making overall energy monitoring and optimization challenging. The COSMIC project aims at taking advantage of the opportunity brought by the Smart Grids to exploit renewable energy availability and to optimize energy management in distributed Clouds. This PRE, led by Anne-Cécile Orgerie also involves Fanny Dufossé from Dolphin team (Inria Lille), Anne Blavette from SATIE laboratory (electrical engineering, Rennes), and Benjamin Camus, who has started a 18 months post-doc in October 2016 in the context of this project. A paper on this project has been presented at SMARTGREENS 2017 and two others are currently under submission.

9.2.8. MIHMES ANR Investissements d'Avenir (2012 - 2017)

Participants: Christine Morin, Manh Linh Pham, Nikos Parlavantzas.

The MIMHES project (<http://www.inra.fr/mihmes>) led by INRA/BioEpAR aimed at producing scientific knowledge and methods for the management of endemic infectious animal diseases and veterinary public health risks. The role of Myriads was to help MIMHES researchers improve the performance of their simulation applications and take advantage of computing resources provided by clouds. To that end, Myriads developed a framework, named DiFFuSE, that provides design support, reusable code, and tools for building and executing epidemic simulations in the cloud.

In 2017, we further developed DiFFuSE and extended the framework to make use of the PaaSage open-source platform, the main outcome of a European FP7 IP project in which Myriads participated (2012-2016). Thanks to PaaSage, DiFFuSE allows deploying and managing services in multi-cloud environments. We applied DiFFuSE to restructure an application that simulates the spread of the bovine viral diarrhoea virus (BVDV) and conducted experiments to evaluate DiFFuSE [45].

9.2.9. *SESAME ASTRID project (2016-2019)*

Participants: Pascal Morillon, Christine Morin, Matthieu Simonin, Cédric Tedeschi, Mehdi Belkhiria.

The Sesame project (<http://www.agence-nationale-recherche.fr/Project-ANR-16-ASTR-0026>) led by IMT Atlantique aims at develop efficient infrastructures and tools for the maritime traffic surveillance. The role of Myriads is to define a robust and scalable infrastructure for the real-time and batch processing of vessel tracking information.

9.2.10. *PIA ELCI (2015-2018)*

Participant: Anne-Cécile Orgerie.

The PIA ELCI project deals with software environment for computation-intensive applications. It is leaded by BULL. In the context of this project, we collaborate with ROMA and Avalon teams from Lyon: we co-supervise a PhD student (Issam Rais) funded by this project with these teams on multi-criteria scheduling for large-scale HPC environments. This collaboration has led to two publications in 2017: a journal article published in IJHPCA and a conference paper presented at EuroPar.

9.2.11. *CNRS GDS EcoInfo*

Participant: Anne-Cécile Orgerie.

The EcoInfo group deals with reducing environmental and societal impacts of Information and Communications Technologies from hardware to software aspects. This group aims at providing critical studies, lifecycle analyses and best practices in order to improve the energy efficiency of printers, servers, data centers, and any ICT equipment in use in public research organizations. In particular, it has led in December 2016 to the publication of an ADEME report jointly with Deloitte Développement Durable, Futuribles, CREDOC and ADEME on the potential contribution of digital to the reduction of environmental impacts: state of play and challenges for the prospective.

9.3. European Initiatives

9.3.1. *FP7 & H2020 Projects*

9.3.1.1. *FogGuru*

Participant: Guillaume Pierre.

Title: MSCA ITN EID

Programm: H2020

Duration: September 2017 - August 2021

Coordinator: Guillaume Pierre

Participants:

University of Rennes 1, France (coordinator)

Technisch Universität Berliun, Germany

Elastisys AB, Sweden

U-Hopper srl, Italy

EIT Digital Rennes, France

Las Naves, Spain

FogGuru is a doctoral training project which aims to to train eight talented PhD students with an innovative and inter-sectoral research program to constitute the next generation of European Cloud and Fog computing experts. Besides their scientific and technical education, FogGuru's PhD students will receive extensive training in technological innovation and entrepreneurship as well as soft skills. These combined skills will enable them to fully master the innovation process stemming from fundamental research towards invention and development of innovative products and services, and to real-life deployment, experimentation and engagement with beta-testers.

9.3.1.2. *Fed4Fire+* (2017-2022)

Participants: David Margery, Yue Li.

Title: Federation for FIRE Plus

Programm: H2020

Duration: January 2017 - December 2021

Coordinator: Interuniversitair Micro-Electronicacentrum Imec VZW

Partners:

Universidad de Malaga

National Technical University of Athens - NTUA

The Provost, Fellows, Foundation Scholars & the other members of board of the College of the Holy & Undivided Trinity of Queen Elizabeth Near Dublin

Ethniko Kentro Erevnas Kai Technologikis Anaptyxis

GEANT Limited

Institut Jozef Stefan

Mandat International Alias Fondation Pour la Cooperation Internationale

Université Pierre et Marie Curie - Paris 6

Universidad De Cantabria

Fundacio Privada I2CAT, Internet I Innovacio Digital A Catalunya

EUROSCOM-European Institute For Research And Strategic Studies in Telecommunications GMBH

Nordunet A/S

Technische Universitaet Berlin

Instytut Chemii Bioorganicznej Polskiej Akademii Nauk

Fraunhofer Gesellschaft zur Foerderung Der Angewandten Forschung E.V.

Universiteit Van Amsterdam

University of Southampton

Martel GMBH

Atos Spain SA

Institut National de Recherche en Informatique et automatique

Inria contact: David Margery

Fed4FIRE+ is a successor project to Fed4FIRE. In Fed4FIRE+, we more directly integrate Grid'5000 into the wider eco-system of experimental platforms in Europe and beyond using results we developed in Fed4FIRE. We have developed a generalized proxy mechanisms to allow users with Fed4FIRE identities to interact with services giving access to different testbeds but not designed to support Fed4FIRE identities. Fed4FIRE+ has started January 1st, 2017.

9.3.2. Collaborations in European Programs, Except FP7 & H2020

9.3.2.1. NESUS

Participant: Anne-Cécile Orgerie.

Program: ICT COST

Project acronym: NESUS

Project title: Network for Sustainable Ultrascale Computing (ICT COST Action IC1305)

Duration: 2014 - 2018

Coordinator: Prof. Jesus Carretero, University Carlos III of Madrid, Spain, <http://www.nesus.eu>

Other partners: 33 COST countries and 11 non-COST countries

Abstract: Ultrascale systems are envisioned as large-scale complex systems joining parallel and distributed computing systems that will be two to three orders of magnitude larger than today's systems. The EU is already funding large scale computing systems research, but it is not coordinated across researchers, leading to duplications and inefficiencies. The goal of the NESUS Action is to establish an open European research network targeting sustainable solutions for ultrascale computing aiming at cross fertilization among HPC, large scale distributed systems, and big data management. The network will contribute to gluing disparate researchers working across different areas and provide a meeting ground for researchers in these separate areas to exchange ideas, to identify synergies, and to pursue common activities in research topics such as sustainable software solutions (applications and system software stack), data management, energy efficiency, and resilience. Some of the most active research groups of the world in this area are members of this proposal. This Action will increase the value of these groups at the European-level by reducing duplication of efforts and providing a more holistic view to all researchers, it will promote the leadership of Europe, and it will increase their impact on science, economy, and society. Anne-Cécile Orgerie is co-responsible of the focus group on metrics, monitoring, instrumentation and profiling in the Working Group 5 on Energy Efficiency. A joint paper has been accepted in 2017 on this topic at the Elsevier journal on Sustainable Computing.

9.3.3. Collaborations with Major European Organizations

Partner 1: EPFL, Network architecture lab (Switzerland)

We collaborate with Katerina Argyraki's research group on the integration of networking and cloud computing technologies in order to support placement constraints between cloud resources.

Partner 2: University of Neuchâtel, dept. of Computer Science (Switzerland)

We collaborate with Pascal Felber's research group on energy efficiency in Clouds and in particular on the design of energy cost models for virtual machines. A joint journal paper has been accepted in 2017 for publication in Sustainable Computing: Informatics and Systems, Elsevier.

Partner 3: Catholic University of Louvain (Belgium)

We collaborate with Etienne Riviere's research group on the efficient service placement and discovery in a SaaS context.

9.4. International Initiatives

9.4.1. Inria International Labs

9.4.1.1. DALHIS

Participants: Christine Morin, Deborah Agarwal, Anna Giannakou, Amir Teshome Wonjiga, Subarna Chatterjee.

Title: Data Analysis on Large Heterogeneous Infrastructures for Science

International Partner (Institution - Laboratory - Researcher):

Lawrence Berkeley National Laboratory (United States) - Data Science and Technology department - Deb Agarwal

Start year: 2016

See also: <https://project.inria.fr/dalhis/>

Data produced by scientific instruments (large facilities like telescopes or field data), large-scale experiments, and high-fidelity simulations are increasing in magnitude and complexity. Existing data analysis methods, tools and infrastructure are often difficult to use and unable to provide the complete data management, collaboration, and curation environment needed to manage these complex, dynamic, and large-scale data analysis environments. The goal of the Inria-LBL DALHIS associate team involving the Myriads (PI) and Avalon Inria project-teams and the Data Science and Technology (DST) department at Lawrence Berkeley National Laboratory (LBL) is to create a collaborative distributed software ecosystem to manage data lifecycle and enable data analytics on distributed data sets and resources. Specifically, our goal is to build a dynamic software stack that is user-friendly, scalable, energy-efficient and fault tolerant. Our research will determine appropriate execution environments that allow users to seamlessly execute their end-to-end dynamic data analysis workflows in various resource environments and scales while meeting energy-efficiency, performance and fault tolerance goals. We will engage in deep partnerships with scientific teams (Fluxnet in environmental science and SNFactory and LSST experiences in cosmology) and use a mix of user research with system software R&D to address specific challenges that these communities face. In 2017, we worked on evaluating data streaming environments (see Section 7.1.4) and on producing tools to help users (scientist in the climate and environment community) to explore the carbon flux datasets from AmeriFlux (Americas) and FLUXNET (global) (see Section 7.4.2.2). We also worked on two facets of security in the context of HPC distributed computing infrastructures: (i) building a workflow for data analysis for anomaly detection and (ii) using the block-chain technology to leverage data integrity at the network and some portion of computation levels.

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

9.4.2.1. SUSTAM associated team

Participants: Anne-Cécile Orgerie, Yunbo Li.

Anne-Cécile Orgerie participates in the associated team named SUSTAM (Sustainable Ultra Scale compuTing, dAta and energy Management) led by Laurent Lefèvre (Avalon team, Lyon) with Prof. Manish Parashar (RDI2, Rutgers University, NJ, USA). The SUSTAM associate team will focus on the joint design of a multi-criteria orchestration framework dealing with resources, data and energy management in a sustainable way.

