



RESEARCH CENTER

FIELD

**Networks, Systems and Services,
Distributed Computing**

Activity Report 2015

Section Partnerships and Cooperations

Edition: 2016-03-21

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ASAP Project-Team

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 or less consciously selling personal data for services. SocioPlug aims to provide an alternative for this model by proposing a novel architecture for large-scale, user centric applications. Instead of concentrating information of cloud platforms owned by a few economic players, we envision services made possible by cheap low-end plug computers available in every home or workplace. This will make it possible to provide a high amount of transparency to users, who will be able to decide their own optimal balance between data sharing and privacy.

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.

ATLANMODELS Team

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 Enterprise 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 card 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 hybrid 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, in 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 ubiquitous 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 Worldline, 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 or less consciously selling personal data for services. SocioPlug aims to provide an alternative for this model by proposing a novel architecture for large-scale, user centric applications. Instead of concentrating information of cloud platforms owned by a few economic players, we envision services made possible by cheap low-end plug computers available in every home or workplace. This will make it possible to provide a high amount of transparency to users, who will be able to decide their own optimal balance between data sharing and privacy.

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-2015/lescolloques/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. Competitiveness 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 **PANOPTESSEC** 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 PANOPTESSEC 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),
- Epistemica (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 led 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 Belgium. 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 objective 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.

COAST Project-Team

7. Partnerships and Cooperations

7.1. National Initiatives

7.1.1. FSN OpenPaaS (2012–2015)

Participants: Olivier Perrin [contact], Ahmed Bouchami.

Partners: SAMOVAR team (Telecom SudParis), COAST project-team (Université de Lorraine, LORIA), ARMINES (Ecole des Mines d'Albi), Brake France, Linagora.

Website: <http://www.open-paas.org/>

The OpenPaaS project aims at developing a PaaS (Platform as a Service) technology dedicated to enterprise collaborative applications deployed on hybrid clouds (private/public). OpenPaaS is a platform that allows to design and deploy applications based on proven technologies provided by partners such as collaborative messaging systems, integration and workflow technologies that will be extended in order to address Cloud Computing requirements. Available as an open-source Enterprise Social Network, the OpenPaaS project innovates both at the collaborative level and by its capacity to leverage heterogeneous cloud technologies at the IaaS level (Infrastructure as a Service). This project is funded under the French FSN umbrella (Fond National pour la société Numérique).

7.1.2. OpenPaas NG (2015–2018)

Participants: Claudia-Lavinia Ignat, François Charoy [contact], Gérald Oster, Olivier Perrin.

Partners: Linagora, XWiki SAS, Nexedi, COAST project-team (Université de Lorraine, LORIA), DaScim team (LIX).

Website: <http://www.open-paas.org/>

This project is financed by BpiFrance and involves French industrial leaders in open-source software development (Linagora, Nexedi, XWiki) and academic partners in collaborative work (COAST team) and recommender systems (DaScim team, LIX). The goal of the project is to develop next generation cloud enabled virtual desktop based on Enterprise Social Network concept to provide advanced collaborative and recommendation services. COAST team is responsible of the work package dedicated to the design of the peer-to-peer collaborative middleware. In this context, we bring our expertise on data replication for collaborative data in peer-to-peer environments and on trust and access control and identity management in distributed collaborative information systems.

7.1.3. Inria ADT PLM (2014-2016)

Participants: Gérald Oster [contact], Matthieu Nicolas.

Partners: COAST project-team, VERIDIS project-team.

Website: <https://github.com/BuggleInc/plm/>

This work is performed jointly with Martin Quison (previously member of project-team VERIDIS, now Professor at ENS Rennes).

The Programmer's Learning Machine (PLM) is a software platform dedicated to computer programming education. This generic platform offers support to teachers for creating programming microworlds suitable to teaching courses. It features an integrated and graphical environment, providing a short feedback loop to students in order to improve the effectiveness of the autonomous learning process.

This project aims at establishing an experimental platform for studying the teaching of basic programming and a research instrument to design new collaborative learning environments.

7.2. European Initiatives

7.2.1. FP7 & H2020 Projects

7.2.1.1. SyncFree (2013-2016)

Participants: Pascal Urso [contact], Jordi Martori Adrian.

Program: FP7-ICT-2013-10

Project acronym: SyncFree

Project title: Large-scale computation without synchronisation

Duration : October 2013 - September 2016

Coordinator: Marc Shapiro, Inria

Other Partners: REGAL project-team (Inria Paris - Rocquencourt / LIP6, coordinator), Basho Technologies Limited (United Kingdom), Trifork AS (Denmark), Rovio Entertainment OY (Finland), Faculdade de Ciências e Tecnologia (Universidade Nova de Lisboa, Portugal), Université Catholique de Louvain (Belgium), Koç University (Turkey), Technische Universität Kaiserslautern (Germany) and COAST project-team.

Large-scale on-line services including social networks and multiplayer games handle huge quantities of frequently changing shared data. Maintaining its consistency is relatively simple in a centralised cloud, but no longer possible due to increased scalability requirements. Instead, data must be replicated across several distributed data centres, requiring new principled approaches to consistency that will be explored by the SyncFree project. <http://syncfree.lip6.fr/>

7.3. International Initiatives

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

7.3.1.1. USCOAST

Title: User Studies on Trustworthy Collaborative Systems

International Partner (Institution - Laboratory - Researcher):

Wright State University (USA) - Department of Psychology - Valerie Shalin

Start year: 2013

See also: <http://uscoast.loria.fr>

USCoast has as main objective the validation of trustworthy collaborative systems using experimental user studies. This type of validation requires the expertise of both computer scientists that designed the systems and social scientists for conceptualizing and measuring human behaviour in collaborative work. The project focuses on the real-time requirements and trust policies in collaborative editing, resulting in a theory for the effect of real-time constraints in collaborative editing and awareness management for the coordination of work in the presence of conflict and disruption. The project also proposes light security mechanisms for decentralised collaboration, based on measures of voluntary compliance with data sharing restrictions. New methods will be developed for the cost-effective evaluation of collaborative work to compensate for otherwise unrealistic sample sizes and costly engineering, using game theory to inspire task analogues and simulated users along with human users.

7.4. International Research Visitors

7.4.1. Visits of International Scientists

Valerie Shalin

Date: October 10, 2015 - November 5, 2015

Institution: Wright State University (USA)

Valerie Shalin worked on the validation of trust-based collaboration, specifically on the design and analysis of the experiments with users on the trust game.

7.4.2. Visits to International Teams

7.4.2.1. Research stays abroad

François Charoy spend 7 weeks at Wright State University, OH, in the Knoesis Team lead by Prof. Amit Sheth as part of the USCOAST associated team.

CTRL-A Team

9. Partnerships and Cooperations

9.1. Regional Initiatives

The Labex Persyval-lab is a large regional initiative, supported by ANR, where we are contributing through two projects:

9.1.1. *Equipe-action HPES*

This project (2013-17) groups members from Inria, LIG, Gipsa-lab, TIMA and Gipsa-lab, around the topic of High-Performance Computing benefitting from technologies originally developed for Embedded Systems. Ctrl-A is directly involved in the co-advising of the PhD of Naweiluo Zhou, with J.F. Méhaut (LIG), on the topic of autonomic management of software transactional memory mechanisms: <https://persyval-lab.org/en/sites/hpes>

9.1.2. *Projet Exploratoire CASE*

This project (2015-16) grouped members from Inria, LIG, Gipsa-lab and CEA LETI/DACLE and concerned the general topic of Control techniques for Autonomic Smart Environments, with a special emphasis on relating discrete and stochastic control models with middleware platforms applied to smart environments. It enables us to hire two Masters students for 2016.

9.2. National Initiatives

9.2.1. *ANR*

HPeC is an ANR project on Self-Adaptive, Energy Efficient High Performance Embedded Computing, with a UAV case study. The Coordinator is Lab-STICC / MOCS (Lorient / Brest), and the duration: 42 month from october 2015. Others Partners are: Inria Rennes, IRIT, Eolas.

In Ctrl-A, it is funding a PhD thesis or a post-doc position, to be hired in Grenoble and co-advised with Lorient. Another PhD based in Brest is co-advised by Stéphane Mocanu.

9.2.2. *Informal National Partners*

We have contacts with colleagues in France, in addition to the cooperation mentioned before, and with whom we are submitting collaboration projects, co-organizing events and workshops, etc. They feature : Avalon Inria team in Lyon (F. Desprez), LIP6 (J. Malenfant), Scales Inria team in Sophia-Antipolis (L. Henrio), LIRRM in Montpellier (A. Gamatié, K. Godary, D. Simon), IRISA/Inria Rennes (J. Buisson, J.L. Pazat, ...), Telecom Paris-Tech (A. Diaconescu, E. Najm), LAAS (Thierry Monteil), LURPA ENS Cachan (J.M. Faure, J.J. Lesage), ...

9.2.3. *Informal National Industrial Partners*

We have ongoing discussions with several industrial actors in our application domains, some of them in the framework of cooperation contracts, other more informal: Eolas/Business decision (G. Dulac), ST Microelectronics (V. Bertin), Schneider Electric (C. El-Kaed, P. Nappey, M. Pitel), Orange labs (J. Pulou, G. Privat).

9.3. International Initiatives

9.3.1. Inria International Partners

9.3.1.1. Informal International Partners

We have ongoing relations with international colleagues in the emerging community on our topic of control for computing e.g., in Sweden at Lund (K.E. Arzen, M. Maggio) and Linnaeus Universities (D. Weyns, N. Khakpour), in the Netherlands at CWI/leiden University (F. Arbab), in China at Heifei University (Xin An), in Italy at University Milano (C. Ghezzi, A. Leva), in the USA at Ann Arbor University (S. Lafortune) and UMass (P. Shenoy, E. Cecchet).

9.3.2. Participation In other International Programs

Eric Rutten is a member of the IFAC Technical Committee 1.3 on Discrete Event and Hybrid Systems, for the 2011-2014 triennium, and for the 2014-2017 triennium <http://tc.ifac-control.org/1/3> ; and of the IEEE Control Systems Society Discrete Event Systems Technical Committee <http://discrete-event-systems.ieeecss.org>.

MIMOVE Team

8. Partnerships and Cooperations

8.1. National Initiatives

8.1.1. Inria Support

8.1.1.1. Inria ADT iCONNECT

Participant: Nikolaos Georgantas [correspondent].

- **Name:** iConnect – *Emergent Middleware Enablers*
- **Related activities:** § 6.2
- **Period:** [October 2013 – December 2015]
- **Partners:** Inria MiMove.

The pervasive computing vision is hampered by the extreme level of heterogeneity in the underlying infrastructure, which impacts on the ability to seamlessly interoperate. Further, the fast pace at which technology evolves at all abstraction layers increasingly challenges the lifetime of networked systems in the digital environment.

Overcoming the interoperability challenge in pervasive computing systems has been at the heart of the FP7 FET IP CONNECT project (<http://www.connect-forever.eu/>), which ran from 2009 to 2012, and was coordinated by Inria ARLES (MiMove’s predecessor team). Specifically, CONNECT has been investigating the paradigm of *Emergent middleware*, where protocol mediators are dynamically synthesized so as to allow networked systems that provide complementary functionalities to successfully coordinate. The CONNECT project has in particular delivered prototype implementation of key enablers for emergent middleware, spanning discovery, protocol learning, and mediator synthesis and deployment. Further, while CONNECT focused on learning and reconciling interaction protocols at the application layer, the FP7 project CHOREOS (<http://www.choreos.eu>) to which ARLES contributed as well, investigated a complementary enabler that supports interoperability across systems implementing heterogeneous interaction paradigms (i.e., client-service, event-based and shared memory). The proposed enabler introduces the concept of XSB - eXtensible Service Bus, which revisits the notion of Enterprise Service Bus and features an end-to-end interaction protocol that preserves the interaction paradigms of the individual components, while still allowing interoperability.

The objective of the Inria iConnect ADT is to leverage and integrate the above complementary results, packaging and further enhancing enabler prototypes, for take-up of the results by the relevant open source community. The work will involve development effort focused on the following core enablers:

- Universal discovery of resources composing legacy discovery protocols,
- Dynamic synthesis and deployment of mediators specified as enhanced labelled transition systems,
- XSB as underlying run-time support for mediators so as to support interoperability across systems based on heterogeneous interaction paradigms,
- Experiment in the area of federated social networking.

We are releasing the software prototypes through the OW2 open source initiative FISSi (Future Internet Software and Services initiative – http://www.ow2.org/view/Future_Internet/), as our solutions are of direct relevance to sustaining interoperability in the Future Internet.

8.1.1.2. Inria ADT CityLab Platform

Participant: Valérie Issarny [correspondent].

- **Name:** CityLab Platform – *A Platform for Smarter Cities Promoting Social and Environmental Sustainability*
- **Related activities:** § 7.3 and § 6.3
- **Period:** [November 2014 – October 2016]
- **Partners:** Inria MiMove, Inria CLIME.

The CityLab Platform ADT is part of the CityLab Inria Project Lab focused on the study of ICT-based smart city systems from supporting “sensing” systems up to advanced data analytics and new services for the citizens. While the topic is broad, the lab leverages relevant effort within Inria project-teams that is further revisited as well as integrated to meet the challenges of smart cities

There is the promise of enabling radically new ways of living in, regulating, operating and managing cities through the increasing active involvement of citizens. The latest technology trends of crowd- sourcing/sensing (crowd-Xing) and location-based social networking have reignited citizen engagement, opening new perspectives for cost-effective ways of making local communities and cities more sustainable. However, this requires investigating supporting systems of systems from advanced sensing systems up to integrated data management and associated data analytics. This is specifically the objective of the CityLab Inria ProjectLab, where the related ADT is focused on the development and maintenance of the CityLab Platform. The platform integrates the software prototypes developed as part of the undertaken research and will be made available under open source license. It is further the objective of the ADT to deploy and experiment with the platform within cities.

8.2. European Initiatives

8.2.1. FP7 & H2020 Projects

8.2.1.1. H2020 ICT CHOReVOLUTION

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

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

URL: <http://www.chorevolution.eu>

Type: Research & Innovation Action (ICT)

Topic: Tools and Methods for Software Development

Related activities: § 7.2 and § 6.2

Period: [January 2015 - December 2017]

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

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

8.2.1.2. H2020 ICT FIESTA

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

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

URL: *Under construction*

Type: Research & Innovation Action (ICT)

Topic: FIRE+ (Future Internet Research & Experimentation)

Related activities: § 7.3 and § 6.3

Period: [February 2015 - January 2018]

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

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

8.2.2. Collaborations in European Programs, except FP7 & H2020

8.2.2.1. EIT ICT Labs 3cixty

Participants: Animesh Pathak [correspondent], Rachit Agarwal [correspondent].

Name: 3cixty – *A Platform for Apps and Services that Offer Comprehensive Views of a City*

URL: <http://www.3cixty.com/>

Period: [January 2014 - December 2015]

Partners: Ambientic (F), CEFRIEL (IT), DFKI (DE) [**coordinator**], Eurecom (F) [**associate leader**], Fondazione Politecnico di Milano (IT), Innovalor (NL), Inria MiMove [**associate leader**], LocaliData (ES), Mobidot (NL), Politecnico di Milano (IT), Telecom Italia (IT) [**associate leader**], Thales (F), TU Delft (NL), UC London (UK).

3city is a platform, well motivated in business terms, for developing apps for city visitors that makes it easy for application developers to access and process comprehensive heterogeneous information about a city; and a Showcase App using the platform that demonstrates its added value. The project will result new opportunities to enable city visitors to exploit the transportation, business, cultural, and touristic opportunities offered by a city more fully and in a more personally and environmentally appropriate way, thereby benefiting cities, their visitors, and application and service developers.

8.3. International Initiatives

8.3.1. Inria International Labs

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

Sara Hachem and Cristhian Parra have been carrying out their postdoc research at UC Berkeley in the context of the Inria@Silicon Valley program and CityLab@Inria.

8.3.2. Inria Associate Teams not involved in an Inria International Lab

8.3.2.1. Inria DRI/DST-CEFIPRA Associate Team: SARATHI

Participants: Animesh Pathak [correspondent], Nikolaos Georgantas [correspondent].

Name: SARATHI – *Personalized Mobility Services for Urban Travelers*

Instrument: Inria DRI/DST-CEFIPRA Associate Team

Period: [January 2014 - December 2016]

Partners: Indraprastha Institute of Information Technology (IIIT), Delhi (India), Inria MiMove.

Website: <https://saarathiproject.wordpress.com/>

The focus of the *Sarathi* project is on creating a personalized mobility service platform for urban travelers. The proposed work would require work on large scale mobile participatory sensing, urban transportation, location-aware services, machine learning, and software engineering. The individual strength of MiMove and IIIT provide complementary technical benefits for the project. MiMove leverages its work on large scale mobile participatory sensing (so far focused on EU-based transit contexts) addressing challenges brought to the fore by dynamic large scale systems in India; IIIT will build up on their previous work on mobile based system to provide route information and work on learning and mining techniques for inferring events of interest in transport systems.

Besides the complementary technical benefits, the collaboration will also help the project in evaluating the proposed solution in context of both developing and developed countries with different societal structure and preferences. Since personalized services are an integral part of the solution, the variety in social structures of India and France will help in developing solutions that are valid across continents. A deployment of the proposed solution in India will also test scalability and robustness of the solution in resource-constrained environments (e.g. intermittent network connectivity, low bandwidth) and will help in developing solutions that can be deployed in different working environments. Similarly, France (with already an advanced transit system) offers opportunities in verifying the requirements of a successful sustainable transport system.

8.3.3. Inria International Partners

8.3.3.1. Informal International Partners

We have a lasting collaboration with Prof. Fabio Costa at the Federal University of Goias (UFG), Brazil, on self-adaptive ubiquitous and cloud-based systems. This collaboration was funded by the Inria-Brazil International Scientific Cooperation Program during the period 2012-2014. In 2015, Raphael de Aquino Gomes, UFG PhD student, conducted an 1-year PhD internship with MiMove, funded by a scholarship of the CAPES/CNPq Brazilian Science without Borders program. A collaborative project proposal by Inria MiMove and UFG was submitted at the "Associate Teams with Brazil Program" 2016 Call, co-funded by Inria and the Brazilian Research Foundations (FAPs). The project was successfully evaluated and will be funded for three years, enabling further fruitful exchanges between UFG and Inria MiMove.

