Activity Report 2015

Section Partnerships and Cooperations

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

9. Partnerships and Cooperations

9.1. National Initiatives

9.1.1. Capacités: Projet "Investissement d'Avenir", 1/11/14 to 31/01/2018

Participants: Damien Hardy, Isabelle Puaut.

The project objective is to develop a hardware and software platform based on manycore architectures, and to demonstrate the relevance of these manycore architectures (and more specifically the Kalray manycore) for several industrial applications. The Kalray MPPA manycore architecture is currently the only one able to meet the needs of embedded systems simultaneously requiring high performance, lower power consumption, and the ability to meet the requirements of critical systems (low latency I/O, deterministic processing times, and dependability). The project partners are Kalray (lead), Airbus, Open-Wide, Safran Sagem, IS2T, Real Time ar Work, Dassault Aviation, Eurocopter, MBDA, ProbaYes, IRIT, Onera, Verimag, Inria, Irisa, Tima and Armines.

9.1.2. Inria Project Lab: Multicore 2013-2016

Participants: Erven Rohou, Nabil Hallou.

The Inria Project Lab (formerly *Action d'Envergure*) started in 2013. It is entitled "Large scale multicore virtualization for performance scaling and portability". Partner project-teams include: ALF, ALGORILLE, CAMUS, REGAL, RUNTIME, as well as DALI. This project aims to build collaborative virtualization mechanisms that achieve essential tasks related to parallel execution and data management. We want to unify the analysis and transformation processes of programs and accompanying data into one unique virtual machine.

9.1.3. ADT IPBS 2013-2015

Participants: Sylvain Collange, Erven Rohou, André Seznec, Thibault Person.

As multi-core CPUs and parallel accelerators become pervasive, all execution platforms are now parallel. Research on architecture, compilers and systems now focuses on parallel platforms. New contributions need to be validated against parallel applications that are expected to be representative of current or future workloads. The research community relies today on a few benchmarks sets (SPLASH, PARSEC ...) Existing parallel benchmarks are scarce, and some of them have issues such as aging workloads or non-representative input sets. The IPBS initiative aims at leveraging the diversity of parallel applications developed within Inria to provide a set of benchmarks, named the Inria Parallel Benchmark Suite http://parasuite.inria.fr/, to the research community.

9.1.4. ANR Continuum 2015–2019

Participant: Erven Rohou.

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

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

9.1.5. ANR CHIST-ERA SECODE 2016-2018

Participants: Damien Hardy, Erven Rohou.

SECODE (Secure Codes to thwart Cyber-physical Attacks) was accepted, and will start on January 1st 2016.

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. Theses 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, University of Sabancı(Turkey), and Université Catholique de Louvain (Belgium).

9.1.6. ANR W-SEPT 2012-2015

Participants: Hanbing Li, 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.

9.2. European Initiatives

9.2.1. FP7 & H2020 Projects

9.2.1.1. ANTAREX

Participant: Erven Rohou.

> Title: Auto-Tuning and Adaptivity appRoach for Energy efficient exascale HPC Systems
>
> Programm: H2020
>
> Duration: September 2015 - September 2018
>
> Coordinator: Politecnico di Milano, Italy (POLIMI)
>
> Partners:
>
> > Consorzio Interuniversitario Cineca (Italy)
> >
> > Dompe Farmaceutici Spa (Italy)
> >
> > Eidgenoessische Technische Hochschule Zuerich (Switzerland)
> >
> > Vysoka Skola Banska - Technicka Univerzita Ostrava (Czech Republic)
> >
> > Politecnico di Milano (Italy)
> >
> > Sygic As (Slovakia)
> >
> > Universidade Do Porto (Portugal)
>
> Inria contact: Erven Rohou

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

9.2.1.2. Eurolab-4-HPC

Participant: André Seznec.

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

Programm: H2020

Duration: September 2015 - September 2017

Coordinator: CHALMERS TEKNISKA HOEGSKOLA AB

Partners:

> Barcelona Supercomputing Center - Centro Nacional de Supercomputacion (Spain)
>
> Chalmers Tekniska Hoegskola (Sweden)
>
> Ecole Polytechnique Federale de Lausanne (Switzerland)
>
> Foundation for Research and Technology Hellas (Greece)
>
> Universitaet Stuttgart (Germany)
>
> Rheinisch-Westfaelische Technische Hochschule Aachen (Germany)
>
> Technion - Israel Institute of Technology (Israel)
>
> Universitaet 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.

9.2.1.3. DAL

Participants: Pierre Michaud, Bharath Narasimha Swamy, Sylvain Collange, Erven Rohou, André Seznec, Arthur Perais, Surya Khizakanchery Natarajan, Sajith Kalathingal, Tao Sun, Andrea Mondelli, Aswinkumar Sridharan.

Title: DAL: Defying Amdahl's Law

Program: FP7

Type: ERC

Duration: April 2011 - March 2016

Coordinator: Inria

Inria contact: André Seznec

Multicore processors have now become mainstream for both general-purpose and embedded computing. Instead of working on improving the architecture of the next generation multicore, with the DAL project, we deliberately anticipate the next few generations of multicores. While multicores featuring 1000's of cores might become feasible around 2020, there are strong indications that sequential programming style will continue to be dominant. Even future mainstream parallel applications will exhibit large sequential sections. Amdahl's law indicates that high performance on these sequential sections is needed to enable overall high performance on the whole application. On many (most) applications, the effective performance of future computer systems using a 1000-core processor chip will significantly depend on their performance on both sequential code sections and single thread. We envision that, around 2020, the processor chips will feature a few complex cores and many (may be 1000's) simpler, more silicon and power effective cores. In the DAL research project, we will explore the microarchitecture techniques that will be needed to enable high performance on such heterogeneous processor chips. Very high performance will be required on both sequential sections -legacy sequential codes, sequential sections of parallel applications- and critical threads on parallel applications -e.g. the main thread controlling the application. Our research will focus on enhancing single process performance. On the microarchitecture side, we will explore both a radically new approach, the sequential accelerator, and more conventional processor architectures. We will also study how to exploit heterogeneous multicore architectures to enhance sequential thread performance.

9.2.1.4. ARGO

Participants: Isabelle Puaut, Damien Hardy.

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 fuer Technologie (KIT)

Université Rennes I contact: Steven Derrien

Partners:

Karlsruher Institut fuer Technologie (KIT)

SCILAB enterprises SAS

Recore Systems BV

Université de Rennes 1

Technologiko Ekpaideftiko Idryma (TEI) Dytikis Elladas

Absint GmbH

Deutsches Zentrum fuer 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.

9.2.2. Collaborations in European Programs, except FP7 & H2020

9.2.2.1. COST Action TACLe - Timing Analysis on Code-Level (http://www.tacle.eu) 10-2012/09-2016
Participants: Damien Hardy, Isabelle Puaut.

Embedded systems increasingly permeate our daily lives. Many of those systems are business- or safety-critical, with strict timing requirements. Code-level timing analysis (used to analyze software running on some given hardware w.r.t. its timing properties) is an indispensable technique for ascertaining whether or not these requirements are met. However, recent developments in hardware, especially multi-core processors, and in software organization render analysis increasingly more difficult, thus challenging the evolution of timing analysis techniques.

New principles for building "timing-composable" embedded systems are needed in order to make timing analysis tractable in the future. This requires improved contacts within the timing analysis community, as well as with related communities dealing with other forms of analysis such as model-checking and type-inference, and with computer architectures and compilers. The goal of this COST Action is to gather these forces in order to develop industrial-strength code-level timing analysis techniques for future-generation embedded systems, through several working groups:

- WG1 Timing models for multi-cores and timing composability
- WG2 Tooling aspects
- WG3 Early-stage timing analysis
- WG4 Resources other than time

Isabelle Puaut is in the management committee of the COST Action TACLe - Timing Analysis on Code-Level (http://www.tacle.eu). She is responsible of Short Term Scientific Missions (STSM) within TACLe.

9.2.3. Collaborations with Major European Organizations

9.2.3.1. HiPEAC3 NoE
Participants: Pierre Michaud, Erven Rohou, André Seznec.

P. Michaud, A. Seznec and E. Rohou are members of the European Network of Excellence HiPEAC3. HiPEAC3 addresses the design and implementation of high-performance commodity computing devices in the 10+ year horizon, covering both the processor design, the optimizing compiler infrastructure, and the evaluation of upcoming applications made possible by the increased computing power of future devices.

9.3. International Initiatives

9.3.1. Inria Associate Teams not involved in an Inria International Labs

9.3.1.1. PROSPIEL

Title: Profiling and specialization for locality

International Partner (Institution - Laboratory - Researcher):

Universidade Federal de Minas Gerais (Brazil) - Dpt of Computer Science - Fernando Magno Quintao Pereira

Start year: 2015

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

9.3.2. Inria International Partners

9.3.2.1. Informal International Partners

The ALF project-team has informal collaborations (visits, common publications) with University of Wisconsin at Madison (Pr Wood), University of Toronto (Pr Moshovos), University of Ghent (Dr Eyerman), University of Upsalla (Pr Hagersten), University of Cyprus (Pr Sazeides), the Egyptian-Japanese University of Science and Technology (Pr Ahmed El-Mahdy).

9.3.3. Participation In other International Programs

9.3.3.1. UFMG Chair (Brazil)

Program: Cátedras Francesas UFMG

Title: A language runtime with fault-resiliency for approximate computing

Inria principal investigator: Sylvain Collange

International Partner (Institution - Laboratory - Researcher):

Universidade Federal de Minas Gerais (UFMG) - Computer Science Department - Fernando Pereira

Duration: Sep 2015 - Oct 2015

In this project we propose to implement fault tolerance at the runtime level within a virtual machine for a managed language. Our approach consists in developing a just-in-time compiler analysis that identifies and extracts side-effect free computations, such as pure functions, within the code. For each of these computations, an approximate implementation will be generated in addition to the regular native code. When the computation is invoked during execution, the runtime will first execute the approximate implementation. In case the quality or accuracy of the result is not sufficient at the time it is needed, the runtime will transparently re-execute the computation in exact mode.

9.4. International Research Visitors

9.4.1. Visits to International Teams

9.4.1.1. Explorer programme

Perais Arthur

Date: Jan 2015 - Apr 2015

Institution: Carnegie Mellon University (United States)

9.4.1.2. Research stays abroad

Sylvain Collange has been invited on a professor chair at Universidade Federal de Minas Gerais, Brazil (September-October 2015).

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

8. Partnerships and Cooperations

8.1. Regional Initiatives

8.1.1. *Images & Réseaux Competitivity Cluster - Embrace (2014-2016)*

Participants: Raphaël Bardoux, Arnaud Carer, Olivier Sentieys.

Embrace (Embedded Radio Accelerator) is a project which involves CAIRNand two Small Medium Enterprises (SMEs): Digidia and PrimeGPS. Embrace aims at developing a software radio platform to enable the digital demodulation of HF signals. Both SMEs will use this platform as the first step to implement new products. These products will be dedicated to two different applications (Global Navigation Satellite System and Navigation Safety) at the heart of the markets of the SMEs. CAIRNgoal is the technological transfer of the methods proposed by the team that enable the rapid prototyping of digital radios.

8.2. National Initiatives

The CAIRNteam mainly collaborates with the following laboratories: CEA List, CEA Leti, LEAT Nice, Lab-Sticc (Lorient, Brest), LIRMM (Montpellier, Perpignan), LIP6 Paris, IETR Rennes, DTIM-ONERA Toulouse, LAAS Toulouse, IRIT Toulouse, Inria Socrate.

The team participates in the activities of the following research organization of CNRS (GdR for in French *"Groupe de Recherche"*):

- GdR SOC-SIP (*System On Chip & System In Package*), working groups on reconfigurable architectures, embedded software for SoC, low power issues. E. Casseau is in charge of the architecture topic of the reconfigurable platform working group.
- GdR ISIS (*Information Signal ImageS*), working group on *Algorithms Architectures Adequation*.
- GdR ASR (*Architectures Systèmes et Réseaux*)
- GdR IM (*Informatique Mathématiques*), C2 working group on Codes and Cryptography and ARITH working group on Computer Arithmetic

8.2.1. *ANR Blanc - PAVOIS (2012–2016)*

Participants: Arnaud Tisserand, Emmanuel Casseau, Philippe Quémerais, Jérémie Métairie, Nicolas Veyrat-Charvillon, Karim Bigou, Pierre Guilloux.

PAVOIS (in French: *Protections Arithmétiques Vis à vis des attaques physiques pour la cryptOgraphIe basée sur les courbeS elliptiques*) is a project on Arithmetic Protections Against Physical Attacks for Elliptic Curve based Cryptography. It involves IRISA-CAIRN(Lannion) and LIRMM (Perpignan and Montpellier). This project will provide novel implementations of curve based cryptographic algorithms on custom hardware platforms. A specific focus will be placed on trade-offs between efficiency and robustness against physical attacks. One of our goal is to theoretically study and practically measure the impact of various protection schemes on the performance (speed, silicon cost and power consumption). Theoretical aspects will include an investigation of how special number representations can be used to speed-up cryptographic algorithms, and protect cryptographic devices from physical attacks. On the practical side, we will design innovative cryptographic hardware architectures of a specific processor based on the theoretical advancements described above to implement curve based protocols. We will target efficient and secure implementations for both FPGA an ASIC circuits. For more details see http://pavois.irisa.fr.

8.2.2. *ANR INFRA 2011 - FAON (2012-2015)*

Participants: Raphaël Bardoux, Arnaud Carer.

The FAON (Frequency based Access Optical Networks) project objectives are to demonstrate the technology and feasibility of a new type of Passive Optical Network (PON) for broadband access which uses a Frequency based shared access technique known as Frequency Division Multiplexing (FDM). These goals completely fall into the line of the expected capacity increase in PON which is today forecasted to go from 100 Mbps per user to 1 Gbps. Faon involves Orange Labs, CEA-LETI, University of South Brittany (Lab-STICC laboratory) and Univ. Rennes I (Foton laboratory and CAIRNteam). CAIRNdeveloped a high-rate architecture at the receiver side. Specific receiver algorithms (synchronization and equalization) and FPGA implementation are the key issues that were addressed. This project ended in 2015.

8.2.3. ANR Ingénérie Numérique et Sécurité - ARDyT (2011-2016)

Participants: Arnaud Tisserand, Philippe Quémerais.

ARDyT (in French: *Architecture Reconfigurable Dynamiquement Tolérante aux fautes*) is a project on a Reliable and Reconfigurable Dynamic Architecture. It involves IRISA-CAIRN(Lannion), Lab-STICC (Lorient), LIEN (Nancy) and ATMEL. The purpose of the ARDyT project is to provide a complete environment for the design of a fault tolerant and self-adaptable platform. Then, a platform architecture, its programming environment and management methodologies for diagnosis, testability and reliability have to be defined and implemented. The considered techniques are exempt from the use of hardened components for terrestrial and aeronautics applications for the design of low-cost solutions. The ARDyT platform will provide a European alternative to import ITAR constraints for fault-tolerant reconfigurable architectures. For more details see http://ardyt.irisa.fr.

8.2.4. ANR Ingénérie Numérique et Sécurité - COMPA (2011-2015)

Participants: Emmanuel Casseau, Steven Derrien, Yaset Oliva Venegas.

COMPA (model oriented design of embedded and adaptive multiprocessor) is a project which involves CAIRN, IETR (Rennes) and Lab-STICC (Lorient). The aim of the project was to design adaptive multiprocessor embedded systems for executing dataflow programs. The use case is the Reconfigurable Video Coding (RVC) standard. More specifically, we focus on the portable and platform-independent RVC-CAL language to describe the applications. We use transformations to refine, increase parallelism and translate the application model into software and hardware components. Specific scheduling and actor's mapping are also investigated for runtime execution. For more details see http://www.compa-project.org. This project ended in 2015.

8.2.5. ANR Ingénérie Numérique et Sécurité - DEFIS (2011-2015)

Participants: Olivier Sentieys, Nicolas Simon.

DEFIS (Design of fixed-point embedded systems) is a project which involves CAIRN, LIP6 (University of Paris 6), LIRMM (University of Perpignan), CEA LIST, Thales, Inpixal. The main objectives of the project were to propose new approaches to improve the efficiency of the floating-point to fixed-point conversion process and to provide a complete design flow for fixed-point refinement of complex applications. This infrastructure reduces the time-to-market by automating the fixed-point conversion and by mastering the trade-off between application quality and implementation cost. Moreover, this flow guarantees and validates the numerical behavior of the resulting implementation. The proposed infrastructure was validated on two real applications provided by the industrial partners. For more details see http://defis.lip6.fr. This project ended in 2015.

8.2.6. Labex CominLabs - BoWI (2012-2016)

Participants: Olivier Sentieys, Arnaud Carer.

The BoWi project (Body Wold Interactions) aims at designing an accurate gesture and body movement estimation using very-small and low-power wearable sensor nodes. It initially stems from a proposal of the CominLabs think thank focused on the society challenge called Digital Environment for the Citizen. It is also related to the social challenge ICT for Personalized Medicine and to the research track Energy Efficiency in ICT. The main objective of the project is to propose pioneer interfaces for an emerging interacting world based on smart environments (house, media, information and entertainment systems...). Basically the

project relies on Wireless Body Areas Sensor Networks; the aim is the accurate Gesture and Body Movement estimation with extremely severe constraints in terms of footprint and power consumption according to on-body energy harvesting perspectives. The BoWI geolocation approach will combine radio communication distance measurement and inertial sensors and it will also strongly benefit from cooperative techniques based on multiple observations and distributed computation. Different types of applications, as health care, activity monitoring and environment control, will be considered and evaluated along with a human-machine interface expertise.

The scientific challenge is global and deals with the solution to be interactively invented by all partners: a short-range geolocation method based on distributed and coopering devices processing multisource data issued from radio-communication distance estimation and integrated inertial sensors. It includes several specific contributions:

- Dynamic and cooperative communication coding and protocol for inter-nodes communications. This includes cooperative communications and protocols such as cooperative MIMO, relaying, error coding, network coding and MAC and wake-up radio protocols.

- Node hardware/software architecture design and self-adaptive distributed processing for geolocation with aggressive low-power run-time optimisation.

- Channel models and antennas for short-range communications. This study will be performed for various radio standards from upcoming BAN 802.15.6, 802.15.4a technologies to future UWB solutions.

- Channel models and antennas for WBASN at millimeter waves. This is a promising perspective for antenna miniaturization, however no front-ends are yet available.

- In depth and specific analysis of human-machine interactions to set system constrains and define user requirement according to various application perspectives.

In practice the BoWi partners aim to deliver the design of basic components, a prototype based on available radio front-ends and energy harvesting devices as well as a system simulator including mm-wave models. Results will also concern the specification of future radio-front ends. The BoWI involves CAIRN, IRISA Granit (Lannion), IETR (Rennes), and Lab-STICC (Brest, Lorient, Vannes). For more details see http://www.bowi.cominlabs.ueb.eu/fr.

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

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

3DCORE (3D Many-Core Architectures based on Optical Network on Chip) is a project which involves CAIRN, FOTON (Rennes, Lannion) and Institut des Nanotechnologies de Lyon. 3D integration in the ultra deep submicron domain means the implementation of billions of transistors or of hundreds of cores on a single chip with the need to ensure a large number of exchanges between cores, and the obligation to limit the power consumption. Focusing on system integration rather than transistor density, allows for both functional and technological diversification in integrated systems. The functional diversification allows for non-digital functionalities to migrate from the board level into the (on-)chip level. This allows for integration of new technologies that enable high performance, low power, high reliability, low cost, and high design productivity. The use of Optical Network-on-Chip (ONoC) promises to deliver significantly increased bandwidth, increased immunity to electromagnetic noise, decreased latency, and decreased power consumption while wavelength routing and Wavelength Division Multiplexing (WDM) contributes to the valuable properties of optical interconnect by permitting low contention or even contention free routing. WDM allows for multiple signals to be transmitted simultaneously, facilitating higher throughput. Individual realization of CMOS compatible optical components, such as, waveguides, modulators, and detectors lets the community foresee that such integration may be possible in the next ten years. The aim of the project is therefore to investigate new optical interconnect solutions 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 targeting both embedded and high-performance computing. Moreover, we envisage taking advantage of 3D technologies for designing a specific photonics layer suitable for a flexible and energy efficient high-speed optical network on chip (ONoC).

8.2.8. Labex CominLabs - RELIASIC (2014-2018)

Participants: Emmanuel Casseau, Arnaud Tisserand.

RELIASIC (Reliable Asic) is a project which involves CAIRN, Lab-STICC (University of Bretagne Sud) and IETR (Institut d'Electronique et de Télécommunications de Rennes). One of the most critical challenges of the next design technologies will be fault-tolerant computation. The increase in integration density and the requirement of low-energy consumption can only be sustained through low-powered components, with the drawback of a looser robustness against transient errors. In the near future, electronic gates to process information will be inherently unreliable. New techniques will be required to increase the reliability of operators and components. The aim of the project is to address this problem 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.

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

Participants: Arnaud Tisserand, Nicolas Veyrat-Charvillon, Karim Bigou, Gabriel Gallin.

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 involves IRISA-CAIRN(Lannion) and IRMAR (Rennes).

Arithmetic has an important role to play in providing algorithms robust against physical attacks (e.g., analysis of the power consumption, electromagnetic radiations or computation timings). Currently, there are only a very few hardware implementations of HECC (without any open source availability). This project will provide novel implementations of HECC based cryptographic algorithms on custom hardware platforms. For more details see http://h-a-h.inria.fr/.

8.3. European Initiatives

8.3.1. FP7 FLEXTILES

Participants: Olivier Sentieys, Emmanuel Casseau, Daniel Chillet, Philippe Quémerais, Christophe Huriaux.

> Program: FP7-ICT-2011-7
>
> Project acronym: Flextiles
>
> Duration: Oct. 2011 - Mar. 2015
>
> Coordinator: Thales
>
> Other partners: Thales (FR), UR1 (FR), KIT (GE), TU/e (NL), CSEM (SW), CEA LETI (FR), Sundance (UK)
>
> Project title: Self Adaptive Heterogeneous Manycore Based on Flexible Tiles

A major challenge in computing is to leverage multi-core technology to develop energy-efficient high performance systems. This is critical for embedded systems with a very limited energy budget as well as for supercomputers in terms of sustainability. Moreover the efficient programming of multi-core architectures, as we move towards manycores with more than a thousand cores predicted by 2020, remains an unresolved issue. The FlexTiles project defined and developed an energy-efficient yet programmable heterogeneous manycore platform with self-adaptive capabilities. The manycore is associated with an innovative virtualisation layer and a dedicated tool-flow to improve programming efficiency, reduce the impact on time to market and reduce the development cost by 20 to 50%. FlexTiles raised the accessibility of the manycore technology to industry - from small SMEs to large companies - thanks to its programming efficiency and its ability to adapt to the targeted domain using embedded reconfigurable technologies. This project ended in 2015.

8.3.2. *FP7 ALMA*

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

Program: FP7-ICT-2011-7

Project acronym: Alma

Project title: Architecture oriented paraLlelization for high performance embedded Multicore systems using scilAb

Duration: Sep. 2011 - Nov. 2014

Coordinator: KIT

Other partners: KIT (GE), UR1 (FR), Recore Systems (NL), Univ. of Peloponnese (GR), TEI-MES (GR), Intracom SA (GR), Fraunhofer (GE)

The mapping process of high performance embedded applications to today's multiprocessor system on chip devices suffers from a complex toolchain and programming process. The problem here is the expression of parallelism with a pure imperative programming language which is commonly C. This traditional approach limits the mapping, partitioning and the generation of optimized parallel code, and consequently the achievable performance and power consumption of applications from different domains. The Architecture oriented paraLlelization for high performance embedded Multicore systems using scilAb (ALMA) project aimed to bridge these hurdles through the introduction and exploitation of a Scilab-based toolchain which enables the efficient mapping of applications on multiprocessor platforms from high-level abstraction descriptions. This holistic solution of the toolchain allows the complexity of both the application and the architecture to be hidden, which leads to a better acceptance, reduced development cost and shorter time-to-market. Driven by the technology restrictions in chip design, the end of Moore's law and an unavoidable increasing request of computing performance, ALMA was a fundamental step forward in the necessary introduction of novel computing paradigms and methodologies. This project ended in 2015.

8.4. International Initiatives

8.4.1. *Inria Associate Teams*

8.4.1.1. *HARDIESSE*

Title: Heterogeneous Accelerators for Reconfigurable DynamIc, Energy efficient, Secure SystEms

International Partner (Institution - Laboratory - Researcher):

University of Massachusetts at Ahmerst (United States) - Department of Electrical and Computer Engineering - Prof. Russel Tessier and Prof. Maciej Ciesielski

Start year: 2014

See also: https://team.inria.fr/cairn/hardiesse/

Rapid evolutions of applications and standards require frequent in-the-field system modifications and thus strengthens the need for adaptive devices. This need for a strong flexibility, combined with technology evolution (and the so-called power wall) has motivated the surge towards the use of multiple processor cores on a single chip (MPSoC). While it is now clear that we have entered the multi-core era, it is however indisputable that, especially for energy-efficient embedded systems, these architectures will have to be heterogeneous, by combining processor cores and specialized accelerators. We foresee a need for systems able to continuously adapt themselves to changing environments where software updates alone will not be enough for tackling energy management and error tolerance challenges. We believe that a dynamic and transparent adaptation of the hardware structure is the key to success. Security will also be an important challenge for embedded devices. Protections against physical attacks will have to be integrated in all secured components. In this Associated Team, we will study new reconfigurable structures for such hardware accelerators with specific focus on: energy efficiency, runtime dynamic reconfiguration, security, and verification.

8.4.2. Inria International Partners

8.4.2.1. Declared Inria International Partners

8.4.2.1.1. 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

8.4.2.1.2. DAVIAP

>>Title: From DAtaflow-based VIdeo Appications to embedded multicore Platforms

>>International Partner (Institution - Laboratory - Researcher):

>>>Tampere University of Technology (Finland) - Department of Pervasive Computing - Prof. Jarmo Takala

8.4.2.1.3. HARAMCOP

>>Title: Hardware accelerators modeling using constraint-based programming

>>International Partner (Institution - Laboratory - Researcher):

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

8.4.2.1.4. 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.

8.4.2.2. Informal International Partners

>>Imec (Belgium), Optimization of embedded systems using fixed-point arithmetic, fault-tolerant computing architectures.

>>Ecole Polytechnique Fédérale de Lausanne - EPFL (Switzerland), Optimization of embedded systems using fixed-point arithmetic.

>>Technical University of Madrid - UPM (Spain),

>>Optimization of embedded systems using fixed-point arithmetic.

>>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, Data Merging, Priority Scheduling, Loop Transformations for Memory Optimizations.

>>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.

8.5. International Research Visitors

8.5.1. Visits of International Scientists

>Prof. Liam Marnane, Dept. of Electrical and Electronic Engineering, University College, Cork, Ireland, for two weeks in October. This visit was founded by ENSSAT.

Prof. Emanuel Popovici, Dept. of Electrical and Electronic Engineering, University College, Cork, Ireland, for two weeks in July. This visit was founded by ENSSAT.

Dr. Michele Magno, Integrated Systems Laboratory, ETH Zurich, Switzerland, for two weeks in June. This visit was founded by ENSSAT.

Prof. Guy Lemieux, Department of Electrical and Computer Engineering, University of British Columbia, Vancouver, Canada, for two weeks in December. This visit was founded by HARDIESSE Inria Associate Team.

Prof. Russel Tessier, University of Massachusetts, Amherst, US, for one week in December. This visit was founded by HARDIESSE Inria Associate Team.

Porf. Renato J. Cintra, TDepartment of Statistics, Universidade Federal de Pernambuco, Recife, Brazil, for six months from January 2015.

8.5.1.1. Internships

Minh Thanh Cong, Master ICT, University of Science and Technology of Hanoi, Vietnam, from Apr 2015 until Sep 2015.

Soumitr Dubey, B.Tech./M.Sc. in Electronics and Communication, Indian Institute of Technology (IIT) Hyderabad, India, from May 2015 until Jul 2015.

Chi Dinh Ma, Master ICT, University of Science and Technology of Hanoi, Vietnam, from Apr 2015 until Sep 2015.

Prannoy Pilligundla, B.Eng. Electronics & Instrumentation Engineering, Birla Institute of Technology & Science, Pilani, India, from May 2015 until Jul 2015.

Madhav Singh, B.Tech. in Electrical Engineering, Indian Institute of Technology (IIT) Patna, India, from May 2015 until Jul 2015.

8.5.2. *Visits to International Teams*

Simon Rockiki visited University of Massachusetts, Amherst, US, for 6 months from January to July 2015. This visit was founded by HARDIESSE Inria Associate Team.

<div align="center">

CELTIQUE Project-Team

</div>

7. Partnerships and Cooperations

7.1. National Initiatives

7.1.1. *The ANR VERASCO project*

Participants: Sandrine Blazy, Delphine Demange, Vincent Laporte, David Pichardie.