9.4.3. Inria International Partners

9.4.3.1. Informal International Partners

Partner: Rutgers University, dept. of Computer Science (New Jersey, United States)

We collaborate with Manish Parashar's research group on energy efficiency in edge Clouds and in particular on the design of energy cost models for such environments involving renewable energy. A joint paper has been presented at IEEE/ACM CCGrid 2017.

Partner: Northeastern University, dept. of Computer Science (Massachusetts, United States)

We collaborate with Gene Cooperman's research group on the study of large-scale distributed systems. More specifically, we actively collaborate on virtualization technologies and system snapshotting (we obtained a postdoc funding on that topic from the Brittany Regional Council, but all applicants declined in the last minute). We plan to reinforce and extend our collaboration to formal methods for distributed systems in the next year.

Partner: University of Guadalajara (Mexico)

We collaborate with the team of Prof. Hector Duran-Limon on application and resource management in the cloud. In 2017, we produced a joint publication [46]. Nikos Parlavantzas is co-advising a PhD student enrolled in the University of Guadalajara (Carlos Ruiz Diaz).

Partner: Tlemcen University (Algeria)

We collaborate with Djawida Dib on energy-efficient fault-tolerant resource and application management in containerized clouds. Christine Morin and Nikos Parlavantzas have been co-advising Yasmina Bouizem, a PhD student enrolled in the University of Tlemcen from December 2016.

9.5. International Research Visitors

9.5.1. Visits of International Scientists

Deb Agarwal, senior scientist at Lawrence Berkeley National Laboratory, who has been awarded an Inria International Chair for the 2015-2019 period, visited Myriads team during two months from August 1st to October 15th, 2017.

Professor Gene Cooperman, Northeastern University, Boston, USA, visited the Myriads team for one week in July to reinforce our collaboration on the virtualization of large-scale distributed systems.

9.5.1.1. Internships

Betsegaw Lemma Amersho

Date: Feb-June 2017

Institution: University of Rennes 1 & Aalto University (Finland)

Supervisors: Anne-Cécile Orgerie and Martin Quinson

Vinothkumar Nagasayanan

Date: May-August 2017

Institution: University of Rennes 1 & TU Berlin (Germany)

Supervisor: Guillaume Pierre

Salsabil Amri

Date: May-August 2017

Institution: University of Rennes 1

Supervisor: Guillaume Pierre

Bérenger Nguyen Nhon

Date: July-August 2017

Institution: University of Rennes 1

Supervisor: Guillaume Pierre

9.5.2. Visits to International Teams

9.5.2.1. Research Stays Abroad

- Genc Tato started a 6-month research visit at the Catholic University of Louvain in November 2017 to work with Etienne Riviere on service placement and discovery in a SaaS context.
- Amir Teshome Wonjiga did a 3-month research internship in the Data Science and Technology department of the Lawrence Berkeley National Laboratory from April to June 2017. He worked with Sean Peisert, staff scientist, on ensuring data integrity in the workflow of high performance applications.
- Anne-Cécile Orgerie visited for 1 week the team of Prof. Manish Parashar in the RDI2 laboratory at Rutgers University in October 2017.

PACAP Project-Team

8. Partnerships and Cooperations

8.1. Regional Initiatives

8.1.1. *Britanny region fellowship*

Participants: Niloofar Charmchi, André Seznec.

The Brittany Region is partially funding a Ph.D. fellowship for Niloofar Charmchi on the topic “Hardware prefetching and related issues”.

8.2. National Initiatives

8.2.1. *Capacités: Projet “Investissement d’Avenir”, 1/11/14 to 31/01/2018*

Participants: Damien Hardy, Isabelle Puaud, Viet Anh Nguyen, Sébastien Martinez.

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

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

8.2.2. *Zero Power Computing Systems (ZEP): Inria Project Lab, 2017–2020*

Participant: Erven Rohou.

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

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

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

8.2.3. *ANR Continuum 2015–2019*

Participants: Erven Rohou, Rabab Bouziane.

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

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

8.2.4. ANR W-SEPT 2012-2017

Participants: Isabelle Puaut, Erven Rohou.

Critical embedded systems are generally composed of repetitive tasks that must meet drastic timing constraints, such as termination deadlines. Providing an upper bound of the worst-case execution time (WCET) of such tasks at design time is thus necessary to prove the correctness of the system. Static WCET estimation methods, although safe, may produce largely over-estimated values. The objective of the project is to produce tighter WCET estimates by discovering and transforming flow information at all levels of the software design process, from high level-design models (e.g. Scade, Simulink) down to binary code.

The ANR W-SEPT project partners are Verimag Grenoble, IRIT Toulouse, Inria Rennes. A case study is provided by Continental Toulouse.

8.3. European Initiatives

8.3.1. FP7 & H2020 Projects

8.3.1.1. ANTAREX

Participants: Erven Rohou, Imane Lasri.

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

Program: H2020

Duration: September 2015 - September 2018

Coordinator: Politecnico di Milano, Italy (POLIMI)

Partners:

Consorzio Interuniversitario Cineca (Italy)

Dompé Farmaceutici Spa (Italy)

Eidgenoessische Technische Hochschule Zürich (Switzerland)

Vysoka Skola Banska - Technicka Univerzita Ostrava (Czech Republic)

Politecnico di Milano (Italy)

Sygic As (Slovakia)

Universidade do Porto (Portugal)

Inria contact: Erven Rohou

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

8.3.1.2. *EuroLab-4-HPC*

Participant: André Seznec.

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

Program: H2020

Duration: September 2015 - September 2017

Coordinator: Chalmers Tekniska Högskola AB

Partners:

Barcelona Supercomputing Center - Centro Nacional de Supercomputación (Spain)

Chalmers Tekniska Högskola (Sweden)

École Polytechnique Fédérale de Lausanne (Switzerland)

Foundation for Research and Technology Hellas (Greece)

Universität Stuttgart (Germany)

Rheinisch-Westfälische Technische Hochschule Aachen (Germany)

Technion - Israel Institute of Technology (Israel)

Universität Augsburg (Germany)

The University of Edinburgh (United Kingdom)

Universiteit Gent (Belgium)

The University of Manchester (United Kingdom)

Inria contact: Albert Cohen (Inria Paris)

Europe has built momentum in becoming a leader in large parts of the HPC ecosystem. It has brought together technical and business stakeholders from application developers via system software to exascale systems. Despite such gains, excellence in high performance computing systems is often fragmented and opportunities for synergy missed. To compete internationally, Europe must bring together the best research groups to tackle the 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 oriented communities in Europe, working across all layers of the system stack and, at the same time, fueling new industries in HPC.

8.3.1.3. *ARGO*

Participants: Isabelle Puaut, Damien Hardy, Imen Fassi.

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

Program: H2020

Type: RIA

Duration: Jan 2016 - Dec 2018

Coordinator: Karlsruher Institut für Technologie (KIT)

Université Rennes I contact: Steven Derrien

Partners:

Karlsruher Institut für Technologie (KIT)

SCILAB enterprises SAS

Recore Systems BV

Université de Rennes I

Technogiko Ekpaideftiko Idryma (TEI) Dytikis Elladas
 Absint GmbH
 Deutsches Zentrum für Luft - und Raumfahrt EV
 Fraunhofer

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

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

8.3.1.4. *HiPEAC4 NoE*

Participants: Pierre Michaud, Erven Rohou, André Seznec.

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

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

8.4. International Initiatives

8.4.1. *ANR CHIST-ERA SECODE 2016-2018*

Participants: Nicolas Kiss, Damien Hardy, Erven Rohou.

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

Partners are Télécom Paris Tech, Université Paris 8, Sabancı Üniversitesi (Turkey), and Université Catholique de Louvain (Belgium).

8.4.2. *PHC IMHOTEP*

Participant: Erven Rohou.

Title: Thoth – An Automatic Dynamic Binary Parallelisation System

International Partner (Institution - Laboratory - Researcher):

Egypt-Japan University of Science and Technology - Prof. Ahmed ElMahdy.

Dates: 2016–2017

With the current global trend towards utilizing cloud computing and smart devices, executing the same application across becomes a necessity. Moreover, parallelism is now abundant with various forms that include thread- and data-parallel execution models. Such diversity in ISA and explicit parallelism makes software development cost prohibitive, especially for natively optimized binaries. This project leverages dynamic binary translation technology to provide for exploiting the underlying parallel resources without the need of having the source code of the application. In particular the project integrates low overhead dynamic profiling, novel OSR parallel de-optimization and a retargetable parallelization modules to allow for dynamic parallelization of binaries.

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

8.4.3.1. PROSPIEL

Participant: Sylvain Collange.

Title: Profiling and specialization for locality

International Partner (Institution - Laboratory - Researcher):

Universidade Federal de Minas Gerais (Brazil) - DCC - Fernando Magno Quintão Pereira

Start year: 2015

See also: <https://team.inria.fr/pacap/prospiel/>

The PROSPIEL project aims at optimizing parallel applications for high performance on new throughput-oriented architectures: GPUs and many-core processors. Traditionally, code optimization is driven by a program analysis performed either statically at compile-time, or dynamically at run-time. Static program analysis is fully reliable but often over-conservative. Dynamic analysis provides more accurate data, but faces strong execution time constraints and does not provide any guarantee. By combining profiling-guided specialization of parallel programs with runtime checks for correctness, PROSPIEL seeks to capture the advantages of both static analysis and dynamic analysis. The project relies on the polytope model, a mathematical representation for parallel loops, as a theoretical foundation. It focuses on analyzing and optimizing performance aspects that become increasingly critical on modern parallel computer architectures: locality and regularity.

8.5. International Research Visitors

Prof. Ahmed ElMahdy, from the Egypt-Japan University of Science and Technology (E-JUST), Alexandria, Egypt, visited PACAP for two weeks in September, in the context of the project PHC IMHOTEP.

8.5.1. Visits of International Scientists

8.5.1.1. Internships

Stefano Cherubin, PhD student at Politecnico di Milano for one month in Mar 2017, within the context of the ANTAREX H2020 project.

Andrei Rimsa Alvares, PhD at UFMG and Assistant Professor at CEFET-MG, 1 month from January 6 to February 5, 2017, PROSPIEL Associate Team.

PANAMA Project-Team

9. Partnerships and Cooperations

9.1. National Initiatives

9.1.1. Labex Comin Labs projects

CominLabs is a Laboratoire d'Excellence funded by the PIA (Programme Investissements d'Avenir) in the broad area of telecommunications.