8.4. International Research Visitors

8.4.1. Visits of International Scientists

8.4.1.1. Internships

Raphael de Aquino Gomes (from Sep. 2014 until Aug. 2015)

PhD internship funded by a visitor PhD student scholarship of the Brazilian Science without Borders program provided by CAPES and CNPq.

Subject: *Self-Adaptive Use of Cloud Resources for Heterogeneous Dynamic Service Choreographies*

Institution: Federal University of Goiás - UFG (Brazil)

8.4.2. Visits to International Teams

8.4.2.1. Research stays abroad

Valérie Issarny is visiting scholar at CITRIS at UC Berkeley, in the context of which she carries out collaborative research in the area of smart cities and acts as scientific coordinator of the Inria@SiliconValley program.

MYRIADS Project-Team

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 Pizat, 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 Pizat.

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-Com⁰ 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.

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 to 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 extent, 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 led 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) Université Pierre et Marie Curie - Paris 6 (UPMC, France) Fraunhofer-Gesellschaft zur Förderung der Angewandten Forschung e.v (Fraunhofer, Germany) Technische Universität 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. *HARNES*

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 Informationstechnik Berlin (ZIB, Germany), Maxeler Technologies (MAX, United Kingdom), SAP AG (SAP, Germany)

UR1 contact: Guillaume Pierre

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

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 led 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 HARNNESS project, and it is expected to continue after the end of HARNNESS. 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.

REGAL Project-Team

8. Partnerships and Cooperations

8.1. National Initiatives

8.1.1. Labex SMART - (2012–2019)

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

Funding: Sorbonne Universités, ANR.

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

The project involves a PhD grant of 100 000 euros over 2,5 years.

8.1.2. InfraJVM - (2012–2015)

Members: LIP6 (Regal), Ecole des Mines de Nantes (Constraint), IRISA (Triskell), LaBRI (LSR).

Funding: ANR Infra.

Objectives: The design of the Java Virtual Machine (JVM) was last revised in 1999, at a time when a single program running on a uniprocessor desktop machine was the norm. Today’s computing environment, however, is radically different, being characterized by many different kinds of computing devices, which are often mobile and which need to interact within the context of a single application. Supporting such applications, involving multiple mutually untrusted devices, requires resource management and scheduling strategies that were not planned for in the 1999 JVM design. The goal of InfraJVM is to design strategies that can meet the needs of such applications and that provide the good performance that is required in an MRE.

The coordinator of InfraJVM is Gaël Thomas, who left the team in 2014. Infra-JVM brings a grant of 202 000 euros from the ANR to UPMC over three years.

8.2. European Initiatives

8.2.1. FP7 & H2020 Projects

8.2.1.1. SyncFree

Title: Large-scale computation without synchronisation

Programm: FP7

Duration: October 2013 - September 2016

Coordinator: Inria

Partners:

Basho Technologies (United Kingdom)

Faculdade de Ciencias e Tecnologia da Universidade Nova de Lisboa (Portugal)

Koç University (Turkey)

Rovio Entertainment Oy (Finland)

Trifork As (Denmark)
 Université Catholique de Louvain (Belgium)
 Technische Universitaet Kaiserslautern (Germany)

Inria contact: Marc Shapiro

The goal of SyncFree is to enable large-scale distributed applications without global synchronisation, by exploiting the recent concept of Conflict-free Replicated Data Types (CRDTs). CRDTs allow unsynchronised concurrent updates, yet ensure data consistency. This revolutionary approach maximises responsiveness and availability; it enables locating data near its users, in decentralised clouds. Global-scale applications, such as virtual wallets, advertising platforms, social networks, online games, or collaboration networks, require consistency across distributed data items. As networked users, objects, devices, and sensors proliferate, the consistency issue is increasingly acute for the software industry. Current alternatives are both unsatisfactory: either to rely on synchronisation to ensure strong consistency, or to forfeit synchronisation and consistency altogether with ad-hoc eventual consistency. The former approach does not scale beyond a single data centre and is expensive. The latter is extremely difficult to understand, and remains error-prone, even for highly-skilled programmers. SyncFree avoids both global synchronisation and the complexities of ad-hoc eventual consistency by leveraging the formal properties of CRDTs. CRDTs are designed so that unsynchronised concurrent updates do not conflict and have well-defined semantics. By combining CRDT objects from a standard library of proven datatypes (counters, sets, graphs, sequences, etc.), large-scale distributed programming is simpler and less error-prone. CRDTs are a practical and cost-effective approach. The SyncFree project will develop both theoretical and practical understanding of large-scale synchronisation-free programming based on CRDTs. Project results will be new industrial applications, new application architectures, large-scale evaluation of both, programming models and algorithms for large-scale applications, and advanced scientific understanding.

8.3. International Initiatives

8.3.1. Inria International Labs

Inria Chile

Associate Team involved in the International Lab:

8.3.1.1. ARMADA

Title: hARnessing MAssive DAta flows

International Partner (Institution - Laboratory - Researcher):

Universidad Tecnica Federico Santa Maria (Chile) - Department of Computer Science
 (Department of Comput) - Xavier Bonnaire

Start year: 2014

See also: <http://web.inria-armada.org>

The ARMADA project aims at designing and implementing a reliable framework for the management and processing of massive dynamic dataflows. The project is two-pronged: fault-tolerant middleware support for processing massive continuous input, and a redundant storage service for mutable data on a massive scale.

8.3.2. Participation In other International Programs

8.3.2.1. PHC Maimonide

Title: Application dependent intrusion (byzantine) detection in Dynamic cloud systems

International Partner (Institution - Laboratory - Researcher):

Technion Haifa - Prof. Roy Friedman

Duration: 2014–2015

The goal of this project is to study the ability to tolerate Byzantine failures in dynamic environments. The Byzantine model allows arbitrary behaviour of a certain fraction of nodes. Our goal is to provide both a theoretical framework and performance evaluation to tolerate Byzantine behaviour in dynamic distributed environments. We consider "bag of tasks" (BoT) applications characterized by trivial parallelism where a large computational problem is broken into a large number of independent tasks. These tasks can be spread on commodity hardware and operating systems. We target different executions environments: (1) Clouds: tasks are submitted to virtual machines hosted at cloud providers, (2) Desktop grid: tasks are submitted to federate large pool of donated machines hosted at user home, (3) Hybrid cloud: combining both cloud and desktop nodes.

8.3.2.2. *CNRS-Inria-FAP's*

Title: Autonomic and Scalable Algorithms for Building Resilient Distributed Systems

International Partner (Institution - Laboratory - Researcher):

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

Duration: 2015–2017

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

8.4. International Research Visitors

8.4.1. *Visits of International Scientists*

8.4.1.1. *Internships*

Dastagiri Reddy MalikiReddy

Date: May—Aug. 2015

Institution: IITKGP (India)

Alvarez Colombo Santiago Javier

Date: Jul. 2015—Jan. 2016

Institution: Universidad de Buenos Aires (Argentina)

SCALE Team

8. Partnerships and Cooperations

8.1. National Initiatives

8.1.1. ANR Songs

Title: Simulation of Next Generation Systems

Program: Infra 13

Duration: January 2012 - December 2015

Coordinator: Inria (Nancy, Grenoble, Bordeaux)

Others partners: IN2P3 Villeurbanne, LSIIT Strasbourg, I3S Sophia-Antipolis, LINA Nantes

See also: <http://infra-songs.gforge.inria.fr/>

Abstract: SONGS (2012-2015) is the continuity of SIMGRID project (2009-2012), in the ANR INFRA program. The aim of SONGS is to continue the development of the SimGrid simulation platform for the study of large distributed architectures, including data grids, cloud computing facilities, peer-to-peer applications and HPC/exascale architectures.

8.1.2. FUI CloudForce (now OpenCloudWare)

Program: FSN, labelled by Minalogic, Systematic and SCS.

Duration: January 2012 - September 2015

Coordinator: France-Telecom Research

Others partners: ActiveEon, Armines, Bull, eNovance, eXo Platform, France Telecom (coordinator), Inria, IRIT-INP Toulouse, Linagora, OW2, Peergreen, Télécom Paris Tech, Télécom Saint Etienne, Thales Communications, Thales Services, Université Joseph Fourier, Université de Savoie - LISTIC, UShareSoft

See also: <http://www.opencloudware.org/>

Abstract: 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.

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) for their deployment, orchestration, performance testing, self-management (elasticity, green IT optimisation), and provisioning. Applications will be deployed potentially on multi IaaS (supporting either one IaaS at a time, or hybrid scenarios). The results of the project will be made available as open source components through the OW2 Open Source Cloudware initiative.

8.1.3. Oseo-Isis Spinnaker

Duration: June 2011 - September 2015

Coordinator: Tagsys-RFID

Others partners: SMEs: Inside-Secure, STIC, Legrand; Academic: IPG, ENS des Mines de St Etienne, Un. du Maine, Un. F. Rabelais Tours, AETS ESEO Angers, Un. Marne la Vallée, Un. Paris 6, Un. Rennes 1, Inria.

See also: <http://www.spinnaker-rfid.com/>

Abstract: The objective of Spinnaker is to really allow RFID technology to be widely and easily deployed. The role of the OASIS team in this project is to allow the wide scale deployment and management of the specific RFID application servers in the cloud, so to build an end-to-end robust and flexible solution using GCM technology.

8.2. European Initiatives

8.2.1. FP7 & H2020 Projects

8.2.1.1. DC4Cities

Type: COOPERATION

Defi: FP7 Smartcities 2013

Instrument: Specific Targeted REsearch Project

Objectif: ICT-2013.6.2: Data Centers in an energy-efficient and environmentally friendly Internet

Duration: September 2013 - February 2016

Coordinator: Freemind Consulting (BE)

Partners: U. Mannheim (DE), U. Passau (DE), HP Italy Innovation Center (IT), Create-Net (IT), ENEA (IT), CESCA Catalonia (ES), Gas Natural SA (ES), Inst. Munic. Informatica Barcelona (ES), Inria (FR)

Inria contact: Eric Madelaine

See also:

Abstract: Data centres play two different and complementary roles in Smart Cities' energy policies: as ICT infrastructures supporting Smart City resource optimization systems - more in general, delivering ICT services to the citizens - and as large energy consumers. Therefore there are huge expectations on data centres being able to run at the highest levels of renewable energy sources: this is the great challenge of DC4Cities project.

The goal of DC4Cities is to make existing and new data centres energy adaptive, without requiring any modification to the logistics, and without impacting the quality of the services provided to their users. Finally new energy metrics, benchmarks, and measurement methodologies will be developed and proposed for the definition of new related standards. DC4Cities will promote the data centres role as an "eco-friendly" key player in the Smart Cities energy policies, and will foster the integration of a network of local renewable energy providers (also interconnected with local Smart Grids and Micro Grids) to support the pursued increase of renewable energy share.

8.2.2. Collaborations with Major European Organizations

Program: EIT Digital

Project acronym: Data Science programme, Activity 15 327 from Master School action line (MSL)

Project title: EIT Digital Data Science Master

Duration: submitted in 2014, funded from 2014 onwards

Coordinator: Farideh Heidari, Technische Universiteit Eindhoven

Other partners (besides UNS, with Françoise Baude as local coordinator): Univ. Politecnico Madrid, Univ. Trento, Politecnico Milano, Tech. Univ. Berlin, KTH

Abstract: The activity has successfully launched a new major for the EIT Digital KIC called "Data Science", with the purpose of breeding a new generation of ICT professionals, equipped with advanced technical and entrepreneurial skills in the key area of data science and data engineering. There is a tremendous demand in industry/society for data scientists, and hence a huge market potential for DS programs. DS positions in the industry requires a different educational program, with next to technical skills, more emphasis on awareness of multifaceted challenges and improving business efficiency based on the challenge outcomes. Expected impact is that DS graduates will be quickly recruited for attractive positions as they can help EU ICT industry achieve a higher rate of innovation successes.

8.3. International Initiatives

8.3.1. Inria International Labs

8.3.1.1. CIRIC Chili

Ciric research line: Telecommunications

Inria principal investigator: Eric Madelaine

Duration: 2012 - 2021

This CIRIC activity is loosely coupled with our (now terminated) SCADA associated team with the Universidad de Chile (UdC). We have some research collaboration with our chilean colleagues, in particular on new usages of the GCM component model for cloud management[7].

8.3.1.2. LIAMA Shanghai

Liama project: CASCADES

Inria principal investigator: Vania Joloboff

SCALE researchers involved: Eric Madelaine, Ludovic Henrio,

AOSTE researchers: Robert de Simone, Julien DeAntoni, Frederic Mallet

International Partner (Institution - Laboratory - Researcher):

East China Normal University (ECNU) Shanghai - Software Engineering Institute - MOE
International Lab of Trustworthy Software : Jifeng HE, Changbo WANG, Huibiao ZHU,
Min ZHANG, Yixiang CHEN.

Duration: 2016 - 2017

The SACCADDES 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 Scale team is involved in particular, with our chinese partners, on studies of semantics and compositional properties, and on the development of software tools supporting the Model-Driven Engineering approaches.

This LIAMA project is tightly linked with our FM4CPS Associated team (Inria principal investigator: Robert de Simone, SCALE participants: Eric Madelaine, Ludovic Henrio, Oleksandra Kulankhina).

8.3.2. Inria International Partners

8.3.2.1. Informal International Partners

- Advanced Real-Time Simulation Laboratory, Carleton University, Ottawa Canada: collaboration on simulation methodology, the DEVS formalism, and SDN Networks [16], [8], [15]

8.4. International Research Visitors

8.4.1. Visits of International Scientists

8.4.1.1. Internships

- Alexandros Tsantilas. *Fuzzing a VM Scheduler*. Co-supervised by Ludovic Henrio. Master 2 Ubinet 2014-15

- Wafa Khlif. *How sustainable data centres can be ?* Co-supervised by Fabien Hermenier. Master 2 IFI 2014-15
- Mario Taddei. *An integrated system for building and running reproducible research.* Supervised by Olivier Dalle. Master 2 Ubinet, 2014-2015;

8.4.1.2. *Research stays abroad*

- Olivier Dalle visited Carleton University (Ottawa, Canada) for one month (Dec 2015 - Jan 2016)
- Eric Madelaine visited East China Normal University in Shanghai for 3 weeks (July and November)

SPIRALS Project-Team

9. Partnerships and Cooperations

9.1. Regional Initiatives

9.1.1. Région Nord-Pas De Calais

9.1.1.1. Citizen Awareness and Contribution to Air Quality Monitoring

Participants: Daniel Romero Acero, Romain Rouvoy [correspondant], Lionel Seinturier.

This is a 3-year granted in the context of the so-called "Chercheur citoyen" program that started in 2015. The partners are LISIC/Université Côte d'Opale (leader), ATMO Nord-Pas De Calais, Association Bâisseurs d'Economie Solidaire. This project targets the distributed monitoring of air quality with crowd-sensing solutions obtained via sensors connected to smart devices. We aim at inciting citizens to perform their own measures, and to obtain thanks to GPS geo-localisation a large-scale database and a dynamic fine-grained cartography of air quality. This project takes advantage of the APISENSE[®] crowdsensing platform (see Section 6.1).

9.1.2. Inria Lille - Nord Europe

9.1.2.1. ADT eSurgeon

Participants: Maxime Colmant, Loïc Huertas, Romain Rouvoy [correspondant].

ADT eSurgeon (2013–15) is a technology development initiative supported by the Inria Lille - Nord Europe Center that aims at supporting the development of the POWERAPI software library (see Section 6.2) for measuring and monitoring the energy consumption of middleware and software systems.

9.1.2.2. ADT Spoon3R

Participants: Gérard Paligot, Martin Monperrus [correspondant].

ADT Spoon3R (2014–16) is a technology development initiative supported by the Inria Lille - Nord Europe Center that aims at supporting the development of the SPOON software library. (see Section 6.4) Spoon3R aims at extending SPOON with the features defined in the context of our research activities on automated software repair.

9.1.2.3. North European Lab LLEX

Participants: Benoit Cornu, Martin Monperrus [correspondant], Lionel Seinturier.

North European Lab LLEX (2015–17) is an international initiative supported by the Inria Lille - Nord Europe Center that takes place in the context of a collaboration between Inria and University College London. LLEX deals with research on automatic diagnosis and repair of software bugs. Automatic software repair is the process of fixing software bugs automatically. An automatic software repair system fixes software bugs with no human intervention. The goal of automatic software repair is to save maintenance costs and to enable systems to be more resilient to bugs and unexpected situations. This research may dramatically improve the quality of software systems. The objective of the partnership is to work on the automated diagnosis of exceptions with a focus on null pointer exceptions.

9.1.2.4. North European Lab SOCS

Participants: Maria Gomez Lacruz, Christophe Ribeiro, Romain Rouvoy [correspondant], Lionel Seinturier.

North European Lab SOCS (2013–15) is an international initiative supported by the Inria Lille - Nord Europe Center that takes place in the context of a well-established collaboration between Inria and *Universitetet i Oslo* (UiO) initiated in 2008. SOCS (Self-Optimization of Cyber-physical Systems) focuses on the self-optimization issues in cyber-physical systems. Cyber-Physical Systems (CPS) are complex systems-of-systems that blend hardware and software to fulfill specific missions. However, traditional CPS are statically configured to achieve predefined goals, which not only limit their sharing and their reuse, but also hinder their sustainability. We believe that this waste of resources stems from the lack of agility of CPS to adapt to change in their environment or objectives. The SOCS Inria Lab takes advantage of the technologies developed as part of the APISENSE[®] crowd-sensing platform (see Section 6.1) to leverage the development of agile CPS.

9.1.2.5. LEDA

Participant: Philippe Merle [correspondant].

LEDA (2013–16) Laboratoire d'Expérimentation et de Démonstrations Ambiantes is a demonstration space allocated by the Inria Lille - Nord Europe Center whose goal is to show the scientific results of the Spirals team in the domains of distributed systems, adaptable middleware, software product lines, green computing, and ambient computing. These results are illustrated around the scenario of a mock digital home.

9.2. National Initiatives

9.2.1. ANR

9.2.1.1. ANR BottleNet

Participants: Romain Rouvoy [correspondant], Walter Rudametkin Ivey, Lionel Seinturier.