Static program analysis, Certified static analysis

The VERASCO project (2012–2015) is funded by the call ISN 2011, a program of the Agence Nationale de la Recherche. It investigates the formal verification of static analyzers and of compilers, two families of tools that play a crucial role in the development and validation of critical embedded software. It is a joint project with the Inria teams ABSTRACTION, GALLIUM, The VERIMAG laboratory and the Airbus company.

7.1.2. *The ANR AnaStaSec project*

Participants: Frédéric Besson, Sandrine Blazy, Thomas Jensen.

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.

7.1.3. *The ANR Binsec project*

Participants: Frédéric Besson, Sandrine Blazy, Pierre Wilke.

Binary code, Static program analysis

The Binsec project (2013–2017) is founded 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.

7.1.4. *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 (Estasys and Celtique), Inria Saclay (MAXPLUS) and VISEO/Object Direct.

7.1.5. *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 June 2018.

7.1.6. *The ANR DISCOVER project*

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

The DISCOVER project 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 2018.

7.1.7. *Labex COMIN Labs Seccloud project*

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

The SecCloud project, started in 2012, will provide a comprehensive language-based approach to the definition, analysis and implementation of secure applications developed using Javascript and similar languages. Our high level objectives is to enhance the security of devices (PCs, smartphones, ect.) on which Javascript applications can be downloaded, hence on client-side security in the context of the Cloud. We will achieve this by focusing on three related issues: declarative security properties and policies for client-side applications, static and dynamic analysis of web scripting programming languages, and multi-level information flow monitoring.

This is a joint project with Supelec Rennes and Ecole des Mines de Nantes.

7.2. International Initiatives

7.2.1. *Inria Associate Teams not involved in an Inria International Labs*

7.2.1.1. JCERT

       Title: Verified Compilation of Concurrent Managed Languages

       International Partner (Institution - Laboratory - Researcher):

           Purdue University (United States) - Suresh Jagannathan

Start year: 2014

See also: http://www.irisa.fr/celtique/ea/jcert/

Safety-critical applications demand rigorous, unambiguous guarantees on program correctness. While a combination of testing and manual inspection is typically used for this purpose, bugs latent in other components of the software stack, especially the compiler and the runtime system, can invalidate these hard-won guarantees. To address such concerns, additional laborious techniques such as manual code reviews of generated assembly code are required by certification agencies. Significant restrictions are imposed on compiler optimizations that can be performed, and the scope of runtime and operating system services that can be utilized. To alleviate this burden, the JCert project is implementing a verified compiler and runtime for managed concurrent languages like Java or C#.

7.2.2. Inria International Partners

7.2.2.1. Declared Inria International Partners

Professor Philippa Gardner, Imperial College, UK, since December 2015.

7.2.2.2. Informal International Partners

Alan Schmitt is part of a Polonium Hubert Curien Partnership (PHC) with the University of Wrocław. This partnership is lead by Sergueï Lenglet, from Loria, Nancy, France.

7.3. International Research Visitors

7.3.1. Visits to International Teams

7.3.1.1. Sabbatical programme

Jensen Thomas

Date: Sep 2014 - Aug 2015

Institution: University of Copenhagen (Denmark)

7.3.1.2. Research stays abroad

Martin Bodin visited the Department of Computing at Imperial College London for three months.

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

7. Partnerships and Cooperations

7.1. Regional Initiatives

We obtained ARED funding (40% of a PhD) from the region (starting 11-2015). The focus of the proposed research is how to preserve a free and independent quality press in the age of online distribution. We propose to tackle this challenge from two sides: First, we will broaden the online revenue stream by enabling convenient anonymous payments that preserve the reader's privacy and are more efficient and secure than traditional payment systems. Thus, the resulting system will allow for a larger fraction of the payment to arrive at the newspaper, and for a higher conversion of visitors to purchases. Second, we will consider an alternative means for distributing news, which integrates the typical Web-processes of third parties linking to, commenting on, translating and regurgitating stories while also enabling fair compensation of those involved in the creative process. A key challenge here will be to semi-automate the editorial process, leaving it to readers and decentralized, privacy-preserving algorithms to filter worthwile news. The ideal outcome will be a news distribution system that provides censorship resistance, financial compensation for quality (online) journalism and privacy for readers.

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

7. Partnerships and Cooperations

7.1. Regional Initiatives

7.1.1. Privacy

Participants: Axel Legay, Fabrizio Biondi, Jean Quilbeuf.

Privacy is a regional project whose objective is to quantify privacy of data. This includes, e.g., quantifying the anonymity of a voting protocol.

7.1.2. Variability

Participants: Axel Legay, Jin Hyun Kim, Louis-Marie Traonouez.

Variability is a regional project whose objective is to lift scheduling techniques to connected-objects. The main application of the project is Systems of Systems.

7.2. National Initiatives

7.2.1. ANR Malthy

Participants: Axel Legay, Rudolf Fahrenberg, Louis-Marie Traonouez.

The objective of this project is to study new models and techniques to reason on quantitative systems. We mainly focus on the composition of timed components in a dynamic setting.

7.2.2. BGLE SyS2Soft

Participants: Axel Legay, Thomas Given-Wilson, Cyrille Jegourel.

This national project studies various languages and techniques for quantitative systems.

7.3. European Initiatives

7.3.1. FP7 & H2020 Projects

7.3.1.1. ACANTO

Title: ACANTO: A Cyber physicAl social NeTwOrk using robot friends

Programm: H2020

Duration: February 2015 - August 2018

Coordinator: Universita di Trento

Partners:

Atos Spain (Spain)

Envitel Tecnologia Y Control S.A. (Spain)

Foundation for Research and Technology Hellas (Greece)

Servicio Madrileno Delud (Spain)

Siemens Aktiengesellschaft Oesterreich (Austria)

Telecom Italia Spa (Italy)

Universita' Degli Studi di Siena (Italy)

Universita Degli Studi di Trento (Italy)

University of Northumbria At Newcastle. (United Kingdom)

Inria contact: Axel Legay

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

7.3.2. Danse

Program: FP7

Project acronym: DANSE

Project title: Designing for Adaptability and evolutioN in System of systems Engineering

Duration: Octobre 2011 – March 2015

Coordinator: Offis

Abstract: Design and verification of Systems of Systems. We contributed by proposing the first verification engine for Heterogeneous SoS. For doing so, we have combined Plasma with Desyre that is a simulator for SoS described via the standardised FMI/FMU approach.

7.3.3. Meals

Program: Marie Curie

Project acronym: Meals

Project title: Mobility between Europe and Argentina applying Logics to Systems

Duration: Octobre 2012 – Octobre 2015

Coordinator: Germany (Saarbrucken) and Argentina (Corona)

Abstract: Collaborative action on the topic of quantitative systems

7.3.4. Sensation

Program: Fet ProActif

Project acronym: Sensation

Project title: Self Energy-Supporting Autonomous Computation

Duration: Octobre 2012 – Octobre 2015

Coordinator: Aalborg University

Abstract: Development of new results for energy-centric systems. We contributed by proposing new algorithms for rare-event simulation.

7.3.5. EMC2

Program: ARTEMIS

Project acronym: EMC2

Project title: Embedded Multi-Core systems for Mixed Criticality applications in dynamic and changeable real-time environments

Duration: mars 2014 – mars 2017

Coordinator: Infineon

Abstract: Large initiative on embadded systems and SoS. We will contribute with our expertise from DANSE and Sensation projects.

7.3.6. Collaborations with Major European Organizations

- Partner 1: Aalborg University, Computer Science, Denmark
- Statistical Model Checking, and Systems of Systems
- Partner 2: Rice University, Computer Science, USA
- Synthesis of components of Systems of Systems
- Partner 3: Namur University, Computer Science, Belgium
- Variability in software engineering
- Partner 4: Louvain University, Computer Science, Belgium
- Verification of Systems of Systems via Statistical Model Checking, especially train stations in collaboration with Alstom.
- Partner 5: Waterloo University, Computer Science, Canada
- Variability in Systems of Systems

7.4. International Initiatives

7.4.1. Visits of International Scientists

7.4.1.1. Internships

- Karin Quaas, PostDoc at Leipzig University
- Kim Larsen, Professor at Aalborg University
- Rafael Olochea, PhD student at Waterloo University
- Yusuke Yamamoto, Assistant Professor, Japan.

HYCOMES Team

7. Partnerships and Cooperations

7.1. Regional Initiatives

- Ayman Aljarbouh's PhD is partially funded by an ARED grant of the Brittany Regional Council. His doctoral work takes place in the context of the Modrio and Sys2Soft projects on hybrid systems modeling — see sections 7.2 and 7.2 . Ayman Aljarbouh 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 is participating to the S3PM project of the CominLabs excellence laboratory [0]. This project focuses on the computation of surgical procedural knowledge models from recordings of individual procedures, and their execution [32]. 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.

7.2. National Initiatives

Program:« Briques génériques du logiciel embarqué » (Embedded Software Generic Building-Blocks)

Project acronym: Sys2soft

Project title: Physics Aware Software

Duration: June 2012 – November 2015

Coordinator: Dassault Systèmes (France)

Other partners: Thales TGS / TRT / TAS, Alstom Transport, Airbus, DPS, Obeo, Soyatec

Abstract: The Sys2soft project aims at developing methods and tools supporting the design of embedded software interacting with a complex physical environment. The project advocates a methodology where both physics and software are co-modeled and co-simulated early in the design process and embedded code is generated automatically from the joint physics and software models. Extensions of the Modelica language with synchronous programming features are being investigated, as a unified framework where interacting physical and software artifacts can be modeled.

7.3. European Initiatives

7.3.1. Collaborations in European Programs, except FP7 & H2020

Program: ITEA2

Project acronym: Modrio

Project title: Model Driven Physical Systems Operation

Duration: September 2012 – May 2016

Coordinator: EDF (France)

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[0] http://www.s3pm.cominlabs.ueb.eu/

Other partners: ABB (Sweden), Ampère Laboratory / CNRS (France), Bielefeld University (Germany), Dassault Systèmes (Sweden), Dassault Aviation (France), DLR (Germany), DPS (France), EADS (France), Equa Simulation (Sweden), IFP (France), ITI (Germany), Ilmenau University (Germany), Katholic University of Leuven (Belgium), Knorr-Bremse (Germany), LMS (France and Belgium), Linköping University (Sweden), MathCore (Sweden), Modelon (Sweden), Pöry (Finland), Qtronic (Germany), SICS (Sweden), Scania (Sweden), Semantum (Finland), Sherpa Engineering (France), Siemens (Germany and Sweden), Simpack (Germany), SKF (Sweden), Supmeca (France), Triphase (Belgium), University of Calabria (Italy), VTT (Finland), Vattenfall (Sweden), Wapice (Finland).

Abstract: Modelling and simulation are efficient and widely used tools for system design. But they are seldom used for systems operation. However, most functionalities for system design are beneficial for system operation, provided that they are enhanced to deal with real operating situations. Through open standards the benefits of sharing compatible information and data become obvious: improved cooperation between the design and the operation communities, easier adaptation of operation procedures wrt. design evolutions. Open standards also foster general purpose technology. The objective of the ITEA 2 MODRIO project is to extend modelling and simulation tools based on open standards from system design to system operation.

7.4. International Research Visitors

7.4.1. Research stays abroad

Ayman Aljarbouh has visited for two months Walid Taha's team (http://www.hh.se/english/research/professors/walidmohamedtaha.10235.html) at Halmstad university in Sweden. He has been working on the implementation in the Accumen language of the regularization techniques he is developing in his PhD work.

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

9. Partnerships and Cooperations

9.1. National Initiatives

9.1.1. ANR

ANR VACSIM: Validation of critical control-command systems by coupling simulation and formal analysis, 2011-2015, web site
Partners: EDF R&D, Dassault Systèmes, LURPA, I3S, LaBRI, and Inria SUMO.
The project aims at developing both methodological and formal contributions for the simulation and validation of control-command systems. SUMO contributes to quantitative analysis and its application to testing, monitoring of timed systems, and verification of communicating timed automata.

ANR Ctrl-Green: Autonomic management of green data centers, 2011-2014, web site
Partners: UJF/LIG, INPT/IRIT, Inria SUMO, EOLAS, Scalagent.
This project aims at developing techniques for the automatic optimal management of reconfigurable systems in the context of data centers using discrete controller synthesis methodology applied in the synchronous paradigm.

ANR STOCH-MC: Model-Checking of Stochastic Systems using approximated algorithms, 2014-2018, web site.
Led by SUMO.
Partners: Inria Project Team CONTRAINTES (Rocquencourt), LaBRI (Bordeaux), and LIAFA (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. National informal collaborations

We collaborate with Yliès Falcone (VaSCO - LIG) and Antoine Rollet (Labri) on the enforcement of timed properties.

We collaborate with Arnaud Sangnier (LIAFA) on the parameterized verification of probabilistic systems.

We collaborate with B.Bérard (LIP6) on problems related to security.

We collaborate with Eric Rutten and Gwenael delaval on the control of reconfigurable systems as well as making the ling between Reax and Heptagon / BZR (http://bzr.inria.fr/)

9.2. International Initiatives

9.2.1. Inria International Labs

Éric Badouel is member of the team Aloco (Architecture logicielle à composants) of LIRIMA, the Inria International Lab in Africa. This collaboration is on the development of artifact-centric business process models.

9.2.2. Inria Associate Teams not involved in an Inria International Labs

9.2.2.1. DISTOL

Title: Distributed systems, stochastic models and logics

International Partner (Institution - Laboratory - Researcher):

CMI (India) - Madhavan Mukund

Start year: 2013

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

The context of this project is formal modeling, and analysis of behaviors of distributed systems. We want to address verification and supervision of distributed systems through formal modeling and automated reasoning on models. By distributed systems, we mean software architectures made of several independent communicating entities. In the 90?s the kind of system addressed was mainly telecommunication protocols. Nowadays, distributed systems are frequently web-based systems such as Web Services, but several aspects of distributed systems can be found in biological applications. Within this context, a challenge is to propose formal tools with potential applications to real systems. We want to address this challenge along three main axes: The first one is realism of models. Models are often an abstraction of real systems. We want to build and study properties of models that are close enough from their implementations, and with robust properties. By robustness, we mean that properties checked on a model (for instance safety properties) should still hold for implementations of this model. The second one is quantitative analysis of systems. Rather that considering boolean answers to formal properties, one can consider the probability that such property holds on a run of the system, and return answers of probabilistic form ("almost surely, a call to a service is successful") or quantitative ("the average failure rate is lower than 0.01"). One possibility to obtain a probability is to compute its exact value. Such questions have answers for markovian models and some quantitative logics (PCTL). However, such computations are expensive, and one can divide the problem into sub-components at the cost of some approximation. We plan to develop efficient algorithms for quantitative analysis of systems. The third one is unification of control theories. There are many proposals for supervisory control, including distributed control with communications. However, none of them seems fully satisfactory. We want to consider connections between control theory, epistemic reasoning (which seems to solve some problems raised by communications between local supervisors), and game theory (which emphasizes the notion of goal to be achieved in a problem), and give a unified framework for supervision of distributed systems.

9.2.3. Inria International Partners

9.2.3.1. Informal International Partners

The team collaborates on runtime enforcement with the group of Prof. Stavros Tripakis (http://users.ics.aalto. fi/stavros/) at Aalto University (Finland), where our former PhD student Srinivas Pinisetty is doing a Post-doc.

In the context of LIRIMA, the Inria International Lab in Africa, we have strong collaborations with University of Yaoundé I on an artifact-centric model of workflow system based on guarded attribute grammars. In particular with the co-supervision of the PhD thesis of Robert Nsaibirni.

We collaborate with Laurie Ricker (Mount Allison University, Canada) on the control of distributed systems and the enforcement of opacity

9.2.4. Participation In other International Programs

AVeRTS is an Indo-French project on the algorithmic verification of real-time systems. The project is funded by CNRS on the french side, and by DST on the Indian side, under the CEFIPRA - Indo-French Program in ICST 2014-2016. From SUMO, Nathalie Bertrand and Blaise Genest are involved and contribute on stochastic games. In the context of this project, Miheer Dewaskar, a CMI (Chennai Mathematical Institute) master student did an internship in our team on the control of a population of Markov decision processes.

9.3. International Research Visitors

9.3.1. Visits of International Scientists

S. Akshay visited the SUMO team for three weeks in May 2015.

Robert Nsaibirni (University of Yaoundé) visited SUMO from March to May 2015 on the use of the Guarded Attribute Grammar formalism for the description of the workspaces of actors of a disease surveillance system.

9.3.1.1. Internships

Achille Aknin

Date: May 2015 - July 2015

Institution: ENS Ulm (France)

Alexandre Blanche

Date: May 2015 - July 2015

Institution: ENS Rennes (France)

Miheer Dewaskar

Date: May 2015 - July 2015

Institution: Chennai Mathematical Institute (India)

André Gueney

Date: April 2015 - September 2015

Institution: CNAM (France)

9.3.2. Visits to International Teams

9.3.2.1. Research stays abroad

Eric Fabre visited Michele Pinna during 2 weeks (Univ. of Cagliari, Italy). This collaboration focuses on the design of compact unfoldings for Petri nets.

TASC Project-Team

9. Partnerships and Cooperations

9.1. Regional Initiatives

9.1.1. SmartCat
Participants: Eric Monfroy, Charlotte Truchet.

> Title: Online optimization for chemical reactions.

> Others partners: CEISAM.

The SmartCat project, started in 2015 on regional fundings, aims at developing an intelligent automatised tool for online chemistry. Contrarily to the traditional batch chemistry, where reactants are mixed in a glass, online chemistry consists in having a flow of reactants in a tube, possibly passing through ovens are pressure control mechanisms. This way, the reaction happens continuously and it can produce much more products within a system of reasonable size. SmartCat integrates a controller for which intelligent tools need to be developed. These tools will analyse the product of the reaction and adapt the conditions (stoechiometry, pressure, temperature, catalysis) in order to optimise the yield. TASC contributes to this project by developing these methods, based on local search techniques.

9.1.2. Atlanstic
Participants: Raphael Chenouard, Laurent Granvilliers, Christophe Jermann, Frédéric Lardeux, Éric Monfroy, Frédéric Saubion.

> Title: Atlanstic project about problem modelisation, conversion, and transformation.

> Duration: 2014-2015.

> Budget: 8000 Euros.

> Others partners: LERIA, IRCYNN.

Topic: modelling and model transformation.

9.1.3. Search
Participants: Nicolas Galvez, Éric Monfroy, Frédéric Saubion.

> Title: Hybrid Algorithms for Search Based Software Engineering.

> Others partners: LERIA.

Topic: hybrid algorithms for search.

9.2. National Initiatives

9.2.1. IBEX
Participants: Ignacio Araya, Clément Carbonnel, Gilles Chabert, Benoit Desrochers, Luc Jaulin, Bertrand Neveu, Jordan Ninin, Gilles Trombettoni.

> Title: Development of IBEX.

> Others partners: ENSTA Bretagne, ENPC PariTech, Lirmm, LAAS, University Federico Santa Maria, Chile.

Development of IBEX (see Section 6.3).

9.2.2. ANR NetWMS2

Participants: Gilles Chabert, Ignacio Salas Donoso, Nicolas Beldiceanu.

Title: Networked Warehouse Management Systems 2: packing with complex shapes.

Duration: 2011-2014.

Type: cosinus research program.

Budget: 189909 Euros.

Others partners: KLS Optim and CONTRAINTES (Inria Rocquencourt).

This project builds on the former European FP6 Net-WMS Strep project that has shown that constraint-based optimisation techniques can considerably improve industrial practice for box packing problems, while identifying hard instances that cannot be solved optimally, especially in industrial 3D packing problems with rotations, the needs for dealing with more complex shapes (e.g. wheels, silencers) involving continuous values. This project aims at generalizing the geometric kernel *geost* for handling non-overlapping constraints for complex two and three dimensional curved shapes as well as domain specific heuristics. This will be done within the continuous solver IBEX, where discrete variables will be added for handling polymorphism (i.e., the fact that an object can take one shape out of a finite set of given shapes). A filtering algorithm has been devised in the case of objects described by nonlinear inequalities and is now under testing with the Ibex library. This work has been presented in a workshop on interval methods & geometry in ENSTA Bretagne.

9.3. European Initiatives

9.3.1. FP7 & H2020 Projects

Within the context of the First Future and Emerging Technologies (FET) Proactive projects under Horizon 2020 Framework Programme the GRACeFUL project started this year. From an application point of view the project develops scalable rapid assessment tools for collective policy making in global systems, and test these on climate-resilient urban design. From a technical point of view it provides domain specific languages that are embedded in functional programming and constraint programming languages. Within the project TASC is responsable for the constraint part.

9.4. International Initiatives

9.4.1. Inria Associate Teams not involved in an Inria International Labs

9.4.1.1. TASCMELB

Title: Synergy between Filtering and Explanations for Scheduling and Placement Constraints

International Partner (Institution - Laboratory - Researcher):

NICTA (Australia) - Optimisation Research Group (Optimisation) - Pascal van Hentenryck

Start year: 2014

See also: http://www.normalesup.org/~truchet/TASCMELB.html

In the context of Constraint Programming and SAT the project addresses the synergy between filtering (removing values from variables) and explanations (explaining why values were removed in term of clauses) in order to handle in a more efficient way correlated resource scheduling and placement constraints. It combines the strong point of Constraint Programming, namely removing value that leads to infeasibility, with the strong point of SAT, namely taking advantage from past failure in order to quickly identify infeasible sub-problems.

9.5. International Research Visitors

9.5.1. Visits of International Scientists

- One visit regarding time-series constraints of Mats Carlsson, Andreina Francisco RodriguezHelmut Simonis, Pierre Flener and Justin Pearson in Nantes.
- One visit in Nantes of Andreas Schutt from NICTA in the context of the TASCMELB associated team.

9.5.1.1. Internships

- Master thesis : Ekaterina Arafailova (February-June 2015), *reformulation of automata with accumulators as linear programs*.
- Master thesis : Julien Fradin (February-June 2015), *extensions to the GHOST library*.
- Master thesis : Adrien Bodineau (January-April 2015), *extensions to the GHOST library*.
- Internship : Guillaume Legru (April-May 2015), *IA for combat games*.

9.5.2. Visits to International Teams

Three visits to Insight Cork, Centre for Data Analytics and to Uppsala University were done to continue the work with Helmut Simonis, Pierre Flener and Mats Carlsson on time-series constraints. An extra visit took place in Nantes. Two visits of Nicolas Beldiceanu and Charlotte Truchet in Melbourne to Peter Stuckey and Marck Wallace took place.

TEA Project-Team

9. Partnerships and Cooperations

9.1. National Initiatives

9.1.1. ANR

Program: ANR

Project acronym: **Feever**

Project title: Faust Environment Everyware

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 synthesised from different physical locations.

9.1.2. Competitivity Clusters

Program: FUI

Project acronym: P

Project title: Project P

Duration: March 2011 - Sept. 2015

Coordinator: Continental Automotive France

Other partners: 19 partners (Airbus, Astrium, Rockwell Collins, Safran, Thales Alenia Space, Thales Avionics...)

URL: http://www.open-do.org/projects/p/

Abstract:

The aim of project P is 1/ to aid industrials to deploy model-driven engineering technology for the development of safety-critical embedded applications, 2/ to contribute on initiatives such as ITEA2 OPEES and Artemisia CESAR to develop support for tools inter-operability, and 3/ to provide state-of-the-art automated code generation techniques from multiple, heterogeneous, system-levels models. The focus of project P is the development of a code generation toolchain starting from domain-specific modeling languages for embedded software design and to deliver the outcome of this development as an open-source distribution, in the aim of gaining an impact similar to GCC for general-purpose programming, as well as a kit to aid with the qualification of that code generation toolchain.

The contribution of project-team TEA in project P is to bring the necessary open-source technology of the Polychrony environment to allow for the synthesis of symbolic schedulers for software architectures modeled with P in a manner ensuring global asynchronous deterministic execution..

9.1.3. PAI CORAC

Program: 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...

URL: http://www.corac-ame.com/

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. *International Project Grants*

9.2.1.1. *US Air Force Office for Scientific Research – Grant FA8655-13-1-3049*

Title: Co-Modeling of Safety-Critical Multi-threaded Embedded Software for Multi-Core Embedded Platforms

Inria principal investigator: Jean-Pierre Talpin

International Partner (Institution - Laboratory - Researcher):

> Virginia Tech Research Laboratories, Arlington (United States)

> Embedded Systems Group, Teschnische Universität Kaiserslautern (Germany)

Duration: 2013 - 2016

See also: http://www.irisa.fr/espresso/Polycore

Abstract: The aim of the USAF OSR Grant FA8655-13-1-3049 is to support collaborative research entitled "Co-Modeling of safety-critical multi-threaded embedded software for multi-core embedded platforms" between Inria project-team ESPRESSO, the VTRL Fermat Laboratory and the TUKL embedded system research group, under the program of the Polycore associate-project.

9.2.1.2. *Applied Science & Technology Research Institute (ASTRI, Hong Kong)*

Title: Virtual Prototyping of Embedded Software Architectures

Inria principal investigator: Jean-Pierre Talpin

International Partner: ASTRI, Hong Kong

Duration: 2015 - 2016

Abstract: the topics of our present collaboration is essentially on heterogeneous time modelling for virtual prototyping in cyber-physical systems. Our project covers a wide spectrum of area of experience developed since 2012 and comprising

- model-based design and analysis of cyber-physical systems;
- system-level virtual prototyping and validation;
- design space exploration and system synthesis;

9.2.2. *Inria International Labs*

9.2.2.1. *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

9.2.3. Inria International Partners

9.2.3.1. POLYCORE

Title: Models of computation for embedded software design

International Partner:

Virginia Tech Research Laboratories (USA)

University of Kanpur (India)

Duration: 2002 - now

Team TEA collaborates with Sandeep Shukla (now with IIT Kanpur) and his team at Virginia Tech, since 2002 (NSF-Inria BALBOA and Polycore projects, USAF OSR grant).

To date, our fruitful and sustained collaboration has yield the creation of the ACM-IEEE MEM-OCODE conference series [0] in 2003, of the ACM-SIGDA FMGALS workshop series, and of a full-day tutorial at ACM-IEEE DATE'09 on formal methods in system design. We have jointly edited two books with Springer [00], two special issues of the IEEE Transactions on Computers and one of the IEEE Transactions on Industrial Informatics, and published more than 40 joint journal articles and conference papers.

This year, we published a joint paper at the 52nd. Digital Automation Conference in San Francisco [19].

9.2.3.2. VESA

Title: Virtual Prototyping of embedded software architectures

International Partner:

Applied Science & Technology Research Institute (ASTRI, Hong Kong)

The University of Hong Kong

Duration: 2012 - now

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[0]ACM-IEEE MEMOCODE conference series
[0]*Formal methods and models for system design*, R. Gupta, S. Shukla, J.-P. Talpin, Eds. ISBN 1-4020-8051-4. Springer, 2004.
[0]*Synthesis of embedded systems*. S. Shukla, J.-P. Talpin, Eds. ISBN 978-1-4419-6399-4. Springer, 2010

We collaborate with John Koo, now with ASTRI, and LIAMA since 2012 through visiting grants of the Chinese Academy of Science and of the University of Rennes on the topics of heterogeneous time modelling and virtual prototyping in cyber-physical systems.

9.2.3.3. TIX

Title: Time In Cybernetic Systems

International Partner:

Rajesh Gupta, UCSD

Mani Srivastava, UCLA

Start year: 2015

The first topic of our collaboration is the formal definition of cross-domains clock models in system design and the formal verification of time stabilisation and synchronisation protocols used in distributed systems (sensor networks, data-bases). In this prospect, the NSF project Roseline is our basis of investigation (https://sites.google.com/site/roselineproject). Roseline aims at enabling robust, secure and efficient knowledge of time across the system stack.

Our second topic of collaboration is the refoundation of time modelling in high-level reactive and scripting languages, for application to the above using uni-kernels to cut through system stacks. We aim at applying the concepts of refinement types to formally specify and infer timing properties in CPS models from different system design view-point (physical, hardware, software) and using different levels of abstraction into multi-sorted 1st order logic (delta-decidability, linear arithmetic, Boolean logic, temporal logic).

9.3. International Research Visitors

9.3.1. Visits to International Teams

9.3.1.1. Research stays abroad

Jean-Pierre Talpin was awarded a visiting researcher grant by USAF OSR in 2014. In this context, he visited the Arlington and Falls Church VT campuses in Spring, Summer of 2015, and UC San Diego in Autumn 2015.

Thierry Gautier was invited to visit NUAA (Nanjing University of Aeronautics and Astronautics), Nanjing, China, in September 2015.

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

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 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. International research visitors

7.3.1. *Visits to international teams*

François Le Gland has been invited by Joaquín Míguez to visit the department of signal theory and communications of Universidad Carlos III de Madrid, in February 2015.