9.1.1.1. HEMISFER

Participant: Rémi Gribonval.

Acronym: HYBRID (Hybrid Eeg-MrI and Simultaneous neuro-feedback for brain Rehabilitation)

<http://www.hemisfer.cominlabs.ueb.eu/>

Research axis: 3.1

CominLabs partners : VISAGES, HYBRID and PANAMA Inria project-teams;

External partners : EA 4712 team from University of Rennes I; ATHENA Inria project-team, Sophia-Antipolis;

Coordinator: Christian Barillot, VISAGES Inria project-team

Description: The goal of HEMISFER is to make full use of neurofeedback paradigm in the context of rehabilitation and psychiatric disorders. The major breakthrough will come from the use of a coupling model associating functional and metabolic information from Magnetic Resonance Imaging (fMRI) to Electro-encephalography (EEG) to "enhance" the neurofeedback protocol. We propose to combine advanced instrumental devices (Hybrid EEG and MRI platforms), with new man-machine interface paradigms (Brain computer interface and serious gaming) and new computational models (source separation, sparse representations and machine learning) to provide novel therapeutic and neuro-rehabilitation paradigms in some of the major neurological and psychiatric disorders of the developmental and the aging brain (stroke, attention-deficit disorder, language disorders, treatment-resistant mood disorders, ...).

Contribution of PANAMA: PANAMA, in close cooperation with the VISAGES team, contributes to a coupling model between EEG and fMRI considered as a joint inverse problem addressed with sparse regularization. By combining both modalities, one expects to achieve a good reconstruction both in time and space. This new imaging technique will then be used for improving neurofeedback paradigms in the context of rehabilitation and psychiatric disorders, which is the final purpose of the HEMISFER project.

9.1.1.2. TEPN

Participant: Rémi Gribonval.

Acronym: TEPN (Toward Energy Proportional Networks)

<http://www.tepn.cominlabs.ueb.eu/>

Research axis: 3.1

CominLabs partners : IRISA OCIF - Telecom Bretagne; IETR SCN; IETR SCEE; PANAMA Inria project-team

Coordinator: Nicolas Montavont, IRISA OCIF - Telecom Bretagne

Description: As in almost all areas of engineering in the past several decades, the design of computer and network systems has been aimed at delivering maximal performance without regarding to the energy efficiency or the percentage of resource utilization. The only places where this tendency was questioned were battery-operated devices (such as laptops and smartphones) for which the users accept limited (but reasonable) performance in exchange for longer use periods. Even though the end users make such decisions on a daily basis by checking their own devices, they have no way of minimizing their energy footprint (or conversely, optimize the network resource usage) in the supporting infrastructure. Thus, the current way of dimensioning and operating the infrastructure supporting the user services, such as cellular networks and data centers, is to dimension for peak usage. The problem with this approach is that usage is rarely at its peak. The overprovisioned systems are also aimed at delivering maximal performance, with energy efficiency being considered as something desired, but non-essential. This project aims at making the network energy consumption proportional to the actual charge of this network (in terms of number of served users, or requested bandwidth). An energy proportional network can be designed by taking intelligent decisions (based on various constraints and metrics) into the network such as switching on and off network components in order to adapt the energy consumption to the user needs. This concept can be summarized under the general term of Green Cognitive Network Approach.

Contribution of PANAMA: PANAMA, in close cooperation with the SCEE team at IETR (thesis of Marwa Chafii, 2016), focuses on the design of new waveforms for multi carrier systems with reduced Peak to Average Power Ratio (PAPR).

9.1.2. ANR INVATE project with IRT b<>com, Rennes

Participants: Rémi Gribonval, Nancy Bertin, Mohammed Hafsati.

Thesis on 3D audio scene decomposition for interactive navigation

Duration: 3 years (2016-2019)

Research axis: 3.2.2

Partners: IRT b<>com; Inria-Rennes; IRISA

Funding: ANR INVATE project (PIA)

The objective of this thesis is to develop tools to analyze audio scenes in order to identify, locate, and extract the sources present in the scene to re-spatialize them according to the user head orientation and the movement of the user in the targeted virtual scene.

9.1.3. ANR OATMIL project

Participants: Rémi Gribonval, Antoine Chatalic.

Duration: 4 years (2017-2021)

Acronym: OATMIL (Bringing Optimal Transport and Machine Learning Together)

<http://people.irisa.fr/Nicolas.Courty/OATMIL/>

Research Axis 3.1

Partners: Obelix team and PANAMA Inria project-team, IRISA; LITIS, Rouen; Lagrange Laboratory, Nice; Technicolor R&I France, Rennes.

Coordinator: Nicolas Courty (Obelix team)

Description: The OATMIL project will propose novel concepts, methodologies, and new tools for exploiting large data collections. This will result from a cross-fertilization of fundamental tools and ideas from optimal transport (OT) and machine learning (ML). The main objective of OATMIL is to develop new techniques for large-scale machine learning, encompassing adaptability, scalability, and robustness, by a cross-fertilization of ideas coming from OT and ML. This cross-fertilization leads to two complementary scientific challenges : bringing OT to ML and bringing ML to OT.

Contribution of PANAMA: PANAMA will explore the use of dimension-reduction with sketching strategies in the context compressive optimal transport.

Funding: ANR

9.1.4. OSEO-FUI: voiceHome

Participants: Nancy Bertin, Frédéric Bimbot, Romain Lebarbenchon, Ewen Camberlein.

Duration: 3 years (2015-2017)

Research axis: 3.2

Partners: voicebox (formerly known as onMobile), Delta Dore, eSoftThings, Orange, Technicolor R&I France, LOUSTIC, Inria Nancy

Coordinator: voicebox

Description: The goal of the project is to design and implement a multi-channel voice interface for smart home and multimedia (set-top-box) appliances.

Contributions of PANAMA are focused on audio source localization and separation with distant microphones in real environments. In both cases, the issue of energy frugality is central and strongly constrains the available resources. This cooperation, which reached its end in November 2017, allowed us to make progress towards operational low-resource audio source localization and separation schemes, to disseminate software, collected data and scientific results, and to identify new research and development perspectives in adaptive microphone array processing for fast and robust audio scene analysis.

9.2. International Initiatives

9.2.1. Inria International Partners

9.2.1.1. Informal International Partners

PANAMA has strong recurrent collaborations with the LTS2 lab at EPFL, the Center for Digital Music at Queen Mary University of London, the Institute for Digital Communications at the University of Edinburgh, and the Institute for Mathematics of the Postdam University.

9.3. International Research Visitors

9.3.1. Visits of International Scientists

- Flavio Castro Alves Teixeira, in May-June 2017, Post-doc, University of Innsbruck, Austria
- Pierre Vandergheynst, in June-July 2017, Professor of Signal and Image Processing, EPFL (Chaire Internationale Inria), Lausanne, Switzerland
- Gilles Blanchard, in September 2017, Professor, University of Potsdam, Germany
- Mike Davies, in October 2017, Professor, University of Edinburgh, UK
- Jérémy Cohen, in November 2017, Post-doc, University of Mons, Belgium
- Andreas Loukas, in December 2017, Post-doc, EPFL, Lausanne, Switzerland

9.3.1.1. Internships

- Helena Peic Tukuljac, from October to December 2017, PhD Student at EPFL, Lausanne, Switzerland
- Martin Strauss, from October to December 2017, M1 student, Friedrich-Alexander University, Erlangen, Germany

SERPICO Project-Team

9. Partnerships and Cooperations

9.1. Regional Initiatives

ENSAI-CREST: Statistical methods and models for image registration, PhD thesis of Vincent Briane is co-funded by Inria and ENSAI-CREST and co-supervised by Myriam Vimond (ENSAI-CREST).

Région Bretagne: Identification, localization and enumeration of ribosomes within a tomogram by combining state-of-the-art denoising methods and object descriptor-based recognition (CATLAS, see Section 8.2.1) (PhD thesis of Emmnuel Moebel); motion saliency in video sequences (PhD thesis of Léo Maczyta).

BioGenOuest: Collaboration with S. Prigent (engineer) in charge of the organization of image processing services for Biogenouest bio-imaging facilities.

IGDR: Collaboration with J. Pecreaux, Y. Le Cunff (co-supervision of PhD thesis of A. Caranfil).

9.2. National Initiatives

9.2.1. *France-BioImaging project*

Participants: Charles Kervrann, Patrick Bouthemy.

The goal of the France-BioImaging project (<http://france-bioimaging.org/>) is to build a distributed coordinated French infrastructure for photonic and electronic cellular bioimaging, dedicated to innovation, training and technology transfer. High-computing capacities are needed to exhaustively analyse image flows. Serpico is co-head of the IPDM (Image Processing and Data Management) node of the FBI network composed of 6 nodes. In this context, we address the following scientific problems: i/ exhaustive analysis of bioimaging data sets; ii/ deciphering of key steps of biological mechanisms at organ, tissular, cellular and molecular levels through the systematic use of time-lapse 3D microscopy and image processing methods; iii/ storage and indexing of extracted and associated data and metadata through an intelligent data management system. Serpico recruited R&D engineers (2011-2016) to disseminate image processing software, to build the Moby@Serpico web portal and to manage the IGRIDA-Serpico cluster (200 nodes; batch scheduler: OAR; File management: Puppet/Git/Capistrano; OS: Linux Debian 7; User connexion: public ssh key) opened for end-users and dedicated to large scale computing and data sets processing (storage: 200 TeraBytes).

- **Coordinator:** CNRS (Jean Salamero, UMR 144 CNRS-Institut Curie).
- **Partners:** University of Paris-Diderot-Paris 7, Aix-Marseille University, University of Bordeaux, University of Montpellier, Institut Pasteur, Institut Curie, Inria, ENS Ulm, University of Paris Descartes, UPMC, Ecole Polytechnique, Inserm.
- **Funding:** Investissement d'Avenir Infrastructures Nationales en Biologie et Santé, ANR INBS-PIA 2011.
- **Total amount:** 26 000 Keuros (Inria Serpico: 606 Keuros).

9.2.2. *ANR DALLISH project (2016-2020): Data Assimilation and Lattice Light Sheet imaging for endocytosis/exocytosis pathway modeling in the whole cell*

Participants: Charles Kervrann, Vincent Briane, Ancageorgiana Caranfil, Antoine Salomon.