BottleNet is a 48-month project funded by ANR that started on October 2015. The objective of BottleNet is to deliver methods, algorithms, and software systems to measure Internet Quality of Experience (QoE) and diagnose the root cause of poor Internet QoE. Our goal calls for tools that run directly at users' devices. We plan to collect network and application performance metrics directly at users' devices and correlate it with user perception to model Internet QoE, and to correlate measurements across users and devices to diagnose poor Internet QoE. This data-driven approach is essential to address the challenging problem of modeling user perception and of diagnosing sources of bottlenecks in complex Internet services. BottleNet will lead to new solutions to assist users, network and service operators as well as regulators in understanding Internet QoE and the sources of performance bottleneck.

9.2.1.2. ANR SATAS

Participants: Philippe Merle [correspondant], Romain Rouvoy, Lionel Seinturier.

SATAS is a 48-month project funded by ANR that started on October 2015. SATAS aims to advance the state of the art in massively parallel SAT solving with a particular eye to the applications driving progress in the field. The final goal of the project is to be able to provide a “pay as you go” interface to SAT solving services, with a particular focus on its power consumption. This project will extend the reach of SAT solving technologies, daily used in many critical and industrial applications, to new application areas, which were previously considered too hard, and lower the cost of deploying massively parallel SAT solvers on the cloud.

9.2.2. Competitiveness Clusters

9.2.2.1. FUI Hermes

Participants: Laurence Duchien, Romain Rouvoy, Lionel Seinturier [correspondant].

Hermes is a 41-month project funded by FUI and labeled by the PICOM (**Pôle des Industries du Commerce**) competitiveness cluster which has started in August 2012. The partners are Norsys (leader), Keynosoft, NumSight, Cylande, Auchan, Brand Alley, Kiabi, Leroy Merlin, Univ. Lille 1, LIPN, LITIS. The goal of the project is to define a modular and context-aware marketing platform for the retail industry. The focus is put on the interactions with customers in order to extract and mine relevant informations related to shopping habits, and on a multi-device, cross-canal, approach to better match customer usages.

9.2.3. Programme Investissement d’Avenir (PIA)

9.2.3.1. PIA Datalyse

Participants: Filip Krikava, Romain Rouvoy, Lionel Seinturier [correspondant], Bo Zhang.

Datalyse is a 42-month project of the Programme Investissement d’Avenir Cloud Computing 3rd call for projects. The project started in May 2013. The partners are Eolas (leader), Business & Decision, Groupement des Mousquetaires, Université Grenoble 1, Université Lille 1, Inria, Université Montpellier 2. The project aims at defining an elastic cloud computing infrastructure for processing big volumes of data. The originality of the project is to consider jointly data generated by users and by the infrastructure, and to correlate data at these two levels.

9.2.3.2. PIA OCCIware

Participants: Romain Rouvoy, Philippe Merle [correspondant], Lionel Seinturier.

OCCIware is a 36-month project of the Programme Investissement d’Avenir Cloud Computing and Big Data 4th call for projects. The project started in December 2014. The partners are Open Wide (leader), ActiveEon SA, CSRT, Institut Mines-Télécom/Télécom SudParis, Inria, Linagora GSO, Obeo, OW2 Consortium, Pôle Numérique, and Université Joseph Fourier - Grenoble. The project aims at defining a formal framework for managing every digital resources in the clouds, based on *Open Cloud Computing Interface* (OCCI) recommendations from *Open Grid Forum* (OGF).

9.2.4. Inria National Initiatives

9.2.4.1. Inria ADT Focus CrowdLab

Participants: Clive Ferret-Canape, Julien Duribreux, Maria Gomez Lacruz, Christophe Ribeiro, Romain Rouvoy [correspondant], Antoine Veuille.

The purpose of the ADT Focus CrowdLab (2014–2016) is to strengthen the technological part of the **Metroscope** consortium and to promote the APISENSE[®] crowd-sensing platform (see Section 6.1) as a reference platform for gathering mobile data within the scientific community. The CrowdLab project focuses on three stringent goals: (1) consolidating the current technological solutions, (2) technical and logistical support of the research activities initiated in different scientific domains, and (3) the improvement of security and anonymity of collected data. In addition to the **Metroscope** consortium, the Inria research teams participating of the ADT Focus CrowdLab project are: Spirals (coordinator), Madynes, Diana, Muse.

9.2.5. Other National Initiatives

9.2.5.1. ADEME Web Energy Archive 2

Participants: Maxime Colmant, Loïc Huertas, Filip Krikava, Romain Rouvoy [correspondant], Lionel Seinturier.

Web Energy Archive 2 (WEA2) is a 12-month project funded in 2015 by ADEME. The purpose of the project is to define innovative solutions for measuring the energy consumption of web sites as experienced by users. The output of the project can be consulted on <http://webenergyarchive.com> where web sites are ranked based on their energy profile (from A to G, where A denotes web sites that are the more energy friendly). This project contributes to the development of our PowerAPI library (see Section 6.2).

9.3. European Initiatives

9.3.1. FP7 & H2020 Projects

Program: FP7 ICT.

Project acronym: **PaaSage**.

Project title: Model Based Cloud Platform Upperware.

Duration: October 2012–September 2016.

Coordinator: ERCIM.

Other partners: ERCIM (Fr), SINTEF (No), STFC (UK), U. of Stuttgart (De), Inria (Fr), CETIC (Be), FORTH (El), Be.Wan (Be), EVRY Solutions (No), SysFera (Fr), Flexiant (UK), Lufthansa Systems AG (De), Gesellschaft für wissenschaftliche Datenverarbeitung mbh Göttingen (De), Automotive Simulation Center Stuttgart (De).

Abstract: Cloud computing is a popular and over-hyped concept in ICT. The concept of infinitely scalable elastic resources changing without complex systems administration and paying only for resources used is attractive. These benefits are not immediately realizable. Within organisation benefits are realizable at considerable cost. IaaS (*Infrastructure-as-a-Service*) public Clouds have different interfaces and conditions of use thus for an organisation to "scale out" requires considerable investment using skilled technical staff. The business need is to allow organisations to "scale out" from their private Cloud to public Clouds without a technical chasm between. This cannot easily be achieved. Aligned with the EU strategic direction of an open market for services, SOA (*Service-Oriented architecture*) offers a way to virtualize across heterogeneous public Clouds and organizational private Clouds. It opens a market for European SMEs to provide services to be utilized (and paid for) by business applications and for all organisations to benefit from a catalogue of services that can be used across the environment. PaaS will deliver an open and integrated platform, to support both deployment and design of Cloud applications, together with an accompanying methodology that allows model-based development, configuration, optimisation, and deployment of existing and new applications independently of the existing underlying Cloud infrastructures. Specifically it will deliver an IDE (*Integrated Development Environment*) incorporating modules for design time and execution time optimisation of applications specified in the Cloud Modeling Language (Cloud ML), execution-level mappers and interfaces and a metadata database.

Participants: Laurence Duchien, Daniel Romero Acero [correspondant], Romain Rouvoy, Lionel Seinturier.

Program: FP7 FET.

Project acronym: **DIVERSIFY**.

Project title: More software diversity. More adaptivity in CAS.

Duration: 36 months (2013–16).

Coordinator: Inria.

Other partners: SINTEF (Norway), Trinity College Dublin (Ireland), University of Rennes 1 (France).

Abstract: DIVERSIFY explores diversity as the foundation for a novel software design principle and increased adaptive capacities in CASs (*Collective Adaptive Systems*). 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.

Participants: Martin Monperrus [correspondant], Matias Martinez.

9.4. International Initiatives

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

9.4.1.1. SOMCA

Title: Self-Optimization of Service Oriented Architectures for Mobile and Cloud Applications

International Partner (Institution - Laboratory - Researcher):

Université du Québec À Montréal (Canada) - LATECE - Naouel MOHA

Start year: 2014

See also: <http://sofa.uqam.ca/somca.php>

The long-term goal of this research program is to propose a novel and innovative methodology embodied in an software platform, to support the runtime detection and correction of anti-patterns in large-scale service-oriented distributed systems in order to continuously optimize their quality of service. One originality of this program lies in the dynamic nature of the service-oriented environments and the application on emerging frameworks for embedded and distributed systems (e.g., Android/iOS for mobile devices, PaaS/SaaS for Cloud environments), and in particular mobile systems interacting with remote services hosted on the Cloud.

9.4.2. Inria International Partners

9.4.2.1. Declared Inria International Partners

9.4.2.1.1. University of Los Andes, Bogota, Colombia

We have a long term collaboration since 2005 with this university. Over the years, four PhD thesis (Carlos Noguera, Carlos Parra, Daniel Romero Acero, Gabriel Tamura) have been defended in our team with students who obtained their MSc in this university. The first three were full French PhD, whereas the last one was a co-tutelle with this university. Professor Rubby Casallas from University of Los Andes is frequently visiting our team. The most recently defended PhD thesis, that of Gabriel Tamura, deals with QoS (quality-of-service) contract preservation in distributed service-oriented architectures. A formal theory to perform, in a safe way, the process of self-adaptation in response to quality-of-service (QoS) contracts violation has been proposed. The results have been published in [90], [88] and in the PhD thesis document itself [87].

Participants: Laurence Duchien [correspondant], Daniel Romero Acero, Romain Rouvoy, Lionel Seinturier.

9.4.2.1.2. University of Oslo, Norway

The scientific collaboration with this international partner deals with complex distributed systems that have to seamlessly adapt to a wide variety of deployment targets. This is due to the fact that developers cannot anticipate all the runtime conditions under which these systems are immersed. A major challenge for these software systems is to develop their capability to continuously reason about themselves and to take appropriate decisions and actions on the optimizations they can apply to improve themselves. This challenge encompasses research contributions in different areas, from environmental monitoring to real-time symptoms diagnosis, to automated decision making. The collaboration has been supported by the SEAS Inria associated team (2012-14).

Participants: Maria Gomez Lacruz, Daniel Romero Acero, Romain Rouvoy [correspondant], Lionel Seinturier.

9.4.3. Participation In other International Programs

9.4.3.1. STIC AmSud - Project MineAPI

Participants: Benoit Cornu, Maria Gomez Lacruz, Matias Martinez, Martin Monperrus [correspondant], Vincenzo Musco, Gérard Paligot, Romain Rouvoy.

MineAPI is a STIC AmSud project (2015–16) between with University Diego Portales, Santiago, Chile, and Federal University of Uberlândia, Brazil. The coordinator on the French side is Damien Cassou from the Inria/Lille1 project-team Rmod. The project aims at facilitating the usage of frameworks and application programming interfaces (APIs) by mining software repositories. Our intuition is that mining reveals how existing projects instantiate these frameworks. By locating concrete framework instantiations in existing projects, we can recommend to developers the concrete procedures for how to use a particular framework for a particular task in a new system. Our project also tackles the challenge of adapting existing systems to new versions of a framework or API by seeking repositories for how other systems adapted to such changes.

9.5. International Research Visitors

9.5.1. Visits of International Scientists

9.5.1.1. Internships

Mayank Gupta

Date: May 2015 - Jul 2015

Institution: Indian Institute of Technology Delhi (India)

Supervisor: Romain Rouvoy

Spyros Lalos

Date: August 2015 - October 2015

Institution: Technical University Munich (Germany)

Supervisor: Romain Rouvoy

WHISPER Project-Team

9. Partnerships and Cooperations

9.1. National Initiatives

9.1.1. ANR

InfraJVM - (2012 - 2015)

Members: LIP6 (Regal-Whisper), Ecole des Mines de Nantes (Constraint), IRISA (Triskell), LaBRI (LSR).

Coordinator: Gaël Thomas

Whisper members: Julia Lawall, Gilles Muller

Funding: ANR Infra, 202 000 euros.

Objectives: The design of the Java Virtual Machine(JVM) was last revised in 1999, at a time when a single program running on a uniprocessor desktop machine was the norm. Today's computing environment, however, is radically different, being characterized by many different kinds of computing devices, which are often mobile and which need to interact within the context of a single application. Supporting such applications, involving multiple mutually untrusted devices, requires resource management and scheduling strategies that were not planned for in the 1999 JVM design. The goal of InfraJVM is to design strategies that can meet the needs of such applications and that provide the good performance that is required in an MRE. The PhD of Florian David was supported in part by InfraJVM.

Chronos network, Time and Events in Computer Science, Control Theory, Signal Processing, Computer Music, and Computational Neurosciences and Biology - (2015 - 2016)

Coordinator: Gerard Berry

Whisper member: Gilles Muller

Funding: ANR 2014, Défi "Société de l'information et de la communication".

The Chronos interdisciplinary network aims at placing in close contact and cooperation researchers of a variety of scientific fields: computer science, control theory, signal processing, computer music, neurosciences, and computational biology. The scientific object of study will be the understanding, modeling, and handling of time- and event-based computation across the fields.

Chronos will work by organizing a regular global seminar on subjects ranging from open questions to concrete solutions in the research fields, workshops gathering subsets of the Chronos researchers to address specific issues more deeply, a final public symposium presenting the main contributions and results, and an associated compendium.

9.1.2. Multicore Inria Project Lab

The Multicore IPL is an Inria initiative, led by Gilles Muller, whose goal is to develop techniques for deploying parallel programs on heterogeneous multicore machines while preserving scalability and performance. The IPL brings together researchers from the ALF, Algorille, CAMUS, Compsys, DALI, REGAL, Runtime and Whisper Inria Teams. These connections provide access to a diversity of expertise on open source development and parallel computing, respectively. In this context, Gilles Muller and Julia Lawall are working with Jens Gustedt and Mariem Saeid of Inria Lorraine and on developing a domain-specific language that eases programming with the ordered read-write lock (ORWL) execution model. The goal of this work is to provide a single execution model for parallel programs and to allow them to be deployed on multicore machines with varying architectures.

9.2. International Initiatives

9.2.1. Inria International Partners

9.2.1.1. Informal International Partners

David Lo, of Singapore Management University, is an expert in the use of statistical methods in understanding software and associated artifacts, with over 140 publications in this area. Julia Lawall has worked with Lo over the past 5 years, exploiting the complementarity of her expertise in Linux code and in program analysis with Lo's expertise in statistical methods, resulting in 10 joint publications [47], [44], [66], [70], [71], [72], [73], [69], [76]. This collaboration has been reinforced in the form of a Merlion collaboration grant from the Institut Français for the years 2013 and 2014, resulting in the exchange of researchers and PhD students between Whisper and Singapore Management University.

Wouter Swierstra is lecturer in the Software Technology Group of Utrecht University. His work lies at the crossroad between dependent type theory, generic programming, and domain-specific languages embedded in type theory. As part of his PEPS JCJC, Pierre-Évariste Dagand visited him to apply for a joint Van Gogh grant on the topic of extending type theory with language interoperability, allowing unsafe operations to be performed in a type-safe framework.

Timothy Roscoe is a Professor in the Institute for Pervasive Computing at ETH Zurich. His research areas are operating systems, distributed systems, and networking. As part of his PEPS JCJC, Pierre-Évariste Dagand visited the Systems group at ETH to explore avenues for collaboration on applying synchronous programming concepts to the design and implementation of network stacks.

9.3. International Research Visitors

9.3.1. Visits of International Scientists

Greg Kroah-Hartman visited the Whisper team in March and April 2015, as an Inria invited researcher. Kroah-Hartman is one of the leading developers of the Linux kernel, and at the time only one of two developers employed by the Linux Foundation, with the other being Linus Torvalds. During his visit, he gave a number of courses and seminars at UPMC, Paris Diderot University, and Ecole Normale Supérieure, and a keynote in a conference on the Internet of Things organized by the GTLL. He also participated throughout his visit in the activities of the Whisper team around the use of Coccinelle and research projects related to the Linux kernel.

9.3.1.1. Internships

Iago Abal, a PhD student at the IT University in Copenhagen, Denmark, visited the Whisper team from January 14, 2015 to March 1, 2015.

9.3.1.2. Research stays abroad

As part of Academics Without Borders, Pierre-Évariste Dagand was a visiting researcher at the University of Cape Coast (Ghana) during 2 months. Aside from his teaching duties, his role was to foster the research activity of the university's Computer Science department. He was thus in charge of the organisation of a weekly research seminar, whose purpose was to perform scientific dissemination and to transmit academic best practices.

ALPINES Project-Team

9. Partnerships and Cooperations

9.1. National Initiatives

9.1.1. ANR

9.1.1.1. *Medimax*

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

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

9.1.1.2. *Non-local DD*

ANR appel à projet générique October 2015 - September 2020

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

9.1.1.3. *Soil μ -3D*

ANR appel à projet générique October 2015 - September 2020

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

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

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

9.2. European Initiatives

9.2.1. FP7 & H2020 Projects

9.2.1.1. NLA FET

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

Programm: H2020

Duration: November 2015 - November 2018

Coordinator: UMEÅUniversitet

Partners:

Science and Technology Facilities Council (United Kingdom)

Computer Science Department, UmeåUniversitet (Sweden)

Mathematics Department, The University of Manchester (United Kingdom)

Inria contact: Laura Grigori

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

9.2.1.2. EXA2CT

Title: EXascale Algorithms and Advanced Computational Techniques

Programm: FP7

Duration: September 2013 - August 2016

Coordinator: IMEC

Partners:

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

Interuniversitair Micro-Electronica Centrum Vzw (Belgium)

Intel Corporations (France)

Numerical Algorithms Group Ltd (United Kingdom)

T-Systems Solutions for Research (Germany)

Universiteit Antwerpen (Belgium)

Universita della Svizzera italiana (Switzerland)

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

Vysoka Skola Banska - Technicka Univerzita Ostrava (Czech Republic)

Inria contact: Luc Giraud

Numerical simulation is a crucial part of science and industry in Europe. The advancement of simulation as a discipline relies on increasingly 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.