<div align="center" style="color:red">

I4S Project-Team

</div>

9. Partnerships and Cooperations

9.1. Regional Initiatives

9.1.1. MAG2C-Pont Tabarly

Participant: Ivan Guéguen.

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.

The instrumentation auscultates globally the structure, a structural defect in a given location changes its modal parameters and thus the vibration behavior. Then it can be detected on any part of the structure with an accelerometer. These measures coupled with a wireless data transmission system type or wifi 3g will allow remote monitoring of the evolution of the structure. And where appropriate, to deploy when necessary, for maintenance. The different objectives are

- Experimentation on a bridge
- Equipment qualification in real conditions over the long term
- Apply different vibration processing algorithms
- Surveillance and Detection
- Measurement database

The instrument proposed is based on an accelerometer-based distributed network on the structure. This assembly is connected to a data acquisition system and a modem 3g for continuous measurements and remotely. The vibration will be collectable on the internet.

9.1.2. Project wind turbine in St Hilaire de Chaleon

Participant: Ivan Guéguen.

Type: GIS

Objectif: bridge instrumentation

Duration: Since 2014

Coordinator : LIRGEC

Partners: IFSTTAR

Inria contact: Ivan Guéguen

Abstract: The project deals with the instrumentation of the wind turbine.

The aim is firstly, to instrument the foundation before casting with continuous optical fibers, optical strain gauges, temperature sensors and accelerometers for a detailed analysis of the behavior of the founding quasi static and dynamic. In a second time to instrument the mast with accelerometers to the study by SSI under ambient vibration method. All of which should help better understand the global behavior of the structure.

9.1.3. Collaboration with GEM

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

Md Delwar Hossain Bhuyan has started a PhD on Damage localisation on offshore platforms, The thesis is co-directed by L. Mevel and F. Schoefs from GEM, Nantes, with supervision shared with M. Doehler and Y. Lecieux from GEM. It is funded by the Brittany region for 3 years.

9.2. National Initiatives

9.2.1. High speed rail track Instrumentation

Participant: Ivan Guéguen.

Type: IRT

Objectif: bridge 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

The instrumentation will include: A Weather station measures environmental conditions (temperature, precipitation on the site). Accelerometers, to monitor the dynamic behavior of the track, with measures at several levels: the hammer beams on top of the grave-bitumen layer, on top of the soil. These measures will include acceleration compare the dynamic response of a section with and without GB. Instrumentation of severe bitumen strain gauges for measuring the longitudinal and transverse tensile strains at the base of the UK, and temperature probes (top and bottom layer). This instrumentation will estimate the fatigue life of the GB, temperature changes in this layer, and will calculate a temperature equivalent to the layer of GB. Instrumentation subgrade by means of measurement gauges at the top of the vertical deformation of the soil, and TDR probes to measure changes in water content. Its objective is to measure the levels of distortion in the upper part of the soil, and their variations, in conjunction with the seasonal variations in water content. An anchored sensor, measuring the total deflection between the top of the GB and a reference point that is 4 m deep. This sensor will measure the total displacement of the structure beneath the ballast (GB + layer of granular soil leveling + support). These will also serve as a reference for comparison with the movements deducted from accelerometer measurements. Continuous optical fiber, to measure static permanent deformation in the transverse direction over the entire width of the structure at the base of the sub-layer. These optical fibers used to monitor deformation obtained following the transverse profile in the game with underlay in the UK (in ballast) and the part with underlay GNT (Differential settlement, appearance of a crack ...).

9.2.2. REPTILES

Participant: Jean Dumoulin.

Type: FUI

Objectif: Innovation for rehabilitation of potable water tubes

Duration: Since 11/2012

Coordinator: FREYSSINET

Inria contact: J. Dumoulin

Since 2012, within FUI Reptiles, J. Dumoulin was coordinator of the conception, study and development of a thermoplastic composite assembly system for water tubes reenforcement. Moreover, infrared thermography was used for active control. [37]

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. [43], [27] (http://sense-city.ifsttar.fr/)

9.3. European Initiatives

9.3.1. *FP7 & H2020 Projects*

9.3.1.1. *Built to Specifications (Built2Spec)*
Participants: Jean Dumoulin, Alexandre Nassiopoulos, Jordan Brouns.

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 a Horizon 2020 EU-funded project involving 20 European partners that seeks to reduce the gap between a building's designed and as-built energy performance. To do this, the project will put a new set of breakthrough technological advances for self-inspection checks and quality assurance measures into the hands of construction professionals. This collection of smart tools will help building stakeholders at all levels in meeting EU energy efficiency targets, new build standards and related policy goals.
Built2Spec will deliver a new set of tools:

- 3D and Imagery Tools
- Building Information Modelling (BIM)
- Smart Building Components
- Energy Efficiency Quality Checks
- Indoor Air Quality Tools
- Airtightness Test Tools with Air-pulse Checks
- Thermal Imaging Tools
- Acoustic Tools

All connected to a Virtual Construction Management Platform supporting the collection and sharing of all project data, from initial design to the delivery. During the project, this platform will be integrated into the operations of small and medium-sized enterprise (SME) contractors, large construction firms and end user clients directly within the consortium and work program activities, assuring systematic and scientific performance measures, feedback and powerful exploitation.

9.3.2. Collaborations in European Programs, except FP7 & H2020

9.3.2.1. Collaboration with BAM, Berlin
Participants: Laurent Mevel, Michael Doehler, Eva Viefhues.

Eva Viefhues is currently student in BAM, Berlin. a PhD will start in 2016. Michael Doehler has visited a few times BAM in 2015 to prepare and plan the PhD.

9.3.2.2. Collaboration with CNR-IREA, Italy
Participants: Jean Dumoulin, Nicolas Le Touz.

This internship aims to identify defects in the interior walls, using thermal and electromagnetic reconstruction method, developed by IFSTTAR (in Bouguenais) for thermal and CNR-IREA (in Naples) for electromagnetism.

First, we make a numerical study for the two direct problems, with the resolution of the heat equation with finite elements, allowing a detailed study of how is made the assembly of matrices for a problem in two or three dimensions. A study of Maxwell's equations solving by using a centered finite difference method is also conducted for the direct problem of electromagnetism.

We also study the resolution of these inverse problems, in particular with the calculation of a functional gradient using the adjoint method for the thermal reconstruction, what allows the resolution of the problem with the Levenberg-Marquardt algorithm, and a study of the Born model for the electromagnetism problem.

Applications to the reconstructions of various types of defects are then lead. These different situations allow to highlight the stimuli, thermal of electrical, to bring to the system so that the reconstruction is made correctly. We could thus reconstruct defects in domains of various dimensions with thermal or electromagnetism highlighting the electrical (conductivity, permittivity and permeability), thermal (effusivity) and mathematical parameters (regularization terms) playing on the fidelity of the reconstruction.

A coupling of these two reconstruction methods is then carried out to improve the fidelity of the reconstructions realized with only one of these two methods. In the case of this coupling, the reconstruction get with GPR data provides a priori information to the thermal inverse problem allowing to get a better location of the defects.

9.3.2.3. 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.

9.3.2.4. MODRIO
Participants: Qinghua Zhang, Liangquan Zhang.

> Type: ITEA2
>
> Defi: Model Driven Physical Systems Operation
>
> Objectif: To meet the evermore stringent safety and environmental regulations for power plants and transportation vehicles, system operators need new techniques to improve system diagnosis and operation.
>
> Duration: June 2012 to November 2015
>
> Coordinator: Daniel Bouskela (EDF)
>
> Inria teams PARKAS, HYCOMS, I4S
>
> Inria contact: B. Caillaud

Abstract: Open standards are necessary for different teams to cooperate by sharing compatible information and data. To meet the evermore stringent safety and environmental regulations for power plants and transportation vehicles, system operators need new techniques to improve system diagnosis and operation. Open standards are necessary for different teams to cooperate by sharing compatible information and data. The objective of the MODRIO project is to extend modeling and simulation tools based on open standards from system design to system diagnosis and operation. This project joined by partners from Austria, Belgium, Finland, France, Germany, Italy and Sweden has been selected by the board of Information Technology for European Advancement (ITEA 2). The involved Inria project-teams are PARKAS, HYCOMES and I4S. This project is funded from June 2012 to November 2015.

9.3.2.5. 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 technologies and structural performance".

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: This COST Action enhances the benefit of Structural Health Monitoring (SHM) by novel utilization of applied decision analysis on how to assess the value of SHM - even before it is implemented. This improves decision basis for design, operation and life-cycle integrity management of structures and facilitates more cost efficient, reliable and safe strategies for maintaining and developing the built environment to the benefit of society. SHM is increasingly applied for collecting information on loads and aggressive environments acting on structures, structural performances, deterioration processes and changes in the use of structures. However, there is an urgent need to establish a better understanding of the value of SHM before its implementation, together with practically applicable methods and tools for its quantification. This Action thus 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. The COST Action will be conducted with the support of the Joint Committee on Structural Safety (JCSS). The networks of researchers and industries established during COST Actions TU0601, C26, E55 and E24, the EU FP7 project IRIS, the Marie Curie Network SmartEn and the JCSS will ensure visibility, impact and dissemination.

9.4. International Initiatives

9.4.1. *Collaboration with British Columbia University, Canada*

Participants: Laurent Mevel, Michael Doehler, Saeid Allahdadian.

Saeid Allahdadian is currently 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 starting in 2016 for 3 years.

9.5. International Research Visitors

9.5.1. *Visits of International Scientists*

S. Allahdadian from British Columbia University has visited us for a week in 2015.

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

6. Partnerships and Cooperations

6.1. National Initiatives

6.1.1. ANR Programme blanc international (BLAN) LODIQUAS 2012-2015

Participants: Philippe Chartier, Florian Méhats, François Castella, Mohammed Lemou.

The project, entitled "LODIQUAS" (for: Low DImensional QUANtum Systems), received fundings for 4 postdocs (48 months) and one pre-doc (36 months). The whole project involves the following researchers : Norbert Mauser (Vienna), Erich Gornik (Vienna), Mechthild Thalhammer (Innsbruck), Christoph Naegerl (Innsbruck), Jörg Schmiedmayer (Vienna), Hans-Peter Stimming (Vienna),Francis Nier (Rennes), Raymond El Hajj (Rennes), Claudia Negulescu (Toulouse), Fanny Delebecque (Toulouse), Stéphane Descombes (Nice), Christophe Besse (Lille).

The expected scientific and technological progress brought by the present project are as follows.

Quantum technology as the application of quantum effects in macroscopic devices has an increasing importance, not only for far future goals like the quantum computer, but already now or in the near future. The present project is mainly concerned with the mathematical and numerical analysis of these objects, in conjunction with experimental physicists. On the side of fermions quantum electronic structures like resonant tunnelling diodes show well studied non classical effects like a negative differential resistance that are exploited for novel devices. On the side of bosons the creation and manipulation of Bose Einstein Condensates (the first creation of BECs by Ketterle et al merited a Nobel prize) has become a standard technique that allows to study fundamental quantum concepts like matter-wave duality with increasingly large objects and advanced quantum effects like decoherence, thermalization, quantum chaos. In state-of-the-art experiments e.g. with ultracold atoms in optical lattices the bosonic or fermionic nature of quantum objects can change and it makes a lot of sense to treat the models in parallel in the development of mathematical methods. The experimental progress in these fields is spectacular, but the mathematical modelling and analysis as well as the numerical simulation are lagging behind. Low dimensional models are mostly introduced in a heuristic way and there is also a need for systematic derivations and comparison with the 3-d models. To close the gap is a main goal of this project that aims to deliver reliable tools and programme packages for the numerical simulation of different classes of quantum systems modelled by partial differential equation of NLS type. Virtually all participants have a strong track record of international collaboration, they grew up with the concept of the European Research Area where science knows no boundaries and scientists used to work in different countries, as it was the case in a pronounced way in mathematics and in quantum physics in the thirties of the last century. The Pre- and Post-Docs to be funded by this project will be trained in this spirit of mobility between scientific fields and between places.

This project gave rise to the following scientific achievements

PhD students

Boris Pawilowski, has been hired as a PhD student, under the supervision of F. Nier and N. Mauser. His contract started october 2012, and the PhD thesis was defended on December 2015. His PhD subject is "Mean field limit for discrete models and nonlinear discrete Schrödinger equations".

Postdocs

Loïc Le Treust has been hired as a Postdoc, under the supervision of F. Méhats (main) and N. Mauser. His contract started October 2013, and it did last two years, in Rennes and Vienna.

Yong Zhang, under contract in Vienna, has been invited for several one month periods in Rennes. There are works in progress with F. Méhats and P. Chartier.

Kristelle Roidot, had a six months contract in Vienna, and this gave rise to works with N. Mauser, C. Klein, J.-C. Saut, S. Descombes.

Workshops

July 2012, kick-off meeting of the LODIQUAS project, WPI, Vienna (one week, approx. 40 people, amongst which most of the participants of the project).

February 2013, WPI, Vienna, with a similar organization as the kick-off meeting.

July 2013, WPI, Vienna. At the WPI for one week. "Quantized Vortices in Superfluidity and Superconductivity and Related Problems", organisers W. Bao, C. Bardos, Q. Du, N. Mauser.

September 2013, WPI Vienna, "Modified dispersion for dispersive equations and systems ", organisers R. Carles, Mauser, J.C. Saut.

September 2013, WPI Vienna, "Modified dispersion for dispersive equations and systems ", organisers R. Carles, Mauser, J.C. Saut.

October 2014, WPI Vienna, "Blow-up and Dispersion in nonlinear Schrödinger and Wave equations", organizers G. Lebeau, A. Jüngel, O. Ivanovici, J.-C. Saut, H.-P. Stimming.

December 2014, Saint-Malo, "Lodiquas Meeting", organisers F. Castella and P. Chartier.

December 2015, Dinard, "Joint Lodiquas and Ipso Meeting",

6.1.2. ANR MOONRISE: 2015-2019

Participants: Nicolas Crouseilles, Philippe Chartier, Florian Méhats, François Castella, Mohammed Lemou.

The project *Moonrise* submitted by F. 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, F. Castella, P. Chartier, N. Crouseilles and M. Lemou are members of the project Moonrise.

6.1.3. 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.

6.2. European Initiatives

6.2.1. FP7 & H2020 Projects

6.2.1.1. Geopardi

Title: Numerical integration of Geometric Partial Differential Equations

Programm: FP7

Duration: September 2011 - August 2016

Coordinator: E. Faou

Inria contact: E. Faou

'The goal of this project is to develop new numerical methods for the approximation of evolution equations possessing strong geometric properties such as Hamiltonian systems or stochastic differential equations. In such situations the exact solutions endow with many physical properties that are consequences of the geometric structure: Preservation of the total energy, momentum conservation or existence of ergodic invariant measures. However the preservation of such qualitative properties of the original system by numerical methods at a reasonable cost is not guaranteed at all, even for very precise (high order) methods. The principal aim of geometric numerical integration is the understanding and analysis of such problems: How (and to which extend) reproduce qualitative behavior of differential equations over long time? The extension of this theory to partial differential equations is a fundamental ongoing challenge, which require the invention of a new mathematical framework bridging the most recent techniques used in the theory of nonlinear PDEs and stochastic ordinary and partial differential equations. The development of new efficient numerical schemes for geometric PDEs has to go together with the most recent progress in analysis (stability phenomena, energy transfers, multiscale problems, etc..) The major challenges of the project are to derive new schemes by bridging the world of numerical simulation and the analysis community, and to consider deterministic and stochastic equations, with a general aim at deriving hybrid methods. We also aim to create a research platform devoted to extensive numerical simulations of difficult academic PDEs in order to highlight new nonlinear phenomena and test numerical methods.'

6.2.1.2. EUROfusion 2015-2017

N. Crouseilles and M. Lemou are members of the EUROFusion project entitled "Enabling research project for the implementation of the fusion roadmap". The leader is E. Sonnendrücker (IPP Garching, Germany).

6.3. International Initiatives

6.3.1. *Inria International Partners*

6.3.1.1. Informal International Partners

Several IPSO members have international collaborations

- L. Einkemmer, University of Innsbruck. Collaboration on numerical schemes for Vlasov-Maxwell equations with N. Crouseilles and E. Faou.
- M. Thalhammer, University of Innsbruck. Collaboration on multi-revolution methods for the Schrödinger equation and Dirac equation with F. Méhats and P. Chartier.
- S. Jin, University of Madison. Collaboration on numerical schemes for highly-oscillatory problems with N. Crouseilles and M. Lemou.
- G. Vilmart, University of Geneva. Collaboration on uniformly accurate methods for highly-oscillatory problems with F. Méhats and P. Chartier
- F. Casas, University Jaume. Collaboration on splitting methods for Vlasov equations with N. Crouseilles and E. Faou.

6.4. International Research Visitors

6.4.1. *Visits of International Scientists*

6.4.1.1. Internships

S. Jin (University of Madison) spent 2 months at IRMAR (University of Rennes) within the framework of the Labex H. Lebesgue semester "PDEs and long time behavior", to collaborate with N. Crouseilles and M. Lemou.

6.4.2. Visits to International Teams

6.4.2.1. Research stays abroad

- P. Chartier: invitation at the University of Geneva (Switzerland), by G. Vilmart (one month in July).
- F. Méhats: invitation at the University of Geneva (Switzerland), by G. Vilmart (one week).
- F. Méhats: invitation at the Beijing Computational Science Research Center (China), by W. Bao (10 days).
- M. Lemou: invitation at the University of Wisconsin-Madison (US), by S. Jin (two weeks, october 2015).
- M. Lemou: invitation at the University of Geneva (Switzerland), by G. Vilmart (two weeks, july 2015).
- A. Debussche participated to the semester "New challenges in PDE: Deterministic dynamics and randomness in high and infinite dimensional systems" at MSRI (Berckeley, US).

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

8. Partnerships and Cooperations

8.1. Regional Initiatives

8.1.1. *Regional partnership with computer science laboratories in Nantes*

Participants: Anne Siegel, Jérémie Bourdon, Damien Eveillard, François Coste, Jacques Nicolas, Vincent Picard.

Methodologies are developed in close collaboration with university of Nantes (LINA) and Ecole centrale Nantes (IRCCyN). This is acted through the Biotempo and Idealg ANR projects and co-development of common software toolboxes within the Renabi-GO platform process. The Ph-D students V. Picard and J. Laniau are also co-supervised with members of the LINA laboratory.

8.1.2. *Regional partnership in Marine Biology*

Participants: Catherine Belleannée, Jérémie Bourdon, Guillaume Collet, Jean Coquet, François Coste, Damien Eveillard, Olivier Dameron, Clémence Frioux, Clovis Galiez, Jeanne Got, Yann Guitton, Julie Laniau, Jacques Nicolas, Vincent Picard, 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. The IDEALG consortium is 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. Other research contracts concern the modeling of the initiation of sea-urchin translation (former PEPS program Quantoursin, Ligue contre le cancer and ANR Biotempo), the analysis of extremophile archebacteria genomes and their PPI networks (former ANR MODULOME and PhD thesis of P.-F. Pluchon) and the identification of key actors implied in competition for light in the ocean (PELICAN ANR project). In addition, the team participates to a collaboration program with the Biocore and Ange teams, together with Ifremer-Nantes, focused on the understanding on micro-algae (thesis of Julie Laniau).

8.1.3. *Regional partnership in agriculture and bio-medical domains*

Participants: Aymeric Antoine-Lorquin, Catherine Belleannée, Charles Bettembourg, François Coste, Jean Coquet, Olivier Dameron, Victorien Delannée, Jacques Nicolas, Anne Siegel, Nathalie Théret, Aurélie Evrard.

We have a strong and long term collaboration with biologists of INRA in Rennes : PEGASE and IGEEP units. This partnership is acted by the co-supervision of one post-doctoral student and the co-supervision of several PhD students. The Ph-D thesis of V. Wucher was supported by collaborations with the IGEPP laboratory. The post-doc of Charles Bettembourg strengthens these collaborations. This collaboration is also reinforced by collaboration within ANR contracts (MirNadapt, FatInteger). Lately, Aurélie Evrard joined the team at mid-part of her time in collaboration with Agrocampus Ouest and INRA to apply the semantic web to technologies developed within the mirnAdapt framework to new agriculture applications (Brassicae).

We also have a strong and long term collaboration in the bio-medical domain, namely with the IRSET laboratory at Univ. Rennes 1/Irset, acted by the co-supervised Ph-D theses of V. Delannée (Metagenotox project, funded by Anses) and J. Coquet. This partnership was reinforced in the former years 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 will be pushed forward in the recent TGFSYSBio project funded by Plan Cancer on the modelling of the microenvironment of TGFbeta signaling network.

8.2. National Initiatives

8.2.1. Long-term contracts

8.2.1.1. "Omics"-Line of the Chilean CIRIC-Inria Center

Participants: Anne Siegel, Jérémie Bourdon, François Coste, Marie Chevallier, Meziane Aite, Clémence Frioux, Damien Eveillard, Jacques Nicolas.

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 2022. In this context, IntegrativeBioChile is 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.

8.2.1.2. ANR Idealg

Participants: Jérémie Bourdon, Marie Chevallier, Guillaume Collet, François Coste, Damien Eveillard, Clémence Frioux, Clovis Galiez, Jeanne Got, Yann Guitton, 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. It is organized in ten workpackages. We are participating to workpackages 1 (establishment of a virtual platform for integrating omics studies on seaweed) and 4 (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 extraction of important parameters for the production of targeted compounds. We will also contribute to the prediction of specific enzymes (sulfatases) within workpackage 5 [More details].

8.2.2. Proof-of-concept on dedicated applications

8.2.2.1. ANR Fatinteger

Participants: Aymeric Antoine-Lorquin, Catherine Belleannée, Jacques Nicolas, Anne Siegel.

This project (ANR Blanc SVE7 "biodiversité, évolution, écologie et agronomie" from 2012 to 2015) is leaded by INRA UMR1348 PEGASE (F. Gondret). Its goal is the identification of key regulators of fatty acid plasticity in two lines of pigs and chickens. To reach these objectives, this project has for ambition to test some combination of statistics, bioinformatics and phylogenetics approaches to better analyze transcriptional data of high dimension. Data and methods integration is a key issue in this context. We work on the recognition of specific common cis-regulatory elements in a set of differentially expressed genes and on the regulation network associated to fatty acid metabolism with the aim of extracting some key regulators.

8.2.2.2. ANR Mirnadapt

Participants: Jacques Nicolas, Anne Siegel, Olivier Dameron, Charles Bettembourg.

This ANR project is coordinated by UMR IGEPP, INRA Le Rheu (D. Tagu) and funded by ANR SVSE 6 "Génomique, génétique, bioinformatique, biologie systémique" from 2012 to 2014. This cooperation was strengthened by a co-tutored PhD thesis (V. Wucher) defended in Nov. 2014 [92]. It proposes an integrative study between bioinformatics, genomics and mathematical modeling focused on the transcriptional basis of the plasticity of the aphid reproduction mode in response to the modification of environment. An important set of differentially expressed mRNAs and microRNAs are available for the two modes, asexual parthenogenesis and sexual reproduction. Our work is to combine prediction methods for the detection of putative microRNA/mRNA interactions as well as transcription factor binding sites from the knowledge of genomic sequences and annotations available on this and other insects. The results will be integrated within a coherent putative interaction network and serve as a filter for the design of new targeted experiments with the hope to improve functional annotations of implied genes.

8.2.2.3. ANR Samosa
Participants: Anne Siegel, Jeanne Got, Damien Eveillard.

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.

8.2.3. Programs funded by research institutions

8.2.3.1. INSERM TGFSYSBIO
Participants: Nathalie Théret, Jacques Nicolas, Olivier Dameron, Anne Siegel, Jean Coquet.

TGFSYSBIO project aims to develop the first model of extracellular and intracellular TGF-β system that might permit to analyze the behaviors of TGF-β activity during the course of liver tumor progression and to identify new biomarkers and potential therapeutic targets. Based on collaboration with Jerome 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-β-dependent intracellular signaling pathways. The multi-scale integrated model will be enriched with a large-scale analysis of liver tissues using shotgun proteomics to characterize protein networks from tumor microenvironment whose remodeling is responsible for extracellular activation of TGF-β. The trajectories and upstream regulators of the final model will be analyzed with symbolic model checking techniques and abstract interpretation combined with causality analysis. Candidates will be classified with semantic-based approaches and symbolic bi-clustering technics. The project is funded by the national program "Plan Cancer - Systems biology" from 2015 to 2018.

8.2.3.2. ADT Complex-biomarkers and ADT Proof of concept
Participants: Jeanne Got, Guillaume Collet, Marie Chevallier, Meziane Aite, Anne Siegel.

This project 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).

8.2.3.3. ANSES Mecagenotox
Participants: Victorien Delannée, 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. 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.

8.2.3.4. PEPS VAG

Participants: François Coste, Clovis Galiez, Jacques Nicolas.

PEPS VAG started a collaboration between IMPMC UMR 7590, Institut de biologie de l'Ecole Normale Supérieure (IBENS) UMR8197, Atelier de Bioinformatique UPMC and Dyliss. It aims at defining the needs and means for a larger project about viruses in marine ecosystems. More specifically,we develop new methods based on both sequential and structural information of proteins to improve the detection of viral sequences in marine metagenomes. This will make possible to identify new viruses and to compare the viral populations specifically associated with different environment parameters (temperature, acidity, nutriments...) and ultimately to connect them with the potential hosts identified by population sequencing.

8.2.3.5. PEPS CONFOCAL

Participants: Olivier Dameron, Jean Coquet, Nathalie Théret, Jacques Nicolas, Anne Siegel.

PEPS CONFOCAL aims at developing new bioinformatics methods for analyzing heterogeneous *omics data and for filtering them according to domain knowledge. The current approaches are facing four main limitations: (1) classic biclustering methods do not support partial overlap of clusters, which is too restrictive considering some genes' pleiotropic nature, (2) they assume that the items to analyze (the genes, the molecules, the signaling pathways...) are independent, (3) they tend to generate numerous clusters leaving to the experts the task of identifying the relevant ones, and (4) they are sensitive to noisy or incomplete data. We investigate the extension of Formal Concept Analysis (FCA) with symbolic knowledge from ontologies in order to process large and complex sets of associations between genes, signaling pathways and the molecules involved in these pathways. Future applications cover the discrete model analysis in molecular biology. CONFOCAL initiated a collaboration with Amedeo Napoli (LORIA Nancy) and Elisabeth Rémy (Mathematics Institute Luminy, "Mathematical Methods for Genomics" team).

8.3. European Initiatives

8.3.1. Collaborations with Major European Organizations

Partner: EBI (Great-Britain)

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

Partner: Potsdam university (Germany)

Title: Constraint-based programming for the modeling and study of biological networks.

8.4. International Initiatives

8.4.1. Inria International Labs

The Dyliss team is strongly involved in the Inria CIRIC center, and the research line "Omics integrative center". The associated team "IntegrativeBioChile", the post-doc of S. Thiele (2012) and the co-supervision of A. Aravena (2010-2013) contributed to reinforce the complementarity of both Chilean and French teams. In 2013, a workshop was organized in Chile to develop new French-Chilean collaborations within the framework of the CIRIC center. In 2014, Marie Chevallier joined the team as an engineer to improve softwares resulting from collaborations.

Inria Chile

Associate Team involved in the International Lab:

8.4.1.1. BIOINTEGRATIVECHILE

Title: Integrative Biology in Extreme Environments

International Partner (Institution - Laboratory - Researcher):

Universidad de Chile (Chile) - Center for Mathematical Modeling (CMM) - Alejandro Maass

Start year: 2014

See also: http://www.irisa.fr/dyliss/public/EA/index.html

The project is in the area of bioinformatics, with a special focus on bacteria living in extreme environments, more precisely on microorganisms involved in bio-remediation or bio-production processes. We are particularly interested in bioprocesses such as copper extraction, salmon lethality, metal-resistance, all having an economical interest in Chile. Since the last decade, huge databases of microbial genomic sequences, together with multi-scale and large-scale cellular observations (genomics, transcriptomics, proteomics, metabolomics) have been produced. Each one can be considered as a different scale of a biological process, either in time or space. But ultimately they are related through networks of biological interactions that control the behavior of the system. The reconstruction, analysis and modeling of such networks using all levels of information are biologically, mathematically and computationally challenging. Applied on microorganisms living in extreme environments, this question is even more challenging since relatively few knowledge is publicly available on the species, requiring to develop methods which are robust to uncertainty. We are developing methods to integrate and manage heterogeneous omics and uncertain data, this in the purpose of extracting suitable biomarkers from this multi-scale information. This question will be addressed by coupling probabilistic and static dynamical systems methods with recent and efficient paradigms of constraint programming (Answer Set Programming).