Cutting-edge LLS microscopy represents the novel generation of 3D fluorescence microscopes dedicated to single cell analysis, generating extraordinarily high resolved and sharp, but huge 3D images and videos. One single live cell experiment in one single biological condition can result into up to one terabyte of data. The goal of the project is to develop new paradigms and computational strategies for image reconstruction and 3D molecule tracking/motion estimation. Furthermore, establishing correspondences between image-based measurements and features, stochastic motion models, and underlying biological and biophysical information remains a challenging task. In a larger perspective, the quantitative description of image data corresponding to protein transport will be a prerequisite for understanding the functioning of a cell in normal and pathological situations including cancer, viral infection and neurodegenerative diseases.

- **Coordinator:** Inria (Charles Kervrann)
- **Partners:** Inria (Serpico, Beagle, Fluminance teams), INRA MaIAGE Unit Jouy-en-Josas, Institut Curie (UMR 144 CNRS & U1143 Inserm UMR 3666) Paris
- **Funding:** ANR (Agence Nationale de la Recherche) PRC (Collaborative Research Project)
- **Total amount:** 440 Keuros (Inria Serpico: 170 Keuros).

9.3. European Initiatives

9.3.1. Major European Organizations with which the Team have followed Collaborations

ESFRI Euro-BioImaging initiative: SERPICO participates in the ESFRI Euro-BioImaging project, one of the four new biomedical science projects in the roadmap of the European Strategic Forum on Research Infrastructures (ESFRI). The mission of Euro-BioImaging is to provide access, service and training to state-of-the-art imaging technologies and foster the cooperation and networking at the national and European level including multidisciplinary scientists, industry, regional, national and European authorities. SERPICO also participates to the French counterpart, the so-called “France-BioImaging” (FBI) network which gathers several outstanding cellular imaging centers (microscopy, spectroscopy, probe engineering and signal processing) as described in Section 9.2.1 .

- **Coordinator:** EMBL (Jan Ellenberg, Heidelberg, Germany)
- **Partners:** 15 european countries in 2017
- **Funding:** Member states of the European Union

9.4. International Initiatives

9.4.1. Informal International Partners

Collaboration with Max-Planck Institute, Martinsried (Germany), Dr. Julio Ortiz and Antonio Martinez: Detection and segmentation of macromolecules in cryo-electron tomography (project in progress with Emmanuel Moebel and Charles Kervrann).

Collaboration with Aalborg University (Denmark), Prof. Rasmus Waagepetersen: Estimating equations for inhomogeneous determinantal point processes (project with Frédéric Lavancier).

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

9.4.2.1. CytoDI Inria Associated-Team

Title: Quantitative Imaging of Cytoskeleton Dynamics in 3D

International Partner:

University of Texas, SouthWestern Medical Center, Dallas (United States) - Gaudenz Danuser

Start year: 2016

See also: <http://serpico.rennes.inria.fr/doku.php?id=research:cytodi>

Participants: Sandeep Manandhar, Patrick Bouthemy, Charles Kervrann.

The main scientific goal of the Associated-Team is the spatiotemporal characterization and comparison of cytoskeleton networks involved in cell migration and observed through live cell imaging in three dimensions (3D). Those networks include the cytoskeleton, i.e., microtubules (MT), intermediate filaments (IF), dynamically resolvable by Bessel Beam Light Sheet fluorescent microscopy. The goal will be achieved through the design of local and global descriptors of the spatial conformation and deformation of the cytoskeleton. Subsequently, general metrics to compare and classify the MT and IF networks will be investigated. This study will be carried out on oncogenically transformed lung cancer epithelial cells.

The second meeting of the AT CytoDI took place in Rennes in July 2017 (visit of P. Roudot and K. Dean), to discuss and update current research direction and discuss scientific progress. Several meetings were organized with students (S. Manandhar, V. Briane, E. Moebel, T. Dubois, Q. Delannoy) to synchronize development in optical flow, co-orientation and visualization. The Danuser team focused on presenting recent imaging and analysis capacities as well as the current solution in development for the systematic analysis, contextualization and interpretation of 3D dynamics for quantitative biology.

9.5. International Research Visitors

9.5.1. Visits to International Teams

Emmanuel Moebel attended a summer school (one week): Signal Processing Meets Deep Learning (Capri, Italy, 4-8 september 2017).

Sandeep Manandhar attended a summer school (one week): VISion Understanding and Machine intelligence (Porto, Portugal, 7-14 July 2017).

SIROCCO Project-Team

9. Partnerships and Cooperations

9.1. Regional Initiatives

9.1.1. *CominLabs/InterCom project*

Participants: Aline Roumy, Thomas Maugey.

- Title : Interactive Communication (INTERCOM): Massive random access to subsets of compressed correlated data .
- Research axis : 7.4.2
- Partners : Inria-Rennes (Sirocco team and i4S team); LabSTICC, Telecom Bretagne, Signal & Communications Department; External partner: Kieffer L2S, CentraleSupélec, Univ. Paris Sud.
- Funding : Labex CominLabs.
- Period : Oct. 2016 - Nov. 2019.

This project aims to develop novel compression techniques allowing massive random access to large databases. Indeed, we consider a database that is so large that, to be stored on a single server, the data have to be compressed efficiently, meaning that the redundancy/correlation between the data have to be exploited. The dataset is then stored on a server and made available to users that may want to access only a subset of the data. Such a request for a subset of the data is indeed random, since the choice of the subset is user-dependent. Finally, massive requests are made, meaning that, upon request, the server can only perform low complexity operations (such as bit extraction but no decompression/compression). Algorithms for two emerging applications of this problem will be developed: Free-viewpoint Television (FTV) and massive requests to a database collecting data from a large-scale sensor network (such as Smart Cities).

9.2. European Initiatives

9.2.1. *FP7 & H2020 Projects*

9.2.1.1. *ERC-CLIM*

Participants: Pierre David, Elian Dib, Simon Evain, Christine Guillemot, Laurent Guillo, Mikael Le Pendu, Xiaoran Jiang, Jinglei Shi, Xin Su, Lara Younes.

Light fields yield a rich description of the scene ideally suited for advanced image creation capabilities from a single capture, such as simulating a capture with a different focus and a different depth of field, simulating lenses with different apertures, for creating images with different artistic intents or for producing 3D views. Light fields technology holds great promises for a number of application sectors, such as photography, augmented reality, light field microscopy, but also surveillance, to name only a few.

The goal of the ERC-CLIM project is to develop algorithms for the entire static and video light fields processing chain, going from compact sparse and low rank representations and compression to restoration, high quality rendering and editing.

9.3. International Initiatives

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

Title: Graph-based Omnidirectional video Processing

International Partner (Institution - Laboratory - Researcher):

Ecole Polytechnique Fédérale de Lausanne (Switzerland) - LTS4 - Pascal Frossard

Start year: 2017

See also: <http://people.rennes.inria.fr/Thomas.Maugey/wp/projects/gop/>

Due to new camera types, the format of the video data has become more complex than simple 2D images or videos as it was the case a few years ago. In particular, the omnidirectional cameras provide pixels on a whole sphere around a center point and enable a vision in 360°. In addition to the fact that the data size explodes with such cameras, the inherent structure of the acquired signal fundamentally differs from the 2D images, which makes the traditional video codec obsolete. In parallel of that, an important effort of research has been lead recently, especially at EPFL, to develop new processing tools for signals lying on irregular structures (graphs). It enables in particular to build efficient coding tools for new types of signals. The proposed research project will actually study how graphs can be built for defining a suitable structure on one or several 360° videos and then used for compression.

The collaboration between SIROCCO (Inria) and LTS4 (EPFL) has been very active in the recent years. However, only one-to-one collaboration was involved. When opening these new ambitious research direction, the project GOP will involve more than two or three researchers, and build a bidirectional collaboration between different people of the SIROCCO and LTS4 teams.

9.3.2. Inria International Partners

9.3.2.1. Informal International Partners

We have international collaborations with:

- Reuben Farrugia, Prof. at the University of Malta, with whom we continue collaborating on light field super-resolution. The collaboration started during the sabbatical year (Sept. 2015-Aug. 2016) he spent within the team.
- Ehsan Miandji and Prof. Jonas Unger from Linköping Univ. with whom we collaborate on compressive sampling of light fields. Ehsan Miandji has spent 1.5 month (June- July 2017) within the team.
- Chiara Galdi and Jean Luc Dugelay, prof. at Eurecom, with whom we collaborate on the application of light fields to biometry. Chiara Galdi has spent one month in the team (April 2017).
- Ole Johanssen and Prof. Bastian Goldluecke, from Univ. of Konstanz, with whom we collaborate on scene flow estimation with deep learning. Ole Johanssen has spent one month (Nov. 20- Dec. 20, 2017) in the team.
- The study on guided image inpainting is carried out in collaboration with Prof. Pascal Frossard from EPFL (Ecole Polytechnique Fédérale de Lausanne).

SUMO Project-Team

9. Partnerships and Cooperations

9.1. National Initiatives

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

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

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

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

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

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

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

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

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

This year we have been mainly intrested in dynamic partial-order-reduction methods that allow to reduce the explored state space, and a first prototype implementation of an existing method that combines DPOR with true-concurrency models.

9.1.4. CNRS INS2I JCJC SensAs (2017)

- Led by Ocan Sankur (SUMO).
- Participants: Ocan Sankur
- Partners: Benjamin Monmege, Pierre-Alain Reynier (Université Aix-Marseille).

Model-checking allows one to analyse the reliability of critical systems. There is currently an ongoing effort to extend formal verification and synthesis techniques to check non-functional properties such as performance, energy consumption or robustness, that are particularly important for real-time systems. SensAS is a project whose objective is to develop techniques to analyse the sensitivity of such systems with formal tools. In this context, a nominal behaviour, described with a deterministic timed automaton, is submitted to nondeterministic or stochastic perturbations. We seek then to quantify the variability of perturbed behaviours, giving formal guarantees on the computed result.

9.1.5. National informal collaborations

The team collaborates with the following researchers:

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

9.2. International Initiatives

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

9.2.1.1. QuantProb

- Title: Quantitative analysis of non-standard properties in probabilistic models
- International Partner (Institution - Laboratory - Researcher):
Technical University of Dresde (Germany) - Faculty of Computer Science - Christel Baier
- Start year: 2016
- See also: <http://www.irisa.fr/sumo/QuantProb/>

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

9.2.2. Inria International Partners

9.2.2.1. Informal International Partners

The team collaborates with the following researchers:

- Jean-François Raskin, Gilles Geeraerts (Université Libre de Bruxelles, Belgium) on multiplayer game theory and synthesis;
- Thomas Brihaye (UMons, Belgium) on the verification of stochastic timed systems;
- Mickael Randour (UMons, Belgium) on quantitative games for synthesis;
- Kim G. Larsen (Aalborg University, Denmark) on quantitative timed games, and on topics related to urban train systems modeling;
- Josef Widder, Igor Konnov and Marijana Lažić (TU Wien, Austria) on the automated verification of randomized distributed algorithms.
- John Mullin (Polytechnique Montréal, Canada), on topics related to security and opacity;
- S. Akshay (IIT Bombay, India) on topics related to timed concurrent models;
- Andrea D’ariano (University Roma Tre, Italy), on topics related to train regulation;
- Stavros Tripakis, Srinivas Pinisetty (Aalto University, Finland) on runtime verification and enforcement.