9.3. International Initiatives

9.3.1. Inria International Labs

Inria@SiliconValley

Associate Team involved in the International Lab:

9.3.1.1. COALA

Title: Communication Optimal Algorithms for Linear Algebra

International Partner (Institution - Laboratory - Researcher):

University of California Berkeley (United States) - Electrical Engineering and Computer Science (EECS) - James Demmel

Start year: 2010

See also: <https://who.rocq.inria.fr/Laura.Grigori/COALA2010/coala.html>

Our goal is to continue COALA associated team that focuses on the design and implementation of numerical algorithms for today's large supercomputers formed by thousands of multicore processors, possibly with accelerators. We focus on operations that are at the heart of many scientific applications as solving linear systems of equations or least squares problems. The algorithms belong to a new class referred to as communication avoiding that provably minimize communication, where communication means the data transferred between levels of memory hierarchy or between processors in a parallel computer. This research is motivated by studies showing that communication costs can already exceed arithmetic costs by orders of magnitude, and the gap is growing exponentially over time. An important aspect that we consider here is the validation of the algorithms in real applications through our collaborations. COALA is an Inria associate team that focuses on the design and implementation of numerical algorithms for today's large supercomputers formed by thousands of multicore processors, possibly with accelerators. We focus on operations that are at the heart of

many scientific applications as solving linear systems of equations or least squares problems. The algorithms belong to a new class referred to as communication avoiding that provably minimize communication, where communication means the data transferred between levels of memory hierarchy or between processors in a parallel computer. This research is motivated by studies showing that communication costs can already exceed arithmetic costs by orders of magnitude, and the gap is growing exponentially over time. An important aspect that we consider here is the validation of the algorithms in real applications through our collaborations.

9.4. International Research Visitors

9.4.1. Visits to International Teams

9.4.1.1. Sabbatical programme

Grigori Laura

Date: Aug 2014 - June 2015

Institution: [University of California Berkeley](#) (United States)

9.4.1.2. Research stays abroad

- Laura Grigori: long term mission at UC Berkeley, Computer Science Department, from September 2015 to June 2016.
- Xavier Claeys: Seminar of Applied Mathematics, ETH Zürich, Switzerland, June. 7th - 20th, 2015.
- Frédéric Hecht: Cours FreeFem++, Maths departement, Universty of Oxford, England, march 16th - 20th, 2015.
- Frédéric Hecht: FreeFem++, Cimpa Summer School on Current Research in FEM at IIT Bombay, India 6-17 July , 2015.

AVALON Project-Team

9. Partnerships and Cooperations

9.1. National Initiatives

9.1.1. PIA

9.1.1.1. PIA ELCI, Environnement Logiciel pour le Calcul Intensif, 2014-2017

Participants: H el ene Coullon, Thierry Gautier, Laurent Lef evre, Christian Perez, Issam Rais, J er ome Richard.

The ELCI PIA project is coordinated by BULL with several partners: CEA, Inria, SAFRAB, UVSQ.

This project aims to improve the support for numerical simulations and High Performance Computing (HPC) by providing a new generation software stack to control supercomputers, to improve numerical solvers, and pre- and post computing software, as well programming and execution environment. It also aims to validate the relevance of these development by demonstrating their capacity to deliver better scalability, resilience, modularity, abstraction, and interaction on some application use-cases. Avalon is involved in WP1 and WP3 ELCI Work Packages through the PhD of Issam Rais and the postdoc of H el ene Coullon. Laurent Lefevre is the Inria representative in the ELCI technical committee.

9.1.2. French National Research Agency Projects (ANR)

9.1.2.1. ANR EMERGENCE CloudPower, Cloud Service providing HPC on-demand to innovative SME's, 35 months, ANR-12-EMMA-0038

Participant: Gilles Fedak.

High performance computing (HPC) allows scientists and industries to run large numerical application on huge data volumes. The HPC is a key factor in knowledge and innovation in many fields of industry and service, with high economic and social issues: aerospace, finance and business intelligence, energy and environment, chemicals and materials, medicine and biology , digital art and games, Web and social networks, ... Today, acquiring HPC supercomputer is very expensive, making HPC unreachable to SMIs / SMEs for their research and development. The CloudPower project results from the XtremWeb research and development project. Its goal is to offer a low cost Cloud HPC service for small and medium-sized innovative companies. With CloudPower, companies and scientists will run their simulations to design and develop new products on a powerful, scalable, economical, reliable and secure infrastructure.

The project will lead the creation of a new and innovative company operating the platform implemented in the framework of the ANR Emergence. CloudPower will implement SaaS / PaaS portal for customers and develop extensions to allow commercial exploitation of unused resources. Building on the network of SMIs from the competitiveness clusters System@tic and LyonBiopole, we will implement scenarios and/or demonstrators which illustrate the ability of CloudPower to increase competitiveness, research and marketing of innovative SMEs.

9.1.2.2. ANR INFRA MOEBUS, Multi-objective scheduling for large computing platforms, 4 years, ANR-13-INFR-000, 2013-2016

Participants: Christian Perez, Laurent Lef evre, Fr ed eric Suter.

The ever growing evolution of computing platforms leads to a highly diversified and dynamic landscape. The most significant classes of parallel and distributed systems are supercomputers, grids, clouds and large hierarchical multi-core machines. They are all characterized by an increasing complexity for managing the jobs and the resources. Such complexity stems from the various hardware characteristics and from the applications characteristics. The MOEBUS project focuses on the efficient execution of parallel applications submitted by various users and sharing resources in large-scale high-performance computing environments.

We propose to investigate new functionalities to add at low cost in actual large scale schedulers and programming standards, for a better use of the resources according to various objectives and criteria. We propose to revisit the principles of existing schedulers after studying the main factors impacted by job submissions. Then, we will propose novel efficient algorithms for optimizing the schedule for unconventional objectives like energy consumption and to design provable approximation multi-objective optimization algorithms for some relevant combinations of objectives. An important characteristic of the project is its right balance between theoretical analysis and practical implementation. The most promising ideas will lead to integration in reference systems such as SLURM and OAR as well as new features in programming standards implementations such as MPI or OpenMP.

9.1.2.3. ANR INFRA SONGS, *Simulation Of Next Generation Systems*, 4 years, ANR-12-INFRA-11, 2012-2016

Participant: Frédéric Suter.

The last decade has brought tremendous changes to the characteristics of large scale distributed computing platforms. Large grids processing terabytes of information a day and the peer-to-peer technology have become common even though understanding how to efficiently such platforms still raises many challenges. As demonstrated by the USS SIMGRID project, simulation has proved to be a very effective approach for studying such platforms. Although even more challenging, we think the issues raised by petaflop/exaflop computers and emerging cloud infrastructures can be addressed using similar simulation methodology.

The goal of the SONGS project is to extend the applicability of the SIMGRID simulation framework from Grids and Peer-to-Peer systems to Clouds and High Performance Computation systems. Each type of large-scale computing system will be addressed through a set of use cases and lead by researchers recognized as experts in this area.

Any sound study of such systems through simulations relies on the following pillars of simulation methodology: Efficient simulation kernel; Sound and validated models; Simulation analysis tools; Campaign simulation management.

9.1.3. Inria Large Scale Initiative

9.1.3.1. C2S@Exa, *Computer and Computational Sciences at Exascale*, 4 years, 2013-2017

Participants: Hélène Coullon, Christian Perez, Laurent Lefèvre, Jérôme Richard, Thierry Gautier.

Since January 2013, the team is participating to the C2S@Exa Inria Project Lab (IPL). This national initiative aims at 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. At the current state of the art in technologies and methodologies, a multidisciplinary approach is required to overcome the challenges raised by the development of highly scalable numerical simulation software that can exploit computing platforms offering several hundreds of thousands of cores. Hence, the main objective of C2S@Exa is the establishment of a continuum of expertise in the computer science and numerical mathematics domains, by gathering researchers from Inria project-teams whose research and development activities are tightly linked to high performance computing issues in these domains. More precisely, this collaborative effort involves computer scientists that are experts of programming models, environments and tools for harnessing massively parallel systems, algorithmists that propose algorithms and contribute to generic libraries and core solvers in order to take benefit from all the parallelism levels with the main goal of optimal scaling on very large numbers of computing entities and, numerical mathematicians that are studying numerical schemes and scalable solvers for systems of partial differential equations in view of the simulation of very large-scale problems.

9.1.3.2. DISCOVERY, *Distributed and COoperative management of Virtual Environments autonomousLY*, 4 years, 2015-2019

Participants: Christian Perez, Gilles Fedak.

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

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

To achieve this, the consortium is composed of experts in research areas such as large-scale infrastructure management systems, network and P2P algorithms. Moreover two key network operators, namely Orange and RENATER, are involved in the project.

By deploying and using such a LUC Operating System on backbones, our ultimate vision is to make possible to host/operate a large part of the Internet by its internal structure itself: A scalable set of resources delivered by any computing facilities forming the Internet, starting from the larger hubs operated by ISPs, government and academic institutions, to any idle resources that may be provided by end-users.

9.2. European Initiatives

9.2.1. FP7 & H2020 Projects

9.2.1.1. PaaSage

Participants: Christian Perez, Laurent Pouilloux.

Title: PaaSage: Model-based Cloud Platform Upperware

Type: Seventh Framework Programme

Instrument: Collaborative project

Duration: October 2012 - September 2016 (48 months)

Coordinator: Pierre Guisset (GEIE ERCIM)

Others partners: SINTEF, STFC, HLRS, University of Stuttgart, Inria, CETIC, FORTH, be.wan, EVRY, SysFera, Flexiant, Lufthansa Systems, AG GWDG, Automotive Simulation Center Stuttgart e.V.

See also: <http://paasage.eu>

Abstract: PaaSage will deliver an open and integrated platform, to support both deployment and design of Cloud applications, together with an accompanying methodology that allows model-based development, configuration, optimization, and deployment of existing and new applications independently of the existing underlying Cloud infrastructures. Specifically it will deliver an IDE (Integrated Development Environment) incorporating modules for design time and execution time optimizations of applications specified in the CLOUD Modeling Language (CLOUD ML), execution-level mappers and interfaces and a metadata database.

9.2.2. Collaborations in European Programs, except FP7 & H2020

9.2.2.1. CHIST-ERA STAR

Participants: Marcos Dias de Assunção, Radu Carpa, Laurent Lefèvre, Olivier Glück.

Title: SwiTching And tRansmission project

Type: CHIST-ERA (European Coordinated Research on Long-term Challenges in Information and Communication Sciences & Technologies ERA-Net)

Duration: 2013-2015

Coordinator: Jaafar Elmirghani (University of Leeds - UK)

Others partners: Inria ,University of Cambridge (UK), University of Leeds (UK), AGH University of Science and Technology Department of Telecommunications (Poland)

See also: <http://www.chistera.eu/projects/star>

Abstract: The Internet power consumption has continued to increase over the last decade as a result of a bandwidth growth of at least 50 to 100 times. Further bandwidth growth between 40% and 300% is predicted in the next 3 years as a result of the growing popularity of bandwidth intensive applications. Energy efficiency is therefore increasingly becoming a key priority for ICT organizations given the obvious ecological and economic drivers. In this project we adopt the GreenTouch energy saving target of a factor of a 100 for Core Switching and Routing and believe this ambitious target is achievable should the research in this proposal prove successful. A key observation in core networks is that most of the power is consumed in the IP layer while optical transmission and optical switching are power efficient in comparison, hence the inspiration for this project. Initial studies by the applicants show that physical topology choices in networks have the potential to significantly reduce the power consumption, however network optimization and the consideration of traffic and the opportunities afforded by large, low power photonic switch architectures will lead to further power savings. Networks are typically over provisioned at present to maintain quality of service. We will study optimum resource allocation to reduce the overprovisioning factor while maintaining the quality of service. Protection is currently provided in networks through the allocation of redundant paths and resources, and for full protection there is a protection route for every working route. Avalon is contributing to STAR in terms of software network protocols and services optimizations which will be combined with more efficient photonic switches in order to obtain a factor of 100 power saving in core networks can be realised through this project with significant potential for resulting impact on how core photonic networks are designed and implemented.

9.2.2.2. COST IC1305 : Nesus

Participants: Laurent Lefèvre, Marcos Dias de Assunção, Violaine Villebonnet.

Program: COST

Project acronym: IC1305

Project title: Network for Sustainable Ultrascale Computing (NESUS)

Duration: 2014-2019

Coordinator: Jesus Carretero (Univ. Madrid)

Abstract: Ultrascale systems are envisioned as large-scale complex systems joining parallel and distributed computing systems that will be two to three orders of magnitude larger than today's systems. The EU is already funding large scale computing systems research, but it is not coordinated across researchers, leading to duplications and inefficiencies. The goal of the NESUS Action is to establish an open European research network targeting sustainable solutions for ultrascale computing aiming at cross fertilization among HPC, large scale distributed systems, and big data management. The network will contribute to glue disparate researchers working across different areas and provide a meeting ground for researchers in these separate areas to exchange ideas, to identify synergies, and to pursue common activities in research topics such as sustainable software solutions (applications and system software stack), data management, energy efficiency, and resilience. In Nesus, Laurent Lefevre is co-chairing the Working on Energy Efficiency (WG5). In 2015, Violaine Villebonnet has been involved in a short term scientific mission with University of La Lagune (Spain) on the topic of energy proportionality and profiling of HPC systems (May 18-29, 2015).

9.2.2.3. SEED4C

Program: Celtic-Plus

Project acronym: SEED4C

Project title: Security Embedded Element and Data privacy for the Cloud.

Duration: 2012-2015

Coordinator: Stéphane Betge-Brezetz (Alcatel-Lucent lab)

Other partners: Gemalto, ENSI Bourges, Inria, Wallix, VTT Technical Research centre of Finland, Mikkelin Puhelin Oyj, Cygate, Nokia Siemens Networks, Finceptum OY (Novell), Solacia, Innovalia Association, Nextel, Software Quality Systems, Ikusi, Vicomtech, Biscaytik

Abstract: SEED4C is a Celtic-Plus project: an industry-driven European research initiative to define, perform and finance through public and private funding common research projects in the area of telecommunications, new media, future Internet, and applications and services focusing on a new "Smart Connected World" paradigm. Celtic-Plus is a EUREKA ICT cluster and is part of the inter-governmental EUREKA network.

The cloud security challenge not only reflects on the secure running of software on one single machine, but rather on managing and guaranteeing security of a computer group or cluster seen as a single entity. Seed4C focus is to evolve from cloud security with an isolated point or centralized points of enforcement for security to cloud security with cooperative points of enforcement for security.

9.3. International Initiatives

9.3.1. Inria International Labs

9.3.1.1. Inria-UIUC-NCSA Joint Laboratory for Petascale Computing

Participants: Eddy Caron, Hélène Coullon, Olivier Glück, Vincent Lanore, Laurent Lefèvre, Christian Perez.

The University of Illinois at Urbana-Champaign, Inria, the French national computer science institute, Argonne National Laboratory, Barcelona Supercomputing Center, Jülich Supercomputing Centre and the Riken Advanced Institute for Computational Science formed the Joint Laboratory on Extreme Scale Computing, a follow-up of the Inria-Illinois Joint Laboratory for Petascale Computing. The Joint Laboratory is based at Illinois and includes researchers from Inria, and the National Center for Supercomputing Applications, ANL, BSC and JSC. It focuses on software challenges found in extreme scale high-performance computers.

9.3.1.2. Informal International Partners

- Université Gaston Berger, Saint Louis, Sénégal. Contact: Pr. Ousmane Thiaré.
- École Centrale Mahindra, Hyderabad, India. Contact: Dr. Arya Kumar Bhattacharya.

9.3.2. Participation In other International Programs

9.3.2.1. GreenTouch

Participants: Jean-Patrick Gelas, Laurent Lefèvre.

GreenTouch is a consortium of leading Information and Communications Technology (ICT) industry, academic and non-governmental research experts dedicated to fundamentally transforming communications and data networks, including the Internet, and significantly reducing the carbon footprint of ICT devices, platforms and networks. The GreenTouch project has ended in June 2015 through the dissemination and demonstration of main results during a final celebration in New York. Our activities on designing virtual home gateway at large scale have been demonstrated.

9.4. International Research Visitors

9.4.1. Visits of International Scientists

Dr Dan Emanoil Grigoras. University College Cork (UK). September 16-18 2015.

9.4.2. Visits to International Teams

9.4.2.1. Research stays abroad

9.4.2.1.1. Gilles Fedak visited CAS, Beijing, China

Dates: 15/8/15 - 15/9/15

Local contact: Pr Haiwu He

Gilles Fedak has been awarded the President's International Fellowship Initiative (PIFI) from the Chinese Academy of Sciences. He visited the CSNET institute in Beijing for one month, working with Pr. Haiwu He on D³ MapReduce.

9.4.2.1.2. Daniel Balouek Thomert visited Mahindra Ecole Centrale, India

Dates: 10/5/15 - 12/19/15

Local contact: Dr Arya K. Bhattacharya (Arya.Bhattacharya@mechyd.ac.in)

Other avalon researcher involved: Eddy Caron and Laurent Lefevre.

Abstract: Our work synergizes two state-of-the-art technologies by combining Multi-Objective Evolutionary Algorithms (MOEA) with trade-off mechanisms using the DIET toolkit, in a context of cloud computing workflow placement. Evaluation of the proposed solution under different scheduling policies shows significant gains of energy consumption with some improvement on the overall workflow completion time. Following this work, a paper has been submitted.

HIEPACS Project-Team

9. Partnerships and Cooperations

9.1. Regional Initiatives

9.1.1. Innovative simulation methods for large scale numeric prototypes on emerging architectures computers

Participants: Emmanuel Agullo, Olivier Coulaud, Aurélien Esnard, Mathieu Faverge, Luc Giraud, Abdou Guermouche, Pierre Ramet, Jean Roman.

Grant: Regional council

Dates: 2013 – 2015

Partners: EPIs **REALOPT**, **STORM** from Inria Bordeaux Sud-Ouest, CEA-CESTA and l'Institut pluridisciplinaire de recherche sur l'environnement et les matériaux (IPREM) .

Overview: Numerical simulation is now integrated into all the design levels and the scientific studies for both academic and industrial contexts. Given the increasing size and sophistication of the simulations carried out, the use of parallel computing is inescapable. The complexity of such achievements requires collaboration of multidisciplinary teams capable of mastering all the necessary scientific skills for each component constituting the chain of expertise. In this project we consider each of these elements as well as efficient methods for parallel codes coupling. All these works are intended to contribute to the design of large scale parallel multi-physics simulations. In addition to this research human activities the regional council also support some innovative computing equipment that will be embedded in the PlaFRIM experimental platform, project led by O. Coulaud.