8.4.2. Inria Associate Teams

8.4.2.1. INTEGRATIVEBIOCHILE

Title: Bioinformatics and mathematical methods for heterogeneous omics data

Inria principal investigator: Anne Siegel

International Partner (Institution - Laboratory - Researcher):

University of Chile (Chile) - Center for Mathematical Modeling - Alejandro Maass

Duration: 2011 - 2016

See also: http://www.irisa.fr/dyliss/public/EA/index.html

IntegrativeBioChile is an Associate Team between Inria project-team "Dyliss" and the "Laboratory of Bioinformatics and Mathematics of the Genome" hosted at CMM at University of Chile. The Associated team is funded from 2011 to 2016. The project aims at developing bioinformatics and mathematical methods for heterogeneous omics data. Within this program, we funded long and short stay visitings in France.

8.5. International Research Visitors

8.5.1. Visits of International Scientists

- **Chile**. Centro de Modelimiento Matematico, Santiago [A. Maass, N. Loirà, M. Latorre]
- **Germany**. Frei Universitat Berlin [A. Bockmayr, H. Siebert]
- **Niger**. University of Maradi [O. Abdou-Arbi]
- **Turkey**. University of Istambul [A. Aravena]

8.5.2. Visits to International Teams

8.5.2.1. Explorer program

Galiez Clovis

Date: Mar 2015 - May 2015

Institution: University of California, Irvine (United States)

8.5.2.2. Short visits

- **Chile**. Centro de Modelimiento Matematico, Santiago de Chile [J. Bourdon, M. Chevallier, C. Frioux, A. Siegel]
- **Chile**. Centro de Modelimiento Matematico, Santiago de Chile [M. Chevallier]
- **Germany**. Frei Berlin University [A. Siegel]

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

8. Partnerships and Cooperations

8.1. Regional Initiatives

8.1.1. Comins'lab: SEACS

Participant: Etienne Mémin.

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

8.2. National Initiatives

8.2.1. ANR JCJC GERONIMO : Advanced GEophysical Reduced-Order Model construction from IMage Observations

Participant: Cédric Herzet.

duration 48 months. The GERONIMO project which starts 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.

8.2.2. INSU-LEFE: Toward new methods for the estimation of sub-meso scale oceanic streams

Participant: Cédric Herzet.

duration 36 months. This project tackles the problem of deriving a precise submesoscale characterization of ocean currents from satellite data. The targeted methodologies should in particular enable the exploitation of data of different nature (for example sea surface temperature or height) and/or resolutions. This 36-month project benefits from a collaboration with the Laboratoire de Météorologie Dynamique, Ecole Normale Supérieure, Paris.

8.2.3. INSU-LEFE: MODELER

Participant: Etienne Mémin.

duration 24 months. This project with MeteoFrance aims at exploring error modeling and stochastic parameterization in geophysical flow dynamics. The theory explored in this context should enable the construction of unified image data assimilation strategies.

8.3. International Initiatives

8.3.1. Informal International Partners

Universidad de Buenos Aires (ARGENTINA) We have maintained academic exchanges with the group of Guillermo Artana.

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

8.3.2. Participation In other International Programs

SticAMSUD project Voiceproduction leaded by Denisse Sciamarella (CNRS, LIMSI)

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GENSCALE Project-Team

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9. Partnerships and Cooperations

9.1. Regional Initiatives

9.1.1. Bioinformatics computing center of Roscoff

Participants: Sébastien Brillet, Erwan Drezen, Patrick Durand, Dominique Lavenier, Ivaylo Petrov.

Through the collaborative project KORIBLAST2 funded by Région Bretagne (June 2014-December 2015) and within the KoriScale lab, we worked: (1) to improve the KLAST software with new alignment methods developed by GenScale; (2) to extend the capabilities of KLAST toward metagenomic processing; (3) to develop a cloud version targeting huge sequence comparison processing.

9.1.2. Etablissement Français du sang (EFS)

Participant: Dominique Lavenier.

An active collaboration with EFS started in 2015 to speed up individual HLA genotyping. A first prototype has been designed (see section New Results) and should be intensively tested in 2016 on many patient data.

9.1.3. Rennes Hospital, Hematology service, Genetic service

Participants: Patrick Durand, Dominique Lavenier, Claire Lemaitre, Pierre Peterlongo, Guillaume Rizk.

The collaboration with the Hematology service and with the Genetic service of the Rennes hospital aims to set up advanced bioinformatics pipelines for cancer diagnosis.

9.1.4. Partnership with INRA in Rennes

Participants: Cervin Guyomar, Dominique Lavenier, Fabrice Legeai, Claire Lemaitre, Sébastien Letort, Pierre Peterlongo, François Moreews.

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 two INRA engineers (F. Legeai, F. Moreews) and one PhD student (C. Guyomar).

9.2. National Initiatives

9.2.1. ANR

9.2.1.1. Project FATINTEGER
Participants: Dominique Lavenier, François Moreews.

Coordinateur: F. Gondret
Duration: 36 months (Mar. 2012 - feb. 2015)
Partners: PEGASE Inra Rennes, CNRS IRISA Rennes, AgroCampus Ouest LMA-IRMAR Rennes

The FatInteger project aims to identify some of the transcriptional key players of animal lipid metabolism plasticity, combining high throughput data with statistical approaches, bioinformatics and phylogenetic. GenScale is involved in the design of the workflow for processing the genomic data.

9.2.1.2. Project ADA-SPODO: Genetic variation of Spodoptera Frugiperda
Participants: Claire Lemaitre, Fabrice Legeai, Anaïs Gouin, Dominique Lavenier, Pierre Peterlongo.

Coordinator: E. D'Alençon (Inra, Montpellier)
Duration: 45 months (Oct. 2012 – May 2016)

Partners: DGIMI Inra Montpellier, CBGP Inra Montpellier, URGI Inra Versailles, Genscale Inria/IRISA Rennes.

The ADA-SPODO project aims at identifying all sources of genetic variation between two strains of an insect pest: Lepidoptera Spodoptera Frugiperda in order to correlate them with host-plant adaptation and speciation. GenScale's task is to develop new efficient methods to compare complete genomes along with their postgenomic and regulatory data.

9.2.1.3. Project COLIB'READ: Advanced algorithms for NGS data

Participants: Pierre Peterlongo, Antoine Limasset, Camille Marchet, Claire Lemaitre, Dominique Lavenier, Fabrice Legeai, Guillaume Rizk, Chloé Riou.

Coordinator: P. Peterlongo (Inria, GenScale, Rennes)
Duration: 45 months (Mar. 2013 – Dec. 2016)
Partners: LIRMM Montpellier, Erable Inria Lyon, Genscale Inria/IRISA Rennes.

The main goal of the Colib'Read project is to design new algorithms dedicated to the extraction of biological knowledge from raw data produced by High Throughput Sequencers (HTS). The project proposes an original way of extracting information from such data. The goal is to avoid the assembly step that often leads to a significant loss of information, or generates chimerical results due to complex heuristics. Instead, the strategy proposes a set of innovative approaches that bypass the assembly phase, and that does not require the availability of a reference genome. https://colibread.inria.fr/

9.2.1.4. Project GATB: Genome Analysis Tool Box

Participants: Dominique Lavenier, Erwan Drezen, Pierre Peterlongo, Claire Lemaitre, Guillaume Rizk, Charles Deltel.

Coordinator: D. Lavenier (Inria/Irisa, GenScale, Rennes)
Duration: 24 months (Feb. 2013 – Jan. 2015)
Partners: GenScale Inria/IRISA, Rennes – DTI Inria, Rennes.

This project aims to develop algorithms and tools for genome analysis based on a compact data structure having a very low memory footprint allowing end-users to process huge volume of genomic data on a simple desktop computer. The GATB is structured around a C++ library from which many efficient NGS tools can be developed. GATB has been published and is used outside Genscale (LIRMM, Inria Erable team). http://gatb.inria.fr

9.2.1.5. Project HydroGen: Metagenomic applied to ocean life study

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

Coordinator: D. Lavenier (Inria/Irisa, GenScale, Rennes)
Duration: 42 months (Nov. 2014 – Apr. 2018)
Partners: CEA (GenosScope, 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.

9.2.1.6. Project SpeCrep: speciation processes in butterflies

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

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 butterflies 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, Pierre Peterlongo.

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

9.2.2.2. France Génomique: Bio-informatics and Genomic Analysis
Participants: Laurent Bouri, Dominique Lavenier.

Coordinator: J. Weissenbach (Genoscope, Evry)
France Génomique gathers resources from the main French platforms in genomic and bio-informatics. It offers to the scientific community an access to these resources, a high level of expertise and the possibilities to participate in ambitious national and international projects. The GenScale team is involved in the work package "assembly" to provide expertise and to design new assembly tools for the 3rd generation sequencing.

9.3. International Initiatives

9.3.1. Brazil

- IMECC, UNICAMP, Campinas [A. Mucherino]
- Federal University of Florianópolis, Santa Catarina: Distance geometry, optimal vertex orders [A. Mucherino]

9.3.2. Chile

- university of Utalca, genomes of aphid parasitoids [F. Legeai]

9.3.3. USA

- Los Alamos National Laboratory (LANL), Los Alamos: Graph algorithms, Parallelism, GPU [R. Andonov, D. Lavenier]
- University of Miami, member of the international Aphid genome consortium [F. Legeai]
- University of Arizona, genomes of aphid parasitoids [F. Legeai]
- University of Ohio, genomics of the soybean aphid [F. Legeai]

9.3.4. China

- SouthWest university, member of the international Spodoptera litura genome project [F. Legeai]

SAGE Project-Team

9. Partnerships and Cooperations

9.1. National Initiatives

9.1.1. *ANR-MN: H2MNO4 project*

Participants: Yvan Crenner, Benjamin Delfino, Jean-Raynald de Dreuzy, Jocelyne Erhel, Lionel Lenôtre, Géraldine Pichot.

Contract with ANR, program Modèles Numériques
Duration: four years from November 2012.
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. We organized a project meeting in February.

9.1.2. *Inria Project Lab: C2S@EXA project*

Participants: Édouard Canot, Yvan Crenner, Jocelyne Erhel, Géraldine Pichot.

Title: C2S@EXA - Computer and Computational Scienecs at Exascale
Duration: from January 2012.
Coordination: S. Lanteri, Nachos team.
Partners: Inria teams working on HPC; external partners: ANDRA and CEA.
Webpage: http://www-sop.inria.fr/c2s_at_exa/
Abstract: The C2S@Exa Inria Project Lab is concerned with the development of numerical modeling methodologies that fully exploit the processing capabilities of modern massively parallel architectures in the context of a number of selected applications related to important scientific and technological challenges for the quality and the security of life in our society. The team participated in several workshops.

9.1.3. *GENCI: project on advanced linear solvers*

Participants: Yvan Crenner, Jocelyne Erhel, David Imberti, Lionel Lenôtre, Géraldine Pichot.

Title: Numerical models for hydrogeology
Duration: 2015
Coordination: J. Erhel and G. Pichot.
Webpage: http://www.genci.fr/
Abstract: To run large scale simulations, we defined a project, based on the platform H2OLab and on a new GMRES solver. We obtained and used computing time on machines located at GENCI supercomputing centers.

9.1.4. *GDR MOMAS: projects on multiphase flow and reactive transport*

Participants: Benjamin Delfino, Jocelyne Erhel.

Title: Workshops on multiphase flow and reactive transport
Duration: 2015
Coordination: J. Erhel
Partner: IFPEN

Webpage: http://www.irisa.fr/sage/RTworkshop and https://www.ljll.math.upmc.fr/cances/gdrmomas/
Abstract: The working group MOMAS includes many partners from CNRS, Inria, universities, CEA, ANDRA, EDF and BRGM. It covers many subjects related to mathematical modeling and numerical simulations for nuclear waste disposal problems. The team participated in a workshop on multiphase flow and organized an international workshop on reactive transport, in Paris, with IFPEN.

9.2. European Initiatives

9.2.1. FP7 & H2020 Projects: EXA2CT project
Participants: Jocelyne Erhel, David Imberti.

Title: EXascale Algorithms and Advanced Computational Techniques

Programm: FP7

Duration: September 2013 - August 2016

Coordinator: S. Ashby, IMEC, Belgium

Partners:

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

Interuniversitair Micro-Electronica Centrum Vzw (Belgium)

Intel Corporations (France)

Numerical Algorithms Group Ltd (United Kingdom)

Systems Solutions for Research (Germany)

Universiteit Antwerpen (Belgium)

Universita della Svizzera italiana (Switzerland)

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

Vysoka Skola Banska - Technicka Univerzita Ostrava (Czech Republic)

Inria contact: Luc Giraud

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

9.2.2. FP7 & H2020 Projects: EOCOE project

Participant: Jocelyne Erhel.

Program: EINFRA-5-2015

Project acronym: EoCoE

Project title: Energy oriented Center of Excellence for computer applications

Duration: 36 months

Coordinator: CEA

Other partners: organisme, labo (pays) : 12 other partners

Abstract: the EoCoE objectives aims at firstly, to design, test and spread new methodological and organisational paradigms (Objectives 1, 3, and 4) driven by the users communities and, secondly, to contribute to mathematical and computer sciences challenges on the whole HPC tool chain (Objective 2).

9.3. International Initiatives

9.3.1. Inria International Labs: LIRIMA Afrique, EPIC team (Tunisia)

Participants: Édouard Canot, Jocelyne Erhel.

Program: Laboratoire International de Recherche en Informatique et Mathématiques Appliquées

Title: Problèmes Inverses et Contrôle

Inria principal investigator: Houssem Haddar, Defi team

International Partner (Institution - Laboratory - Researcher): ENIT, University of Tunis, Tunisia - LAMSIN - Amel ben Abda

Duration: 2011-2015

See also: http://www.lirima.uninet.cm/index.php/recherche/equipes-de-recherche/epic

Abstract: The team deals with nonlinear and inverse problems.

9.3.2. International Program ECOS Sud (Chili): ARPHYMAT project

Participant: Édouard Canot.

Program: CONICYT

Title: Processus de formation et transformation de structures de combustion archéologique : un regard interdisciplinaire

Inria principal investigator: Édouard CANOT

International Partner (Institution - Laboratory - Researcher): Universidad de Tarapaca (Chili)

Duration: Jan 2014 - Dec 2016

Abstract: Multidisciplinary study of prehistoric fire traces in South America, by means of different approaches: taphonomy of the soil, physical processes involved during the heat transfer, modeling and numerical simulations.

9.3.3. Inria Euromediterranean: HYDRINV project

Participants: Édouard Canot, Jocelyne Erhel.

Program: Euromediterranean 3+3

Title: Direct and inverse problems in subsurface flow and transport

Coordination: H. ben Ameur, ENIT, Tunisia and J. Jaffré, Inria, Paris

Inria-Rennes principal investigator: Jocelyne Erhel

Duration: Jan 2012 - Dec 2015

International Partners (Institution - Laboratory - Researcher):

Université Ibn Tofail - Faculté des Sciences de Kénitra (Morocco) - Laboratoire Interdisciplinaire en Ressources Naturelles et en Environnement - Zoubida Mghazli

Ecole Nationale d'Ingénieurs de Tunis (Tunisia) - Laboratoire de Modélisation en Hydraulique et Environnement - Rachida Bouhlila

Universidad de Sevilla (Spain) - Department Ecuaciones Diferenciales y Anålisis Numérico - Tomas Chacon Rebollo

Universitat Politècnica de Catalunya (Spain) - Department of Geotechnical Engineering and Geo-Sciences - Xavier Sànchez Vila

University Centre of KHEMIS MILIANA (Algeria) - Laboratoire de l'Energie et des Systèmes Intelligents - Mohammed Hachama

Ecole Mohammadia d'Ingénieurs (Morocco) - LERMA - Rajae Aboulaich

Ecole Nationale d'Ingénieurs de Tunis (Tunisia) - Laboratoire de Modélisation Mathématique et Numérique dans les Sciences de l'Ingénieur - Hend Ben Ameur

The management of water resources is a problem of great importance in all countries, and is particularly acute around the Mediterranean sea. The goal is to find a reasonable balance between these resources and demand while preserving the quality of water. Towards this goal it is essential to understand and simulate flow and transport in the subsurface. The science corresponding to this topic is hydrogeology. Since models become more and more complicated and quantitative answers must be given, numerical modeling become more and more sophisticated and mathematicians must also be involved. This project brings together hydrogeologists and mathematicians from France, Spain, Algeria, Morocco and Tunisia in order to develop, analyze, and validate numerical methods for several problems arising from modeling flow and transport in the subsurface. The emphasis is put on direct nonlinear problems (air-water flow, density driven flow related to salinization, transport with chemistry) and on inverse problems.

9.4. International Research Visitors

9.4.1. Visits of International Scientists

- Nabil Nassif, American University of Beirut, Lebanon, April, 1 week
- Lamia Guellouz, ENIT, Tunisia, May, 1 week

9.4.2. Internships (Joint supervision of Ph-D students)

- Marwen ben Refifa, University of Tunis, 5 months, April-July 2015
- Salwa Mansour, Lebanese University, 8 months, Feb-Sep 2015

9.4.3. Visits to International Teams

- Lionel Lenôtre visited Pr. Dr. Sylvie Roelly and her students at Potsdam University, Potsdam, Germany, one week, December 2015.

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

9. Partnerships and Cooperations

9.1. Regional Initiatives

ENSAI-CREST: Statistical methods and models for image registration, Vincent Briane PhD thesis 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).

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

9.2. National Initiatives

9.2.1. France-BioImaging project

Participants: Charles Kervrann, Patrick Bouthemy, Thierry Pécot, Emmanuel Moebel, Ancageorgiana Caranfil.

The goal of the project 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. We address the following 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 is co-head of the IPDM (Image Processing and Data Management) node of the FBI network composed of 6 nodes.
Funding: Investissement d'Avenir - Infrastructures Nationales en Biologie et Santé ANR (2011-2016).
Partners: CNRS, Institut Jacques Monod, Institut Pasteur, Institut Curie, ENS Ulm, Ecole Polytechnique, INRA, INSERM.

9.3. European Initiatives

9.3.1. Collaborations with Major European Organizations

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 .

9.4. International Initiatives

9.4.1. Inria International Partners

9.4.1.1. Informal International Partners

Collaboration with UT Southwestern Medical Center, Dallas (TX), Prof. Gaudenz Danuser: Object tracking in video-microscopy.

Collaboration with Max-Planck Institute, Martinsried (Germany), Dr. Julio Ortiz: Detection and segmentation of macromolecules in cryo-electron tomography.

Collaboration with Aalborg University (Denmark), Prof. Jesper Møller: Modeling aggregation on the large scale and regularity on the small scale in spatial point pattern datasets (visit of Frédéric Lavancier from 26-30 January 2015).

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

9. Partnerships and Cooperations

9.1. Regional Initiatives

9.1.1. *Biogenouest*

The VisAGeS team and the Neurinfo platform integrated the Biogenouest "Groupement d'Intérêt Scientifique (GIS)" in 2012.

Biogenouest is a Western France life science and environment core facility network. Research programmes are undertaken in the fields of Marine biology, Agriculture/Food-processing, Human health, and Bioinformatics. Set up in keeping with the inter-regional principle of complementarity, Biogenouest coordinates over twenty technological core facilities in both the Brittany and Pays de la Loire regions.

9.1.2. *Projet Fondation de France: PERINE*

Participants: Elise Bannier, Isabelle Corouge, Olivier Commowick, 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 will continue over 2 years.

9.1.3. *Fondation de l'Avenir - Depression, suicide and fMRI*

Participants: Elise Bannier, Isabelle Corouge, Jean-Christophe Ferré, Christian Barillot.

initial duration: 12 months from November 2012. Project extended in 2015.

In collaboration with EA 4712 "Comportement et Noyaux Gris Centraux" of the University of Rennes I, a complementary funding (20 000€) was obtained to support an ongoing fMRI research project on emotions, impulsivity and suicide. The study protocol and the fMRI task was finalized. Inclusions started in early 2013. The project was extended in 2014 to recruit more patients.

9.1.4. *Fondation de l'Avenir - Stroke, rehabilitation and fMRI*

Participants: Elise Bannier, Isabelle Bonan, Isabelle Corouge, Jean-Christophe Ferré, Christian Barillot, Jean-Yves Gauvrit.

duration: 12 months from November 2012. Project extended in 2015.

A complementary funding (20 000€) was obtained to support a new research project on rehabilitation of stroke patients. The fMRI protocol was setup, the task developed and validation on volunteers is ongoing. Patient inclusions started in spring 2013. This project was also extended to 2014 to recruit more patients. Group analysis on the control group was performed and a paper will be submitted soon.

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

Participants: Pierre-Yves Jonin, Elise Bannier, Christian Barillot, Isabelle Corouge, Quentin Duché, Jean-Christophe Ferré.

duration: 2 years from July 2015

This project evaluates memory effects in healthy adults and in patients presenting cognitive impairments using BOLD fMRI and diffusion MRI. A pilot study has been completed in 2015 in order to optimize the experimental design. The inclusions of patients wil start early 2016.

9.2. National Initiatives

9.2.1. ANR

9.2.1.1. ANR "TRANSLATE-MS-REPAIR", RPIB 2012 program
Participants: Laurence Catanese, Olivier Commowick, Isabelle Corouge, Jean-Christophe Ferré, Elise Bannier, Gilles Edan, Christian Barillot.

It is now commonly admitted that MS is not only an inflammatory disease but a neurodegenerative disease as well. This project is devoted to show that the olesoxime molecule is not only neuroprotective, but it has the ability to promote the maturation of oligodendrocyte progenitor cells (OPCs) into myelinating oligodendrocytes. However, before considering a large-scale clinical trial to assess efficacy. An important aspect is that to date, no treatment for neuroprotection / remyelination has reached the stage of clinical proof of concept that aims Trophos company who is leading this project. It appears that the best criteria for assessing neuroprotective/remyelinating effect of the drug candidate, are MRI criteria. However, these imaging criteria have not yet been validated for use in multicentre trials - so we will also check the feasibility of such measures under this condition. In addition to Trophos company, the partners of this project are AP-HM/CNRSCEMEREM-CRMBM, CHU Rennes, CHU Reims, and Inria-VISAGES.

9.2.1.2. ANR "MAIA", 2015 generic projects program
Participants: Maia Proisy, Pierre Maurel, Olivier Commowick, 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 technics 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.

9.2.2. Competitivity Clusters

9.2.2.1. The HEMISFER Project
Participants: Elise Bannier, Isabelle Bonan, Isabelle Corouge, Jean-Christophe Ferré, Jean-Yves Gauvrit, Pierre Maurel, 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).

9.2.2.2. France Life Imaging (FLI)

Participants: Christian Barillot, Olivier Commowick, Florent Leray, Michael Kain, Yao Yao.

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 U746 Inria Rennes; CATI CEA Saclay; LSIIT/ICube Strasbourg) that will increase their capacities for the FLI infrastructure. Inter-connections and access to services will be achieved through a dedicated software platform that will be developed based on the expertise gained through successful existing developments. The IAM node has several goals. It aims first at building a versatile facility for data management that will inter-connect the data production sites and data processing for which state-of-the-art solutions, hardware and software, will be available to infrastructure users. Modular solutions are preferred to accommodate the large variety of modalities acquisitions, scientific problems, data size, and adapted for future challenges. Second, it aims at offering the latest development that will be made available to image processing research teams. The team VISAGES fulfills multiple roles in this nation-wide project. Christian Barillot is the chair of the node IAM, Olivier Commowick is participating in the working group workflow and image processing and Michael Kain the technical manager. Apart from the team members, software solutions like medInria and Shanoir will be part of the final software platform.

9.2.2.3. OFSEP

Participants: Justine Guillaumont, Elise Bannier, Christian Barillot, Olivier Commowick, Gilles Edan, Isabelle Corouge, 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

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[0]https://iww.inria.fr/cominlabs-newsletter/april-2013-four-projects-selected/#hemisfer

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.

9.2.3. Collaboration with the CEA (Commissariat à l'Energie Atomique): Standardization of Arterial Spin Labeling acquisitions and imaging data quality assessment in the context of dementia related studies

Participants: Elise Bannier, Christian Barillot, Isabelle Corouge, Jean-Christophe Ferré, Cédric Meurée.

duration: from August 2014 to December 2015

Around 900,000 people are affected by various forms of dementia in France. As an early and reliable diagnosis remains difficult to provide, neuroimaging is crucial as a diagnosis assistance by analyzing structural and functional brain abnormalities related to these diseases. The CATI (Centre pour l'Acquisition et le Traitement des Images) is a multicenter neuroimaging network dedicated to the management of dementia related imaging protocols. As VisAGeS and the Neurinfo platform are recognized for their expertise in Arterial Spin Labeling (ASL) acquisition and post-processing, a collaboration contract was signed between Inria and CEA, the coordinator of the CATI initiative, in order to host an engineer in the VisAGeS team for one year. The collaboration resulted in the standardization of the ASL acquisition parameters of the CATI protocols, the setup of these parameters on the scanneres participating in the CATI studies, as well as the development and the integration of post-processing and quality assessment tools into qualiCATI, the quality control software of the CATI.

9.2.4. PEPS JCJC CNRS INS2I: FastMicroDiff: Fast acquisition for microstructure-enabled diffusion MRI

Participants: Elise Bannier, Emmanuel Caruyer.

duration: from January 2015 to December 2015 Diffusion MRI is a unique tool for the observation of brain white matter structure in vivo. Several studies have shown that it is possible to estimate intrinsic tissue parameters from diffusion, such as axonal diameter, axonal density, orientation dispersion, compartment-specific diffusion coefficients, etc. However, the reconstruction of these parameters requires specific acquisition protocols, which are to date very long and therefore poorly compatible with in vivo applications. Besides, recent development have shown that a higher sensitivity to some microstructural paramters could be obtained using non-conventional diffusion gradient sequences, such as oscillating gradient waveforms. This project aims at developping faster acquisition methods, using sparse representation for microstructure-enabled diffusion signal and time-varying diffusion sensitizing gradients.

In cooperation with the Neurinfo imaging platform and Siemens, a modification of the protocol to enable the use of non-rectangular gradient pulses has been developped and is being tested on phantom. A group of 6 healthy subjects will be scanned using this novel protocol, and acquisition will be repeated 3 times for each subject so that we can evaluate the reproducibility of the technique.

9.2.5. PHRC EMISEP: Evaluation of early spinal cord injury and late physical disability in Relapsing Remitting Multiple Sclerosis

Participants: Elise Bannier, Christian Barillot, Emmanuel Caruyer, Olivier Commowick, Gilles Edan, Jean-Christophe Ferré, Anne Kerbrat.

duration: from January 2014 to December 2017 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 focuses on physical impairment and especially on the ability to walk. Several studies, whether epidemiolgic 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, this 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 a 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 to perfom 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 on the 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, 40 of the 80 subjects have been included. A PhD student started in November 2015 to work on diffusion imaging in the spinal cord.

9.3. European Initiatives

9.3.1. FP7 & H2020 Projects

9.3.1.1. EuroBioimaging

Type: CAPACITIES

Defi: Provide access and training in imaging technologies, and share the best practice and image data in order to make Euro-BioImaging an engine that will drive European innovation in imaging research and technologies

Instrument: Combination of COLLABORATIVE PROJECTS and COORDINATION and SUPPORT ACTIONS

Objective: Euro-BioImaging is a large-scale pan-European research infrastructure project on the European Strategy Forum on Research Infrastructures (ESFRI) Roadmap.

Duration: December 2010 - 2016

Coordinators: Jan Ellenberg (EMBL) and Oliver Speck (University of Magdeburg)

Partner: EMBL (Germany); Erasmus Medical Center (Netherlands) for WG11

Inria contact: C. Kervrann, C. Barillot

Abstract: Euro-BioImaging is a pan-European infrastructure project whose mission is to build a distributed imaging infrastructure across Europe that will provide open access to innovative biological and medical imaging technologies for European researchers. The project is funded by the EU and currently the consortium is finalizing the basic principles for the operation of future Euro-BioImaging organisation.

Euro-BioImaging will be governed by representatives of the European countries that will join Euro-BioImaging (Euro-BioImaging member states).

The infrastructure established by Euro-BioImaging will consist of a set of geographically distributed but strongly interlinked imaging facilities (Euro-BioImaging Nodes), which will be selected among the leading European imaging facilities based on an independent evaluation process.

Inria and the Visages team is involved through the FLI national infrastructure and contributes to the WG11 Working Group on Data Storage and Analysis. This WG performs a series of tasks to define a European Biomedical Imaging Data Storage and Analysis infrastructure plan for the construction phase.