9.3. International Research Visitors

9.3.1. Visits of International Scientists

- Laurie Ricker visited the SUMO team for 2 months in May-June 2017.

9.3.1.1. Internships

- M2 Internship of Aina Toky Rasoamanana, Feb-July 2017, Nathalie Bertrand and Nicolas Markey
- L3 Internship of Balasubramanian A.R., May-July 2017, Nathalie Bertrand and Nicolas Markey

9.3.2. Visits to International Teams

9.3.2.1. Research Stays Abroad

- Éric Badouel made in September 2017 a one-month visit to Luca Bernardinello and Lucia Pomello from Milan University, and Carlo Ferigato from EJCR at Ispra. A work has been initiated on computer tools for the coordination of debates (from open citizen debates to parliamentary debates) and for managing the related documents (minutes, syntheses, ...) in an open data perspective.
- Engel Lefauchaux spent 6 weeks (May-June 2017) in Cagliari, working with Alessandro Giua and Carla Seatzu on the diagnosis of stochastic Petri nets.

TACOMA Team

8. Partnerships and Cooperations

8.1. Regional Initiatives

Project: EkoHub

Partner: Ekolis, Delaye transport, Telecom Bretagne

Starting: Nov 2014; Ending : Nov 2017

Contact: JM Bonnin

Abstract: The EkoHub project has been architected around our multi-technologies gateway and leverages on the one developed in the ITSSv6 European project. In addition to the multiple interfaces of our platforms, sensor devices have been incorporated into the project and we studied different scenarios elaborated with our professional partners (Layaye Logistics). Intelligent data management schemes are being studied to adapt to the communication environment and the needs of the application consuming the data. The data model has been derived from the outcomes of the SEAS project.

The final EkoHub demonstration held in november 2017 with project partners.

8.2. European Initiatives

8.2.1. Collaborations in European Programs, Except FP7 & H2020

Project: SCOOP@F part 2

Partner: MEDE, Renault, PSA

Starting: Jan 2016; Ending : Dec 2018

Coordinator: JM Bonnin

Abstract: SCOOP@F is a Cooperative ITS pilot deployment project that intends to connect approximately 3000 vehicles with 2000 kilometers of roads. It consists of 5 specific sites with different types of roads: Ile-de-France, "East Corridor" between Paris and Strasbourg, Brittany, Bordeaux and Isère. SCOOP@F is composed of SCOOP@F Part 1 from 2014 to 2015 (ongoing) and SCOOP@F Part 2 from 2016 to 2018. Its main objective is to improve the safety of road transport and of road operating staff during road works or maintenance. The project includes the validations of Cooperative ITS services in open roads, cross border tests with other EU Member States (Spain, Portugal and Austria) and development of a hybrid communication solution (3G-4G/ITS G5). We are involved in the project to study the security and privacy properties of the hybrid architecture that allow to use non dedicated communication networks (WiFi, 5G) as well as the vehicular dedicated communication technologies (G5).

Project acronym: SEAS (ITEA3)

Partners: Telecom Paris Tech, Telecom Saint Etienne, Mines Saint Etienne, Engie, Kerlink, BeNo-mad, ICAM, CNR, VTT

Starting: Feb 2014; ending: Jan 2017

Contact: JM Bonnin

Abstract: The SEAS project addresses the problem of inefficient and unsustainable energy consumption, which is due to a lack of sufficient means to control, monitor, estimate and adapt the energy use of systems versus the dynamic use situations and circumstances influencing the energy use. The objective of the SEAS project is to enable energy, ICT and automation systems to collaborate at consumption sites, and to introduce dynamic and refined ICT-based solutions to control, monitor and estimate energy consumption. Proposed solution should enable energy market participants to incorporate micro-grid environments and active customers. We are involved in the project to design a distributed system architecture and to implement two proofs of concept: the first one is related to the electric vehicle charging and the other one to the prevision of solar energy production.

Project: SCHIEF

Partner: TUM (Technical University of Munchen), IMT Atlantique, Eurecom

Starting: Sept 2016; **Ending :** Dec 2018

Coordinator: JM Bonnin

Abstract: In SCHEIF, we create a pilot for an enabler platform for the industrial Internet of Things. We envision a three-layered architecture with Sensors and actuators on the lowest layer. This layer includes industrial robots. On top of this hardware layer we envision site-local processing of data. Such a processing is beneficial since it allows keeping latency boundaries on the one hand and being in full control of all data on the other hand. The latency is relevant for enabling diverse time-critical operations as they often happen in industrial production environments. The local processing is relevant for protecting data. A privacy-conform processing is required to protect company secrets and to protect the privacy of workers. The third layer comprises data processing in the cloud. We envision mostly local data processing. However, offloading computing tasks to public or private clouds will be relevant for compute-intense tasks and those tasks that require coordination between production sites. The main scenario of SCHEIF is an industrial production site where mobile robots and human workers coexist. The focus is providing the data required to manage and optimize the production process always at the most suitable quality. The suitability of data relies on the requirements of the data producers and consumers. A planned demo scenario is a provoked system crash that leads to reprioritization of data streams to mitigate from the failure.

TAMIS Team

9. Partnerships and Cooperations

9.1. Regional Initiatives

- ARED grant for Lamine Nouredine and Florian Dolt
- Postdocs grants for Najah Ben Said, Jeffrey Paul Burdges, Ronan Lashermes, Ludovic Claudepierre
- Starting Grant for hardware for Annelie Heuser from Rennes Metropole
- Software developer grant for Laurent Morin from "Chaire Mobilité dans une ville durable" (mobility in a sustainable city) by Fondation Université Rennes 1

9.2. National Initiatives

9.2.1. ANR

- ANR MALTHY, Méthodes ALgébriques pour la vérification de modèles Temporisés et HYbrides, Thao Dang, 4 years, Inria and VISEO and CEA and VERIMAG
- ANR COGITO, Runtime Code Generation to Secure Devices, 3 years, Inria and CEA and ENSMSE and XLIM.

9.2.2. DGA

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

9.2.3. Autres

- INS2I JCJC grant for Axel Legay, Annelie Heuser, Fabrizio Biondi.

9.3. European Initiatives

9.3.1. FP7 & H2020 Projects

9.3.1.1. ACANTO

Title: ACANTO: A Cyberphysical social NeTwOrk using robot friends

Program: H2020

Duration: February 2015 - July 2018

Coordinator: Università di Trento

Partners:

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

Inria contact: Axel Legay

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

Axel Legay and Olivier Zendra are the permanent researchers of Tamis involved in this project. The project supports two postdocs in Tamis.

9.3.1.2. DIVIDEND

Title: DIVIDEND: Distributed Heterogeneous Vertically Integrated Energy Efficient Data centres

Program: CHIST-ERA 2013

Duration: 10/2014 - 10/2016 (extended 10/2017)

Coordinator: University of Edinburgh (UK)

Partners:

École Normale Supérieure de Paris, Département d'Informatique (France); Inria (France); Ecole Polytechnique Fédérale de Lausanne, Computer & Communication Sciences (Switzerland); Queen's University of Belfast, School of Electronics, Electrical Engineering and Computer Science, Belfast (UK); University of Edinburgh, Scotland, (UK); University of Lancaster, School of Computing and Communications (UK); University Politehnica Timisoara, Department of Computer Engineering (Romania)

Inria contact: Albert Cohen

The DIVIDEND project (<http://www.chistera.eu/projects/dividend>) attacks the data centre energy efficiency bottleneck through vertical integration, specialization, and cross-layer optimization. Our vision is to present heterogeneous data centres, combining CPUs, GPUs, and task-specific accelerators, as a unified entity to the application developer and let the runtime optimize the utilization of the system resources during task execution. DIVIDEND embraces heterogeneity to dramatically lower the energy per task through extensive hardware specialization while maintaining the ease of programmability of a homogeneous architecture. To lower communication latency and energy, DIVIDEND refers a lean point-to-point messaging fabric over complex connection-oriented network protocols. DIVIDEND addresses the programmability challenge by adapting and extending the industry-led heterogeneous systems architecture programming language and runtime initiative to account for energy awareness and data movement. DIVIDEND provides for a cross-layer energy optimization framework via a set of APIs for energy accounting and feedback between hardware, compilation, runtime, and application layers. The DIVIDEND project will usher in a new class of

vertically integrated data centres and will take a first stab at resolving the energy crisis by improving the power usage effectiveness of data centres.

Contributions of Inria in the project addresses the development of an energy aware distributed heterogeneous system (distributed HSA) between data center applications and HSA accelerators. It includes the design of a common API able to interface two tasks: the monitoring of the energy consumption, and the management of distributed heterogeneous hardware at a data center scale. The project ended by a project review the 23th March 2017, and the last contributions to the project ended the 30th September 2017.

One of the main contribution is the design of and energy-aware distributed heterogeneous system architecture framework (D-HSA) built using the combination of three major levels: the hardware platform based on an aggregation of HSA compliant devices, the system level based on device drivers and energy monitoring libraries, and finally the application layer using an extension of standard OpenCL programming model. This OpenCL extension is proposed as the main API for the energy-aware distributed HSA, and was made available for the tools and applications developed in the project.

A second contribution is the specification and the implementation of a distributed extension of the standard HSA Runtime API, and its functional validation on a basic system. The extension integrates the discovery, the management, and the execution of kernel computations on remote HSA agents in a distributed environment. The validation is based on an implementation using the Message Passing Interface (MPI) standard on an HSA compliant AMD machine. The Distributed HSA extension proposed offers a fully functional API for managing remote and distributed HSA agents, but at the cost of a limitation of the capability of the D-HSA system: the standard HSA memory model, based essentially on a coherent shared memory, is not supported for distributed HSA agents. As a primary implementation, focusing on a functional support of the new D-HSA verbs, this works tend to demonstrate that the extension is light and easy-to-use for a set of examples.