9.2. National Initiatives

9.2.1. Inria Project Lab

9.2.1.1. C2S@Exa - Computer and Computational Sciences at Exascale

Since January 2013, the team is participating to the **C2S@EXA** Inria Project Lab (IPL). This national initiative aims at 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. At the current state of the art in technologies and methodologies, a multidisciplinary approach is required to overcome the challenges raised by the development of highly scalable numerical simulation software that can exploit computing platforms offering several hundreds of thousands of cores. Hence, the main objective of **C2S@EXA** is the establishment of a continuum of expertise in the computer science and numerical mathematics domains, by gathering researchers from Inria project-teams whose research and development activities are tightly linked to high performance computing issues in these domains. More precisely, this collaborative effort involves computer scientists that are experts of programming models, environments and tools for harnessing massively parallel systems, algorithmists that propose algorithms and contribute to generic libraries and core solvers in order to take benefit from all the parallelism levels with the main goal of optimal scaling on very large numbers of computing entities and, numerical mathematicians that are studying numerical schemes and scalable solvers for systems of partial differential equations in view of the simulation of very large-scale problems.

9.2.2. ANR

9.2.2.1. SOLHAR: SOLvers for Heterogeneous Architectures over Runtime systems

Participants: Emmanuel Agullo, Mathieu Faverge, Abdou Guermouche, Xavier Lacoste, Pierre Ramet, Jean Roman, Guillaume Sylvand.

Grant: ANR-MONU

Dates: 2013 – 2017

Partners: Inria (**REALOPT**, **STORM** Bordeaux Sud-Ouest et **ROMA** Rhone-Alpes), IRIT/INPT, CEA-CESTA et Airbus Group Innovations.

Overview:

During the last five years, the interest of the scientific computing community towards accelerating devices has been rapidly growing. The reason for this interest lies in the massive computational power delivered by these devices. Several software libraries for dense linear algebra have been produced; the related algorithms are extremely rich in computation and exhibit a very regular pattern of access to data which makes them extremely good candidates for GPU execution. On the contrary, methods for the direct solution of sparse linear systems have irregular, indirect memory access patterns that adversely interact with typical GPU throughput optimizations.

This project aims at studying and designing algorithms and parallel programming models for implementing direct methods for the solution of sparse linear systems on emerging computer equipped with accelerators. The ultimate aim of this project is to achieve the implementation of a software package providing a solver based on direct methods for sparse linear systems of equations. To date, the approaches proposed to achieve this objective are mostly based on a simple offloading of some computational tasks to the accelerators and rely on fine hand-tuning of the code and accurate performance modeling to achieve efficiency. This project proposes an innovative approach which relies on the efficiency and portability of runtime systems. The development of a production-quality, sparse direct solver requires a considerable research effort along three distinct axes:

- linear algebra: algorithms have to be adapted or redesigned in order to exhibit properties that make their implementation and execution on heterogeneous computing platforms efficient and reliable. This may require the development of novel methods for defining data access patterns that are more suitable for the dynamic scheduling of computational tasks on processing units with considerably different capabilities as well as techniques for guaranteeing a reliable and robust behavior and accurate solutions. In addition, it will be necessary to develop novel and efficient accelerator implementations of the specific dense linear algebra kernels that are used within sparse, direct solvers;
- runtime systems: tools such as the **StarPU** runtime system proved to be extremely efficient and robust for the implementation of dense linear algebra algorithms. Sparse linear algebra algorithms, however, are commonly characterized by complicated data access patterns, computational tasks with extremely variable granularity and complex dependencies. Therefore, a substantial research effort is necessary to design and implement features as well as interfaces to comply with the needs formalized by the research activity on direct methods;
- scheduling: executing a heterogeneous workload with complex dependencies on a heterogeneous architecture is a very challenging problem that demands the development of effective scheduling algorithms. These will be confronted with possibly limited views of dependencies among tasks and multiple, and potentially conflicting objectives, such as minimizing the makespan, maximizing the locality of data or, where it applies, minimizing the memory consumption.

Given the wide availability of computing platforms equipped with accelerators and the numerical robustness of direct solution methods for sparse linear systems, it is reasonable to expect that the outcome of this project will have a considerable impact on both academic and industrial scientific computing. This project will moreover provide a substantial contribution to the computational science and high-performance computing communities, as it will deliver an unprecedented example of a complex numerical code whose parallelization completely relies on runtime scheduling systems and which is, therefore, extremely portable, maintainable and evolvable towards future computing architectures.

9.2.2.2. *SONGS: Simulation Of Next Generation Systems*

Participant: Abdou Guermouche.

Grant: ANR 11 INFRA 13

Dates: 2011 – 2015

Partners: Inria (Bordeaux Sud-Ouest, Nancy - Grand Est, Rhone-Alpes, Sophia Antipolis - Méditerranée), I3S, LSIIT

Overview:

The last decade has brought tremendous changes to the characteristics of large scale distributed computing platforms. Large grids processing terabytes of information a day and the peer-to-peer technology have become common even though understanding how to efficiently exploit such platforms still raises many challenges. As demonstrated by the USS SimGrid project funded by the ANR in 2008, simulation has proved to be a very effective approach for studying such platforms. Although even more challenging, we think the issues raised by petaflop/exaflop computers and emerging cloud infrastructures can be addressed using similar simulation methodology.

The goal of the **SONGS** project is to extend the applicability of the SimGrid simulation framework from Grids and Peer-to-Peer systems to Clouds and High Performance Computation systems. Each type of large-scale computing system will be addressed through a set of use cases and lead by researchers recognized as experts in this area.

Any sound study of such systems through simulations relies on the following pillars of simulation methodology: Efficient simulation kernel; Sound and validated models; Simulation analysis tools; Campaign simulation management.

9.2.2.3. ANEMOS: Advanced Numeric for ELMs : Modeling and Optimized Schemes

Participants: Xavier Lacoste, Guillaume Latu, Pierre Ramet.

Grant: ANR-MN

Dates: 2012 – 2016

Partners: Univ. Nice, CEA/IRFM, CNRS/MDS.

Overview: The main goal of the project is to make a significant progress in understanding of active control methods of plasma edge MHD instabilities Edge Localized Modes (ELMs) which represent particular danger with respect to heat and particle loads for Plasma Facing Components (PFC) in ITER. The project is focused in particular on the numerical modelling study of such ELM control methods as Resonant Magnetic Perturbations (RMPs) and pellet ELM pacing both foreseen in ITER. The goals of the project are to improve understanding of the related physics and propose possible new strategies to improve effectiveness of ELM control techniques. The tool for the non-linear MHD modeling is the **JOEK** code which was essentially developed within previous ANR **ASTER**. **JOEK** will be largely developed within the present project to include corresponding new physical models in conjunction with new developments in mathematics and computer science strategy. The present project will put the non-linear MHD modeling of ELMs and ELM control on the solid ground theoretically, computationally, and applications-wise in order to progress in urgently needed solutions for ITER.

Regarding our contributions, the **JOEK** code is mainly composed of numerical computations on 3D data. The toroidal dimension of the tokamak is treated in Fourier space, while the poloidal plane is decomposed in Bezier patches. The numerical scheme used involves a direct solver on a large sparse matrix as a main computation of one time step. Two main costs are clearly identified: the assembly of the sparse matrix, and the direct factorization and solve of the system that includes communications between all processors. The efficient parallelization of **JOEK** is one of our main goals, to do so we will reconsider: data distribution, computation distribution or GMRES implementation. The quality of the sparse solver is also crucial, both in term of performance and accuracy. In the current release of **JOEK**, the memory scaling is not satisfactory to solve problems listed above, since at present as one increases the number of processes for a given problem size, the memory footprint on each process does not reduce as much as one can expect. In order to access finer meshes on available supercomputers, memory savings have to be done in the whole code. Another key point for improving parallelization is to carefully profile the application to understand the regions of the code that do not scale well. Depending on the timings obtained, strategies to diminish communication overheads will be evaluated and schemes that improve load balancing will be initiated. **JOEK** uses **PaStiX** sparse matrix library for matrix inversion. However, large number of toroidal harmonics and particular thin structures to resolve for realistic plasma parameters and ITER machine size still require more aggressive optimisation in numeric

dealing with numerical stability, adaptive meshes etc. However many possible applications of **JOEK** code we proposed here which represent urgent ITER relevant issues related to ELM control by RMPs and pellets remain to be solved.

9.2.2.4. *RESCUE: Résilience des applications SCientifiqUEs*

Participants: Emmanuel Agullo, Luc Giraud, Abdou Guermouche, Jean Roman, Mawussi Zounon.

Grant: ANR-Blanc (computer science theme)

Dates: 2010 – 2015

Partners: Inria EPI **ROMA** (leader) and GRAND LARGE.

Overview: The advent of exascale machines will help solve new scientific challenges only if the resilience of large scientific applications deployed on these machines can be guaranteed. With 10,000,000 core processors, or more, the time interval between two consecutive failures is anticipated to be smaller than the typical duration of a checkpoint, i.e., the time needed to save all necessary application and system data. No actual progress can then be expected for a large-scale parallel application. Current fault-tolerant techniques and tools can no longer be used. The main objective of the **RESCUE** project is to develop new algorithmic techniques and software tools to solve the exascale resilience problem. Solving this problem implies a departure from current approaches, and calls for yet-to-be-discovered algorithms, protocols and software tools.

This proposed research follows three main research thrusts. The first thrust deals with novel checkpoint protocols. This thrust will include the classification of relevant fault categories and the development of a software package for fault injection into application execution at runtime. The main research activity will be the design and development of scalable and light-weight checkpoint and migration protocols, with on-the-fly storing of key data, distributed but coordinated decisions, etc. These protocols will be validated via a prototype implementation integrated with the public-domain MPICH project. The second thrust entails the development of novel execution models, i.e., accurate stochastic models to predict (and, in turn, optimize) the expected performance (execution time or throughput) of large-scale parallel scientific applications. In the third thrust, we will develop novel parallel algorithms for scientific numerical kernels. We will profile a representative set of key large-scale applications to assess their resilience characteristics (e.g., identify specific patterns to reduce checkpoint overhead). We will also analyze execution trade-offs based on the replication of crucial kernels and on decentralized ABFT (Algorithm-Based Fault Tolerant) techniques. Finally, we will develop new numerical methods and robust algorithms that still converge in the presence of multiple failures. These algorithms will be implemented as part of a software prototype, which will be evaluated when confronted with realistic faults generated via our fault injection techniques.

We firmly believe that only the combination of these three thrusts (new checkpoint protocols, new execution models, and new parallel algorithms) can solve the exascale resilience problem. We hope to contribute to the solution of this critical problem by providing the community with new protocols, models and algorithms, as well as with a set of freely available public-domain software prototypes.

9.2.2.5. *DEDALES: Algebraic and Geometric Domain Decomposition for Subsurface/Groundwater Flows*

Participants: Emmanuel Agullo, Luc Giraud, Mathieu Faverge, Louis Poirel.

Grant: ANR-14-CE23-0005

Dates: 2014 – 2018

Partners: Inria EPI POMDAPI (leader); Université Paris 13 - Laboratoire Analyse, Géométrie et Applications; Maison de la Simulation; Andra.

Overview: Project **DEDALES** aims at developing high performance software for the simulation of two phase flow in porous media. The project will specifically target parallel computers where each node is itself composed of a large number of processing cores, such as are found in new generation many-core architectures. The project will be driven by an application to radioactive waste deep geological disposal. Its main feature is phenomenological complexity: water-gas flow in highly heterogeneous medium, with widely varying space and time scales. The assessment of large scale model is of major importance and issue for this application, and realistic geological models have several million grid cells. Few, if at all, software codes provide the necessary physical features with massively parallel simulation capabilities. The aim of the **DEDALES** project is to study, and experiment with, new approaches to develop effective simulation tools with the capability to take advantage of modern computer architectures and their hierarchical structure. To achieve this goal, we will explore two complementary software approaches that both match the hierarchical hardware architecture: on the one hand, we will integrate a hybrid parallel linear solver into an existing flow and transport code, and on the other hand, we will explore a two level approach with the outer level using (space time) domain decomposition, parallelized with a distributed memory approach, and the inner level as a subdomain solver that will exploit thread level parallelism. Linear solvers have always been, and will continue to be, at the center of simulation codes. However, parallelizing implicit methods on unstructured meshes, such as are required to accurately represent the fine geological details of the heterogeneous media considered, is notoriously difficult. It has also been suggested that time level parallelism could be a useful avenue to provide an extra degree of parallelism, so as to exploit the very large number of computing elements that will be part of these next generation computers. Project **DEDALES** will show that space-time DD methods can provide this extra level, and can usefully be combined with parallel linear solvers at the subdomain level. For all tasks, realistic test cases will be used to show the validity and the parallel scalability of the chosen approach. The most demanding models will be at the frontier of what is currently feasible for the size of models.

9.2.2.6. *TECSER: Novel high performance numerical solution techniques for RCS computations*

Participants: Emmanuel Agullo, Luc Giraud, Matthieu Kuhn.

Grant: ANR-14-ASTRID

Dates: 2014 – 2017

Partners: Inria EPI NACHOS (leader), Corida, HiePACS; Airbus Group Innovations, Nucléutudes.

Overview: the objective of the **TECSER** projet is to develop an innovative high performance numerical methodology for frequency-domain electromagnetics with applications to RCS (Radar Cross Section) calculation of complicated structures. This numerical methodology combines a high order hybridized DG method for the discretization of the frequency-domain Maxwell in heterogeneous media with a BEM (Boundary Element Method) discretization of an integral representation of Maxwell's equations in order to obtain the most accurate treatment of boundary truncation in the case of theoretically unbounded propagation domain. Beside, scalable hybrid iterative/direct domain decomposition based algorithms are used for the solution of the resulting algebraic system of equations.

9.3. European Initiatives

9.3.1. *FP7 & H2020 Projects*

9.3.1.1. *HPC4E*

Title: HPC for Energy

Programm: H2020

Duration: 2015 - 2018

Coordinator: Barcelona Supercomputing Center

Inria contact: Stephane Lanteri

Objectives: This project has three general objectives and a large list of specific technical objectives related with research in each technology:

1. The main objective is to develop beyond the state of the art high performance simulation tools that can help the energy industry to respond future energy demands and also to carbon related environmental issues using the state of the art HPC systems.
2. Improve the cooperation between energy industries from EU and Brazil. The project includes relevant energy industrial partners from Brazil and EU, which will benefit from the project's results. They guarantee that TRL of the project technologies will be very high
3. Improve the cooperation between the leading research centres in EU and Brazil in HPC applied to energy industry. This includes sharing supercomputing infrastructures between Brazil and EU. The cross fertilization between energy related problems and other scientific fields will be beneficial at both sides of the Atlantic.

9.3.1.2. EXA2CT

Type: FP7

Defi: Special action

Instrument: Specific Targeted Research Project

Objectif: Exascale computing platforms, software and applications

Duration: September 2013 - August 2016

Coordinator: IMEC, Belgium

Partner: Particular specializations and experience of the partners are:

- Applications:
 - NAG - long experience in consultancy for HPC applications
 - Intel France - collaboration with industry on the migration of software for future HPC systems
 - TS-SFR - long experience in consultancy for HPC applications in Aerospace and Oil & Gas
- Algorithms – primarily numerical:
 - UA - broad experience in numerical solvers, with some taken up by the PETSc numerical library and other work published in high-ranking journals such as Science.
 - USI - expertise in parallel many-core algorithms for real-world applications on emerging architectures
 - Inria - expertise on large scale parallel numerical algorithms
 - IT4I - experience in the development of scalable solvers for large HPC systems (e.g. PRACE)
- Programming Models & Runtime Environments:
 - Imec - leads the programming model research within the Flanders ExaScience Lab
 - UVSQ - specialized in code optimization and performance evaluation in the area of HPC
 - TS-SFR - leading the BMBF funded GASPI project
 - Fraunhofer - developed a GASPI runtime environment used in industrial applications
- Hardware Optimization:
 - Intel France - investigates workloads for new hardware architectures within the context of the Exascale Computing Research centre

Inria contact: Luc Giraud

Abstract: 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. 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.

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.

9.4. International Initiatives

We are involved in the Inria@SiliconValley initiative through the associate team FASTLA described below.

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

9.4.1.1. MORSE

Title: Matrices Over Runtime Systems @ Exascale

International Partner (Institution - Laboratory - Researcher):

KAUST Supercomputing Laboratory (USA)

Duration: 2014 - 2016

See also: <http://icl.cs.utk.edu/projectsdev/morse/index.html>

The goal of Matrices Over Runtime Systems at Exascale (MORSE) project is to design dense and sparse linear algebra methods that achieve the fastest possible time to an accurate solution on large-scale multicore systems with GPU accelerators, using all the processing power that future high end systems can make available. To develop software that will perform well on petascale and exascale systems with thousands of nodes and millions of cores, several daunting challenges have to be overcome, both by the numerical linear algebra and the runtime system communities. By designing a research framework for describing linear algebra algorithms at a high level of abstraction, the MORSE team will enable the strong collaboration between research groups in linear algebra, runtime systems and scheduling needed to develop methods and libraries that fully benefit from the potential of future large-scale machines. Our project will take a pioneering step in the effort to bridge the immense software gap that has opened up in front of the High-Performance Computing (HPC) community.

9.4.1.2. FASTLA

Title: Fast and Scalable Hierarchical Algorithms for Computational Linear Algebra

International Partner (Institution - Laboratory - Researcher):

Stanford University (USA)

Lawrence Berkeley National Laboratory (USA)

Duration: 2014 - 2016

See also: http://people.bordeaux.inria.fr/coulaud/projets/FastLA_Website/

In this project, we propose to study fast and scalable hierarchical numerical kernels and their implementations on heterogeneous manycore platforms for two major computational kernels in intensive challenging applications. Namely, fast multipole methods (FMM) and sparse hybrid linear solvers, that appear in many intensive numerical simulations in computational sciences. Regarding the FMM we plan to study novel generic formulations based on \mathcal{H} -matrices techniques, that will be eventually validated in the field of material physics: the dislocation dynamics. For the hybrid solvers, new parallel preconditioning approaches will be designed and the use of \mathcal{H} -matrices techniques will be first investigated in the framework of fast and monitored approximations on central components. Finally, the innovative algorithmic design will be essentially focused on heterogeneous manycore platforms. The partners, Inria HiePACS, Lawrence Berkeley Nat. Lab and Stanford University, have strong, complementary and recognized experiences and backgrounds in these fields.

9.4.2. Participation In other International Programs

9.4.2.1. HOSCAR

We are involved in the Inria-CNPq **HOSCAR** project led by Stéphane Lanteri.