9.3.2. Collaborations in European Programs, except FP7 & H2020

9.3.2.1. COST-AID

Program: COST

Project acronym: AID (oc-2010-2-8615)

Project title: Arterial spin labeling Initiative in Dementia

Acceptation date: 18/05/2011

Coordinator: X. Golay, UCL, London, UK

Other partners: Ghent University (BE), Liege University (BE), Hospital Cantonal de Geneve (CH), Fraunhofer MEVIS (D), Freiburg University (D), Max Planck Institute for Human Cognitive & Brain Sciences (D), Glostrup Hospital (DK), Hospital Santa Creu I Sant Pau (ES), Universidad Rey Juan Carlos (ES), University of Narvarra (ES), INSERM U836 Grenoble (FR), University of Rennes I (FR), Centro San Giovanni di Dio - Fatebenefratelli (IT), Fondazione Instituto Neurologico Besta (IT), Leiden University Medical Center (NL), UMC Utrecht (NL), VU University Medical Centre (NL), Instituto Superior Técnico (PT), University of Porto (PT), Lund University Hospital (SE), Uppsala University Hospital (SE), Skane University Hospital (SE), Bogazici University (TR), King's College London (UK), University College London (UK), University of Nottingham (UK), University of Oxford (UK)

Abstract: Dementia is a major clinical challenge with care costs approaching 1% of global GDP. Recent estimates suggest that delaying disease onset by 5 years would halve its prevalence. As new disease-modifying treatments will be specific to causative diseases, expensive and bear significant side effects, early diagnosis of dementia will be essential. Current diagnostic criteria include the use of image-based biomarkers using radiotracers. The AID Action aims at coordinating the development of an alternative and cost-effective tool based on an MRI technique, Arterial Spin Labeling (ASL), to obtain reproducible brain perfusion measurements in dementia patients by bringing together scientists and clinicians from across Europe through the flexibility of the COST mechanism. The scientific program is centered around four work packages and three workgroups aiming at developing standards, improving the reliability of the technique and as establishing it as a possible clinical trial outcome measure. Development of MRI methods, post-processing tools, protocols of cross-validation, statistical analyses and launch of clinical and comparative studies will be undertaken. The main benefit of this Action will be to provide a cost-effective alternative to radiotracer-based biomarkers, and help care providers throughout Europe balancing the need for early diagnosis of dementia with the necessary healthcare cost containment. The Visages team is involved in the workgroups ASL data acquisition (E. Bannier), ASL data analysis (C. Barillot, I. Corouge, P. Maurel, C. Meurée) and clinical validation of ASL in cognitive impairment (J.-C. Ferré).

9.3.2.2. Kic-EIT-eHealth

Program: KIC-EIT: European Institute of Innovation and Technology

Project acronym: e-Health

Project title: Innovation for healthy living and active ageing

Acceptation date: 01/12/2014

website: http://eithealth.eu/about-us/

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. C. Barillot is representing Inria as one expert in the dedicated WG "Healthy Brain". Visages is also concerned by the WG "big data".

9.4. International Initiatives

9.4.1. Inria Associate Teams not involved in an Inria International Labs

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: 2012 (renewed 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.

In 2015, Renaud Hedouin had a 3 month visit in Boston in the context of the BARBANT associated team

9.4.1.2. Informal International Partners

- Collaboration with Duke University, NC : From November 2014 to February 2015, Hrishikesh Deshpande visits Duke University (in Durham, North Carolina, United States) to collaborate with Professor Guillermo Sapiro on classification using Dictionary Learning. This visit was partially founded by a mobility grant from the doctoral school MATISSE.
- Collaboration with the MS Center, Dpt. of Neurology and Center for Clinical Neuroscience, Charles University in Prague on Brain atrophy in Multiple Sclerosis. O. Commowick, C. Barillot, A. Kerbray and G. Edan had a two-days visit in April 2015.

9.5. International Research Visitors

9.5.1. Visits of International Scientists

- Within the BARBANT associate team, P. Simon K. Warfield, Dr. Benoit Scherrer and Dr. Maxime Taquet (Computational Radiology Laboratory, Harvard Medical School) visited us for a workshop on multiple sclerosis and diffusion image processing.

9.5.2. Visits to International Teams

- Several members of the Visages team (Christian Barillot, Olivier Commowick, Renaud Hédouin, Yogesh Karpate) visited the Computational Radiology Laboratory (Harvard Medical School) for an associate team (BARBANT) meeting to discuss new research topics.

9.5.2.1. Explorer programme

Hédouin Renaud

Date: Sep 2015 - Dec 2015

Institution: Boston Children's Hospital (United States)

Renaud Hédouin visited the Computational Radiology Laboratory at Boston Children's Hospital, United States, for a 3 month exchange within the BARBANT associate team working on distortion correction topic.

9.5.2.2. Research stays abroad

- From November 2014 to February 2015, Hrishikesh Deshpande visits Duke University (in Durham, North Carolina, United States) to collaborate with Professor Guillermo Sapiro on classification using Dictionary Learning. This visit was partially founded by a mobility grant from the doctoral school MATISSE.

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

8. Partnerships and Cooperations

8.1. National Initiatives

8.1.1. ANR project SocioPlug

Participants: Davide Frey, Anne-Marie Kermarrec, Pierre-Louis Roman, François Taïani.

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 of 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.

8.1.2. DeSceNt CominLabs

Participants: Resmi Ariyattu Chandrasekharannair, Davide Frey, Michel Raynal, François Taïani.

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.

8.1.3. ANR Blanc project Displexity

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

The Displexity project started in Oct 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.

8.2. International Initiatives

8.2.1. Inria International Labs

Anne-Marie Kermarrec has been scientific collaborator at EPFL, Lausanne, since February 2014.

Anne-Marie Kermarrec has been the scientific coordinator of the EPFL/Inria International Lab since February 2015.

Anne-Marie Kermarrec organized the *First EPFL/Inria Workshop*, Lausanne, January 2015.

8.2.2. Inria Associate Teams not involved in an Inria International Labs

8.2.2.1. RADCON

Title: Randomized Algorithms for Distributed Computing and Networks

International Partner (Institution - Laboratory - Researcher):

University of Calgary (Canada) - Computer Science (cpsc) - Philipp Woelfel

Start year: 2013

See also: http://www.irisa.fr/asap/radcon

Over recent years, computing systems have seen a massive increase in parallelism and interconnectivity. Peer-to-peer systems, ad-hoc networks, sensor networks, or the "cloud" are based on highly connected and volatile networks. Individual nodes such as cell phones, desktop computers or high performance computing systems rely on parallel processing power achieved through multiple processing units. To exploit the power of massive networks or multiple processors, algorithms must cope with the scale and asynchrony of these systems, and their inherent instability, e.g., due to node, link, or processor failures. In this research project we explore randomized algorithms for large-scale networks of distributed systems, and for shared memory multi-processor systems.

For large-scale networks, decentralized gossip protocols have emerged as a standard approach to achieving fault-tolerant communication between nodes with simple and scalable algorithms. We will devise new gossip protocols for various complex distributed tasks, and we will explore the power and limits of gossip protocols in various settings.

For shared memory systems, randomized algorithms have proved extremely useful to deal with asynchrony and failures. Sometimes probabilistic algorithms provide the only solution to a problem; sometimes they are more efficient; sometimes they are simply easier to implement. We will devise efficient algorithms for some of the fundamental problems of shared memory computing, such as mutual exclusion, renaming, and consensus.

8.3. International Research Visitors

8.3.1. Visits of International Scientists

Shlomi Dolev, Jan 21-24

Frederic Mallmann-Trenn Feb 11-18, 2015

Emmanuel Godard April 23-24, 2015

Hamouma Moumen, June 1-30, 2015

Stevens Le Blond, July 14, 2015

Raluca Halalai Aug 1-15, 2015

Diogo Lima Aug 3-28, 2015

Damien Imbs, Oct 11-24, 2015

8.3.1.1. Internships

Tom Ferragut; May 18 to June 27. *Study and evaluation of effective recommendation algorithms* Supervised by Anne-Marie

Nominoe Kervadec; from June 1 to Aug 31 2015. *Non-blocking I/O in YALPS* Supervised by Davide Frey.

Yasamin Nazari. *Asynchronous vs. Synchronous Rumor Spreading* Sep 1 - Dec 15 2015 Supervised by George Giakkoupis.

8.3.2. Visits to International Teams

8.3.2.1. Research stays abroad

George Giakkoupis visited University of Calgary, Canada, 1-8 Mar, 18 Jun - 10 Jul, and 5-21 Dec, Simon Fraser University, Canada, 22 Feb - 1 Mar, and University of Cambridge, UK, 22-30 Jul.

8.3.2.2. Internships

Nupur Mittal did an internship at NICTA, Sydney from March 30, 2015 to July 1, 2015 under the supervision of Dr. Dali Kaafar. She also received Ecole Doctorale Mobility grant for the same.

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

8. Partnerships and Cooperations

8.1. Regional Initiatives

8.1.1. *Competitiveness cluster Images-et-Reseaux*

8.1.1.1. EcoCloud

Participant: Jean-Marc Menaud.

The project EcoCloud is a cooperative research project running for 2 years. Three other partners collaborate within the project that is coordinated by the company EasyVirt: the Ascola team and another company Pentasonic. The partners aim at developing an economically-valid and ecologic cloud platform in the context of micro and mono-site data centers (all resources are in the same physical location). A high SLA level must be provided with a specific focus on high availability satisfying strong redundancy and placement constraints.

8.2. National Initiatives

8.2.1. *CominLabs laboratory of excellence*

8.2.1.1. EPOC

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

The project EPOC (Energy Proportional and Opportunistic Computing system) is an (academic) Labex CominLabs 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'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). 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.

8.2.1.2. SecCloud

Participants: Jacques Noyé [coordinator], Florent Marchand de Kerchove de Denterghem, Mario Südholt.

The high-level objective of the 3-year SecCloud (Secure Scripting for the Cloud) project is to enhance the security of devices on which web applications can be downloaded, i.e. to enhance client-side security in the context of the Cloud. In order to do so, the project relies on a language-based approach, focusing on three related issues:

- The definition of security policies for web architectures, especially on the client-side.
- Formally-proven analyses of web programming languages.
- Multi-level enforcement mechanisms for the security policies (based on static and dynamic analysis encompassing application-level and system-level software).

ASCOLA members are mainly interested in JavaScript as a programming language as well as the use of aspects as a seamless path from the definition of security policies and their composition to their implementation.

This year we have investigated how to extend real-world Javascript environments, such as Narcissus in a modular way.

8.2.2. ANR

8.2.2.1. SONGS (ANR/INFRA)

Participants: Adrien Lebre [coordinator], Jonathan Pastor, Anthony Simonet.

The SONGS project (Simulation of Next Generation Systems) is an ANR/INFRA project running for 48 months (starting in January 2012 with an allocated budget of 1.8MEuro, 95KEuro for ASCOLA).

The consortium is composed of 11 academic partners from Nancy (AlGorille, coordinator), Grenoble (MESCAL), Villeurbanne (IN2P3 Computing Center, GRAAL/Avalon - LIP), Bordeaux (CEPAGE, HiePACS, RUNTIME), Strasbourg (ICPS - LSIIT), Nantes (ASCOLA), Nice (MASCOTTE, MODALIS).

The goal of the SONGS project (http://infra-songs.gforge.inria.fr) is to extend the applicability of the SimGrid simulation framework from Grids and Peer-to-Peer systems to Clouds and High Performance Computation systems.

8.2.3. FSN

8.2.3.1. OpenCloudware (FSN)

Participants: Jean-Marc Menaud [coordinator], Thomas Ledoux.

The OpenCloudware project is coordinated by France Telecom, funded by the French Fonds National pour la Société Numérique (FSN, call Cloud n°1) and endorsed by competitiveness clusters Minalogic, Systematic and SCS. OpenCloudware is developed by a consortium of 18 partners bringing together industry and academic leaders, innovative technology start-ups and open source community expertise. The project started in 2012 for a duration of 42 months.

The OpenCloudware project aims at building an open software engineering platform, for the collaborative development of distributed applications to be deployed on multiple Cloud infrastructures. It will be available through a self-service portal. We target virtualized multi-tier applications such as JavaEE - OSGi. The results of OpenCloudware will contain a set of software components to manage the lifecycle of such applications, from modelling(Think), developing and building images (Build), to a multi-IaaS compliant PaaS platform (Run).

The ASCOLA project-team is mainly involved in the sub-projects "Think" (SLA model across Cloud layers) and "Run" (virtual machine manager for datacenters and placement constraints). The team has developed btrCloudStack, a private cloud based on the OpenSource CloudStack and integrating the work on placement rules and energy optimization. This software system has been extended this year.

8.2.3.2. Hosanna (FSN)

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

The Hosanna project (aims to scientifically and technically addresses the problem of deploying applications on a distributed multi-cloud virtual infrastructure (private cloud, Amazon, OVH, CloudWatt, Numergy etc.). This recent need is an important topic issue highlighted by recent major Outages in 2013 by the biggest players in the cloud such as Amazon or Netflix. This project aims to provide services that allow users to deploy their cloud multi-tier applications on hybrid Clouds infrastructures without any separation between IaaS. The Ascola team is extending its optimization solution to address the task placement problem in a multi-cloud environment and will develop a case study on a secure distributed file system. The project started in 2015 for a duration of 2 years.

8.2.4. CPER

8.2.4.1. SeDuCe

Participants: Jean-Marc Menaud [coordinator], Adrien Lebre.

The SeDuCe project (Sustainable Data Centers: Bring Sun, Wind and Cloud Back Together), aims to design an experimental infrastructure dedicated to the study of data centers with low energy footprint. This innovative data center will be the first experimental data center in the world for studying the energy impact of cloud computing and the contribution of renewable energy (solar panels, wind turbines) as well on the scientific, technological, that economical. This project is integrated in the national context of grid computing (Grid'5000), and the Constellation project, which will be an inter-node (Pays de la Loire, Brittany). He also participated in the validation of scientific work in interdisciplinary axis STIC and energy efficiency of the laboratory of excellence COMIN Labs.

8.2.5. *Inria Project Labs*

8.2.5.1. DISCOVERY
Participants: Adrien Lebre [coordinator], Mario Südholt.

To accommodate the ever-increasing demand for Utility Computing (UC) resources, while taking into account both energy and economical issues, the current trend consists in building larger and larger Data Centers in a few strategic locations. Although such an approach enables UC providers to cope with the actual demand while continuing to operate UC resources through centralized software system, it is far from delivering sustainable and efficient UC infrastructures for future needs.

The DISCOVERY initiative [40] aims at exploring a new way of operating Utility Computing (UC) resources by leveraging any facilities available through the Internet in order to deliver widely distributed platforms that can better match the geographical dispersal of users as well as the ever increasing demand. Critical to the emergence of such locality-based UC (LUC) platforms is the availability of appropriate operating mechanisms. The main objective of DISCOVERY is to design, implement, demonstrate and promote the LUC Operating System (OS), a unified system in charge of turning a complex, extremely large-scale and widely distributed infrastructure into a collection of abstracted computing resources which is efficient, reliable, secure and at the same time friendly to operate and use.

The consortium is composed of experts in the following research areas: large-scale infrastructure management systems, networking and P2P algorithms. Moreover, two key network operators, namely Orange and RENATER, are involved in the project.

By deploying and using a LUC Operating System 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.

8.3. European Initiatives

8.3.1. *FP7 & H2020 Projects*

8.3.1.1. ERC Starting Grant: The CoqHoTT project
Participant: Nicolas Tabareau [coordinator].

CoqHoTT stands for Coq for Homotopy Type Theory. The goal of this project is to go further in the correspondence between proofs and programs which has allowed in the last 20 years the development of useful proof assistants, such as Coq (developed by Inria). This project starts from the recent discovery by field medal Vladimir Voevosdky, of the strong link between homotopy theory (which studies the notion of continuous deformation in topology) and type theory (which is at the heart of the Coq proof assistant). The main goal of the CoqHoTT project is to provide a new generation of proof assistants based on this fascinating connection.

The CoqHoTT project has started in June 2015 with a budget of 1,5M€.

8.3.1.2. A4Cloud (IP)

Participants: Mario Südholt [coordinator], Walid Benghabrit, Ronan-Alexandre Cherrueau, Rémi Douence, Hervé Grall, Jean-Claude Royer.

The integrated project "Accountability for the Cloud" (A4Cloud) is coordinated by HP Labs, UK, and fosters cooperation of a consortium of five industrial and eight academic partners. It has been started in Oct. 2012 for a duration of 42 months.

A4Cloud focuses on accountability properties for the cloud and other future internet services as the most critical prerequisite for effective governance and control of corporate and private data processed by cloud-based IT services. The research being conducted in the project will increase trust in cloud computing by devising methods and tools, through which cloud stakeholders can be made accountable for the privacy and confidentiality of information held in the cloud. These methods and tools will combine risk analysis, policy enforcement, monitoring and compliance auditing. They will contribute to the governance of cloud activities, providing transparency and assisting legal, regulatory and socio-economic policy enforcement. For further information, see http://www.a4cloud.eu. ASCOLA, whose financial support consists of 550 K€, is mainly involved in the sub-projects on the enforcement of accountability and security policies, as well as tool validation efforts.

This year we have proposed new logic-based and language-level means for the formal specification and implementation of accountability properties and have proposed a new composition approach for distributed systems that enforces privacy-properties through statically-verified types (see 6.3).

8.3.1.3. BigStorage (MSCA-ETN)

Participants: Adrien Lebre [coordinator], Linh-Thuy Nguyen, Mario Südholt.

BigStorage is a European Training Network (ETN) whose main goal is to 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.

Nowadays there is a lack of professionals who know how to deal with storage, management and analysis of Big Data. Indeed, there is a gap between infrastructures for dealing with Big Data and applications using these volumes of data. In 2011, the McKinsey Global Institute published a study that found that, by 2018, there could be a shortage of up to 190,000 data scientists in the United States, representing a 50 percent to 60 percent gap between supply and demand. Similarly, European officials estimate that 300,000 data scientists will be needed in Europe in the forthcoming years. Other reports, such as those from PRACE and ETP4HPC, have also emphasized the need of skills in HPC, Cloud, Storage, Energy, or Big Data to maintain Europe's economy. In this context, a major goal of this project is to bring a substantial contribution to the training process of these future experts.

Within this project, ASCOLA leads the WP 3 that deals with the convergence between HPC and Cloud storage backends.

8.3.1.4. GRACeFUl (FETPROACT)

Participant: Rémi Douence [coordinator].

The GRACeFUl project is coordinated by Universitat Politecnica de Catalunya, Spain, and fosters cooperation of a consortium of two institutes and five academic partners. It has been started in Feb. 2015 for a duration of 36 months. For information, see https://www.graceful-project.eu.

Global Systems Science is a FET Proactive initiative under Horizon 2020 that seeks to improve the way scientific knowledge can help inform and evaluate policy and societal responses to global challenges like climate change and global financial crises.

The GRACeFUL project strives for a base for domain-specific languages aimed at building scalable rapid assessment tools for collective policy making in global systems. It involves several different disciplines. ASCOLA is involved in WP5 in order to provide expertise in functional programming . In this context Rémi Douence codirects the PhD thesis of Ekaterina Arafailova. This work has already produced a generalization of automata-based constraints [12].

8.4. International Initiatives

8.4.1. Inria Associate Teams

8.4.1.1. REAL

Title: Reasoning about Effects in Aspect Languages

International Partner (Institution - Laboratory - Researcher):

Universidad de Chile (CHILI)

Duration: 2010 - 2015

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

During the period 2013-2015, REAL has studied means to reason about aspect interference, providing foundations for secure aspects, and the link of secure aspects with security aspects. This last year has been devoted to developing a general mechanism for modular composition of session types, applying our ideas on modular instrumentation of interpreters to Narcissus and information flow analyses, and exploring ideas for future collaboration, in particular in the area of gradual certification.

8.4.2. Inria International Partners

8.4.2.1. Informal International Partners

Apart from the Inria associate team rapids with the Pleiad group (Prof. Éric Tanter) at U. Chile, the Ascola team has formalized cooperations, notably in the context of co-financed and co-supervised PhD theses with the PROG group (Prof. Wofgang de Meuter) at VU Brussel, Belgium, and the Software Technology group (Prof. Mira Mezini) at TU Darmstadt, Germany.

Furthermore, the Ascola team has long-term cooperations that resulted in common results in 2015, typically joint publications or common software artifacts, with partners from the AIST research institute (Dr. Takahiro Hirofuchi) and U. of Bogota, Colombia (Prof. Rubby Casallas).

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

9. Partnerships and Cooperations

9.1. National Initiatives

9.1.1. FUI

Program: FUI - AAP 15

Project acronym: MoNoGe

Project title: Atelier de Modélisation de Nouvelle Génération

Duration: 2013 - 2016

Coordinator: Softeam

Other partners: Industry (DCNS), Research and University (ARMINES AtlanMod, LIP6) and Vendors and service providers (Softeam, Soft-Maint, Mia-Software)

Abstract: There is currently in companies a wide diversity of models and modeling tools according to the application domains, services or contexts which are concerned. This implies different problems forbidding their plain exploitation: traceability, global coherence, continuity between works, knowledge management, etc. All are largely penalized by this situation that harms the mastering of the complexity of the related systems and software. The MoNoGe project has for objective to bring innovative solutions allowing to ensure the agility of the models and modeling tools. The term agility is here referring to the properties of interoperability, extensibility and evolution of models. The dynamic extension mechanism to be developed in MoNoGe, potentially inspiring from the OMG MEF standard currently under definition, is intended to preserve the original metamodel which can be conserved, partially hidden or extended. Thus, the legacy data and models can stay operational with the extended metamodel. The user does not have to deal with heavy migration or conversion operations, and can this way focus on its modeling activities while continuously exploiting past models. Our focus within the project is on defining conceptually such a (meta)model extension solution and proposing an implementing prototype based on Eclipse/EMF. To this intent, we are already studying the potential reuse (and improvement) of our EMF Views prototype in this given context.

Program: FUI - AAP 13

Project acronym: TEAP

Project title: TOGAF Entreprise Architecture Platform

Duration: 2012 - 2014

Coordinator: Obeo

Other partners: Industry (DCNS), Research and University (Inria AtlanMod) and Vendors and service providers (Obeo, Capgemini)

Abstract: The fast evolution of technologies (SOA, Cloud, mobile environments), the systems complexity and the growing need for agility require to be able to represent information systems as a whole. The high-level approach promoted by Enterprise Architecture (EA) is a key element in this context and intends to address all the systems dimensions: software components, associated physical resources, relationships with the companies requirements and business processes, implied actors/roles/structures, etc. The objective of the TEAP project was to specify and implement an EA platform based on the Open Group international standard named TOGAF and on the SmartEA technical solution. In addition to its base modeling capabilities, this platform now allows data federation from different existing sources (e.g. for reverse engineering purposes such as retro-cartography) as well as the definition of possible transformation chains (for governance and modernization). As part of this project, we have been notably using in practice (and improving accordingly) some of our works and corresponding prototypes such as EMF Views, ATL or some MoDisco components.

Program: FUI - AAP 13

Project acronym: ITM Factory

Project title: Information Technology Modernisation Factory

Duration: 04/2012 - 10/2014

Coordinator: Soft-Maint (Groupe SODIFRANCE)

Other partners: Mia-Software (Groupe SODIFRANCE), ACAPNOS, MMA and Inria AtlanMod.

Abstract: Application maintenance represents about 80 per cent of the computer market (at the French and global level). The challenge of software maintenance is to keep running applications with technologies that are no longer required to be maintained and with changing development teams and whose skills are not always validated on ancient languages. The main goal of the ITM Factory is to propose a software modernization framework, based on the ModDisco project and including: (i) an integrated workbench for software modernization engineers and (ii) a set of ready to use modernization cartirdges, i.e., a solution brick that meets a business challenge level, as opposed to a technical bricks that provides technical solutions that are integrated into a business solution.

9.2. European Initiatives

9.2.1. FP7 & H2020 Projects

Program: FP7 - COOPERATION (ICT)

Project acronym: MONDO

Project title: Scalable Modelling and Model Management on the Cloud

Duration: November 2013 - May 2016

Coordinator: The Open Group - X/Open Company

Other partners: The Open Group - X/Open Company (United Kingdom), University of York (United Kingdom), Universidad Autonoma de Madrid (Spain), Budapest University of Technology and Economics (Hungary), IKERLAN (Spain), Soft-Maint (France), SoftTeam (France), UNINOVA (Portugal)

Abstract: As Model Driven Engineering (MDE) is increasingly applied to larger and more complex systems, the current generation of modelling and model management technologies are being pushed to their limits in terms of capacity and efficiency, and as such, additional research is imperative in order to enable MDE to remain relevant with industrial practice and continue delivering its widely recognised productivity, quality, and maintainability benefits. The aim of MONDO is to tackle the increasingly important challenge of scalability in MDE in a comprehensive manner. Achieving scalability in modelling and MDE involves being able to construct large models and domain specific languages in a systematic manner, enabling teams of modellers to construct and refine large models in a collaborative manner, advancing the state-of-the-art in model querying and transformations tools so that they can cope with large models (of the scale of millions of model elements), and providing an infrastructure for efficient storage, indexing and retrieval of large models. To address these challenges, MONDO brings together partners with a long track record in performing internationally-leading research on software modelling and MDE, and delivering research results in the form of robust, widely-used and sustainable open-source software, with industrial partners active in the fields of reverse engineering and systems integration, and a global consortium including more than 400 organisations from all sectors of IT.

Program: FP7 - Research For SMEs

Project acronym: AutoMobile

Project title: Automated Mobile App Development Type: Research For SMEs

Duration: November 2013 - October 2015

Coordinator: WebRatio s.r.l. (Italy)

Other partners: Politecnico di Milano (Italy), AtlanMod-Armines, Moon Submarine (UK), Forward-Software (Rumania).

Abstract: The AutoMobile project aims at designing and bringing to the market innovative methodologies, software tools, and vertical applications for the cost-effective implementation of cross-platform, multi-device mobile applications, i.e. business applications that can be accessed by users on a variety of devices and operating systems, including PC, cellular / smart phones and tablets. Cross-platform and multi-device design, implementation and deployment is a barrier for today's IT solution providers, especially SME providers, due to the high cost and technical complexity of targeting development to a wide spectrum of devices, which differ in format, interaction paradigm, and software architecture. AutoMobile will exploit the modern paradigm of Model-Driven Engineering and code generation to dramatically simplify multi-device development, reducing substantially cost and development times, so as to increase the profit of SME solution providers and at the same time reduce the price and total cost of ownership for end-customers. AutoMobile will rely on modeling languages such as IFML (Interaction Flow Modeling Languages) and on tools like WebRatio.

9.3. International Initiatives

9.3.1. Inria International Partners

9.3.1.1. Informal International Partners

The six main research partners of the team are:

- Politecnico di Milano (Italy) - DB Group, especially Marco Brambilla
- TU Wien (Austria) - BiG Group, especially Manuel Wimmer
- Politecnica de Catalunya (Spain) - GESSI Group, especially Xavier Franch
- Universitat Poliècnica de València (Spain) - ISSI Group, especially José H. Canós
- ICREA (Spain)- SOM Group, especially Jordi Cabot
- National Institute of Informatics in Tokyo - BiG group, especially Soichiro Hidaka

9.4. International Research Visitors

9.4.1. Visits of International Scientists

- In March, Soichiro Hidaka, from the National Institute of Informatics (NII) in Tokyo, Japan, visited AtlanModels for one month, in the frame of a collaboration on bidirectionalization of model-transformation languages.

CIDRE Project-Team

9. Partnerships and Cooperations

9.1. Regional Initiatives

- **Région Bretagne ARED grant:** the PhD of Regina Marin on privacy protection in distributed social networks (defended in Sep 2015) was supported by a grant from the Région Bretagne.

- **Labex COMINLAB contract (2012-2015): "POSEIDON" -** http://www.poseidon.cominlabs.ueb.eu/fr/

  POSEIDON deals with the protection of data in outsourced or shared systems such as cloud computing and peer-to-peer networks. While these approaches are very promising solutions to outsourced storage space, contents, data and services, they also raise serious security and privacy issues since users lose their sovereignty on their own data, services and systems. Instead of trying to prevent the bad effects of the cloud and of peer-to-peer systems, the main objective of the POSEIDON project is to turn benefit from their main characteristics (distribution, decentralization, multiple authorities, etc.) to improve the security and the privacy of the users' data, contents and services.

  This project is conducted in cooperation with Télécom Bretagne and Université de Rennes I. The PhD of Julien Lolive (co-supervised by Sébastien Gambs and Caroline Fontaine), which deals with the entwining of identification and privacy mechanisms, is funded by the POSEIDON project. The postdoctoral research of Wei Pan (co-supervised by Gouenou Coatrieux and Nicolas Prigent) that deals with a distributed system to ensure patients' privacy in the context of medical imaging is also funded by this project.

  POSEIDON will be over at the end of this year. It has received very positive feedback during the COMINLAB review meeting.

- **Labex COMINLAB contract (2012-2015): "SecCloud" -** http://www.seccloud.cominlabs.ueb.eu

  Nowadays attacks targeting the end-user and especially its web browser constitute a major threat. Indeed web browsers complexity has been continuously increasing leading to a very large attack surface. Among all possible threats, we tackle in the context of the SecCloud project those induced by client-side code execution (for example javascript, flash or HTML5).