Laurent Morin from Tamis is involved in this project

9.3.1.3. EMC2

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

Program: FP7

Duration: April 2014 - March 2017

Coordinator: Infineon Technologies

Partners:

Aicas (Germany) Avl Software and Functions (Germany), Denso Automotive Deutschland (Germany), Elektrobit Automotive (Germany), Evision Systems (Germany), Nxp Semiconductors Germany (Germany), Tttech Computertechnik (Austria), "kompetenzzentrum - Das Virtuelle Fahrzeug, Forschungsgesellschaft MbH" (Austria), Frequentis (Austria), Thales Austria (Austria), Blueice Bvba (Belgium), Freescale Polovodice Ceska Republika Sro (Czech Republic), Sysgo Sro (Czech Republic), Silkan Rt (France), "united Technologies Research Centre Ireland," (Ireland), Mbda Italia Spa (Italy), Fornebu Consulting As (Norway), Westerngeco As (Norway), Simula Research Laboratory As (Norway), Ixion Industry and Aerospace Sl (Spain), Visure Solutions Sl (Spain), Seven Solutions Sl (Spain), Telvent Energia (Spain), Instituto Tecnológico de Informatica (Spain), Ambar Telecomunicaciones Sl (Spain), Sics Swedish Ict (Sweden), Arcticus Systems (Sweden), Arccore (Sweden), Xdin Stockholm (Sweden), Systemite (Sweden), Stichting Imec Nederland (Netherlands), Tomtom International Bv (Netherlands), Infineon Technologies Uk Ltd (United Kingdom), Sundance Multiprocessor Technology Ltd (United Kingdom), Systonomy (United Kingdom), Ensilica Ltd (United Kingdom), Test and Verification Solutions Ltd (United Kingdom), Abb (Sweden), Ait Austrian Institute of Technology (Austria),

Alenia Aermacchi Spa (Italy), Avl List (Austria), Airbus Defence and Space (Germany), Bayerische Motoren Werke Aktiengesellschaft (Germany), Vysoke Ucení Technické V Brně (Czech Republic), Commissariat A L Energie Atomique et Aux Energies Alternatives (France), Consorzio Interuniversitario Nazionale Per l'Informatica (Italy), Centro Ricerche Fiat (Italy), Critical Software (Portugal), Chalmers Tekniska Högskola (Sweden), Danfoss Power Electronics As (Denmark), Danmarks Tekniske Universitet (Denmark), Ericsson (Sweden), Fraunhofer-Gesellschaft Zur Förderung Der Angewandten Forschung E.V (Germany), Hi Iberia Ingeniería Y Proyectos SL (Spain), Harokopio University (Greece), Infineon Technologies Austria (Austria), Institut Mikroelektronických Aplikací S.R.O. (Czech Republic), Inesc Id - Instituto de Engenharia de Sistemas E Computadores, Investigação E Desenvolvimento Em Lisboa (Portugal), Infineon Technologies (Germany), Integrasy (Spain), Instituto Superior de Engenharia Do Porto (Portugal), Kungliga Tekniska Högskolan (Sweden), Luleå Tekniska Universitet (Sweden), Magillem Design Services (France), Nxp Semiconductors Netherlands Bv (Netherlands), Offis E.V. (Germany), Philips Medical Systems Nederland Bv (Netherlands), Politecnico di Torino (Italy), Quobis Networks SL (Spain), Rockwell Collins France (France), Rigas Tehniskā Universitāte (Latvia), Selex Es Spa (Italy), Siemens Aktiengesellschaft (Germany), Systematic Paris Region Association (France), Sysgo (Germany), Thales Alenia Space Italia Spa (Italy), "thales Alenia Space Espana," (Spain), Technolution B.V. (Netherlands), Fundación Tecnalia Research & Innovation (Spain), Thales Communications & Security (France), Thales Avionics (France), Thales (France), Nederlandse Organisatie Voor Toegepast Natuurwetenschappelijk Onderzoek Tno (Netherlands), Technische Universität Braunschweig (Germany), Technische Universiteit Delft (Netherlands), Technische Universität Dortmund (Germany), Technische Universitaet Kaiserslautern (Germany), Technische Universitaet Wien (Austria), Technische Universiteit Eindhoven (Netherlands), Università Degli Studi di l'aquila (Italy), Università Degli Studi di Genova (Italy), The University of Manchester (United Kingdom), University of Bristol (United Kingdom), University of Limerick (Ireland), "ustav Teorie Informace A Automatizace Av Cr, V.V.I." (Czech Republic), Universitetet I Oslo (Norway), Vector Fabrics Bv (Netherlands), Volvo Technology (Sweden)

Inria contact: Albert Cohen and Axel Legay

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 EMC2 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. EMC2 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.

The permanent members of Tamis who are involved are Axel Legay and Olivier Zendra. The project was initiated during the lifetime of the ESTASYS.Inria team.

9.3.1.4. ENABLE-S3

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

Program: H2020

Duration: 05/2016 - 04/2019

Coordinator: Avl List Gmbh (Austria)

Partners:

Aalborg Universitet (Denmark); Airbus Defence And Space Gmbh (Germany); Ait Austrian Institute Of Technology Gmbh (Austria); Avl Deutschland Gmbh (Germany); Avl Software And Functions Gmbh (Germany); Btc Embedded Systems Ag (Germany); Cavotec Germany Gmbh (Germany); Creanex Oy(Finland); Ceske Vysoke Ucení Technické V Praze (Czech Republic); Deutsches Zentrum Fuer Luft - Und Raumfahrt Ev (Germany); Denso Automotive Deutschland Gmbh (Germany); Dr. Steffan Datentechnik Gmbh (Austria); Danmarks Tekniske Universitet (Denmark); Evidence Srl (Italy); Stiftung Fzi Forschungszentrum Informatik Am Karlsruher Institut Fur Technologie (Germany); Gmv Aerospace And Defence Sa (Spain); Gmvis Skysoft Sa (Portugal); Politechnika Gdanska (Poland); Hella Aglaia Mobile Vision Gmbh (Germany); Ibm Ireland Limited (Ireland); Interuniversitair Micro-Electronica Centrum (Belgium); Iminds (Belgium); Institut National De Recherche Eninformatique Et Automatique (France); Instituto Superior De Engenharia Do Porto (Portugal); Instituto Tecnológico De Informatica (Spain); Ixion Industry And Aerospace Sl (Spain); Universitat Linz (Austria); Linz Center Of Mechatronics Gmbh (Austria); Magillem Design Services Sas (France); Magneti Marelli S.P.A. (Italy); Microelectronica Maser Slspain); Mdal (France); Model Engineering Solutions Gmbhgermany); Magna Steyr Engineering Ag & Co Kg (Austria); Nabto Aps (Denmark); Navtor As (Norway); Nm Robotic Gmbh (Austria); Nxp Semiconductors Germany Gmbh(Germany); Offis E.V.(Germany); Philips Medical Systems Nederland Bvnletherlands); Rohde & Schwarz Gmbh&Co Kommanditgesellschaft(Germany); Reden B.V. (Netherlands); Renault Sas (France); Rugged Tooling Oyfinland); Serva Transport Systems Gmbh(Germany); Siemens Industry Software Nvbelgium); University Of Southampton (Uk); Safetrans E.V. (Germany); Thales Alenia Space Espana, Saspain); Fundacion Tecnalia Research & Innovationspain); Thales Austria Gmbh (Austria); The Motor Insurance Repair Researchcentre (Uk); Toyota Motor Europe (Belgium); Nederlandse Organisatie Voor Toegepast Natuurwetenschappelijk Onderzoek Tno (Netherlands); Ttcontrol Gmbh (Austria); Tttech Computertechnik Ag (Austria); Technische Universiteit Eindhoven (Netherlands); Technische Universitat Darmstadt (Germany); Technische Universitaet Graz (Austria); Twt Gmbh Science & Innovation (Germany); University College Dublin, National University Of Ireland, Dublin (Ireland); Universidad De Las Palmas De Gran Canaria (Spain); Universita Degli Studi Di Modena E Reggio Emilia (Italy); Universidad Politecnica De Madrid (Spain); Valeo Autoklimatizace K.S. (Czech Republic); Valeo Comfort And Driving Assistance (France); Valeo Schalter Und Sensoren Gmbh (Germany); Kompetenzzentrum - Das Virtuelle Fahrzeug, Forschungsgesellschaft Mbh (Austria); Vires Simulationstechnologie Gmbh (Germany); Teknologian Tutkimuskeskus Vtt Oy (Finland); Tieto Finland Support Services Oy (Finland); Zilinska Univerzita V Ziline (Slovakia);

Inria contact: Axel Legay

The objective of ENABLE-S3 (<http://www.enable-s3.eu>) is to establish cost-efficient cross-domain virtual and semi-virtual V&V platforms and methods for ACPS. Advanced functional, safety and security test methods will be developed in order to significantly reduce the verification and validation

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

Axel Legay and Jean-Louis Lanet are involved in this project. The project supports one postdoc in Tamis starting in 2017.

9.3.1.5. *SUCCESS*

Title: SUCCESS: SecUre aCCESSibility for the internet of things

Program: CHIST-ERA 2015

Duration: 10/2016 - 10/2018

Coordinator: Middlesex University (UK)

Partners:

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

Inria contact: Axel Legay

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

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

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

9.3.1.6. *TeamPlay*

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

Program: H2020

Duration: 01/2018 - 12/2020

Coordinator: Inria

Partners:

Absint Angewandte Informatik Gmbh (Germany), Institut National De Recherche en Informatique et Automatique (France), Secure-Ic Sas (France), Sky-Watch A/S (Denmark), Syddansk Universitet (Denmark), Sythmata Ypologistikis Orashs Irida Labs Ae (Greece), Technische Universität Hamburg-Harburg (Germany), Thales Alenia Space Espana (Spain), Universiteit Van Amsterdam (Netherlands), University Of Bristol (UK), University Of St Andrews (UK)

Inria contact: Olivier Zendra and Axel Legay

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

The permanent members of Tamis who are involved are Axel Legay, Olivier Zendra and Annelie Heuser.

TEA Project-Team

9. Partnerships and Cooperations

9.1. National Initiatives

9.1.1. ANR

Program: ANR

Project acronym: **Feever**

Project title: Faust Environment Everywhere

Duration: 2014-2016

Coordinator: Pierre Jouvelot, Mines ParisTech

Other partners: Grame, Inria Rennes, CIEREC

URL: <http://www.feever.fr>

Abstract: The aim of project FEEVER is to ready the Faust music synthesis language for the Web. In this context, we collaborate with Mines ParisTech to define a type system suitable to model music signals timed at multiple rates and to formally support playing music synthesized from different physical locations.

9.1.2. PAI

Program: PAI/CORAC

Project acronym: CORAIL

Project title: Composants pour l'Avionique Modulaire Étendue

Duration: July 2013 - May 2017

Coordinator: Thales Avionics

Other partners: Airbus, Dassault Aviation, Eurocopter, Sagem...