The general objective of the project is to setup a multidisciplinary Brazil-France collaborative effort for taking full benefits of future high-performance massively parallel architectures. The targets are the very large-scale datasets and numerical simulations relevant to a selected set of applications in natural sciences: (i) resource prospection, (ii) reservoir simulation, (iii) ecological modeling, (iv) astronomy data management, and (v) simulation data management. The project involves computer scientists and numerical mathematicians divided in 3 fundamental research groups: (i) numerical schemes for PDE models (Group 1), (ii) scientific data management (Group 2), and (iii) high-performance software systems (Group 3).

The final annual meeting has been organized in Inria Sophia, on September 21-24, 2015, while a follow-up of the project will exist as a H2020 project entitles HPC4E (HPC for Energy) to be started in 2016 with an enlarged partnership.

9.5. International Research Visitors

9.5.1. Visits to International Teams

9.5.1.1. Research stays abroad

Mathieu Faverge has been invited to KAUST University from October to December 2015 in the context of the associate team **MORSE**.

Pierre Blanchard participated to the Gene Golub SIAM Summer school on Randomized Numerical Linear Algebra held in Delphi, Greece in June 2015.

KERDATA Project-Team

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 been 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: **Ultra-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 project 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).

MESCAL Project-Team

8. Partnerships and Cooperations

8.1. Regional Initiatives

8.1.1. CIMENT

The CIMENT project (Intensive Computing, Numerical Modeling and Technical Experiments, <http://ciment.ujf-grenoble.fr/>) gathers a wide scientific community involved in numerical modeling and computing (from numerical physics and chemistry to astrophysics, mechanics, bio-modeling and imaging) and the distributed computer science teams from Grenoble. Several heterogeneous distributed computing platforms were set up (from PC clusters to IBM SP or alpha workstations) each being originally dedicated to a scientific domain. More than 600 processors are available for scientific computation. The MESCAL project-team provides expert skills in high performance computing infrastructures. The members of MESCAL involved in this project are Pierre Neyron and Olivier Richard.

8.1.2. Cluster Région

Partners: the Inria GRAAL project-team, the LSR-IMAG and IN2P3-LAPP laboratories.

The MESCAL project-team is a member of the regional "cluster" project on computer science and applied mathematics, the focus of its participation is on handling large amount of data large scale architecture.

8.2. National Initiatives

8.2.1. Inria Large Scale Initiative

- *HEMERA, 2010-2014* Leading action "Completing challenging experiments on Grid'5000 (Methodology)" (see <https://www.grid5000.fr/Hemera>).

Experimental platforms like Grid'5000 or PlanetLab provide an invaluable help to the scientific community, by making it possible to run very large-scale experiments in controlled environment. However, while performing relatively simple experiments is generally easy, it has been shown that the complexity of completing more challenging experiments (involving a large number of nodes, changes to the environment to introduce heterogeneity or faults, or instrumentation of the platform to extract data during the experiment) is often underestimated.

This working group explores different complementary approaches, that are the basic building blocks for building the next level of experimentation on large scale experimental platforms.

8.2.2. ANR

- *ANR GAGA (2014-2017)*

GAGA is a "Young Researchers" project funded by the French National Research Agency (ANR) to explore the Geometric Aspects of GAMES. The GAGA team is spread over three different locations in France (Paris, Toulouse and Grenoble), and is coordinated by Vianney Perchet, assistant professor (Maître de Conférences) in the Probabilities and Random Models laboratory in Université Paris VII.

As the name suggests, our project's focus is game theory, a rapidly developing subject with growing applications in economics, social sciences, computer science, engineering, evolutionary biology, etc. As it turns out, many game theoretical topics and tools have a strong geometrical or topological flavor: the structure of a game's equilibrium set, the design of equilibrium-computing algorithms, Blackwell approachability, the geometric character of the replicator dynamics, the use of semi-algebraicity concepts in stochastic games, and many others. Accordingly, our objective is to perform a systematic study of these geometric aspects of game theory and, by so doing, to establish new links between areas that so far appeared unrelated (such as Hessian-Riemannian geometry and discrete choice theory).

- *ANR MARMOTE, 2013-2016*. Partners: Inria Sophia (MAESTRO), Inria Rocquencourt (DIOGEN), PRiSM laboratory from University of Versailles-Saint-Quentin, Telecom SudParis (SAMOVAR), University Paris-Est Créteil (*Spécification et vérification de systèmes*), Université Pierre-et-Marie-Curie/LIP6.

The project aims at realizing a software prototype dedicated to Markov chain modeling. It gathers seven teams that will develop advanced resolution algorithms and apply them to various domains (reliability, distributed systems, biology, physics, economy).

- *ANR NETLEARN, 2013-2015*. Partners: PRiSM laboratory from University of Versailles-Saint-Quentin, Telecom ParisTech, Orange Labs, LAMSADE/University Paris Dauphine, Alcatel-Lucent, Inria (MESCAL).

The main objective of the project is to propose a novel approach of distributed, scalable, dynamic and energy efficient algorithms for managing resources in a mobile network. This new approach relies on the design of an orchestration mechanism of a portfolio of algorithms. The ultimate goal of the proposed mechanism is to enhance the user experience, while at the same time to better utilize the operator resources. User mobility and new services are key elements to take into account if the operator wants to improve the user quality of experience. Future autonomous network management and control algorithms will thus have to deal with a real-time dynamicity due to user mobility and to traffic variations resulting from various usages. To achieve this goal, we focus on two central aspects of mobile networks (the management of radio resources at the Radio Access Network level and the management of the popular contents users want to get access to) and intend to design distributed learning mechanisms in non-stationary environments, as well as an orchestration mechanism that applies the best algorithms depending on the situation.

- *ANR SONGS, 2012-2015*. Partners: Inria Nancy (Algorille), Inria Sophia (MASCOTTE), Inria Bordeaux (CEPAGE, HiePACS, RunTime), Inria Lyon (AVALON), University of Strasbourg, University of Nantes.

The last decade has brought tremendous changes to the characteristics of large scale distributed computing platforms. Large grids processing terabytes of information a day and the peer-to-peer technology have become common even though understanding how to efficiently exploit such platforms still raises many challenges. As demonstrated by the USS SimGrid project funded by the ANR in 2008, simulation has proved to be a very effective approach for studying such platforms. Although even more challenging, we think the issues raised by petaflop/exaflop computers and emerging cloud infrastructures can be addressed using similar simulation methodology.

The goal of the SONGS project (Simulation of Next Generation Systems) is to extend the applicability of the SimGrid simulation framework from grids and peer-to-peer systems to clouds and high performance computation systems. Each type of large-scale computing system will be addressed through a set of use cases and led by researchers recognized as experts in this area.

Any sound study of such systems through simulations relies on the following pillars of simulation methodology: Efficient simulation kernel; Sound and validated models; Simulation analysis tools; Campaign simulation management.

8.2.3. National Organizations

Jean-Marc Vincent is member of the scientific committees of the CIST (Centre International des Sciences du Territoire).

8.3. European Initiatives

8.3.1. FP7 & H2020 Projects

8.3.1.1. Mont-Blanc 2

Program: FP7 Programme

Project acronym: Mont-Blanc 2

Project title: Mont-Blanc: European scalable and power efficient HPC platform based on low-power embedded technology

Duration: October 2013 - September 2016

Coordinator: BSC (Barcelone)

Other partners: BULL - Bull SAS (France), STMicroelectronics - (GNB SAS) (France), ARM - (United Kingdom), JUELICH - (Germany), BADW-LRZ - (Germany), USTUTT - (Germany), CINECA - (Italy), CNRS - (France), Inria - (France), CEA - (France), UNIVERSITY OF BRISTOL - (United Kingdom), ALLINEA SW LIM - (United Kingdom)

Abstract: Energy efficiency is already a primary concern for the design of any computer system and it is unanimously recognized that future Exascale systems will be strongly constrained by their power consumption. This is why the Mont-Blanc project has set itself the following objective: to design a new type of computer architecture capable of setting future global High Performance Computing (HPC) standards that will deliver Exascale performance while using 15 to 30 times less energy. Mont-Blanc 2 contributes to the development of extreme scale energy-efficient platforms, with potential for Exascale computing, addressing the challenges of massive parallelism, heterogeneous computing, and resiliency. Mont-Blanc 2 has great potential to create new market opportunities for successful EU technology, by placing embedded architectures in servers and HPC.

The Mont-Blanc 2 proposal has 4 objectives:

1. To complement the effort on the Mont-Blanc system software stack, with emphasis on programmer tools (debugger, performance analysis), system resiliency (from applications to architecture support), and ARM 64-bit support.
2. To produce a first definition of the Mont-Blanc Exascale architecture, exploring different alternatives for the compute node (from low-power mobile sockets to special-purpose high-end ARM chips), and its implications on the rest of the system.
3. To track the evolution of ARM-based systems, deploying small cluster systems to test new processors that were not available for the original Mont-Blanc prototype (both mobile processors and ARM server chips).
4. To provide continued support for the Mont-Blanc consortium, namely operations of the Mont-Blanc prototype, and hands-on support for our application developers

8.3.1.2. *QUANTICOL*

Program: The project is a member of Fundamentals of Collective Adaptive Systems (FOCAS), a FET-Proactive Initiative funded by the European Commission under FP7.

Project acronym: QUANTICOL

Project title: A Quantitative Approach to Management and Design of Collective and Adaptive Behaviours

Duration: 04 2013 – 03 2017

Coordinator: Jane Hillston (University of Edinburgh, Scotland)

Other partners: University of Edinburgh (Scotland); Istituto di Scienza e Tecnologie della Informazione (Italy); IMT Lucca (Italy) and University of Southampton (England).

Abstract: The main objective of the QUANTICOL project is the development of an innovative formal design framework that provides a specification language for collective adaptive systems (CAS) and a large variety of tool-supported, scalable analysis and verification techniques. These techniques will be based on the original combination of recent breakthroughs in stochastic process algebras and associated verification techniques, and mean field/continuous approximation and control theory. Such a design framework will provide scalable extensive support for the verification of developed models, and also enable and facilitate experimentation and discovery of new design patterns for emergent behaviour and control over spatially distributed CAS.

8.3.1.3. NEWCOM#

Program: FP7-ICT-318306

Project acronym: NEWCOM#

Project title: Network of Excellence in Wireless Communications

Duration: 11 2012 – 10 2015

Coordinator: Consorzio Nazionale Interuniversitario per le Telecomunicazioni (Italy)

Other partners: Aalborg Universitet (AAU). Denmark; Bilkent Üniversitesi (Bilkent). Turkey; Centre National de la Recherche Scientifique (CNRS). France; Centre Tecnològic de Telecomunicacions de Catalunya (CTTC). Spain; Institute of Accelerating Systems and Applications (IASA). Greece; Inesc Inovacao; Instituto de Novas Tecnologias (INOV). Portugal; Poznan University of Technology (PUT). Poland; Technion - Israel Institute of Technology (TECHNION). Israel; Technische Universität Dresden (TUD). Germany; University of Cambridge (UCAM). United Kingdom; Université Catholique de Louvain (UCL). Belgium; Oulun Yliopisto (UOULU). Finland

Abstract: NEWCOM# is a project funded under the umbrella of the 7th Framework Program of the European Commission (FP7-ICT-318306). NEWCOM# pursues long-term, interdisciplinary research on the most advanced aspects of wireless communications like Finding the Ultimate Limits of Communication Networks, Opportunistic and Cooperative Communications, or Energy- and Bandwidth-Efficient Communications and Networking.

8.3.1.4. HPC4E

Title: HPC for Energy

Program: H2020

Duration: 01 2016 – 01 2018

Coordinator: Barcelona Supercomputing Center

Inria contact: Stephane Lanteri

Other partners:

- Europe: Lancaster University (ULANC), Centro de Investigaciones Energéticas Medioambientales y Tecnológicas (CIEMAT), Repsol S.A. (REPSOL), Iberdrola Renovables Energía S.A. (IBR), Total S.A. (TOTAL).
- Brazil: Fundação Coordenação de Projetos, Pesquisas e Estudos Tecnológicos (COPPE), National Laboratory for Scientific Computation (LNCC), Instituto Tecnológico de Aeronáutica (ITA), Petróleo Brasileiro S. A. (PETROBRAS), Universidade Federal do Rio Grande do Sul (INF-UFRGS), Universidade Federal de Pernambuco (CER-UFPE)

Abstract: The main objective of the HPC4E project is to develop beyond-the-state-of-the-art high performance simulation tools that can help the energy industry to respond future energy demands and also to carbon-related environmental issues using the state-of-the-art HPC systems. The other objective is to improve the cooperation between energy industries from EU and Brazil and the cooperation between the leading research centres in EU and Brazil in HPC applied to energy industry. The project includes relevant energy industrial partners from Brazil and EU, which will benefit from the project's results. They guarantee that TRL of the project technologies will be very high. This includes sharing supercomputing infrastructures between Brazil and EU. The cross-fertilization between energy-related problems and other scientific fields will be beneficial at both sides of the Atlantic.

8.3.2. Collaborations in European Programs, except FP7 & H2020

8.3.2.1. CROWN

Program: European Community and Greek General Secretariat for Research and Technology

Project acronym: CROWN

Project title: Optimal Control of Self Organized Wireless Networks

Duration: 2012-2015

Coordinator: Tassiulas Leandros

Other partners: Thales, University of Thessaly, National and Kapodistrian University of Athens, Athens University of Economics and Business

Abstract: Wireless networks are rapidly becoming highly complex systems with large numbers of heterogeneous devices interacting with each other, often in a harsh environment. In the absence of central control, network entities need to self-organize to reach an efficient operating state, while operating in a distributed fashion. Depending on whether the operating criteria are individual or global, nodes interact in an autonomic or coordinated way. Despite recent progress in autonomic networks, the fundamental understanding of the operational behaviour of large-scale networks is still lacking. This project will address these emergent network properties, by introducing new tools and concepts from other disciplines.

We will first analyze how imperfect network state information can be harvested and distributed efficiently through the network using machine learning techniques. We will design flexible methodologies to shape the competition between autonomous nodes for resources, with aim to maintain robust social optimality. Both cooperating and non-cooperating game-theoretic models will be used. We also consider networks with nodes coordinating to achieve a joint task, e.g., global optimization. Using algorithms inspired from statistical physics, we will address two representative paradigms in the context of wireless ad hoc networks, namely connectivity optimization and the localization of a network of primary sources from a sensor network.

Finally, we will explore delay tolerant networks as a case study of an emerging class of networks that, while sharing most of the characteristics of traditional autonomic or coordinated networks, they present unique challenges, due to the intermittency and constant fluctuations of the connectivity. We will study tradeoffs involving delay, the impact of mobility on information transfer, and the optimal usage of resources by using tools from information theory and stochastic evolution theory.

8.3.3. Collaborations with Major European Organizations

University of Athens: Panayotis Mertikopoulos was an invited professor for 3 months.

EPFL: Laboratoire pour les communications informatiques et leurs applications 2, Institut de systèmes de communication ISC, Ecole polytechnique fédérale de Lausanne (Switzerland). We collaborate with Jean-Yves Leboudec (EPFL) and Pierre Pinson (DTU) on electricity markets.

University of Edinburgh and Istituto di Scienza e Tecnologia della Informazione: we strongly collaborate through the Quanticol European project.

University of Antwerp: we collaborate with Benny Van Houdt on caching problems.

TU Wien: Research Group Parallel Computing, Technische Universität Wien (Austria). We collaborate with Sascha Hunold on experimental methodology and reproducibility of experiments in HPC.

8.4. International Initiatives

8.4.1. Inria International Labs

8.4.1.1. North America

- JLESC (former JLPC) (Joint Laboratory for Extreme-Scale Computing) with University of Illinois Urbana Champaign, Argonne Nat. Lab and BSC. Several members of MESCAL are partners of this laboratory, and have done several visits to Urbana-Champaign or NCSA.

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

8.4.2.1. EXASE

Title: Exascale Computing Scheduling and Energy

International Partner (Institution - Laboratory - Researcher):

Universidade Federal do Rio Grande do Sul (Brazil) - INF (INF) - Nicolas MAILLARD

Start year: 2014

See also: <https://team.inria.fr/exase/>

The main scientific goal of this collaboration for the three years is the development of state-of-the-art energy-aware scheduling algorithms for exascale systems. Three complementary research directions have been identified : (1) Fundamentals for the scaling of schedulers: develop new scheduling algorithms for extreme exascale machines and use existing workloads to validate the proposed scheduling algorithms (2) Design of schedulers for large-scale infrastructures : propose energy-aware schedulers in large-scale infrastructures and develop adaptive scheduling algorithms for exascale machines (3) Tools for the analysis of large scale schedulers : develop aggregation methodologies for scheduler analysis to propose synthesized visualizations for large traces analysis and then analyze schedulers and energy traces for correlation analysis

8.4.3. Inria International Partners

8.4.3.1. Declared Inria International Partners

- MESCAL has strong connections with both UFRGS (Porto Alegre, Brazil) and USP (Sao Paulo, Brazil). The creation of the LICIA common laboratory (see next section) has made this collaboration even tighter.
- MESCAL has strong bounds with the University of Illinois Urbana Champaign, within the (Joint Laboratory on Petascale Computing, see previous section).

8.4.4. Participation In other International Programs

8.4.4.1. South America

- LICIA. The CNRS, Inria, the Universities of Grenoble, Grenoble INP and Universidade Federal do Rio Grande do Sul have created the LICIA (*Laboratoire International de Calcul intensif et d'Informatique Ambiante*). Jean-Marc Vincent is the director of the laboratory, on the French side.

The main themes are high performance computing, language processing, information representation, interfaces and visualization as well as distributed systems.

More information can be found at <http://www.inf.ufrgs.br/licia/>.

8.5. International Research Visitors

8.5.1. Visits of International Scientists

Stan Zachary and James Cruise, from Heriot-Watt University at Edinburgh, came for a week in the context of the European Quanticol project. Lucas Schnorr and Philippe Navaux from UFRGS (Porto Alegre, Brazil) both came for a week in the context of the EXASE associated team.