  Existing security mechanisms such as OS-level access control often only rely on users identity to enforce the security policy. Such mechanisms are not sufficient to prevent client-side browser attacks as the web browser is granted the same privileges as the user. Consequently, a malicious code can perform every actions that are allowed to the user. For instance, it can read and leak user private data (credit cart numbers, registered passwords, email contacts, etc.) or download and install malware.

  One possible approach to deal with such threats is to monitor information flows within the web browser in order to enforce a security information flow policy. Such a policy should allow to define fine-grained information flow rules between user data and distant web sites.

  Dynamically monitoring information flow at the web browser level may dramatically impact runtime performances of executed codes. Consequently, an important aspect of this work will be to benefit as far as possible from static analysis of application code. This static-dynamic hydride approach should reduce the number of verifications performed at run time.

  This study is conducted in cooperation with other Inria Teams (Ascola and Celtique). Deepak Subramanian is doing his PhD in the context of this project.

- **Labex COMINLAB contract (2013-2018): "DeSceNt" - http://www.descent.cominlabs.ueb.eu**

  In DeSceNt, we propose to investigate how decentralized home-based networks of plug computers can support personal clouds according to sound architectural principles, mechanisms, and programming abstractions. To fulfill this vision we see three core scientific challenges, which we think must be overcome. The first challenge, decentralized churn-poor design, arises from the nature of plug federations, which show much lower levels of churn than traditional peer-to-peer environments. The second challenge, quasi-causal consistency, is caused by the simultaneous needs to produce a highly scalable environment (potentially numbering millions of users), that also offers collaborative editing capabilities of mutable data-structures (to offer rich social interactions). The third and final challenge, intuitive data structures for plug programming, arises from the need by programmers for intuitive and readily reusable data-structures to rapidly construct rich and robust decentralized personal cloud applications.

  This study is conducted in cooperation with other teams (GDD Team (University of Nantes), Inria team ASAP)

- **Labex COMINLAB 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, it this dataset, all malware are entirely manually reverse and documented. We have also developed an analysis platform. This platform is currently under private deployment.

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

  The general context of the HardBlare project is to address Dynamic Information Flow Control 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 DIFC operations are delegated to a coprocessor. Nevertheless, such approaches are based on modified processors. Beyond the fact hardware-assisted DIFC is hardly adopted, existing works do not take care of coprocessor security and multicore/multiprocessor embedded systems.

  We plan to implement DIFC 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 DIFC using static analysis performed at compile-time. Another objective is to manage labels for persistent memory (*i.e., files*) using a modified OS kernel.

9.2. National Initiatives

9.2.1. ANR

- **ANR INS Project: AMORES (2011-2015) - http://amores-project.org/**

  Situated in the mobiquitous context characterized by a high mobility of individuals, most of them wearing devices capable of geolocation (smartphones or GPS-equipped cars), the AMORES project is built around three use-cases related to mobility, namely (1) dynamic carpooling, (2) real-time computation of multi-modal transportation itineraries and (3) mobile social networking. For these three use cases, the main objective of the AMORES project is to define and develop geo-communication primitives at the middleware level that can offer the required geo-located services, while at the same time preserving the privacy of users, in particular with respect to their location (notion of geo-privacy). Within this context, we study in particular the problem of anonymous routing and the design of a key generation protocol tied to a particular geographical location. Each of these services can only work through cooperation of the different entities composing the mobile network. Therefore, we also work on the development of mechanisms encouraging entities to cooperate together in a privacy-preserving manner. The envisioned approach consists in the definition of generic primitives such as the management of trust and the incentive to cooperation. This project is joint between the Université de Rennes I, Supélec, LAAS-CNRS, Mobigis and Tisséo. The research project AMORES received the Innovation Award at the Toulouse Space Show in June 2013. Simon Boche and Paul Lajoie-Mazenc are doing their PhD in the context of this project. Paul has defended successfully his thesis in September [13] just after the final closing workshop of the project (http://www.irisa.fr/prive/sgambs/journee_AMORES.html).

- **ANR INS Project: LYRICS (2011-2015) - http://projet.lyrics.orange-labs.fr/**

  With the fast emergence of the contactless technology such as NFC, mobile phones will soon be able to play the role of e-tickets, credit cards, transit pass, loyalty cards, access control badges, e-voting tokens, e-cash wallets, etc. In such a context, protecting the privacy of an individual becomes a particularly challenging task, especially when this individual is engaged during her daily life in contactless services that may be associated with his identity. If an unauthorized entity is technically able to follow all the digital traces left behind during these interactions then that third party could efficiently build a complete profile of this individual, thus causing a privacy breach. Most importantly, this entity can freely use this information for some undesired or fraudulent purposes ranging from targeted spam to identity theft. The objective of LYRICS (ANR INS 2011) is to enable end users to securely access and operate contactless services in a privacy-preserving manner that is, without having to disclose their identity or any other unnecessary information related to personal data. Within this project, we work mainly on the privacy analysis of the risks incurred by users of mobile contactless services as well as on the development of the architecture enabling the development of privacy-preserving mobile contactless services. The project is joint between France Télécom, Atos Wordline, CryptoExperts, ENSI Bourges, ENSI Caen, MoDyCo, Oberthur Technologies, NEC Corporation, Microsoft and Université de Rennes I.

  The project was originally suppose to end in 2014 but an extension was granted until May 2015. The final closing workshop of the project was held during this month (http://www.irisa.fr/prive/sgambs/journees_LYRICS.html). The project has finished to develop a first prototype that illustrates how can be used privacy preserving protocols for the transport use case. The prototype implements a transportation pass (similar to the Navigo pass) embedded in the SIM card. This transport pass can be interact with a gate at the entrance of the transportation network in order to check the validity of the pass and answers wirelessly, in less than 300ms, without revealing any information about the user. This result has been presented in "Salon Cartes 2012". During the last year of the project, the partners of the LYRICS projects have also worked on two new use cases and their corresponding prototypes: digital surveys and e-cash solutions that respect the privacy of users. The outcomes of the project have been presented at the RESSI conference [49].

- **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 of 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.

9.2.2. Inria Project Labs

- **CAPPRIS (2012-2016)**

  CAPPRIS stands for "Collaborative Action on the Protection of Privacy Rights in the Information Society". The main objective of CAPPRIS is to tackle the privacy challenges raised by the most recent developments and usages of information technologies such as profiling, data mining, social networking, location-based services or pervasive computing by developing solutions to enhance the protection of privacy in the Information Society. To solve this generic objective, the project focuses in particular on the following fundamental issues:

  - The design of appropriate metrics to assess and quantify privacy, primarily by extending and integrating the various possible definitions existing for the generic privacy properties such as anonymity, pseudonymity, unlinkability and unobservability, as well as notions coming from information theory or databases such as the recent but promising concept of differential privacy;
  - The definition and the understanding of the fundamental principles underlying "privacy by design", with the hope of deriving practical guidelines to implement notions such as data minimization, proportionality, purpose specification, usage limitation, data sovereignty and accountability directly in the formal specifications of our information systems;
  - The integration between the legal and social dimensions, intensely necessary since the developed privacy concepts, although they may rely on computational techniques, must be in adequacy with the applicable law (even in its heterogeneous and dynamic nature). In particular, privacy-preserving technologies cannot be considered efficient as long as they are not properly understood, accepted and trusted by the general public, an outcome which cannot be achieved by the means of a mathematical proof.

  Three major application domains have been identified as interesting experimentation fields for this work: online social networks, location-based services and electronic health record systems. Each of these three domains brings specific privacy-related issues. The aim of the collaboration is to apply the techniques developed to the application domains in a way that promotes the notion of privacy by design, instead of simply considering them as a form of privacy add-ons on the top of already existing technologies. CAPPRIS is a joint project between Inria, LAAS-CNRS, Université de Rennes I, Supélec, Université de Namur, Eurecom, and Université de Versailles.

  In addition of the scientific advances in the field of privacy, members of CAPPRIS are actively involved in the animation and federation of the French community on privacy, through the APVP workshop but also interdisciplinary colloquiums. For instance at the end of November, Sébastien Gambs was co-organizer with Daniel Le Métayer of a joint French-Canadian workshop titled "La vie privée à travers les cultures. Convergences et divergences dans un monde globalisé" (http://www.centrejacquescartier.com/les-entretiens/entretiens-2015lescolloques/3-la-vie-privee-a-travers-les-cultures-convergences-et-divergences-dans-un-monde-globalise/) that had approximately 80 attendees coming either from a law or computer science background.

9.2.3. Competitivity Clusters

The AMORES project (ANR INS 2011, http://www.images-et-reseaux.com/en/content/amores) is recognized by the Images & Réseaux cluster.

9.3. European Initiatives

9.3.1. FP7 & H2020 Projects

The **PANOPTESEC** project (http://www.panoptesec.eu) started on the 1st of November 2013. It deals with the automated and assisted security management of IT and SCADA system. The main objective of PANOPTESEC is to provide an integrated solution that will allow to efficiently monitor SCADA systems, detect intrusions and react to them. To that end, it encompasses many of the research topics that are addressed by the CIDRE team: alerts aggregation and correlation, policy-aware intrusion detection, architecture-aware intrusion detection, automated trust management, trust-based automated reaction and visualization.

The CIDRE team is involved in the project on all of these aspects. The partners are:

- REHA (BE),
- Alcatel-Lucent Bell Labs France (FR),
- Epistematica (IT),
- The University of Rome (IT),
- the University of Hamburg (GE),
- the Institut Mines-Telecom (FR),
- ACEA (IT),
- CentraleSupélec (FR).

This year, our work focused on design and implementation. Most of our work focused on WP5 and WP6, that deal with the IDS event correlation system and the visualization system. Two prototypes have been produced and a publication was made to VizSec 2015. Next year, we will be entering in the integration phase.

9.4. International Initiatives

9.4.1. Inria International Partners

9.4.1.1. 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 two conference publications in 2015, one in DEBS [44] and the other one in SRDS [29]. Emmanuelle Anceaume is actively working with James Aspens from Yale University, USA, on population protocols. Their collaboration gave rise to one article published in NCA [43]. Emmanuelle Anceaume is actively working with Ernst Schulte-Geers from the Federal Office for Information Security, Germany. Their collaboration gave rise to one publication in the Journal of Applied Probability [15].

Since several years, Michel Hurfin works with Professor Yun Wang (Southeast University, Nanjing, China). Their joint work focuses on convergence and synchronization problems in unreliable distributed systems prone to byzantine failures [42].

Following the Inria explorer visit of last year, Sébastien Gambs is actively working with Stan Matwin from Dalhousie University (Canada) on the sanitization of location data through non-interactive differentially-private methods, which has lead to a first publication on this subject [26].

9.5. International Research Visitors

9.5.1. Visits of International Scientists

9.5.1.1. Internships

> Sackmann Mario Julián
>> Date: Sep 2014 - Jan 2015
>> Institution: Universidad de Buenos Aires (Argentina)
>> Supervisor: Guillaume Piolle

9.5.2. Visits to International Teams

9.5.2.1. Research stays abroad

Thanks to the support of CentraleSupélec, Christophe Bidan has joined the ETS (École Supérieure de Technologie) of Montréal from july 2014 to july 2015 for working with Prof. Jean-Marc Robert. This stay results from a collaboration that has been initiated 2 years ago when Prof. Jean-Marc Robert has spent 4 months (from september to december 2012) in the CIDRE research group. The conducted research has focused on the use of secure multi-party computation to ensure privacy. Specifically, under the co-supervision of Aurélien Dupin, master student at ETS, we focused on the use of secure multi-party computation to provide proof of localization while ensuring privacy of the participants. An article is being written, and a co-supervised thesis should begin shortly.

From September 2014 to May 2015, Antoine Guellier has joined the "Securing Cyberspace" team leaded by Prof. Batten, at Deakin University (Melbourne, Australia). This stay is possible thanks to the international outgoing fellowships of Rennes Métropole and of the UEB (Université Européenne de Bretagne). This doctoral mobility was the opportunity to start a collaboration with personnel from Deakin University, as well as Radboud University (The Netherlands). Research outputs include a paper submitted to the SPT-IOT workshop (IEEE PERCOM venue). Additionally, by participating in the life of the laboratory and in several academic and information security events based in Melbourne, Antoine Guellier was able to build a network abroad. Through discussion and interactions, he was able to confront the contributions in his thesis with people of different horizons, and start new ones.

In March 2015, Deepak Subramanian has joined, as a Visiting Scholar, the "Faculty of Engineering Science" at KU Leuven in Belgian. During this stay, Deepak Subramanian worked on the topic of WebRTC security analysis with Prof. Frank Piessens, Willem De Greof, and Dr. Lieven Desmet. The objectives was to perform a practical analysis of the current WebRTC framework with the motivation of identifying the various shortcomings. The initial results showed that WebRTC is quite robust and built on strong foundations (based on legacy protocols that also form the foundations of the SIP telephony stack). However, the study also showed that some key modules were made optional in the draft and the implementations are quite ambiguous presently. These results were resumed in a paper that has been submitted and accepted to the ACM SEC@SAC 2016.

<div align="center">

DIONYSOS Project-Team

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8. Partnerships and Cooperations

8.1. National Initiatives

8.1.1. ANR

- Adlen Ksentini 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.

8.2. European Initiatives

8.2.1. 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 (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.

8.2.2. QuEEN project

Program: CELTIC

Project acronym: QuEEN

Project title: Quality of Experience Estimators in Networks

Duration: October 2011 - January 2015

Coordinator: Orange Labs

Other partners: 24 partners in many European partners

Abstract: QuEEN was a large 3-year Celtic project going from end 2011 to January 2015. The project's outputs include the development of automatic QoE measurement modules for Web services and applications, and the organization of these measurement modules as a network of cooperative agents in order to allow each agent to take advantage of the measurements done by the others. Dionysos was involved in most of the activities of the project, and QuEEN partners have benefit from our experience in developing the PSQA technology. QuEEN involved many companies and academic institutions (24 European partners); the project leader was Orange Labs, in Sophia Antipolis.

For more details, visit http://celtic-queen.inria.fr/dokuwiki/doku.php?id=start

8.2.3. Collaborations with Major European Organizations

Partner 1: FTW, Vienna (Austria)

We work with FTW on network economics.

8.3. International Initiatives

8.3.1. CIRIC

In the context of CIRIC, we cooperate with the team of Reinaldo Vallejos, professor at the UTFSM, Valparaíso, Chile, on different topics related to networking and modeling issues. Specifically, these activities have been organized around two collaborative projects, 8.3.2 and 8.3.4.1 below, where one can find the scientific details. We start to work also with Javiera Barrera's team at the University Adolfo Ibañez, Santiago de Chile, on stochastic optimization problems.

CIRIC stopped its activities in some whole areas such as telecommunications, but our cooperative work continues without interruption.

Inria Chile
Associate Team involved in the International Lab:

8.3.2. MANAP

Title: MANAP (Markovian ANalysis and APplications)

International Partner (Institution - Laboratory - Researcher):

Universidad Tecnica Federico Santa Maria (Chile) - Telematics - Vallejos Reinaldo

Start year: 2013

See also: http://people.rennes.inria.fr/Gerardo.Rubino/RESEARCH/MANAP/manap.html

This project had two goals. The main one was to develop techniques allowing to accelerate solving techniques for Markov models, both in equilibrium and in their transient phases. The applications behind these efforts are the evaluation of performance, dependability and performability properties of complex communication systems. The second goal was to apply these solving techniques to specific problems in networking, concerning optical and wireless infrastructures. On both cases there was some emphasis on dependability aspects: fault tolerance routing schemes in the first case, complex dependability characteristics and their analysis in the second one. A third explicit objective was to start the design of a software tool implementing the techniques coming from the main research direction of the project, designed to be used both by engineers and researchers.

We achieved some of these objectives, which made us decide to interrupt the associate team and to study the idea of proposing a new one at the end of 2016 or 2017 (see 8.3.4.1). A supplementary reason to do so is to rebuild some structure like MANAP but in a three-country scheme, including a group in Uruguay with which we worked during all MANAP's life.

8.3.3. Inria International Partners

8.3.3.1. MOCQUASIN

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

International Partner (Institution - Laboratory - Researcher):

University of Montreal (Canada)

Duration: 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 could require a very long time. In this case, there are two main acceleration techniques: importance sampling and splitting, on which we work.

8.3.3.2. Informal International Partners

We restarted the cooperation of G. Rubino with the Cal Poly at Pomona, California, specifically with professor Alan Krinik, Head of the Mathematics Department. The topic is the transient analysis of stochastic processes. See [69] and [68], and the description made in 6.2 , page 6.2 .

8.3.4. Participation in other International Programs

8.3.4.1. Stic AmSud with UDELAR, Uruguay, and UTFSM, Chile

Program: Stic AmSud

Title: Dependability Analysis Tool (DAT)

Inria principal investigator: Gerardo Rubino

International Partners (Institution - Laboratory - Researcher):

University of the Republic (UDELAR), Montevideo, Uruguay – Computer Science at the Engineering Faculty – prof. Héctor Cancela

Technical University Federico Santa María (UTFSM), Valparaíso, Chile – Electronics Department – Prof. Reinaldo Vallejos

Duration: 2 years, Jan. 2015 – Dec. 2016

The main scientific objective of this project is to develop new techniques to assess the most important dependability properties of a complex system subject to the failures and possible repairs of its components. The central argument behind our proposal is our previous work in the area and some unpublished preliminary and promising results that we believe deserve deep exploration and that should lead to faster evaluation procedures than those available today. This constitute the main achievements of the associated team MANAP (see 8.3.2). We also intend to implement these techniques in an integrated software package usable both in industry and for teaching purposes. Concerning applications, again based on the skills of the participating teams and our past common work, we will illustrate our findings on problems coming from the wireless and optical networking domains.

8.4. International Research Visitors

8.4.1. Visits of International Scientists

8.4.1.1. Academic visitors

Reinaldo Vallejos, full professor

Date: 5/9/15 – 24/9/15

Institution: UTFSM, Valparaíso, Chile

Marta Barría, full professor

Date: 5/9/15 – 24/9/15

Institution: University of Valparaíso, Chile

Héctor Cancela, full professor

Date: 9/9/15 – 18/9/15

Institution: UDELAR, Uruguay

Jorge Graneri, assistant professor

Date: 15/11/15 – 15/1/16

Institution: Institution: UDELAR, Uruguay

Leslie Murray, assistant professor

Date: 21/11/15 – 11/12/15

Institution: University of Rosario, Argentina

DIVERSE Project-Team

9. Partnerships and Cooperations

9.1. National Initiatives

9.1.1. ANR

9.1.1.1. GEMOC

- Coordinator: Inria (DIVERSE)
- Other partners: ENSTA Bretagne, Inria, IRIT, I3S, Obeo, Thales
- Dates: 2012-2016
- Abstract: GEMOC focuses on a generic framework for heterogeneous software model execution and dynamic analysis. This work has the ambition to propose an innovative environment for the design of complex software-intensive systems by providing: a formal framework that integrates state-of-the-art in model-driven engineering (MDE) to build domain-specific modeling languages (DSMLs), and models of computation (MoC) to reason over the composition of heterogeneous concerns; an open-source design and modeling environment associated to a well-defined method for the definition of DSMLs, MoCs and rigorous composition of all concerns for execution and analysis purposes.

  This requires addressing two major scientific issues: the design and verification of a formal framework to combine several different DSMLs relying on distinct MoCs; the design and validation of a methodology for DSMLs and MoC development. GEMOC aims at participating in the development of next generation MDE environments through a rigorous, tool-supported process for the definition of executable DSMLs and the simulation of heterogeneous models.

9.1.1.2. INFRA-JVM

- Coordinator: Université Paris 6
- Other partners: Université Bordeaux 1, Université Rennes 1 (DIVERSE), Ecole des Mines de Nantes
- Dates: 2012-2015
- Abstract: INFRA-JVM is an ANR project whose goal is to design and provide a new Java Virtual Machine dedicated to pervasive environments. This project focuses on designing a Java Virtual Machine for embedded computing platform offering dynamic reconfiguration capabilities. In this context, DIVERSEaddresses the problem of efficiently identifying faulty software components running simultaneously in a virtual machine without isolation. Current solutions that perform permanent and extensive monitoring to detect anomalies induce very high overhead on the system, and can, by themselves, make the system unstable. Our main objective is to investigate an optimistic adaptive monitoring system using models@runtime to determine the faulty components of an application.

9.1.1.3. 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.

9.1.2. BGLE / LEOC

9.1.2.1. CONNEXION

- Coordinator: EDF
- Other partners: Atos WorldGrid, Rolls-Royce Civil Nuclear, Corys TESS, Esterel Technologies, All4Tec, Predict, CEA, Inria, CNRS / CRAN, ENS Cachan, LIG, Telecom ParisTech
- Dates: 2012-2016
- Abstract: The cluster CONNEXION (*digital command CONntrol for Nuclear EXport and renovatION*) aims to propose and validate an innovative architecture platforms suitable control systems for nuclear power plants in France and abroad. In this project the Triskell team investigates methods and tools to (i) automatically analyze and compare regulatory requirements evolutions and geographical differences; (ii) automatically generate test cases for critical interactive systems.

9.1.2.2. 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).

9.1.2.3. 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.

9.1.3. DGA

9.1.3.1. MOTIV

- Coordinator: InPixal
- Other partners: Bertin, DGA, Inria
- Dates: 2012-2014

- Abstract: This project investigates innovative software test generation and management solutions to handle the very high degrees of variability in video processing algorithmic chains. The objective is to provide systematic criteria to qualify the testing activity when developing video processing software and to tailor these criteria to the variability dimensions that emerge in the context of visible images.

9.1.3.2. FPML

- Coordinator: DGA
- Partners: DGA MI, Inria
- Dates: 2014-2016
- 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.

9.2. European Initiatives

9.2.1. FP7 & H2020 Projects

9.2.1.1. FP7 FET STREP DIVERSIFY

- Coordinator: Inria (DIVERSE)
- Partners: SINTEF, Université de Rennes 1, Trinity College Dublin, Inria (DiverSE, SPIRALS)
- Dates: 2013-2016
- Abstract: DIVERSIFY explores diversity as the foundation for a novel software design principle and increased adaptive capacities in CASs. Higher levels of diversity in the system provide a pool of software solutions that can eventually be used to adapt to unforeseen situations at design time. The scientific development of DIVERSIFY is based on a strong analogy with ecological systems, biodiversity, and evolutionary ecology. DIVERSIFY brings together researchers from the domains of software-intensive distributed systems and ecology in order to translate ecological concepts and processes into software design principles.

9.2.1.2. FP7 STREP HEADS

- Coordinator: SINTEF
- Other partners: Inria, Software AG, ATC, Tellu, eZmonitoring
- Dates: 2013-2016
- 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.

9.2.2. Collaborations in European Programs, except FP7 & H2020

9.2.2.1. ICT COST Action MPM4CPS (IC1404)

- Chair of the Action: Prof Hans Vangheluwe (BE)
- Dates: 2014-2018

- Abstract: Truly complex, designed systems, known as Cyber Physical Systems (CPS), are emerging that integrate physical, software, and network aspects. To date, no unifying theory nor systematic design methods, techniques and tools exist for such systems. Individual (mechanical, electrical, network or software) engineering disciplines only offer partial solutions. Multi-paradigm Modelling (MPM) proposes to model every part and aspect of a system explicitly, at the most appropriate level(s) of abstraction, using the most appropriate modelling formalism(s). Modelling languages' engineering, including model transformation, and the study of their semantics, are used to realize MPM. MPM is seen as an effective answer to the challenges of designing CPS. This COST Action promotes the sharing of foundations, techniques and tools, and provide educational resources, to both academia and industry. This is achieved by bringing together and disseminating knowledge and experiments on CPS problems and MPM solutions. Benoit Combemale is a member of the management committee.

9.2.2.2. ITEA MERGE

- Coordinator: Thales Research and Technology
- Other partners: Thales Global Services, Thales Communications and Security, OBEO, ALL4TEC, Onera, Inria, Université Paris VI, Codenomicon, STUK - Radiation and Nuclear Safety Authority, POHTOnSense Oy, University of Oulu, University of Jyvaskyla, Space Applications Services NV, Melexis, E2S, Katholieke Universiteit Leuven
- Dates: 2012-2015
- Abstract: MERgE stands for "Multi-Concerns Interactions System Engineering". Within the "Engineering support" theme of ITEA2 roadmap, the purpose of this project is to develop and demonstrate innovative concepts and design tools addressing in combination the "Safety" and "Security" concerns, targeting the elaboration of effective architectural solutions. MERgE will provide tools and solutions for combining safety and security concerns in systems development in a holistic way. It will provide academically solid and practice proven solutions and models for system developers and system owners to tackle the challenges of designing seamless optimal cost effective safe and secure solutions conformant to the model driven engineering paradigm. This will be done by tightly integrating the following paradigms: requirement engineering, safety, security and risk management in an over-all design process which is supported by adequate tools and methods. MERgE aims to bring a system engineering solution for Combined Safe & Secure system design. The main technical innovation of the project is the application of state of the art design tools tailorisation capabilities and "multi concern engineering" core technologies to the issue of interactions of "Safety" and "Security" concerns as well as other concerns like "Performance" or "Timing" in the design process.

9.2.3. Collaborations with Major European Organizations

SINTEF, ICT (Norway): Model-driven systems development for the construction of distributed, heterogeneous applications. We collaborate since 2008 and are currently in two FP7 projects together.

Université du Luxembourg, (Luxembourg): Models@runtime for dynamic adaptation and multi-objective elasticity in cloud management; model-driven development.

Open University (UK): models@runtime for the Internet of Things.

9.3. International Initiatives

9.3.1. Inria International Partners

9.3.1.1. Declared Inria International Partners

9.3.1.1.1. Inria International Chair

Prof. Robert B. France [0] was granted by an Inria international chair for the period 2013-2017. Prof. France collaborate intensively with many members of DIVERSE on various joint work, e.g., the Familiar project and the GEMOC initiative. The Inria International Chair allows Prof. France to visit once a year the team along the period.

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[0] Colorado State University, USA. See. http://www.cs.colostate.edu/~france/

9.3.1.2. Informal International Partners

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

9.3.2. 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

- Prof. Jörg Kienzle from McGill University (Canada) has been in the DIVERSE team during his Sabbatical from September 2015 to December 2015.
- Prof. Betty H.C. Cheng from Michigan State University (USA) visited the DIVERSE team in December 2015.
- Dr. Franck Fleurey from Sintef visited the DIVERSE team two weeks the team in July and November 2015.

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

9. Partnerships and Cooperations

9.1. National Initiatives

9.1.1. ANR

OverFlow (2015–2019). 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. Ultimately, OverFlow will propose a new, pioneering paradigm: Workflow Data Management as a Service — a general and easy-to-use, cloud-provided service that bridges for the first time the gap between single- and multi-site workflow data management. It aims to reap economic benefits from the geo-diversity while accelerating the scientific discovery through a democratization of access to globally distributed data. Within this project, A. Costan is jointly working with Kate Keahey (University of Chicago and Argonne National Laboratory), Bogdan Nicolae (IBM Research) and Christophe Blanchet (Institut Français de Bioinformatique).

9.1.2. Other National Projects

DISCOVERY (2015–2019). An Inria Project Lab, led by Adrien Lebre (ASCOLA), that aims at exploring a new way of operating Utility Computing (UC) resources by leveraging any facilities available through the Internet in order to deliver widely distributed platforms that can better match the geographical dispersal of users as well as the unending demand. Project-teams: ASAP, ASCOLA, Avalon, Myriads, and KerData. Within DISCOVERY, S. Ibrahim (KerData Inria Team) is working with Gilles Fedak (Avalon Inria Project-Team) to address the VM images management challenge.

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

9.2. European Initiatives

9.2.1. FP7 and H2020 Projects

9.2.1.1. BigStorage

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

Program: H2020

Duration: January 2015–January 2019

Coordinator: Universidad politecnica de Madrid

Participants:

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

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

Inria contact: Gabriel Antoniu and Adrien Lèbre

BigStorage is a European Training Network (ETN) whose main goal is to 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. The KerData team will be hosting 2 Early Stage Researchers in this framework.

9.3. International Initiatives

9.3.1. Inria International Labs

9.3.1.1. 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. It has ben created in 2014 as a follow-up of the Inria-UIUC JLPC — *Joint Laboratory for Petascale Computing* to collaborate on concurrency-optimized I/O for Extreme-scale platforms (see details in Section 7.4). The KerData team is collaborating with teams from ANL and UIUC within this lab since 2009. This collaboration has now been formalized as the *Data@Exascale* Associate Team with ANL and UIUC (2013–2015).