Abstract: The CORAIL project aims at defining components for Extended Modular Avionics. The contribution of project-team TEA is to define a specification method and to provide a generator of multi-task applications.

9.2. International Initiatives

9.2.1. Inria International Labs

9.2.1.1. SACCADES

Title: Saccades

International Partner:

LIAMA

East China Normal University

Inria project-teams Aoste and Tea

Duration: 2003 - now

The SACCADES project is a LIAMA project hosted by East China Normal University and jointly led by Vania Joloboff (Inria) and Min Zhang (ECNU). The SACCADES project aims at improving the development of reliable cyber physical systems and more generally of distributed systems combining asynchronous with synchronous aspects, with different but complementary angles:

- develop the theoretical support for Models of Computations and Communications (MoCCs) that are the fundamentals basis of the tools.
- develop software tools (a) to enable the development and verification of executable models of the application software, which may be local or distributed and (b) to define and optimize the mapping of software components over the available resources.
- develop virtual prototyping technology enabling the validation of the application software on the target hardware platform.

The ambition of SACCADES project is to develop

- Theoretical Support for Cyber Physical Systems
- Software Tools for design and validation of CPS
- Virtual Prototyping of CPS

9.2.2. Inria Associate Teams

9.2.2.1. Composite

Title: Compositional System Integration

International Partner (Institution - Laboratory - Researcher):

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

Start year: 2017

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

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

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

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

9.2.3. Inria International Partners

9.2.3.1. Convex

Title: Compositional Verification of Cyber-Physical Systems

International Partner:

- Chinese Academy of Science, Institute of Software
- Beihang University
- Nanhang University
- Nankai University

Duration: 2017 - now

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

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

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

9.3. International Research Visitors

9.3.1. Visits of International Scientists

Rajesh Gupta visited project-team TEA in August and gave two 68NQTR seminars on “Building Computing Machines That Sense, Adapt and Approximate” and on “Compositional Synthesis for High-level Design of System-Chips”.

Deian Stefan visited project-team TEA in September and gave a 68NQTR seminar on “Practical multi-core information flow control”

Shuvra Bhattacharyya visited project-team TEA in August and December and gave a 68NQTR seminar on “The DSPCAD Framework for Dataflow-based Design and Implementation of Signal Processing Systems”

9.3.2. Visits to International Teams

Jean-Pierre Talpin visited UC San Diego and UC Berkeley in the context of the associate-project Composite in June.

In the context of the IIP Convex, Jean-Pierre Talpin was invited at Beihang and Nanhang Universities in April, visited Beihang and Nankai Universities in July, and Beihang, Nankai and ECNU in November, to give seminars and a introductory course on model checking.

Jean-Pierre Talpin gave an invited talk on “Parametric model-checking the FTSP protocol ” at TU Wien June 30.

Simon Lunel visited CMU and UC San Diego in December to give seminars on “compositional proofs in differential dynamic logic”.

VISAGES Project-Team

9. Partnerships and Cooperations

9.1. Regional Initiatives

9.1.1. *Allocation d'Installation Scientifique – Rennes Métropole*

Participant: Emmanuel Caruyer.

Diffusion MRI has been a tremendous tool for the diagnosis of a number of brain pathologies such as abnormal development, neuro-degenerative or inflammatory disorders or brain tumors. Typical resolution in diffusion MRI is about 2mm – this suggests that in white matter, any volume element may contain millions of axons. Although currently we can characterize molecular diffusion, recent developments in diffusion MRI have shown the possibility to quantify more specifically some physical tissue parameters in white matter, such as axonal density and diameter: this means that we can retrieve information from a much smaller scale than the typical imaging resolution.

Acquisition time for this kind of measurements remains long and largely incompatible with in vivo application in humans. This project aims at developing novel signal processing and acquisition methods for the reconstruction of microstructural informations in a reasonable acquisition time. We will study how sparse representations can be applied to the diffusion signal, in order to enable microstructure information reconstruction. In conjunction with this, we will develop acquisition sequences adapted to these sparse representations, in order to reconstruct the diffusion signal from fewer measurements, using results from the compressive sensing theory.

9.2. National Initiatives

9.2.1. *Projet Fondation de France: PERINE*

Participants: Élise Bannier, Isabelle Corouge, Julie Coloigner, Maia Proisy, Jean-Christophe Ferré, Christian Barillot.

This study evaluates the effect of prenatal exposure to neurotoxicants on the developing brain. Following previous studies in the PELAGIE cohort this MRI study involves ASL, Diffusion and working memory as well as motor inhibition BOLD fMRI together with neuropsychological tests in children. Inclusions have started in November 2014 and lasted for 2 years. The MRI acquisitions of the PERINE projects have all been performed and 101 children included. A PhD started in January 2017 to process the functional MRI data of this project and Julie Coloigner was hired as a post doc to work on the Diffusion and ASL data.

9.2.2. *Projet Fondation de France: EPMR-MA*

Participants: Pierre-Yves Jonin, Élise Bannier, Christian Barillot, Quentin Duché.

This project evaluates memory effects in healthy adults and in patients presenting cognitive impairments using BOLD fMRI and diffusion MRI. The inclusions of patients started in 2016 and all inclusions will be over by the end of 2017. Quentin Duché was hired to process the functional MRI and diffusion data end of 2016 and his contract was extended until May 2018.

9.2.3. *ANR "MAIA", 2015 generic projects program*

Participants: Maia Proisy, Pierre Maurel, Antoine Legouhy, Olivier Commowick, Isabelle Corouge, Jean-Christophe Ferré, Christian Barillot.

Each year in France, 55 000 children are born prematurely, i.e., before the 37th week of gestation. Long-term studies of the outcome of prematurely born infants have clearly documented that the majority of such infants may have significant motor, cognitive, and behavioral deficits.

However, there is a limited understanding of the nature of the cerebral abnormality underlying these adverse neurologic outcomes. In this context, the emergence of new modalities of 3D functional MRI, e.g., Arterial Spin Labeling (ASL), or optical imaging technologies, e.g., Near InfraRed Spectroscopy (NIRS), brings new perspectives for extracting cognitive information, via metabolic activity measures. Other classical techniques devoted to cerebral signal measurement, such as ElectroEncephaloGraphy (EEG), provide cognitive information at the cortical level. Each of these various non-invasive imaging technologies brings substantial and specific information for the understanding of newborn brain development.

This project aims at developing innovative approaches for multi-image / multi-signal analysis, in order to improve neurodevelopment understanding methods. From a fundamental point of view, mathematics and computer science have to be considered in association with imaging physics and medicine, to deal with open issues of signal and image analysis from heterogeneous data (image, signal), considered in the multiphysics contexts related to data acquisition (magnetic, optic, electric signals) and biophysics modeling of the newborn brain. A sustained synergy between all these scientific domains is then necessary.

Finally, the sine qua non condition to reach a better understanding of the coupled morphological- cognitive development of premature newborns, is the development of effective software tools, and their distribution to the whole medical community. The very target of this project will be the design of such software tools for medical image / signal analysis, actually operational in clinical routine, and freely available. Academic researchers and industrial partners will work in close collaboration to reach that ambitious goal.

9.2.4. Fondation pour la recherche médicale (FRM) - Project "Hybrid EEG/IRM Neurofeedback for rehabilitation of brain pathologies"

Participants: Élise Bannier, Jean-Marie Batail, Isabelle Bonan, Isabelle Corouge, Jean-Christophe Ferré, Jean-Yves Gauvrit, Pierre Maurel, Mathis Fleury, Giulia Lioi, Christian Barillot.

The goal of this project is to make full use of neurofeedback (NF) paradigm in the context of brain rehabilitation. The major breakthrough will come from the coupling associating functional and metabolic information from Magnetic Resonance Imaging (fMRI) to Electro-encephalography (EEG) to “optimize” the neurofeedback protocol. We propose to combine advanced instrumental devices (Hybrid EEG and MRI platforms), with new hybrid Brain computer interface (BCI) paradigms and new computational models to provide novel therapeutic and neuro-rehabilitation paradigms in some of the major mental and neurological disorders of the developmental and the aging brain (stroke, language disorders, Mood Depressive Disorder (MDD), ...). Though the concept of using neurofeedback paradigms for brain therapy has somehow been experimented recently (mostly through case studies), performing neurofeedback through simultaneous fMRI and EEG has almost never been done before so far (two teams in the world including us within the HEMISFER CominLabs project). This project will be conducted through a very complementary set of competences over the different involved teams: VISAGES U1228, HYBRID and PANAMA Teams from Inria/Irisa Rennes and EA 4712 team from U. of Rennes I.

9.2.5. PHRC EMISEP: Evaluation of early spinal cord injury and late physical disability in Relapsing Remitting Multiple Sclerosis

Participants: Élise Bannier, Christian Barillot, Emmanuel Caruyer, Benoit Combès, Olivier Commowick, Gilles Edan, Jean-Christophe Ferré, Anne Kerbrat, Haykel Snoussi.

Multiple Sclerosis (MS) is the most frequent acquired neurological disease affecting young adults (1/1000 inhabitants in France) and leading to impairment. Early and well adapted treatment is essential in patients presenting aggressive forms of MS. This PHRC project focusses on physical impairment and especially on the ability to walk. Several studies, whether epidemiologic or based on brain MRI, have shown that several factors were likely to announce aggressive development of the disease, such as age, number of focal lesions on baseline MRI, clinical activity. However, these factors only partially explain physical impairment progression, preventing their use at the individual level. Spinal cord is often affected in MS, as demonstrated in postmortem or imaging studies. Yet, early radiological depiction of spinal cord lesions is not always correlated with clinical symptoms. Preliminary data, on reduced number of patients, and only investigating the cervical spinal cord

have shown that diffuse spinal cord injury, observed via diffusion or magnetisation transfer imaging, would be correlated with physical impairment as evaluated by the EDSS score. Besides, the role of early spinal cord affection (first two years) in the evolution of physical impairment remains unknown.

In this project, we propose to address these different issues and perform a longitudinal study on Relapsing Remitting Multiple Sclerosis (RRMS) patients, recruited in the first year of the disease. Our goal is to show that diffuse and focal lesions detected spinal cord MRI in the first 2 years can be used to predict disease evolution and physical impairment at 5 years. Twelve centers are involved in the study to include 80 patients.

To date, all subjects have been included. H. Snoussi is working in the scope of his PhD thesis on diffusion imaging in the spinal cord starting with distortion correction. The results of this study were presented at the ESMRMB 2017 conference [38].

B. Combès started as a post doc in November 2016 to process the EMISEP imaging data, starting with morphological data processing (registration, segmentation) and magnetization transfer data processing. Preliminary results were presented at the ESMRMB and ECTRIMS 2017 conferences [33] [43].