MOAIS Project-Team

7. Partnerships and Cooperations

7.1. Regional Initiatives

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

7.2. National Initiatives

7.2.1. ANR

- **ANR grant MOEBIUS (2013-2015)**. Multi-objective scheduling for large computing platforms. Coordinator: Grenoble-INP (Moais team). Partners: Grenoble-INP, Inria, BULL.
- **ANR grant EXAVIZ (2011-2015)**. Large Scale Interactive Visual Analysis for Life Science. Partners: Inria Rhône-Alpes, Université d'Orléans, the LBT lab from IBPC, the LIMSI from Université d'Orsay, and the CEMHTI labs from CNRS.
- **ANR HPAC (2012-2015)**. High Performance Algebraic Computing. Coordinator: UJF (LJK/CASYS team). Partners: project-team MOAIS (Grenoble), project-team ARENAIRE (LIP, Lyon), project-team SALSA (LIP6, Paris), the ARITH group (LIRMM lab, Montpellier).
- **Equipex Kinovis (2012-2017)**. 2.6 Meuros. Large scale multi-camera platform (extension of the Grimage platform to 60 cameras, depth and X-ray cameras). Coordinator E Boyer, LJK Inria MORPHEO team. Partners: Inria Rhône-Alpes and the LJK, LIG, LADAF and GIPSA labs.
- **ANR-11-LABX-0025 PERSYVAL-Lab** funds the following PhD in collaboration with other labs:
 - in collaboration with Verimag: Multi-objective optimization for resource management on multicore systems, (PhD Abhinav Srivastav, since 9/2012)
 - In collaboration with Gipsa-lab and Inria BiBop: Simulations of Fibrous Materials. (PhD Gilles Daviet, since 9/2013)
 - in collaboration with Inria Privatics and Verimag: Secure Outsourcing (PhD Amrit Kumar, since 11/2013)

7.2.2. Competitivity Clusters

- **SoC-Trace**, Minalogic 2011-2015 contract. This project aims the development of tools for the monitoring and debug of multicore systems on chip. Leader: ST-Microelectronic. Partners: Inria (Mescal, Moais); UJF (TIMA, LIG/Hadas); Magilem, ProBayes. Moais contributes with technics and tools for visual aggregation of application traces. The contract funds 1 PhD thesis (Damien Dosimont) and 1 year engineer.
- **ARAMIS, PIA contract n°P3342-146798 (2014-2017)**: Architecture Robuste pour les Automates et Matériels des Infrastructures Sensibles. Coordinator: ATOS-WorldGrid; Partners: CEA, SecLab, UJF. The UJF gathers the following teams: LIG (Moais, Drakkar, Vasco); LJK (Casys); IF; Verimag (DCS). BPI funds UJF with 775 ke (funds 4 PhDs and 5 years engineers), among which 410ke for LIG. Moais co-advises two PhD Thesis: Nicolas Kox with LIG-VASCO team (Protocol firewall with security guarantees for control-command systems); Maxime Puy with VERIMAG-DCS (Generation of certified filters for control-command systems).

- **PIA ELCI (2014-2017)**. Environnement Logiciel pour le Calcul Intensif. Coordinator BULL. Partners: BULL, CEA, Inria, SAFRAB, UVSQ.

7.2.3. National ADT

- ADT K'STAR with cooperation between EPIs MOAIS and RUNTIME (Bordeaux). Coordinator: T. Gautier. <https://gforge.inria.fr/projects/kstar>. The main objective is to provide OpenMP-3.1 with some extension from OpenMP-4.0 standard to perform OpenMP programs on multi-CPU multi-GPU by using XKaapi and StarPU runtimes.

7.2.4. Inria Project Lab

7.2.4.1. C2S@Exa - Computer and Computational Sciences at Exascale

Participants: Olivier Aumage [RUNTIME project-team, Inria Bordeaux - Sud-Ouest], Jocelyne Erhel [SAGE project-team, Inria Rennes - Bretagne Atlantique], Philippe Helluy [TONUS project-team, Inria Nancy - Grand-Est], Laura Grigori [ALPINE project-team, Inria Saclay - Île-de-France], Jean-Yves L'Excellent [ROMA project-team, Inria Grenoble - Rhône-Alpes], Thierry Gautier [MOAIS project-team, Inria Grenoble - Rhône-Alpes], Luc Giraud [HIEPACS project-team, Inria Bordeaux - Sud-Ouest], Michel Kern [POMDAPI project-team, Inria Paris - Rocquencourt], Stéphane Lanteri [Coordinator of the project], François Pellegrini [BACCHUS project-team, Inria Bordeaux - Sud-Ouest], Christian Perez [AVALON project-team, Inria Grenoble - Rhône-Alpes], Frédéric Vivien [ROMA project-team, Inria Grenoble - Rhône-Alpes].

Since January 2013, the team is participating to the C2S@Exa http://www-sop.inria.fr/c2s_at_exa Inria Project Lab (IPL). This national initiative aims at 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. At the current state of the art in technologies and methodologies, a multidisciplinary approach is required to overcome the challenges raised by the development of highly scalable numerical simulation software that can exploit computing platforms offering several hundreds of thousands of cores. Hence, the main objective of C2S@Exa is the establishment of a continuum of expertise in the computer science and numerical mathematics domains, by gathering researchers from Inria project-teams whose research and development activities are tightly linked to high performance computing issues in these domains. More precisely, this collaborative effort involves computer scientists that are experts of programming models, environments and tools for harnessing massively parallel systems, algorithmists that propose algorithms and contribute to generic libraries and core solvers in order to take benefit from all the parallelism levels with the main goal of optimal scaling on very large numbers of computing entities and, numerical mathematicians that are studying numerical schemes and scalable solvers for systems of partial differential equations in view of the simulation of very large-scale problems.

T. Gautier is coordinator of the Pole 4: Programming Models.

7.3. European Initiatives

7.3.1. FP7 & H2020 Projects

7.3.1.1. HPC4E

Title: HPC for Energy

Programm: H2020

Duration: 2015-2020

Coordinator: Barcelona Supercomputing Center

Inria contact: Stephane Lanteri

The main objective is to develop beyond-the-state-of-the-art high performance simulation tools that can help the energy industry to respond future energy demands and also to carbon-related environmental issues using the state-of-the-art HPC systems. The project also aims at improving the usage of energy using HPC tools by acting at many levels of the energy chain for different energy sources: Exploitation: In wind energy (respond to demand peaks, output prediction) Efficiency: In biomass-derived fuels (develop more efficient and renewable fuels, reduce green-house gas emissions, reduce hydrocarbon dependency and fuel cost) Exploration: In wind energy (resource assessment) and in hydrocarbons (improve available reserves, explore with less financial and environmental risk). Another objective is to improve the cooperation between energy industries from EU and Brazil. The project includes relevant energy industrial partners from Brazil (PETROBRAS) and EU (REPSOL and TOTAL as O&G industries), which will benefit from the project's results. They guarantee that TRL of the project technologies will be very high. A last objective is to improve the cooperation between the leading research centres in EU and Brazil in HPC applied to energy industry. This includes sharing supercomputing infrastructures between Brazil and EU. The cross-fertilization between energy-related problems and other scientific fields will be beneficial at both sides of the Atlantic.

7.3.1.2. VISIONAIR

Title: VISION ADVANCED INFRASTRUCTURE FOR RESEARCH

Programm: FP7

Duration: February 2011 - January 2015

Coordinator: Grenoble-INP

Partners:

Ecole Nationale Supérieure d'arts et Métiers (France)

Université d'Aix Marseille (France)

Consiglio Nazionale Delle Ricerche (Italy)

Cranfield University (United Kingdom)

Ecole Centrale de Nantes (France)

"European Manufacturing and Innovation Research Association, A Cluster Leading Excellence" (Belgium)

Fraunhofer-Gesellschaft zur Förderung der Angewandten Forschung e.V (Germany)

Institut Polytechnique de Grenoble (France)

Inpg Entreprise (France)

Kungliga Tekniska Högskolan (Sweden)

Politecnico di Milano (Italy)

Instytut Chemii Bioorganicznej Polskiej Akademii Nauk (Poland)

Poznan University of Technology (Poland)

Rheinisch-Westfälische Technische Hochschule Aachen (Germany)

Magyar Tudományos Akadémia Számítástechnikai és Automatizálási Kutató Intézet (Hungary)

Technion - Israel Institute of Technology. (Israel)

University College London (United Kingdom)

University of Essex (United Kingdom)

Technische Universität Kaiserslautern (Germany)

University of Patras (Greece)

Universität Stuttgart (Germany)

University of Bristol (United Kingdom)
The University Offord (United Kingdom)
Universite de la Mediterranee' aix-Marseille Ii (France)
Universiteit Twente (Netherlands)
"fundacio Privada I2cat, Internet I Innovacio Digital A Catalunya" (Spain)

Inria contact: G. Dumont

VISIONAIR is a project of creation of a European infrastructure that should be a unique, visible and attractive entry towards high level visualisation facilities. These facilities must be open to the access of a wide set of research communities. By integrating existing facilities, it will create a world-class research infrastructure enabling to conduct frontier research. This integration will provide a significant attractiveness and visibility of the European Research Area. Current scientific challenges concern climate evolution, environmental risks, health, energy, etc. and require the management of more and more complex information. The development of information technologies, the increasing complexity of the information to be handled and analysed, along with the increasing capacities in scientific and engineering simulations, call for the development of increasingly powerful visualisation tools and methods. The Europe Research Area must be able to compete with other big Research Areas when addressing the previously defined challenges. By integrating visualisation facilities with the VISIONAIR project, ERA will be able to answer integrated challenges out of the scope of usually disseminated research teams. Both, physical access and virtual services, will be provided by the infrastructure. A full access to visualisation dedicated software will be organised, while physical access on high level platforms, will be partially (about 20% of global usage) open for other scientists for free on behalf of excellence of submitted projects. The partners of this project propose to build a common infrastructure that would grant access to high level visualisation facilities and resources to researchers. Indeed, researchers from Europe and from around the world will be welcome to carry out research projects using the visualisation facilities provided by the infrastructure. Visibility and attractiveness of ERA will be increased by the invitation of external projects.

7.3.1.3. *VELaSSCo*

Title: Visualization For Extremely Large-Scale Scientific Computing

Program: STREP (Specific Targeted Research Project)

Duration: January 2014 - December 2016

Coordinator: Centre Internacional de Metodes Numerics en Enginyeria (Spain)

Partners: JOTNE (No.), SINTEF (No.), Fraunhofer IGD (D), ATOS (SP), Univ. Edinburgh (UK)

Inria contact: Toan Nguyen, Bruno Raffin

Abstract: VELaSSCo aims at developing a new concept of integrated end-user visual analysis methods with advanced management and post-processing algorithms for engineering modelling applications, scalable for real-time petabyte level simulations [59]. The interface will enable real-time interrogation of simulation data, generating key information for analysis. Main concerns have to do with handling of large amounts of data of a very specific kind intrinsically linked to geometrical properties; how to store, access, simplify and manipulate billion of records to extract the relevant information; how to represent information in a feasible and flexible way; and how to visualise and interactively inspect the huge quantity of information they produce taking into account end-user's needs. VELaSSCo achieves this by putting together experts with relevant background in Big Data handling, advanced visualisation, engineering simulations, and a User Panel including research centres, SMEs and companies from key European industrial sectors such as aerospace, household products, chemical, pharmaceutical and civil engineering.

7.3.1.4. *GRAIN 2*

Type: Cooperation

Defi: Transport (incl. Aeronautics)

Instrument: Coordination and Support Action (CSA)

Duration: October 2013 - June 2016

Coordinator: Centre Internacional de Metodes Numerics en Enginyeria, Barcelone (Spain)

Partner: Airbus (Sp), Alenia (I), EADS-IW (F), Rolls-Royce (UK), Ingenia (Sp.), Numeca (B), U. Sheffield (UK), U. Birmingham (UK), CIRA (I), VKI (B), Airbone (NL), Leitat (Sp), Cerfacs (F), U. Cranfield (UK), CAE (CN), GTE (CN), ARI (CN), FAI (CN), ASRI (CN), SAERI (CN), BIAM (CN), ACTRI (CN), BUAA (CN), NPU (CN), PKU (CN), NUAU (CN), ZIU (CN)

Inria contact: Toan Nguyen

Abstract: The main objective of GRAIN2 is to focus its greening activities following the Flight Path 2050 Vision for Aircraft. GRAIN2 will in particular identify innovative R&D methods, tools and HPC environments (supercomputers and GPGPUs) according to the needs of major aeronautical industries to deeper understand the mechanism of engine exhaust emissions, to improve fuel efficiency and environmental performance.

7.4. International Initiatives

7.4.1. Inria International Labs

JLESC

Associate Team involved in the International Lab:

7.4.1.1. ANOMALIES@EXASCALE

Title: Anomalies Detection and Handling towards Exascale Platforms

International Partner (Institution - Laboratory - Researcher):

University of Chicago (United States) - Argonne National Laboratory (ANL) - Franck Cappello

Start year: 2014

See also: <http://anomalies.imag.fr>

The Anomalies@exascale project intends to prospect new scheduling solutions for very large parallel computing platforms. In particular, we consider the new problems related to fault tolerance raising with the developments of exascale platforms. We expect to define new ways to detect both execution failures and more transient performance anomalies. Information gathered from the detectors will then be taken into account by schedulers to implement corrective measures.

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

7.4.2.1. ExaSE

Title: Exascale Computing Scheduling and Energy

International Partner (Institution - Laboratory - Researcher):

UFRGS, PUC Minas and UPS (Brazil)

Duration: 2014 - 2016

See also: <https://team.inria.fr/exase/>

The main scientific context of this project is high performance computing on Exascale systems: large-scale machines with billions of processing cores and complex hierarchical structures. This project intends to explore the relationship between scheduling algorithms and techniques and the energy constraints present on such exascale systems.

7.4.3. Participation In other International Programs

7.4.3.1. LICIA

Title: International Laboratory in High Performance and Ubiquitous Computing

International Partner (Institution - Laboratory - Researcher):

UFRGS (Brazil)

Duration: 2011 - 2018

See also: <http://licia-lab.org/>

The LICIA is an Internacional Laboratory and High Performance and Ubiquitous Computing born in 2011 from the common desire of members of Informatics Institute of the Federal University of Rio Grande do Sul and of Laboratoire d'Informatique de Grenoble to enhance and develop their scientific partnership that started by the end of the 1970. LICIA is an Internacional Associated Lab of the CNRS, a public french research institution. It has support from several brazilian and french research funding agencies, such as CNRS, Inria, ANR, European Union (from the french side) and CAPES, CNPq, FAPERGS (from the Brazilian side). Moais is deeply invovled in the creation and animation of LICIA. Bruno Raffin is LICIA associate director.

7.4.3.2. CAPES/COFECUB StarShip

Title: Scalable Tools and Algorithms para Resilient, Scalable, Hybrid Interactive Processing

International Partner (Institution - Laboratory - Researcher):

UFRGS (Brazil)

Duration: 2013 - 2016

7.5. International Research Visitors

7.5.1. Visits of International Scientists

- Daouda Traore, Director of Informatics Dept at Seguou Univ., Mali (oct-nov. 2015)

7.5.1.1. Internships

KHATIRI Mohammed

Date: Sep 2015 - Dec 2015

Institution: UMP (Morocco)

Supervisor: Denis Trystram

7.5.2. Visits to International Teams

7.5.2.1. Research stays abroad

- B. Raffin visited the Universidad A Coruña, Spain, from Sept 2015 to Dec 2015.

ROMA Project-Team

9. Partnerships and Cooperations

9.1. Regional Initiatives

9.1.1. PhD grant laboratoire d'excellence MILYON-Mumps consortium

Thanks to the doctoral program from the MILYON labex dedicated to applied research in collaboration with industrial partners, we obtained 50% of a PhD grant, the other 50% being funded by the MUMPS consortium. The PhD student will focus on improvements of the solution phase of the MUMPS solver, in accordance to requirements from industrial members of the consortium.

9.1.2. Cooperation with ECNU

ENS Lyon has launched a partnership with ECNU, the East China Normal University in Shanghai, China. This partnership includes both teaching and research cooperation.

As for teaching, the PROSFER program includes a joint Master of Computer Science between ENS Rennes, ENS Lyon and ECNU. In addition, PhD students from ECNU are selected to conduct a PhD in one of these ENS. Yves Robert is responsible for this cooperation. He has already given two classes at ECNU, on Algorithm Design and Complexity, and on Parallel Algorithms, together with Patrice Quinton (from ENS Rennes).

As for research, the JORISS program funds collaborative research projects between ENS Lyon and ECNU. Yves Robert and Changbo Wang (ECNU) are leading a JORISS project on resilience in cloud and HPC computing.

9.2. National Initiatives

9.2.1. ANR

ANR White Project RESCUE (2010-2015), 4 years. The ANR White Project RESCUE was launched in November 2010, for a duration of 48 months (and was later extended for 6 additional months, up to June 2015). It gathers three Inria partners (ROMA, Grand-Large and Hiepac) and is led by ROMA. The main objective of the project is to develop new algorithmic techniques and software tools to solve the *exascale resilience problem*. Solving this problem implies a departure from current approaches, and calls for yet-to-be-discovered algorithms, protocols and software tools.

This proposed research follows three main research thrusts. The first thrust deals with novel *checkpoint protocols*. The second thrust entails the development of novel *execution models*, i.e., accurate stochastic models to predict (and, in turn, optimize) the expected performance (execution time or throughput) of large-scale parallel scientific applications. In the third thrust, we will develop novel *parallel algorithms* for scientific numerical kernels.

ANR Project SOLHAR (2013-2017), 4 years. The ANR Project SOLHAR was launched in November 2013, for a duration of 48 months. It gathers five academic partners (the HiePACS, Cepage, ROMA and Runtime Inria project-teams, and CNRS-IRIT) and two industrial partners (CEA/CESTA and EADS-IW). This project aims at studying and designing algorithms and parallel programming models for implementing direct methods for the solution of sparse linear systems on emerging computers equipped with accelerators.

The proposed research is organized along three distinct research thrusts. The first objective deals with linear algebra kernels suitable for heterogeneous computing platforms. The second one focuses on runtime systems to provide efficient and robust implementation of dense linear algebra algorithms. The third one is concerned with scheduling this particular application on a heterogeneous and dynamic environment.