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

Title: Ulta-scalable I/O and storage for Exascale systems

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

Start year: 2013

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

As the computational power used by large-scale scientific applications increases, the amount of data manipulated for subsequent analysis increases as well. Rapidly storing this data, protecting it from loss and analyzing it to understand the results are significant challenges, made more difficult by decades of improvements in computation capabilities that have been unmatched in storage. For many applications, the overall performance and scalability clearly become driven by the performance of the I/O subsystem. As we anticipate Exascale systems in 2020, there is a growing consensus in the scientific community that revolutionary new approaches are needed in computational science storage. These challenges are at the center of the activities of the Joint Inria-Illinois-ANL-BSC-JSC-RIKEN/AICS Laboratory for Extreme-Scale Computing (JLESC, formerly called JLPC). This project gathers researchers from Inria, Argonne National Lab and the University of Illinois at Urbana Champaign to address 3 goals: 1) investigate new storage architectures for Exascale systems; 2) investigate new approaches to the design of I/O middleware for Exascale systems to optimize data processing and visualization, leveraging dedicated I/O cores and I/O forwarding techniques; 3) explore techniques enabling adaptive cloud data services for HPC.

9.3.2. Inria International Partners

9.3.2.1. DataCloud@work

Title: DataCloud@Work — Distributed data management for cloud services

International Partner: Politehnica University of Bucharest (Romania) — Computer Science and Engineering Department — Valentin Cristea and Nicolae Tapus

Start year: January 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

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.

9.4. International Research Visitors

9.4.1. Visits of International Scientists

9.4.1.1. Research stays abroad

Luis Eduardo Pineda Morales: Research visit at ANL, hosted by Kate Keahey and Balaji Subramaniam for 3 months (June–August), funded by the PUF NextGen peoject and by the Microsoft Research Inria Joint Centre project. This work is done in the context of the Joint Laboratory for Extreme-Scale Computing (JLESC).

Orçun Yildiz Research visit at ANL, hosted by Rob Rossa and Matthieu Dorier for 3 months, funded by the PUF NextGen project and by the Data@Exascale Associate Team. This work is done in the context of the Joint Laboratory for Extreme-Scale Computing (JLESC).

<div align="center" style="color:red">

MYRIADS Project-Team

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9. Partnerships and Cooperations

9.1. Regional Initiatives

9.1.1. *Security Monitoring of Clouds, collaboration with DGA-MI in the framework of the Cybersecurity Pole of Excellence (2014-2018)*

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

Our study 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.

9.1.2. *CominLabs EPOC project (2013-2016)*

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.

9.1.3. *EcoPaaS, Brittany region SAD project(2014-2015)*

Participants: Maria Del Mar Callau Zori, Anne-Cécile Orgerie, Guillaume Pierre.

Many research efforts have been dedicated to reducing cloud energy consumption, in particular by optimizing the Infrastructure-as-a-Service layer of the Cloud. Infrastructure-as-a-Service (IaaS) is the layer in charge of the virtualization of physical resources, and therefore has direct control over energy-related elements. However, the IaaS layer has no knowledge about the nature of applications which run over these resources, which limits the scope of decisions it can take.

The EcoPaaS project therefore aim at making the IaaS layer (in charge of resources) and the PaaS layer (in charge of applications) collaborate to further reduce the Cloud energy consumption. The idea is to define standard interfaces that allow both layers to exchange relevant information and to coordinate their actions. Exchanging information will for example allow the PaaS layer to estimate the energy consumption of each application it is running. Coordinating actions will in turn allow the system to avoid situations where both layers simultaneously take mutually-damaging actions. This project has been funding Maria del Mar Callau-Zori's postdoc.

9.1.4. IRT B-Com

Participants: Yvon Jégou, Edouard Outin, Jean-Louis Pazat.

Yvon Jégou and Jean-Louis Pazat are at IRT B-Com [0] one day per week. With Édouard Outin, B-com PhD student, they contribute to the B-Com *Indeed* project, which aims at developing a distributed cloud software stack with a high degree of adaptability.

In the last period, they were involved in the elaboration of new projects in the Cloud Computing lab of B-Com.

9.2. National Initiatives

9.2.1. Inria ADT GinFlow (2014-2016)

Participants: Christine Morin, Javier Rojas Balderrama, Matthieu Simonin, Cédric Tedeschi.

The GinFlow technological development action funded by INRIA targets the development of a fully-operational workflow management system based on the HOCL-TS software prototype developed during the PhD thesis of Héctor Fernandez between 2009 and 2012. Also, it allows the integration of this software with the TIGRES workflow engine developed at the Lawrence Berkeley National Lab so as to make the workflows submitted using the TIGRES programming model run in a decentralized fashion. These developments led to the release of the GinFlow software and its deposit at the APP (Agence de Protection des Programmes).

9.2.2. Inria IPL Discovery (2015-2019)

Participants: Anne-Cécile Orgerie, 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. An energy/cost benefit analysis of the fully distributed Discovery architecture will also be performed to show the energy efficiency of the chosen approach.

9.2.3. Inria IPL CityLab (2015-2018)

Participant: Christine Morin.

The Inria Project Lab (IPL) CityLab@Inria (https://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 2015, Christine Morin contributed to the preparation of the MOOC entitled *Villes Intelligentes : défis technologiques et sociétaux* (Smart cities : technological and social challenges) to be run on the FUN platform starting in January 2016. She prepared eight sequences on urban data management in clouds.

9.2.4. MIHMES ANR Investissements d'Avenir (2012 - 2018)

Participants: Yvon Jégou, Christine Morin.

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[0] http://b-com.org/wp/

The MIMHES project (http://www.inra.fr/mihmes) led by INRA/BioEpAR aims at producing scientific knowledge and methods for the management of endemic infectious animal diseases and veterinary public health risks. Myriads team will provide software tools to efficiently manage and ease the use of a distributed computing infrastructure for the execution of different simulation applications.

In 2015, we developed a distributed framework which allows do exploit multiple compute servers in parallel. Parallelism is exploited both at server level using OpenMP and at data-center level using this framework. To facilitate the deployment of the workloads on heterogeneous environments, this framework limits the requirements concerning the server configurations. They need not share any file system, the workloads can be programmed in differing programming language. These servers need only the capability to communicate through the network. The system allows to dynamically add and stop servers. To some extend, it is tolerant to server failures. A first version is available since summer 2015. The framework is currently being repackaged to facilitate its reuse for new workloads.

9.2.5. 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 multicriteria scheduling for large-scale HPC environments.

9.2.6. CNRS GDS EcoInfo

Participant: Anne-Cécile Orgerie.

The EcoInfo group deals with reducing environmental and societal impacts of Information and Communications Technologies from hardware to software aspects. This group aims at providing critical studies, lifecycle analyses and best practices in order to improve the energy efficiency of printers, servers, data centers, and any ICT equipment in use in public research organizations.

9.3. European Initiatives

9.3.1. FP7 & H2020 Projects

9.3.1.1. Fed4FIRE

Participants: Julien Lefeuvre, David Margery.

> Type: FP7
>
> Defi: Future internet experimental facility and experimentally-driven research
>
> Instrument: Integrated Project
>
> Objectif: ICT-2011.1.6 Future Internet Research and Experimentation (FIRE) with a specific focus on b) FIRE Federation
>
> Duration: October 2012 - September 2016
>
> Coordinator:Interdisciplinary institute for broadband technology (iMinds, Belgium)
>
> Partners: Interdisciplinary institute for broadband technology (iMinds, Belgium), University of Southampton (It Innovation, United Kingdom) Universite Pierre et Marie Curie - paris 6 (UPMC, France) Fraunhofer-Gesellschaft zur Foerderung der Angewandten Forschung e.v (Fraunhofer, Germany) Technische Universitat Berlin (TUB, Germany) The University of Edinburgh (UEDIN, United Kingdom) National Ict Australia Limited (NICTA, Australia) Atos Spain SA (Atos, Spain) Panepistimio Thessalias (University of Thessaly) (UTH, Greece) National Technical University of Athens (NTUA, Greece) University of Bristol (UNIVBRIS, United Kingdom) Fundacio Privada i2cat, Internet I Innovacio Digital a Catalunya (i2cat, Spain) Eurescom-European Institute for Research and Strategic Studies in Telecommunications (EUR, Gmbh Germany) Delivery of Advanced Network Technology to Europe limited (DANTE limited, United Kingdom) Universidad de Cantabria (UC, Spain) National Information Society agency (NIA, Korea (republic of))

Inria contact: David Margery

Abstract: In Fed4FIRE, we investigate the means by which our experimental platforms (BonFIRE, and in a secondary way Grid'5000) could be made interoperable with a wider eco-system of experimental platforms in Europe and beyond. The baseline architectural choice for this project is to use the key concepts of the Slice Federation Architecture (SFA) to provision resources on experimental platforms, a Control and Management Framework for Networking Testbeds named OMF for experiment control and OML, the OMF Measurement library for data collection. We investigate whether these can be used to run experiments on BonFIRE and how they need to be extended to support the operating model of BonFIRE or Grid'5000.

9.3.1.2. HARNESS

Participants: Ancuta Iordache, Guillaume Pierre, Damian Serrano, Genc Tato, Georgios Ioannidis, Guillaume Pierre.

Type: COOPERATION

Defi: Pervasive and Trusted Network and Service Infrastructures

Instrument: Small or medium-scale focused research project

Objectif: ICT-2011.1.2 Cloud Computing, Internet of Services and Advanced Software Engineering

Duration: October 2012 - September 2015

Coordinator: Imperial College London (IMP, United Kingdom)

Partner: Ecole polytechnique fédérale de Lausanne (EPFL, Switzerland), Université de Rennes 1 (UR1, France), Konrad-Zuse-Zentrum für Informationtechniek Berlin (ZIB, Germany), Maxeler Technologies (MAX, United Kingdom), SAP AG (SAP, Germany)

UR1 contact: Guillaume Pierre

Abstract: The HARNESS FP7 project aims to incorporate innovative hardware and network technologies seamlessly into data centres that provide platform-as-a-service cloud infrastructures.

The dominant approach in offering cloud services today is based on homogeneous commodity resources: large numbers of inexpensive machines, interconnected by off-the-shelf networking equipment, supported by stock disk drives. However, cloud service providers are unable to use this platform to satisfy the requirements of many important and high-value classes of applications.

Today's cloud platforms are missing out on the revolution in new hardware and network technologies for realising vastly richer computational, communication, and storage resources. Technologies such as Field Programmable Gate Arrays (FPGA), General-Purpose Graphics Processing Units (GPGPU), programmable network routers, and solid-state disks promise increased performance, reduced energy consumption, and lower cost profiles. However, their heterogeneity and complexity makes integrating them into the standard Platform as a Service (PaaS) framework a fundamental challenge.

The HARNESS project brings innovative and heterogeneous resources into cloud platforms through a rich programme of research, validated by commercial and open source case studies.

9.3.1.3. PaaSage

Participants: Christine Morin, Nikolaos Parlavantzas, Aboozar Rajabi, Arnab Sinha.

Type: COOPERATION

Objectif: ICT-2011.1.2 Cloud Computing, Internet of Services and Advanced Software Engineering

Instrument: Collaborative Project

Duration: October 2012 - September 2016

Coordinator: GEIE ERCIM (France)

Partner: SINTEF (Norway), Science and Technology Facilities Council (UK), University of Stuttgart (Germany), Inria (France), Centre d'Excellence en Technologies de l'Information et de la Communication (Belgium), Foundation for Research and Technology Hellas (Greece), BE.Wan SPRL (Belgium), EVRY AS (Norway), SysFera SAS (France), Flexiant Limited (UK), Lufthansa Systems AG (Germany), Gesellschaft fur Wissenschaftliche Datenverarbeitung MBH Gottingen (Germany), Automotive Simulation Center Stuttgart (Germany), University of Ulm (Germany), Akademia Górniczo-Hutnicza im. Stanislawa Staszica (Poland), University of Cyprus (Cyprus), IBSAC-Intelligent Business Solutions ltd (Cyprus), University of Oslo (Norway)

Inria contact: Nikolaos Parlavantzas

See also: http://www.paasage.eu/

Currently there exist several open source and commercial services at the Infrastructure as a Service (IaaS) level. Software developers targeting the cloud would ideally want to develop their software once and be able to deploy it on any of the available services, reaping the benefits of a cloud market without losing on performance, availability, or any other service properties. The impediment to this objective is that IaaS platforms are heterogeneous, and the services and APIs that they provide are not standardized. Porting an existing application to one of these platforms or switching between platforms is thus a challenging task and involves a high risk that the results do not meet the expected requirements.

PaaSage delivers a development and deployment platform, with an accompanying methodology, with which developers of enterprise systems can access services of cloud platforms in a technology neutral approach while guiding developers to configure their applications for best performance. The consortium brings together ERCIM for management and STFC as scientific coordinator together with experts in different aspects of clouds ranging from software and services (SINTEF), High Performance Computing (HLRS) and systems development environments (Inria) to a group of SMEs working on cloud systems and end-user organisations with requirements in the cloud domain.

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: Professor Jesus Carretero, University Carlos III of Madrid, Spain, http://www.nesus.eu

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

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

9.3.2.2. MC-DATA

Participants: Teodor Crivat, Guillaume Pierre.

Program: EIT Digital

Project acronym: MC-DATA

Project title: Multi-cloud data management

Duration: Jan-Dec 2015

Coordinator: Dr. Peter Pietzuch, Imperial College London

Other partners: SICS, U-Hopper, VTT, Proxible.

Abstract: The goal of this activity is to increase developer uptake and commercial exploitation of the previously-developed MC-ConPaaS mobile edge cloud platform through new products in the area of location-based advertising services. The activity will (a) integrate MC-ConPaaS with the Android mobile platform to encourage mobile developer adoption; (b) pilot a location-based interactive advertising service with augmented reality and 3D tracking; (c) commercialise the pilot, demonstrating the business value of a mobile edge cloud model; and (d) model and shape the ecosystem of mobile edge cloud services, enabling new revenue streams for mobile operators.

9.4. International Initiatives

9.4.1. *Inria International Labs*

Christine Morin contributed to the edition of the 2011-2014 activity report of the Inria@SiliconValley Inria International Lab (https://project.inria.fr/siliconvalley/files/2015/06/Inria@SV_Activity_Report_2011_2014. pdf).

Christine Morin was one of the co-organizers of the BIS 2015 workshop held in Berkeley in May 2015 in the framework of the Inria@Silicon Valley Inria International Lab. Deb Agarwal co-chaired the panel on Big Data Science. Christine Morin chaired one of the two keynotes sessions.

9.4.2. *Inria Associate Teams*

9.4.2.1. DALHIS

Participants: Christine Morin, Anne-Cécile Orgerie, Javier Rojas Balderrama, Matthieu Simonin, Arnab Sinha, Cédric Tedeschi.

Title: Data Analysis on Large Heterogeneous Infrastructures for Science

International Partner (Institution - Laboratory - Researcher):

Lawrence Berkeley National Laboratory, Berkeley, USA

Data Science and Technology department

French PI: Christine Morin

American PI: Deb Agarwal, head of the Data Science and Technology department

Duration: 2013 - 2015

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

The worldwide scientific community is generating large datasets at increasing rates causing data analysis to emerge as one of the primary modes of science. Existing data analysis methods, tools and infrastructure are often difficult to use and unable to handle the "data deluge". A scientific data analysis environment needs to address three key challenges: a) programmability: easily composable and reusable programming environments for analysis algorithms and pipeline execution, b) agility: software that can adapt quickly to changing demands and resources, and, c) scalability: take advantage of all available resource environments including desktops, clusters, grids, clouds and HPC environments. The goal of the DALHIS associated team is to coordinate research and create together a software ecosystem to facilitate data analysis seamlessly across desktops, HPC and cloud

environments. Specifically, our end goal is to build a dynamic environment that is user-friendly, scalable, energy-efficient and fault tolerant through coordination of existing projects. We plan to design a programming environment for scientific data analysis workflows that will allow users to easily compose their workflows in a programming environment such as Python and execute them on diverse high-performance computing (HPC) and cloud resources. We will develop an orchestration layer for coordinating resource and application characteristics. The adaptation model will use real-time data mining to support elasticity, fault-tolerance, energy efficiency and provenance. We investigate how to provide execution environments that allow users to seamlessly execute their dynamic data analysis workflows in various research environments.

The work done in 2015 on scientific workflows and energy efficiency is described respectively in 7.6.1 and 7.4.2 .

The recent results of the DALHIS associate team were presented by Lavanya Ramakrishnan from LBNL during the working session on Scientific and Large Scale Computing. Christine Morin, Anne-Cécile Orgerie and Deb Agarwal participated in the BIS 2015 workshop held in Berkeley in May 2015.

Deb Agarwal has been awarded an Inria International Chair for the 2015-2019 period enabling long visits in the Myriads team. She was hosted in Myriads team during 2.5 months from May 1st to July 10th 2015. During this visit, we initiated the work on the design of a mobile application for reliable field data collection for FluxNet. Critical to the interpretation of global Fluxnet carbon flux dataset is the ancillary information and measurements taken at the measurement tower sites (e.g. vegetation species, leaf area index, instrument calibrations, etc). The submission and update of this data using excel sheets is difficult and error prone. In 2015, the team developed some initial sketches of the User Interface design for a mobile application for the reliable collection of FluxNet data and Arnab Sinha, Deb Agarwal, and Christine Morin performed an initial usability feedback interview with Chris Flechard (INRA Rennes), a CarboEurope participant who collects carbon flux data at several sites in Brittany. M. Sandesh (LBL) simultaneously performed a couple of usability interviews at Berkeley. We updated the design based on the combined feedback. Currently, the mobile application prototype development is in progress. The design was presented by Dario Papale at the ICOS meeting in September 2015. The expectation is that the design will be adopted by ICOS (European flux towers) and AmeriFlux (flux towers in the Americas). A first basic working demonstration prototype has been developed.

9.4.3. Inria International Partners

Northeastern University   We started a collaboration with Professor Gene Cooperman, Northeastern University, Boston, USA on the design of a cloud agnostic checkpointing service on top of IaaS clouds for reliable application execution, inter-cloud application migration and easing application "cloudification". Gene Cooperman was hosted in Myriads team during a week in June 2015.

ORNL/TTU   We collaborate on cloud computing with Stephen Scott, Professor at Tennessee Tech University (TTU) and researcher at Oak Ridge National Laboratory (ORNL) in the USA. He participated in Anna Giannakou's mid-PhD thesis defense in October 2015.

University of Guadalajara   Nikolaos Parlavantzas is collaborating with the team of Prof. Héctor Duran-Limon of the University of Guadalajara, Mexico, on adaptive resource management in cloud environments.

VU University Amsterdam   We collaborate with Thilo Kielmann's research group at VU University Amsterdam on research and development around the ConPaaS system. This collaboration has lead to a joint publication this year [24].

EPFL   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. This collaboration has been supported thanks to the extended visit of Georgios Ioannidis in Rennes in the context of the HARNESS project, and it is expected to continue after the end of HARNESS. At least one joint publication on this topic is currently in preparation.

9.5. International Research Visitors

9.5.1. *Visits of International Scientists*

Gene Cooperman, Professor at the Northeastern University (Boston, USA), made a one-week visit in Myriads team in June 2015.

Georgios Ioannidis (PhD student at EPFL, Switzerland) made a 7-months visit in the Myriads team (Jun-Dec 2015). The goal was to reinforce the collaboration between the two teams in the context of the HARNESS FP7 project.

Carlos Ruiz Diaz (PhD student at the University of Guadalajara, Mexico) is visiting Myriads for 6 months (Sep 2015-Feb 2016) in the context of his PhD thesis, directed by Héctor Duran-Limon and co-advised by Nikolaos Parlavantzas. The visit is supported by a grant from Rennes Metropole.

Palakiyem Wallah, assistant professor at the University of Kara (Togo) visited Myriads team from September to December 2015 in the framework of his PhD thesis, which is co-advised by Cédric Tedeschi and Jean-Louis Pazat.

Anita Sobe, post-doctoral researcher at the University of Neuchâtel (Switzerland) visited Myriads team for two weeks in April 2015 in the context of the Nesus COST Action. During her stay, she has worked with Anne-Cécile Orgerie and their work has been accepted in the PDP 2016 conference.

9.5.1.1. Internships

Philippe Fabian (M1 Université Rennes 1) did his internship of first year of Master under the supervision of Marin Bertier and Cédric Tedeschi. Philippe devised and tested in a simulator heuristics for speeding-up the execution of chemical programs on top of an unstructured decentralized platform.

Timothée Haudebourg (L3 ENS Rennes) has done a two-month internship (June - July 2015) under the supervision of Anne-Cécile Orgerie. He has worked on quantifying the energy-efficiency of green leverages in wired networks.

David Guyon (M2 Université Rennes 1) has done his master internship under the supervision of Anne-Cécile Orgerie and Christine Morin. He has worked on energy-efficient cloud elasticity for data-driven applications. He has presented this work at the IEEE GreenCom conference (December 2015).

Ghada Moualla (M2 Université Rennes 1) has done his master internship under the supervision of Christine Morin and Matthieu Simonin. She has worked on reliable and efficient data processing in a cloud environment.

Akshat Puri (M2, EIT ICT Labs, Université Rennes 1) has done his internship under the supervision of Nikolaos Parlavantzas and Guillaume Pierre. He worked on elasticity of cloud applications and approaches for application migration across different cloud vendors.

Benjamin Soulas (M2 Université Rennes 1) did its internship of second year of Master under the supervision of Matthieu Simonin and Cédric Tedeschi. Benjamin developed the *Storm Watcher* prototype, a tool exposing monitoring information about the execution of programs running within the Storm framework.

9.5.1.2. Research stays abroad

Following a first visit which took place in 2014, Ancuta Iordache visited Maxeler Technologies (London, U.K.) again from February 2015 to April 2015. This visit reinforced the collaboration between the two teams in the context of the HARNESS E.U. project, and was funded by the EIT Digital Doctoral Training Center. A concrete outcome of this visit is a joint research paper which is currently under evaluation.

Ismael Cuadrado Cordero, who is a student of the EIT ICT Labs Doctoral School, visited the Queen Mary University of London (UK) for a research internship from June to August 2015. He was hosted in Chris Phillip's team working on micro-clouds architectures for neighborhood services. A joint research paper is currently under review on this topic.

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

7. Partnerships and Cooperations

7.1. National Initiatives

7.1.1. Pervasive_RFID

- Partner: IETR
- Starting: July 2013; ending: July 2016

Pervasive_RFID is a joint effort (within the CominLabs initiative, see http://www.cominlabs.ueb.eu/) started in July 2013 with IETR (institut d'électronique et de télécommunications de Rennes) to study and design innovative RFID reading protocols in the context of pervasive computing applications. Some limitations of existing RFID technology become challenging: unlike standard RFID application scenarios, pervasive computing often involves uncontrolled environment for RFID, where tags and reader have to operate in much more difficult situations that those usually encountered or expected for classical RFID systems.

7.1.2. GLIE - Guidage Lumineux par l'Intelligence de l'Environnement

- Partner: OyaLight
- Starting: December 2014; ending: April 2016

GLIE is a collaborative projet with OYALIGT and TACOMA group. The objective of the project is to design and demonstrate a new service combining connected LEDs provided by OYALIGHT and a software tool developed by TACOMA. By integrating and analyzing data transmitted by the sensors integrated into LEDs, the service must be able to detect a given context and to react accordingly.

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

9. Partnerships and Cooperations

9.1. National Initiatives

9.1.1. PEPS: Pharmaco-epidemiology for Health Products

Participants: Thomas Guyet, René Quiniou, Véronique Masson, Alexandre Termier.

The PEPS project (Pharmaco-epidemiology des Produits de Santé) is funded by 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 (3.6M€).

The PEPS project has two parts: the clinical studies and a research program dedicated to the development of innovative tools for pharmaco-epidemiological studies with medico-administrative databases. The pharmaco-epidemiology is the study of the uses, the effectiveness and the effects of health products (especially drugs) for the patients in a real live context, on a large population. Using medico-administrative databases – that contains information about the reimbursement of the medication, the medical visits and the cares – is a recent approach to enable studies on large cohortes and to reduce the response time to a pharmaco-epidemiology question.

Our contribution to this project will be the proposal of pattern mining algorithms and reasoning techniques to analyze typical care pathways of specific groups of insured patients.

9.2. International Initiatives

9.2.1. Inria International Partners

9.2.1.1. Informal International Partners

9.2.1.1.1. University of Calgary: Monitoring cattle in big herds with multiple sensors
Participant: René Quiniou.

The state of Alberta produces a significant part of the beef meat in Canada. Big farms feeds up around 40.000 bull calves in feedlots grouping 200-300 animals. Diseases such as Bovine Respiratory Diseases (BRD) are frequent and may propagate quickly in such conditions. So, it is important to detect as soon as possible when an animal is sick. We are collaborating with the Department of Production Animal Health, University of Calgary for designing monitoring systems able to generate early alarms when an animal is sick. Precisely, we are studying the properties of new sensors and their aptitude to provide relevant data for BRD detectors.

9.2.1.1.2. University of Potsdam: preferences in mining with ASP
Participant: Thomas Guyet.

The research group "knowledge processing and information systems" of the University of Potsdam, so called Potascco group, develops a collection of tools and programs for Answer Set Programming such as the `clingo` solver or the ASPRIN system, developed by J. Romero to handle preferences on ASP models. They have strong expertise in problem encoding with ASP. In addition to T. Schaub Inria position, we initiate some collaborations with other members of the Potascco group in order to strengthen our relationships. T. Guyet and J. Romero worked together on using preferences to select best sequential patterns with ASP (see section 7.2.4) using the ASPRIN system. T. Guyet visited the Potascco group in may 2015.

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

9. Partnerships and Cooperations

9.1. Regional Initiatives

9.1.1. 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 - IRISA/Inria, Hycomes - IRISA/Inria. 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.

9.1.2. Labex HEMISFER

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

HEMISFER is a 3-year project (2013-2016) funded by Labex CominLabs. It involves 4 Inria/IRISA teams (Hybrid, Visages (lead), Panama, Athena) and 2 medical centers: the Rennes Psychiatric Hospital (CHGR) and the Reeducation Department of Rennes Hospital (CHU Pontchaillou). The goal of HEMISFER is to make full use of neurofeedback paradigm in the context of rehabilitation and psychiatric disorders. The major breakthrough will come from the use of a coupling model associating functional and metabolic information from Magnetic Resonance Imaging (fMRI) to Electro-encephalography (EEG) to "enhance" the neurofeedback protocol. Clinical applications concern motor, neurological and psychiatric disorders (stroke, attention-deficit disorder, treatment-resistant mood disorders, etc).

9.1.3. Labex SABRE

Participants: Anatole Lécuyer [contact], Jussi Lindgren, Nataliya Kosmina.

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 functionnalities 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.

9.1.4. 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 collaborate with b<>com within two 3-year projects: ImData (on "Immersive Interaction") and GestChir (on "Augmented Healthcare").

9.1.5. CNPAO Project

Participants: Valérie Gouranton [contact], Jean-Baptiste Barreau, Quentin Petit.

CNPAO ("Conservatoire Numérique du Patrimoine Archéologique de l'Ouest") is an on-going research project partially funded by the Université Européenne de Bretagne (UEB). 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.

9.1.6. *Imag'In CNRS IRMA*

Participants: Bruno Arnaldi, Jean-Baptiste Barreau, Valérie Gouranton [contact].

The IRMA project is an Imag'In project directly funded by CNRS which aims at developping innovative methodologies for research in the field of cultural heritage based on a combination of medical imaging technologies and methods of interactive 3D modalities (virtual reality, augmented reality, haptic, additive manufacturing). These tools are based on recent research results from a close collaboration between Hybrid team with the National Institute of Preventive Archaeological Research (Inrap), the Research Center Archaeology, and History Archéosciences (CReAAH UMR 6566) and the company Image ET, and are intended for cultural heritage professionals such as museums, curators, restorers, and archaeologists. The innovative methodologies proposed in the project gave rise to a real interest in the archaeological community. We worked on a large number of archeological artefacts (15), of different nature, composition and/or fabrication on various time period (Paleolithic, Mesolithic, and Iron Age Medieval) from all over France. We mention in particular: the oldest human bones found in Brittany (clavicle Beg Er Vil), a bone-made flute outcome of an archeo-musicology study conducted at the University of Burgundy, a cremation of the late First Iron Age Guipry (35), metal and organic furniture from the chariot burial of Warcq (08) (horses harnessed skull, char tiller, buckets), a Bronze Cauldron from a burial of the Merovingian necropolis Crassés Saint-Dizier (51). This work involves a strong collaboration with Ronan Gaugne (IMMERSIA), Théophane Nicolas (INRAP), and Grégor Marchand (CReAAH).

9.2. National Initiatives

9.2.1. *ANR MANDARIN*

Participants: Merwan Achibet, Adrien Girard, Anatole Lécuyer, Maud Marchal [contact].

MANDARIN ("MANipulation Dextre hAptique pour opéRations INdustrielles en RV") is a 4-year ANR project (2012-2015). MANDARIN partners are CEA-List (coordinator), Inria/Hybrid, UTC, Haption and Renault. It aims at designing new hardware and software solutions to achieve natural and intuitive mono and bi-manual dextrous interactions, suitable for virtual environments. The objective of Hybrid in MANDARIN is to design novel multimodal 3D interaction techniques and metaphors allowing to deal with haptic gloves limitations (portability, under-actuation) and to assist the user in virtual reality applications requiring dexterous manipulation. The results will be evaluated with a representative industrial application which is not feasible with currently existing technologies: the bi-manual manipulation of complex rigid objects and cables bundles.