9.2.6. Competitivity Clusters

9.2.6.1. The HEMISFER Project

Participants: Élise Bannier, Jean-Marie Batail, Isabelle Bonan, Isabelle Corouge, Claire Cury, Jean-Christophe Ferré, Jean-Yves Gauvrit, Marsel Mano, Pierre Maurel, Saman Norzade, Lorraine Perronnet, Christian Barillot.

The HEMISFER project ("Hybrid Eeg-MrI and Simultaneous neuro-FEedback for brain Rehabilitation") will be conducted at Inria Rennes with the support of the Cluster of Excellence "CominLabs"⁰. The goal of HEMISFER is to make full use of the neurofeedback paradigm in the context of rehabilitation and psychiatric disorders. The major breakthrough will come from the use of a coupling model associating functional and metabolic information from Magnetic Resonance Imaging (fMRI) to Electro-encephalography (EEG) to "enhance" the neurofeedback protocol. We propose to combine advanced instrumental devices (Hybrid EEG and MRI platforms), with new man-machine interface paradigms (Brain computer interface and serious gaming) and new computational models (source separation, sparse representations and machine learning) to provide novel therapeutic and neuro-rehabilitation paradigms in some of the major neurological and psychiatric disorders of the developmental and the aging brain (stroke, attention-deficit disorder, language disorders, treatment-resistant mood disorders, ...). This project will be conducted with the HYBRID and PANAMA Teams from Inria Rennes, the EA 4712 team from University of Rennes I and the ATHENA team from Inria Sophia-Antipolis. This work will benefit from the research 3T MRI and MRI-compatible EEG systems provided by the NeurInfo in-vivo neuroimaging platform on which these new research protocols will be set up. A budget of 500keuros will be provided by the CominLabs cluster in the next 3 years to support this project (through experimental designs, PhDs, Post-docs and Expert Engineers).

9.2.6.2. France Life Imaging (FLI)

Participants: Christian Barillot, Olivier Commowick, Michael Kain, Florent Leray, Julien Louis, Aneta Morawin, Mathieu Simon, Yao Chi.

France Life Imaging (FLI) is a proposed large-scale research infrastructure project aimed at establishing a coordinated and harmonized network of biomedical imaging in France. This project was recently selected by the call "Investissements d'Avenir - Infrastructure en Biologie et Santé". One node of this project is the node Information Analysis and Management (IAM), a transversal node build by a consortium of teams that will contribute to the construction of a network for data storage and information processing. Instead of building yet other dedicated facilities, the IAM node will use already existing data storage and information processing facilities (LaTIM Brest; CREATIS Lyon; CIC-IT Nancy; VisAGeS U1228 Inria Rennes; CATI CEA Saclay; LSIIT/Cube Strasbourg) that will increase their capacities for the FLI infrastructure. Inter-connections and access to services will be achieved through a dedicated software platform that will be developed based on the expertise gained through successful existing developments. The IAM node has several goals. It aims

⁰<https://www.inria.fr/cominlabs-newsletter/april-2013-four-projects-selected/#hemisfer>

first at building a versatile facility for data management that will inter-connect the data production sites and data processing for which state-of-the-art solutions, hardware and software, will be available to infrastructure users. Modular solutions are preferred to accommodate the large variety of modalities acquisitions, scientific problems, data size, and adapted for future challenges. Second, it aims at offering the latest development that will be made available to image processing research teams. The team VisAGeS fulfills multiple roles in this nation-wide project. Christian Barillot is the chair of the node IAM, Olivier Commowick is participating in the working group workflow and image processing and Michael Kain the technical manager. Apart from the team members, software solutions like MedInria and Shanoir will be part of the final software platform.

9.2.6.3. OFSEP

Participants: Élise Bannier, Christian Barillot, Olivier Commowick, Gilles Edan, Jean-Christophe Ferré, Michael Kain, Inès Fakhfakh.

The French Observatory of Multiple Sclerosis (OFSEP) is one of 10 projects selected in January 2011 in response to the call for proposal in the “Investissements d’Avenir - Cohorts 2010” program launched by the French Government. It allows support from the National Agency for Research (ANR) of approximately € 10 million for 10 years. It is coordinated by the Department of Neurology at the Neurological Hospital Pierre Wertheimer in Lyon (Professor Christian Confavreux), and it is supported by the EDMUS Foundation against multiple sclerosis, the University Claude Bernard Lyon 1 and the Hospices Civils de Lyon. OFSEP is based on a network of neurologists and radiologists distributed throughout the French territory and linked to 61 centers. OFSEP national cohort includes more than 50,000 people with Multiple Sclerosis, approximately half of the patients residing in France. The generalization of longitudinal monitoring and systematic association of clinical data and neuroimaging data is one of the objectives of OFSEP in order to improve the quality, efficiency and safety of care and promote clinical, basic and translational research in MS. For the concern of data management, the Shanoir platform of Inria has been retained to manage the imaging data of the National OFSEP cohort in multiple sclerosis.

9.3. European Initiatives

9.3.1. Collaborations in European Programs, Except FP7 & H2020

- **OpenAire-Connect**

The OpenAire-Connect H2020 project will introduce and implement the concept of Open Science as a Service (OSaaS) on top of the existing OpenAIRE infrastructure, delivering out-of-the-box, on-demand deployable tools. OpenAIRE-Connect will adopt an end-user driven approach (via the involvement of 5 prominent research communities), and enrich the portfolio of OpenAIRE infrastructure production services with a Research Community Dashboard Service and a Catch-All Notification Broker Service. The first will offer publishing, interlinking, packaging functionalities to enable them to share and re-use their research artifacts (introducing methods, e.g., data, software, protocols). This effort, supported by the harvesting and mining “intelligence” of the OpenAIRE infrastructure, will provide communities with the content and tools they need to effectively evaluate and reproduce science. OpenAIRE-Connect will combine dissemination and training with OpenAIRE’s powerful NOAD network engaging research communities and content providers in adopting such services. These combined actions will bring immediate and long-term benefits to scholarly communication stakeholders by affecting the way research results are disseminated, exchanged, evaluated, and re-used. In this project VisAGeS is acting, through CNRS, as the French coordinator to develop the link with the Neuroimaging research community. This will be performed in the context of the FLI-IAM national infrastructure.

- Participants: Christian Barillot; Michael Kain; Camille Maumet
- Partners: PI: CNR, Italy; Athena Research And Innovation Center In Information Communication & Knowledge Technologies, Greece; Uniwersytet Warszawski, Poland; JISC LBG, UK; Universitaet Bremen, Germany; Universidade Do Minho, Portugal; CNRS (Visages, Creatis), France; Universita Di Firenze, Italy; Institut De Recherche Pour Le Developpement (IRD), France; European Organization For Nuclear Research (CERN), Switzerland; International Center For Research On The Environment And The Economy, Greece

- Budget: 2M € (120k€ for CNRS)
- **Health**

EIT Health aims to promote entrepreneurship and develop innovations in healthy living and active ageing, providing Europe with new opportunities and resources. EIT Health will enable citizens to lead healthier and more productive lives by delivering products, services and concepts that will improve quality of life and contribute to the sustainability of healthcare across Europe. EIT Health is a strong, diverse and balanced partnership of best-in-class organisations in education, research, technology, business creation and corporate and social innovation. EIT Health intends to foster cooperation and unlock Europe's innovation and growth potential – developing and retaining the best talents, creating high-quality jobs and boosting the global competitiveness of European industry. VisAGeS is involved in this project through the Inserm and Inria institutions. Christian Barillot is representing Inria as one expert in the dedicated WG “Healthy Brain”. VisAGeS is also concerned by the WG “big data”.

 - Participants: Christian Barillot, Michael Kain
 - Partners: see <https://www.eithealth.eu/partners>

9.4. International Initiatives

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

9.4.1.1. BARBANT

Title: Boston and Rennes, a Brain image Analysis Team

International Partner (Institution - Laboratory - Researcher):

Harvard University (United States) - Mathematics Department - Simon K. Warfield

Start year: 2015

See also: <https://team.inria.fr/barbant/>

BARBANT is an Inria associate team shared between Inria VisAGeS research team and the Computational Radiology Laboratory at the Boston Children's hospital (Harvard Medical School). This associate team aims at better understanding the behavior of normal and pathological Central Nervous System (CNS) organs and systems. Pathologies of particular interest to us are multiple sclerosis, psychiatric, and pediatric diseases such as pediatric multiple sclerosis or tuberous sclerosis. A major challenge is to characterize the future course of the pathological processes in each patient as early as possible in order to predict the progression of the disease and/or adverse neurological outcomes, and to develop better techniques for both monitoring response to therapy and for altering therapy (duration, dose and nature) in response to patient-specific changes in imaging characteristics. At term, this project will allow to introduce objective figures to correlate qualitative and quantitative phenotypic markers coming from the clinic and image analysis, mostly at the early stage of the pathologies. This will allow for the selection or adaptation of the treatment for patients at an early stage of the disease.

9.4.2. Inria International Partners

9.4.2.1. Informal International Partners

- Collaboration with the Department of Computer Science, University of Verona: Emmanuel Caruyer visited the group of Gloria Menegaz and Alessandro Daducci in the context of the 2017 School on Brain Connectomics (<http://brainconnectomics.org/>).
- Collaboration with Neuropoly, Polytechnique Montreal: Haykel Snoussi is visiting the group of Julien Cohen-Adad and received an Inria-MITACS fellowship for a 3 months period (Nov. 2017-Jan. 2018). He will be working on the processing of diffusion-weighted images of multiple sclerosis patients' spinal cord in the context of the EMISEP project.

- Collaboration with Department of Mathematics and Statistics at the Politecnico di Milano, Italy (Simone Vantini, Aymeric Stamm): Lorenzo Rota did visit the team between Oct. 2016 to March 2017 for his Tesi (Master degree) on "Application of shape analysis and functional data analysis tools on fiber bundles analysis".

9.5. International Research Visitors

9.5.1. Visits of International Scientists

- Simon Warfield and Benoit Scherrer, Harvard University, visited the VisAGeS team for the annual seminar on Jun. 2017.

9.5.2. Visits to International Teams

- Sudhanya Chatterjee visited the Computational Radiology Lab, the Boston Children's Hospital, at Harvard University in Nov. 2017. This stay was funded by the international program of University of Rennes 1. Christian Barillot and Olivier Commowick visited the same lab for a 3 days workshop in the context of the Associate Team.
- Haykel Snoussi visited the NeuroPoly Lab for 3 months from Nov. 2017. This stay was funded by the international program of University of Rennes 1.