9.2.2. *ANR HOMO-TEXTILUS*

Participants: Anatole Lécuyer [contact], Maud Marchal, Jonathan Mercier-Ganady.

HOMO-TEXTILUS is a 4-year ANR project (2012-2015). Partners of the project are : Inria/Hybrid, CHART, LIP6, TOMORROW LAND, RCP and potential end-user is Hussein Chalayan fashion designer. The objective of HOMO TEXTILUS is to study what could be the next generation of smart and augmented clothes, and their influence and potential impact on behavior and habits of their users. The project is strongly oriented towards human science, with both user studies and sociological studies. The involvement of Hybrid team in the project consists in studying the design of next-gen prototypes of clothes embedding novel kinds of sensors and actuators. Envisionned sensors relate to physiological measurements such as with EEG (electroencephalograpohy and Brain-Computer Interfaces), EMG (muscular activity), GSR (galvanic skin response) or Heart Rate (HR). Envisionned actuators relate to new sensory stimulations such as vibrotactile displays or novel visual (eg LED) displays. These prototypes will thus be used in the various experiments planned in the project.

9.2.3. FUI Previz

Participants: Bruno Arnaldi [contact], Valérie Gouranton [contact], Emmanuel Badier, Thomas Boggini, Rozenn Bouville Berthelot, Cédric Le Cam.

Previz is a 3-year project (2013-2016) funded by the competitive cluster "Images et Réseaux". Previz involves 4 Academic partners (Hybrid/INSA Rennes, ENS Louis-Lumière, LIRIS, Gipsa-Lab) and 9 Industrial partners (Technicolor, Ubisoft, SolidAnim, loumasystem, Polymorph). Previz aims at proposing new previsualization tools for movie directors. The goal of Hybrid in Previz is to introduce new interactions between real and virtual actors so that the actor's actions, no matter his/her real or virtual nature, impact both the real and the virtual environment. The project will end up with a new production pipeline in order to automatically adapt and synchronize the visual effects (VFX), in space and time, to the real performance of an actor.

9.2.4. ADT MAN-IP

Participant: Valérie Gouranton [contact].

The ADT MAN-IP is a 2-year project (2013-2015) funded by Inria for software support and development. MAN-IP involves two Inria teams: Hybrid and MimeTIC. MAN-IP aims at proposing a common software pipeline for both teams to facilitate the production of populated virtual environments. The resulting software should include functionalities for motion capture, automatic aquisition and modification, and high-level authoring tools.

9.2.5. ADT OpenViBE-NT

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

The ADT OpenViBE-NT is a 3-year project (2012-2015) funded by Inria for support and development of the OpenViBE software (section 6.1). OpenViBE-NT involves four Inria teams: Hybrid, Potioc, Athena, Neurosys - all being extensive users of OpenViBE. OpenViBE-NT aims at improving the current functionalities of OpenViBE platform, and helping in supporting its active and ever growing community of users.

9.2.6. Ilab CertiViBE

Participants: Anatole Lécuyer [contact], Jussi Lindgren, Charles Garraud, Jérôme Chabrol.

CertiViBE is a 1-year "Inria Innovation Lab" (2015-2016) 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 wich should comply with medical certification rules.

9.2.7. IPL BCI-LIFT

Participants: Anatole Lécuyer [contact], Jussi Lindgren [contact], Andéol Evain, Lorraine Perronnet, Nataliya Kosmina.

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 sevearl 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.

9.3. 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 - January 2018

Coordinator: CEA

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 contacts: Nicolas Roussel, 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.

9.4. International Research Visitors

9.4.1. *Visits of Scientists*

We have welcomed Dr. Antonio Capobianco from team IGG (Université de Strasbourg) between November 3rd and December 4th, 2015.

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

9. Partnerships and Cooperations

9.1. Regional Initiatives

9.1.1. *HandiViz project - SATT Ouest Valorisation*

Participants: François Pasteau, Marie Babel.

duration: 12 months.

This project started in June 2014. Thanks to a strong collaboration with Ergovie Company and the rehabilitation center Pôle Saint Hélier (Rennes), the semi-autonomous navigation solution designed for wheelchair systems (see Section 7.3.3) has been medically validated and tested by patients. The resulting technology is currently under transfer towards Ergovie (SATT/INSA funding). This technology, compliant with any off-the-shelf electrical wheelchair, is expected to be commercialized at mid 2016. We expect that this technology should be helpful for many handicapped people. In particular, intensive clinical trials have shown that such a system can lift the medical interdiction to drive wheelchairs for people who suffer from severe handicap such as hemispatial neglect or cerebral palsy.

9.1.2. *ARED NavRob*

Participants: Suman Raj Bista, Paolo Robuffo Giordano, François Chaumette.

no Inria Rennes 8033, duration: 36 months.

This project funded by the Brittany council started in October 2013. It supports in part Suman Raj Bista's Ph.D. about visual navigation (see Section 7.3.1).

9.1.3. *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 shearlet transform. (see Section 7.6.5).

9.1.4. *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 7.5.3).

9.1.5. *"Equipement mi-lourd Rennes Metropoles"*

Participant: Paolo Robuffo Giordano.

no Irisa CNRS Rennes 14C0481, duration: 36 months.

A grant from "Rennes Métropole" has been obtained in June 2014 and supports the activities related to the use of drones (quadrotor UAVs). The platform described in Section 6.12 has been purchased in part thanks to this grant.

9.2. National Initiatives

9.2.1. *ANR P2N Nanorobust*

Participants: Le Cui, Eric Marchand.

no. UR1 11FA310-06D, duration: 48 months.

This project started in November 2011 and will end in March 2016. It is composed of a consortium managed by Femto-ST in Besançon with LPN and Isir in Paris, Thalès and Lagadic group through the "Université de Rennes 1". Nanorobust deals with the development of micro- and nano-manipulation within SEM (Scanning Electron Microscope). We provided visual servoing techniques for positioning and manipulation tasks with a micrometer precision.

9.2.2. ANR Contint Visioland

Participants: Noël Mériaux, Patrick Rives, François Chaumette.

no Inria Rennes 8304, duration: 48 months.

This project started in November 2013. It is composed of a consortium managed by Onera in Toulouse with Airbus, Spikenet Technology, IRCCyN, and Lagadic. Its aim is to develop vision-based localization and navigation techniques for autonomous landing on a runway (see Section 7.1.4).

9.2.3. ANR Platinum

Participants: Patrick Rives, Vincent Drevelle.

duration: 42 months.

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

9.2.4. ANR SenseFly

Participants: Paolo Robuffo Giordano, Riccardo Spica, Thomas Bellavoir, Muhammad Usman.

no Irisa CNRS 50476, duration: 36 months.

The ANR "Jeune Chercheur" project SenseFly 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 will be touched by the project. Part of the platforms described in Section 6.12 has been purchased thanks to this grant.

9.2.5. PEA Decsa

Participants: Aurélien Yol, François Chaumette, Eric Marchand.

no Inria Rennes 6630, duration: 36 months.

This project started in November 2011 and ended in November 2015. It was composed of a consortium managed by Astrium/Airbus with the Novadem, Sirehna, Spot Image and Magellium companies, and with the Inria Lagadic and Steep groups (Peter Sturm). It was devoted to the development of navigation and perception algorithms for small drones in urban environment.

9.2.6. Oseo Romeo 2

Participants: Nicolas Cazy, Suman Raj Bista, Fabien Spindler, François Chaumette.

no Inria Rennes 7114, duration: 48 months.

This project started in November 2012. It is composed of a large consortium managed by Aldebaran Robotics. It aims at developing advanced control and perception functionalities to a humanoid robot. It supports in part Suman Raj Bista's Ph.D. about visual navigation (see Section 7.3.1), as well as Nicolas Cazy's Ph.D. about model-based predictive control for visual servoing (see Section 7.2.3).

9.2.7. Equipex Robotex

Participants: Fabien Spindler, François Chaumette.

no Inria Rennes 6388, duration: 10 years.

Lagadic is one of the 15 French partners involved in the Equipex Robotex network. It is devoted to get significative equipments in the main robotics labs in France. In the scope of this project, we have got the humanoid robot Romeo (see Section 6.11).

9.3. European Initiatives

9.3.1. FP7 & H2020 Projects

9.3.1.1. FP7 Space RemoveDEBRIS

Participants: Aurélien Yol, Eric Marchand, François Chaumette.

Instrument: Specific Targeted Research Project

Duration: October 2013 - September 2016

Coordinator: University of Surrey (United Kingdom)

Partners: Surrey Satellite Technology (United Kingdom), Astrium (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. [38]

9.3.1.2. Comanoid

Participants: Paolo Robuffo Giordano, François Chaumette.

Title: Multi-contact Collaborative Humanoids in Aircraft Manufacturing

Programm: H2020

Duration: January 2015 - January 2019

Coordinator: CNRS (Lirmm)

Partners: Airbus Groups (France), DLR (Germany), Universita Degli Studi di Roma La Sapienza (Italy)

Inria contact: François 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 will be 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. Romans

Participants: Paolo Robuffo Giordano, Nicolo Pedemonte, Firas Abi Farraj, François Chaumette.

Title: Robotic Manipulation for Nuclear Sort and Segregation

Programm: H2020

Duration: May 2015 - May 2018

Coordinator: Univ. Birmingham (UK)

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

CNRS contact: Paolo Robuffo Giordano

The RoMaNS project aims at advancing the state of the art in autonomous, tele-operative and shared control for remote manipulation. This has far reaching cross-sector applications in nuclear, aerospace, oil and gas, space, food and agriculture. Within the nuclear industries of multiple EU states, it applies across the entire sector, such as waste processing, decommissioning, asset care, maintenance, repair, characterization and sampling. The novel technology that will be produced within this project will be applied to a very challenging and safety-critical nuclear "sort and segregate" industrial problem, which is driven by urgent market and societal needs. The purpose of nuclear sort and segregate is to place low-level waste in low-level storage containers, rather than occupying extremely expensive and resource intensive higher level storage containers and facilities. Also, Waste Requiring Additional Treatment (WRAT) will be either decontaminated, recycled, compacted, incinerated or grouted. Finally, any unstable waste items are sorted into a more suitable storage state. Indeed, it can be noted that cleaning up the past half century of nuclear waste, in the UK alone (mostly at the Sellafield site), represents one of the largest environmental remediation projects in Europe. Most EU countries have similar challenges. Many older EU nuclear sites (> 60 years in UK) contain large numbers of legacy storage containers, many of which have contents of mixed contamination levels, and sometimes unknown contents. Some of this waste have been temporarily stored in containers, which may need to be disrupted or cut open, to investigate their contents, before sorted and segregated. Any country that possesses a nuclear plant, even without a current backlog of legacy waste, will face similar challenges when they begin decommissioning. Vast quantities of highly contaminated plant machinery and infrastructure will have to be demolished, cut and resized, and the parts sorted and segregated. Much of this work can only be done by remote manipulation methods, because the high levels of radioactive material are hazardous to humans. In this respect, the RoMaNS project will address the following points: (i) development of novel hardware, and improvement the TRL level of existing experimental hardware, to enable robot arms and grippers with advanced capabilities, but which are suitable for deployment in high radiation environments; (ii) development of advanced autonomy methods for highly adaptive and generalizable automatic grasping and manipulation actions; (iii) development of hardware and software solutions for advanced bi-lateral tele-operation of arms and grippers; (iv) combination of autonomy and tele-operation methods using state-of-the-art understanding of mixed initiative planning, variable autonomy and shared control approaches; (v) delivery of a TRL 6 demonstration in an industrial plant-representative environment at the UK National Nuclear Lab Workington test facility, in close proximity to the Sellafield nuclear site.

9.4. International Initiatives

9.4.1. *Inria Associate Teams not involved in an Inria International Labs*

Participants: Marie Babel, Vishnu Karakkat Narayanan.

Sampen (Self Adaptive Mobile Perception and Navigation) is an Inria associated team with the Iceira Lab supervised by Prof Ren C. Luo at the National University of Taiwan. It has been accepted in 2014 for 2 years. The coordinator of the team for Inria is Anne Spalanzani from UPMF University at Grenoble. The other French participants are Marie Babel, Daney David (Phoenix group in Bordeaux) and Christian Laugier (e-Motion group in Grenoble).

The aim of the project is to propose a self-adaptive system of perception combined with a system of autonomous navigation. Usually, systems of perception rely on a set of specific sensors and a calibration is done in a specific environment. We propose to develop some methods to make perception systems adaptive to the environmental context and to the set of sensors used. This perception, that can be embedded on the mobile robot as well as on home structures (wall, ceiling, floor), will be helpful to localize agents (people, robot) present in the scene. Moreover, it will give information to better understand social scenes.

In the scope of this project, Marie Babel and Vishnu Karakkat Narayanan spent a one-week visit in Iceira Lab in April 2015. Vishnu Karakkat Narayanan was then invited to spend a three-month visit from August till November 2015 in that lab.

9.4.2. Inria International Partners

9.4.2.1. Informal International Partners

- As a follow up to the long term collaboration with the "Centro de Tecnologia da Informação Renato Archer" (CTI) in Campinas (Brazil), Renato José Martins benefits a Ph.D. grant from the CNPq (2013-2017). He is co-directed by Patrick Rives and Samuel Siqueira Bueno from "Divisio de Robotica e Viseo Computacional" at CTI.

- Alexandre Krupa has a collaboration with Nassir Navab from the Technische Universität München concerning the joint supervision of Pierre Chatelain's Ph.D.

- Patrick Rives has a collaboration with Javier Gonzales-Jimenez from the University of Malaga (Spain). Eduardo Fernandez-Moral who received his Ph.D. in Malaga by September 2014, is currently on a Postdoctoral position in Sophia Antipolis.

9.4.3. Participation In other International Programs

The Lagadic group is one of the few external partners of the Australian Center for Robotic Vision roboticvision.org. It groups QUT in Brisbane, ANU in Canberra, Monash University and Adelaide University. In the scope of this project, Riccardo Spica spent a six-month visit at ANU collaborating with Prof Rob Mahony, and François Chaumette spend a short visit at QUT and ANU in November 2015.

9.5. International Research Visitors

9.5.1. Research stays abroad

- Pierre Chatelain spent a nine-month visit in Nassir Navab's lab at TUM, Germany, in the scope of his Ph.D. (see Section 9.4.2).

- Ricardo Spica spent a six-month visit in Rob Mahony's lab at ANU, Canbera, in the scope of the Australian Center of Robotic Vision (see Section 9.4.3).

- Vishnu Karakkat Narayanan spent a three-month visit in Ren Luo's lab at Iceira Lab, National Taiwan University, Taiwan, in the scope of his Ph.D as well as the SAMPEN associated team (see Section 9.4.1).

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

8. Partnerships and Cooperations

8.1. Regional Initiatives

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

Participants: Rémi Bois, Vincent Claveau, Guillaume Gravier, Grégoire Jadi, Pascale Sébillot.

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., graph combining edges of different natures, which provides exploitable links in selected use cases? How collections with explicit links modify usage of multimedia data in all aspects, from a technology point of view as well as from a user point of view? LIMAH studies hypergraph authoring and acceptability taking a multidisciplinary approach mixing ICT, law, information and communication science as well as cognitive and ergonomy psychology.

8.2. National Initiatives

8.2.1. *ANR Project FIRE-ID*

Participant: Hervé Jégou.

Duration: 3 years, started in May 2012
Partner: Xerox Research Center Europe

The FIRE-ID project considers the semantic annotation of visual content, such as photos or videos shared on social networks, or images captured by video surveillance devices or scanned documents. More specifically, the project considers the fine-grained recognition problem, where the number of classes is large and where classes are visually similar, for instance animals, products, vehicles or document forms. We also assumed that the amount of annotated data available per class for the learning stage is limited.

8.2.2. *ANR Project Secular*

Participants: Laurent Amsaleg, Teddy Furon, Hervé Jégou, Ewa Kijak.

Duration: 3 years, started in September 2012
Partners: Morpho, Univ. Caen GREYC, Telecom ParisTech

Content-based retrieval systems (CBRS) are becoming the main multimedia security technology to enforce copyright laws or to spot illegal contents over the Internet. However, CBRS were not designed with privacy, confidentiality and security in mind. This comes in serious conflict with their use in these new security-oriented applications. Privacy is endangered due to information leaks when correlating users, queries and the contents stored-in- the-clear in the database. This is especially the case of images containing faces which are so popular in social networks. Biometrics systems have long relied on protection techniques and anonymization processes that have never been used in the context of CBRS. The project seeks to a better understanding of how biometrics related techniques can help increasing the security levels of CBRS while not degrading their performance.

8.2.3. *ANR Project IDFRAud*

Participant: Teddy Furon.

Duration: 3 years, started in Feb. 2015
Partners: AriadNext, IRCGN, École Nationale Supérieure de Police

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

8.2.4. *FUI 19 NexGenTV*

Participants: Vincent Claveau, Guillaume Gravier, Ewa Kijak, Pascale Sébillot.

Duration: 2.5 years, started in May 2015
Partners: Eurecom, Avisto Telecom, Wildmoka, Envivio

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

8.3. International Initiatives

8.3.1. *Inria Associate Teams not involved in an Inria International Labs*

8.3.1.1. *MOTIF*

> Title: Unsupervised motif discovery in multimedia content

> International Partner (Institution - Laboratory - Researcher):

>> Pontifícia Universidade Católica de Minas Gerais, Brasil - VIPLAB - Silvio Jamil Guimãraes

>> Universidade Federal Minas Gerais, Brasil - NPDI - Arnaldo Albuquerque de Araújo

> Duration: 2014 - 2017

> See also: http://www-linkmedia.irisa.fr/motif

> MOTIF aims at studying various approaches to unsupervised motif discovery in multimedia sequences, i.e., to the discovery of repeated sequences with no prior knowledge on the sequences. On the one hand, we will develop symbolic approaches inspired from work on bioinformatics to motif discovery in the multimedia context, investigating symbolic representations of multimedia data and adaptation of existing symbolic motif discovery algorithms. On the other hand, we will further develop cross modal clustering approaches to repeated sequence discovery in video data, building upon previous work.

8.3.2. Inria International Partners

8.3.2.1. Informal International Partners

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

8.3.3. Participation In other International Programs

- PICS CNRS MM-Analytics
    - Title: Fouille, visualisation et exploration multidimensionnelle de contenus multimédia ; Multi-Dimensional Multimedia Browsing, Mining, Analytics (num 6382).
    - International Partner (Institution - Laboratory - Researcher):
        Reykjavík University, Iceland - Björn Þór Jónsson
    - Jan. 2014 – Dec. 2016
- STIC AmSud MAXIMUM Unsupervised Multimedia Content Mining
    - International coordinator: Guillaume Gravier, CNRS – IRISA, France
    - Scientific coordinators : Arnaldo de Albuquerque Araújo (Universidade Federal de Minas Gerais, Computer Science Department, NPDI); Benjamin Bustos (Universidad de Chile, Department of Computer Science, PRISMA); Silvio Jamil F. Guimarães (Pontifícia Universidade Católica de Minas Gerais, VIPLAB)
    - Jan. 2014 - Dec. 2015
- France Berkeley Fund Graph-NN: Computing and Manipulating Very Large Graphs of Nearest Neighbors
    - International coordinator: Laurent Amsaleg, CNRS – IRISA, France
    - Scientific coordinators : Michael Franklin (AMPLab, UC Berkeley)
    - Jun. 2015 - Dec. 2015

8.4. International Research Visitors

8.4.1. Visits of International Scientists

8.4.1.1. Internships

Bùi Văn Thạch (Ph.D. Student)

Date: Oct 2015 - Nov 2015

Institution: National University of Sokendai, Japan

8.4.2. Visits to International Teams

Ahmet Iscen

Date: Apr 2015 - Jun 2015

Institution: McGill University, Montreal, Canada

8.4.2.1. Explorer programme

Balu Raghavendran

Date: Jul 2015 - Sep 2015

Institution: University of California Berkeley (United States of America)

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

9. Partnerships and Cooperations

9.1. National Initiatives

9.1.1. ANR

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

Cinecitta is a 3-year young researcher project funded by the French Research Agency (ANR) lead by Marc Christie. The project started in October 2012 and will end in March 2016. The main objective of Cinecitta is to propose and evaluate a novel workflow which mixes user interaction using motion-tracked cameras and automated computation aspects for interactive virtual cinematography that will better support user creativity. We propose a novel cinematographic workflow that features a dynamic collaboration of a creative human filmmaker with an automated virtual camera planner. We expect the process to enhance the filmmaker's creative potential by enabling very rapid exploration of a wide range of viewpoint suggestions. The process has the potential to enhance the quality and utility of the automated planner's suggestions by adapting and reacting to the creative choices made by the filmmaker. This requires three advances in the field. First, the ability to generate relevant viewpoint suggestions following classical cinematic conventions. The formalization of these conventions in a computationally efficient and expressive model is a challenging task in order to select and propose the user with a relevant subset of viewpoints among millions of possibilities. Second, the ability to analyze data from real movies in order to formalize some elements of cinematographic style and genre. Third, the integration of motion-tracked cameras in the workflow. Motion- tracked cameras represent a great potential for cinematographic content creation. However given that tracking spaces are of limited size, there is a need to provide novel interaction metaphors to ease the process of content creation with tracked cameras. Finally we will gather feedback on our prototype by involving professionals (during dedicated workshops) and will perform user evaluations with students from cinema schools.

9.1.2. National scientific collaborations

9.1.2.1. Cavaletic
Participant: Franck Multon.

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 a metrics to measure the performance of users. It will be used to develop a technological system embedded on users to evaluate his performance and provide him with real-time feedback to correct potential errors.

9.1.3. ADT

9.1.3.1. ManIP
Participants: Franck Multon, Ludovic Hoyet.

The ADT-MAN-IP aims at proposing a common production pipeline for both MimeTIC and Hybrid teams. This pipeline intends to facilitate the production of populated virtual reality environments.

The pipeline starts with the motion capture of an actor, using motion capture devices such as a Vicon (product of Oxford Metrics) system. To do so, we need to design new methods to automatically adapt all motion captures data to an internal skeleton that can be reused to retarget the motion to various types of skeletons and characters. The purpose is then to play this motion capture data on any type of virtual characters used in the demos, regardless their individual skeletons and morphology. The key point here is to make this process be as automatic as possible.

The second step in the pipeline is to design a high level scenario framework to describe a virtual scene and the possible user's interactions with this scene so that he/she can interact with the story directly.

In this ADT we also connect these two opposite parts into a unique framework that can be used by non-experts in computer animation to design new immersive experiments involving autonomous virtual humans. The resulting framework can consequently be used in the Immersia immersive room for various types of application.

9.1.3.2. Immerstar

Participants: Franck Multon, Georges Dumont.

The ADT-Immerstar is drivenby 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 will have to homogeneize the software modules and development facilities in each platform, help installing new upgrades and to develop collaborative applications between the two sites.

9.2. International Initiatives

9.2.1. Inria Associate Teams not involved in an Inria International Labs

9.2.1.1. FORMOSA

Title: Fostering Research on Models for Storytelling Applications

International Partner (Institution - Laboratory - Researcher):

NCCU (Taiwan) - Computer Science Department - Pr. Tsai-yen Li

Start year: 2013

The application context targeted by this proposal is Interactive Virtual Storytelling. The growing importance of this form of media reveals the necessity to re-think and re-assess the way narratives are traditionally structured and authored. In turn, this requires from the research community to address complex scientific and technical challenges at the intersection of literature, robotics, artificial intelligence, and computer graphics. This joint collaboration addresses three key issues in virtual storytelling: (i) delivering better authoring tools for designing interactive narratives based on literary-founded narrative structures, (ii) establishing a bridge between the semantic level of the narrative and the geometric level of the final environment to enable the simulation of complex and realistic interactive scenarios in 3D, and (iii) providing a full integration of the cinematographic dimension through the control of high-level elements of filmic style (pacing, preferred viewpoints, camera motion). The project is founded on a past solid collaboration and will rely on the team's complementarity to achieve the tasks through the development of a joint research prototype.

9.2.1.2. 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 multidiciplinary direction.

9.2.2. Inria International Partners

9.2.2.1. Informal International Partners

Hubert Shum, Northumbria University, Newcastle, UK, collaboration with Franck Multon with joint papers,

Edouard Auvinet, Imperial College London, UK, collaboration with Franck Multon with joint papers,

Alexandra Covaci, Middlesex University of London, collaboration with Franck Multon with joint papers,

Jean Meunier, Carl-Eric Aubin, and Maxime Raison, University of Montreal, collaboration with Franck Multon with joint papers,

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

9. Partnerships and Cooperations

9.1. National Initiatives

9.1.1. Labex Comin Labs projects

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

9.1.1.1. HEMISFER

Participant: Rémi Gribonval.

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

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

Research axis: 3.1

CominLabs partners : EPI VISAGES; EPI HYBRID; EPI PANAMA

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

Coordinator: Christian Barillot, EPI VISAGES

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; EPI PANAMA

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), focuses on the design of new waveforms for multi carrier systems with reduced Peak to Average Power Ratio (PAPR).

9.1.2. OSEO-FUI: S-POD: "Assistance à personnes en danger potentiel"

Participants: Frédéric Bimbot, Romain Lebarbenchon, Ewen Camberlein, Jérémy Paret, Vincent Soupé.

Duration: August 2012-December 2015

Research axis: 3.2

Partners: ERYMA, CAPT/FOTON, CASSIDIAN, KAPTALIA, KERLINK, le LOUSTIC and Telecom Bretagne

Coordinator: ERYMA

Description: S-POD gathers research teams and industrial partners to that aim at setting up a framework to process and fuse audio, physiological and contextual data. The goal is to design an embedded autonomous system able to detect situations of potential danger arising in the immediate environment of a person (military, police, CIT, fire, etc.)

Contribution of PANAMA: PANAMA is in charge of R&I activities related to the qualitative and quantitative analysis of information from the acoustic environment (intensity, direction of arrival, nature of noise sounds, properties of voices, etc.) as well as to the exploitation of these analyses. The need for real-time embedded processing induces specific constraints.

9.1.3. OSEO-FUI: voiceHome

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

Duration: 3 years (2015-2017)

Research axis: 3.2

Partners: onMobile, Delta Dore, eSoftThings, Orange, Technicolor, LOUSTIC, Inria Nancy

Coordinator: onMobile

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 (i) audio activity monitoring and wake-up word detection and (ii) audio source localization and separation. In both cases, the issue of energy frugality is central and strongly constrains the available resources. We expect from this cooperation to make progress towards operational low-resource audio source separation schemes and we intend to investigate compressive sensing for the characterization of audio and voice activity.

9.2. European Initiatives

9.2.1. FP7 & H2020 Projects

9.2.1.1. ERC-StG: PLEASE (Projections, Learning, and Sparsity for Efficient Data Processing)
Participants: Rémi Gribonval, Srdan Kitic, Pierre Machart, Luc Le Magoarou, Nancy Bertin, Nicolas Keriven, Yann Traonmilin, Laurent Albera, Gilles Puy, Thomas Gautrais, Nicolas Bellot.

Duration: January 2012 - December 2016

Research axis: 3.1

Principal investigator: Rémi Gribonval

Program: ERC Starting Grant

Project acronym: PLEASE

Project title: Projections, Learning and Sparsity for Efficient data processing

Abstract: The Please ERC is focused on the extension of the sparse representation paradigm towards that of sparse modeling, with the challenge of establishing, strengthening and clarifying connections between sparse representations and machine learning

Web site: https://team.inria.fr/panama/projects/please/

9.3. International Initiatives

9.3.1. Inria International Partners

9.3.1.1. 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 Edimburgh.

9.4. International Research Visitors

9.4.1. Visits of International Scientists

- Pierre Vandergheynst, in July, Professor of Signal and Image Processing, EPFL (Chaire Internationale Inria)
- Gitta Kutyniok, in April, Professor, Technical University of Berlin

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

9. Partnerships and Cooperations

9.1. Regional Initiatives

- T. Maugey has received a grant for scientific intallation from Rennes Metropole.
- The postdoc of Xin Su on multi-view data representation and compression is partly funded (at the level of 75%) by the Brittany region.

9.2. International Initiatives

9.2.1. Inria International Partners

9.2.1.1. Informal International Partners

- The study on guided image inpainting is carried out in collaboration with Prof. Pascal Frossard from EPFL (Ecole Polytechique Federal de Lausanne).
- The study on adaptive clustering with Kohonen self-organizing maps for second-order prediction has been carried out in collaboration with Prof. Philippe Salembier from UPC (Universitat Politecnica De Catalunya).

9.3. International Research Visitors

9.3.1. Visits of International Scientists

- Pr. Reuben Farrugia from Malta University, is spending one sabbatical year in the team from Sept. 2015 until August 2016.