9.2.2. Inria Project Lab C2S@Exa - Computer and Computational Sciences at Exascale

Participants: Olivier Aumage [RUNTIME project-team, Inria Bordeaux - Sud-Ouest], Jocelyne Erhel [SAGE project-team, Inria Rennes - Bretagne Atlantique], Philippe Helluy [TONUS project-team, Inria Nancy - Grand-Est], Laura Grigori [ALPINE project-team, Inria Saclay - Île-de-France], Jean-Yves L'Excellent [ROMA project-team, Inria Grenoble - Rhône-Alpes], Thierry Gautier [MOAIS project-team, Inria Grenoble - Rhône-Alpes], Luc Giraud [HIEPACS project-team, Inria Bordeaux - Sud-Ouest], Michel Kern [POMDAPI project-team, Inria Paris - Rocquencourt], Stéphane Lanteri [Coordinator of the project], François Pellegrini [BACCHUS project-team, Inria Bordeaux - Sud-Ouest], Christian Perez [AVALON project-team, Inria Grenoble - Rhône-Alpes], Frédéric Vivien [ROMA project-team, Inria Grenoble - Rhône-Alpes].

Since January 2013, the team is participating to the C2S@Exa http://www-sop.inria.fr/c2s_at_exa Inria Project Lab (IPL). This national initiative aims at 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. At the current state of the art in technologies and methodologies, a multidisciplinary approach is required to overcome the challenges raised by the development of highly scalable numerical simulation software that can exploit computing platforms offering several hundreds of thousands of cores. Hence, the main objective of C2S@Exa is the establishment of a continuum of expertise in the computer science and numerical mathematics domains, by gathering researchers from Inria project-teams whose research and development activities are tightly linked to high performance computing issues in these domains. More precisely, this collaborative effort involves computer scientists that are experts of programming models, environments and tools for harnessing massively parallel systems, algorithmists that propose algorithms and contribute to generic libraries and core solvers in order to take benefit from all the parallelism levels with the main goal of optimal scaling on very large numbers of computing entities and, numerical mathematicians that are studying numerical schemes and scalable solvers for systems of partial differential equations in view of the simulation of very large-scale problems.

9.3. European Initiatives

9.3.1. FP7 & H2020 Projects

9.3.1.1. SCORPIO

Title: Significance-Based Computing for Reliability and Power Optimization

Programm: FP7

Duration: June 2013 - May 2016

Coordinator: Nikolaos Bellas

Partners: CERTH, Greece; EPFL, Switzerland; RWTH Aachen University, Germany; The Queen's University of Belfast, UK; IMEC, Belgium

Inria contact: Frédéric Vivien

Manufacturing process variability at low geometries and power dissipation are the most challenging problems in the design of future computing systems. Currently manufacturers go to great lengths to guarantee fault-free operation of their products by introducing redundancy in voltage margins, conservative layout rules, and extra protection circuitry. However, such design redundancy may result into energy overheads. Energy overheads cannot be alleviated by lowering supply voltage below a nominal value without hardware components experiencing faulty operation due to timing errors. On the other hand, many modern workloads, such as multimedia, machine learning, visualization, etc. are designed to tolerate a degree of imprecision in computations and data. SCORPiO seeks to exploit this observation and to relax reliability requirements for the hardware layer by allowing a controlled degree of imprecision to be introduced to computations and data. It proposes to introduce methodologies that allow the system- and application-software layers to synergistically characterize the significance of various parts of the program for the quality of the end result, and their tolerance

to faults. Based on this information, extracted automatically or semi-automatically, the system software will steer computations and data to either low-power, yet unreliable or higher-power and reliable functional and storage units. In addition, the system will be able to aggressively reduce its power footprint by opportunistically powering hardware modules below nominal values. Significance-based computing lays the foundations for not only approaching the theoretical limits of energy reduction of CMOS technology, but moving beyond those limits by accepting hardware faults in a controlled manner. Significance-based computing promises to be a preferred alternative to dark silicon, which requires that large portions of a chip be powered-off in every cycle to avoid excessive power dissipation.

9.4. International Initiatives

9.4.1. Inria International Labs

The University of Illinois at Urbana-Champaign, Inria, the French national computer science institute, Argonne National Laboratory, Barcelona Supercomputing Center, Jülich Supercomputing Centre and the Riken Advanced Institute for Computational Science formed the Joint Laboratory on Extreme Scale Computing, a follow-up of the Inria-Illinois Joint Laboratory for Petascale Computing. The Joint Laboratory is based at Illinois and includes researchers from Inria, and the National Center for Supercomputing Applications, ANL, BSC and JSC. It focuses on software challenges found in extreme scale high-performance computers.

Research areas include:

- Scientific applications (big compute and big data) that are the drivers of the research in the other topics of the joint-laboratory.
- Modeling and optimizing numerical libraries, which are at the heart of many scientific applications.
- Novel programming models and runtime systems, which allow scientific applications to be updated or reimaged to take full advantage of extreme-scale supercomputers.
- Resilience and Fault-tolerance research, which reduces the negative impact when processors, disk drives, or memory fail in supercomputers that have tens or hundreds of thousands of those components.
- I/O and visualization, which are important part of parallel execution for numerical simulations and data analytics
- HPC Clouds, that may execute a portion of the HPC workload in the near future.

Several members of the ROMA team are involved in the JLESC joint lab through their research on resilience. Yves Robert is the Inria executive director of JLESC.

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

- Laure Gonnord and Maroua Maalej are involved in the PROSPIEL Associate Team (Inria/ Brasil, <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. Specifically, Laure Gonnord and Maroua Maalej are in charge of designing static analyses for GPUs. In Feb.-Apr. 2016, ROMA will host one student coming from the Brazilian team.

9.4.3. Inria International Partners

9.4.3.1. Declared Inria International Partners

- Christophe Alias has a regular collaboration with Sanjay Rajopadhye from Colorado State University (USA) through the advising of the PhD thesis of Guillaume Iooss. Since September 2015, this collaboration led to one publication, see Section 7.27 .
- Anne Benoit and Yves Robert have a regular collaboration with Padma Raghavan from Penn State University (USA). They have achieved several publications in 2015, see Sections 7.8 and 7.26 .

- Anne Benoit, Frédéric Vivien and Yves Robert have a regular collaboration with Henri Casanova from Hawaii University (USA). This is a follow-on of the Inria Associate team that ended in 2014. They have achieved one publication in 2015, see Section 7.1 .

9.5. International Research Visitors

9.5.1. Visits of International Scientists

- Fernando M. Pereira was invited in Jan. 2015 to work with Maroua Maalej and Laure Gonnord on static analyses for pointers.
- Oliver Sinnen was invited for two months (Sept./Oct. 2015) to work with Loris Marchal, Bertrand Simon and Frédéric Vivien on scheduling malleable task trees.
- Samuel McCauley visited the team for four months (Oct. 2015 - Feb. 2016) to work with Loris Marchal, Bertrand Simon and Frédéric Vivien on the minimization of I/Os during the out-of-core execution of task trees.

9.5.1.1. Internships

- Anne Benoit and Yves Robert advised the M2 internship of Loic Pottier on resilient application co-scheduling with processor redistribution.
- Christophe Alias advised the M2 internship of Adilla Susungi on the compilation of pipelined parallelism on multi-GPU.
- Guillaume Aupy and Loris Marchal advised the L3 internship of Clément Brasseur on memory minimization for the parallel processing of task trees.
- Julien Herrmann and Yves Robert advised the L3 internship of Nicolas Vidal on the evaluation of the makespan of stochastic computational workflows.

9.5.2. Visits to International Teams

9.5.2.1. Research stays abroad

- Yves Robert has been appointed as a visiting scientist by the ICL laboratory (headed by Jack Dongarra) at the University of Tennessee Knoxville. He collaborates with several ICL researchers on high-performance linear algebra and resilience methods at scale.
- Bertrand Simon spent six months (Feb.-Jul. 2015) at Stony Brooks University (USA) to work with Michael Bender.

STORM Team

9. Partnerships and Cooperations

9.1. Regional Initiatives

REGION AQUITAINE - CEA The Aquitaine Region Council together with CEA is funding PhD thesis of Marc Sergent (2013-2016) on Scalability for Task-based Runtimes

Labex CPU The Labex CPU local cluster from the University of Bordeaux is funding the engineer position of Adrien Cassagne (2015-2016) to explore the optimization Error Correction Code (ECC) algorithms and simulation chains from IMS Laboratory using STORM software and expertise, for designing the upcoming 5G mobile phone communication technology.

9.2. National Initiatives

9.2.1. PIA

ELCI The ELCI project (Software Environment for HPC) aims to develop a new generation of software stack for supercomputers, numerical solvers, runtime and programming development environments for HPC simulation. The ELCI project also aims to validate this software stack by showing its capacity to offer improved scalability, resilience, security, modularity and abstraction on real applications. The coordinator is Bull, and the different partners are CEA, Inria, SAFRAN, CERFACS, CNRS CORIA, CENAERO, ONERA, UVSQ, Kitware and AlgoTech.

9.2.2. ANR

ANR SOLHAR (<http://solhar.gforge.inria.fr/doku.php?id=start>).

ANR MONU 2013 Program, 2013 - 2016 (36 months)

Identification: ANR-13-MONU-0007

Coordinator: Inria Bordeaux/LaBRI

Other partners: CNRS-IRIT, Inria-LIP Lyon, CEA/CESTA, EADS-IW

Abstract: This project aims at studying and designing algorithms and parallel programming models for implementing direct methods for the solution of sparse linear systems on emerging computers equipped with accelerators. The ultimate aim of this project is to achieve the implementation of a software package providing a solver based on direct methods for sparse linear systems of equations. Several attempts have been made to accomplish the porting of these methods on such architectures; the proposed approaches are mostly based on a simple offloading of some computational tasks (the coarsest grained ones) to the accelerators and rely on fine hand-tuning of the code and accurate performance modeling to achieve efficiency. This project proposes an innovative approach which relies on the efficiency and portability of runtime systems, such as the StarPU tool developed in the runtime team (Bordeaux). Although the SOLHAR project will focus on heterogeneous computers equipped with GPUs due to their wide availability and affordable cost, the research accomplished on algorithms, methods and programming models will be readily applicable to other accelerator devices such as ClearSpeed boards or Cell processors.

ANR Songs Simulation of next generation systems (<http://infra-songs.gforge.inria.fr/>).

ANR INFRA 2011, 01/2012 - 12/2015 (48 months)

Identification: ANR-11INFR01306

Coordinator: Martin Quinson (Inria Nancy)

Other partners: Inria Nancy, Inria Rhône-Alpes, IN2P3, LSIIT, Inria Rennes, I3S.

Abstract: The goal of the SONGS project is to extend the applicability of the SimGrid simulation framework from Grids and Peer-to-Peer systems to Clouds and High Performance Computation systems. Each type of large-scale computing system will be addressed through a set of use cases and lead by researchers recognized as experts in this area.

9.2.3. ADT - Inria Technological Development Actions

ADT K'Star (<http://kstar.gforge.inria.fr/#!/index.md>)

Participants: Olivier Aumage, Nathalie Furmento, Samuel Pitoiset, Samuel Thibault.

Inria ADT Campaign 2013, 10/2013 - 9/2015 (24 months)

Coordinator: Thierry Gautier (team AVALON, Inria Grenoble - Rhône-Alpes) and Olivier Aumage (team RUNTIME, Inria Bordeaux - Sud-Ouest)

Abstract: The Inria action ADT K'Star is a joint effort from Inria teams AVALON and RUNTIME to design the Klang-Omp source-to-source OpenMP compiler to translate OpenMP directives into calls to the API of AVALON and RUNTIME respective runtime systems (XKaaapi for AVALON, StarPU for RUNTIME).

9.2.4. IPL - Inria Project Lab

C2S@Exa - Computer and Computational Sciences at Exascale **Participant:** Olivier Aumage.

Inria IPL 2013 - 2017 (48 months)

Coordinator: Stéphane Lantéri (team Nachos, Inria Sophia)

Since January 2013, the team is participating to the C2S@Exa http://www-sop.inria.fr/c2s_at_exa Inria Project Lab (IPL). This national initiative aims at 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. This collaborative effort involves computer scientists that are experts of programming models, environments and tools for harnessing massively parallel systems, algorithmists that propose algorithms and contribute to generic libraries and core solvers in order to take benefit from all the parallelism levels with the main goal of optimal scaling on very large numbers of computing entities and, numerical mathematicians that are studying numerical schemes and scalable solvers for systems of partial differential equations in view of the simulation of very large-scale problems.

9.3. European Initiatives

9.3.1. FP7 & H2020 Projects

9.3.1.1. INTERTWINE

Title: Programming Model INTERoperability ToWards Exascale

Programm: H2020

Duration: October 2015 - October 2018

Coordinator: EPCC

Partners:

Barcelona Supercomputing Center - Centro Nacional de Supercomputacion (Spain)

Deutsches Zentrum für Luft - und Raumfahrt Ev (Germany)

Fraunhofer Gesellschaft Zur Forderung Der Angewandten Forschung Ev (Germany)

Institut National de Recherche en Informatique et en Automatique (France)

Kungliga Tekniska Hoegskolan (Sweden)

T-Systems Solutions for Research (Germany)
 The University of Edinburgh (United Kingdom)
 Universitat Jaume I de Castellon (Spain)
 The University of Manchester (United Kingdom)

Inria contact: Olivier Aumage

This project addresses the problem of programming model design and implementation for the Exascale. The first Exascale computers will be very highly parallel systems, consisting of a hierarchy of architectural levels. To program such systems effectively and portably, programming APIs with efficient and robust implementations must be ready in the appropriate timescale. A single, “silver bullet” API which addresses all the architectural levels does not exist and seems very unlikely to emerge soon enough. We must therefore expect that using combinations of different APIs at different system levels will be the only practical solution in the short to medium term. Although there remains room for improvement in individual programming models and their implementations, the main challenges lie in interoperability between APIs. It is this interoperability, both at the specification level and at the implementation level, which this project seeks to address and to further the state of the art. INTERTWinE brings together the principal European organisations driving the evolution of programming models and their implementations. The project will focus on seven key programming APIs: MPI, GASPI, OpenMP, OmpSs, StarPU, QUARK and PaRSEC, each of which has a project partner with extensive experience in API design and implementation. Interoperability requirements, and evaluation of implementations will be driven by a set of kernels and applications, each of which has a project partner with a major role in their development. The project will implement a co- design cycle, by feeding back advances in API design and implementation into the applications and kernels, thereby driving new requirements and hence further advances.

9.3.1.2. *Mont-Blanc 2*

Title: Programming Model INTERoperability ToWards Exascale

Programm: H2020

Duration: Sep. 2013 - Sep. 2016

Coordinator: BSC

Partners: Atos/Bull, ARM, Jülich, LRZ, Univ. Stuttgart, CINECA, CNRS, CEA, Univ. Bristol, Allinea Software, Univ. Cantabria

Inria contact: Olivier Aumage

The Mont-Blanc project aims to develop a European Exascale approach leveraging on commodity power-efficient embedded technologies. The project has developed a HPC system software stack on ARM, and will deploy the first integrated ARM-based HPC prototype by 2014, and is also working on a set of 11 scientific applications to be ported and tuned to the prototype system.

9.3.2. *Collaborations with Major European Organizations*

PRACE (Europe): Two-days training session on runtime systems, as part of the Prace Advanced Training Center Program (together with *La Maison de la Simulation*).

9.4. International Initiatives

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

MORSE Matrices Over Runtime Systems at Exascale

- Inria Associate-Teams program: 2011-2016
- Coordinator: Emmanuel Agullo (Hiepac)
- Partners: Inria (Runtime & Hiepac), University of Tennessee Knoxville, University of Colorado Denver and KAUST.

- Abstract: The Matrices Over Runtime Systems at Exascale (MORSE) associate team has vocation to design dense and sparse linear algebra methods that achieve the fastest possible time to an accurate solution on large-scale multicore systems with GPU accelerators, using all the processing power that future high end systems can make available. To develop software that will perform well on petascale and exascale systems with thousands of nodes and millions of cores, several daunting challenges have to be overcome both by the numerical linear algebra and the runtime system communities. With Inria Hiepacs, University of Tennessee, Knoxville and University of Colorado, Denver.

TADAAM Team

8. Partnerships and Cooperations

8.1. National Initiatives

8.1.1. ANR

ANR Songs Simulation of next generation systems (<http://infra-songs.gforge.inria.fr/>).

ANR INFRA 2011, 01/2012 - 12/2015 (48 months)

Identification: ANR-11INFR01306

Coordinator: Martin Quinson (Inria Nancy)

Other partners: Inria Nancy, Inria Rhône-Alpes, IN2P3, LSIIT, Inria Rennes, I3S.

Abstract: The goal of the SONGS project is to extend the applicability of the SimGrid simulation framework from Grids and Peer-to-Peer systems to Clouds and High Performance Computation systems. Each type of large-scale computing system will be addressed through a set of use cases and lead by researchers recognized as experts in this area.

ANR MOEBUS Scheduling in HPC (<http://moebus.gforge.inria.fr/doku.php>).

ANR INFRA 2013, 10/2013 - 9/2017 (48 months)

Coordinator: Denis Trystram (Inria Rhône-Alpes)

Other partners: Inria Bordeaux Sud-Ouest, Bull/ATOS

Abstract: This project focuses on the efficient execution of parallel applications submitted by various users and sharing resources in large-scale high-performance computing environments

ANR SATAS SAT as a Service.

AP générique 2015, 01/2016 - 12-2019 (48 months)

Coordinator: Laurent Simon (LaBRI)

Other partners: CRIL (Univ. Artois), Inria Lille (Spirals)

Abstract: The SATAS project aims to advance the state of the art in massively parallel SAT solving. The final goal of the project is to provide a “pay as you go” interface to SAT solving services and will extend the reach of SAT solving technologies, daily used in many critical and industrial applications, to new application areas, which were previously considered too hard, and lower the cost of deploying massively parallel SAT solvers on the cloud.

8.1.2. IPL - Inria Project Lab

MULTICORE - Large scale multicore virtualization for performance scaling and portability

Participants: Emmanuel Jeannot.

Multicore processors are becoming the norm in most computing systems. However supporting them in an efficient way is still a scientific challenge. This large-scale initiative introduces a novel approach based on virtualization and dynamicity, in order to mask hardware heterogeneity, and to let performance scale with the number and nature of cores. It 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. We hope delivering a solution for compute-intensive applications running on general-purpose standard computers.

8.2. European Initiatives

8.2.1. Collaborations in European Programs, except FP7 & H2020

COLOC: the Concurrency and Locality Challenge (<http://www.coloc-itea.org>).

Program: ITEA2

Project acronym: COLOC

Project title: The Concurrency and Locality Challenge

Duration: November 2014 - November 2017

Coordinator: BULL/ATOS

Other partners: BULL/ATOS (France); Dassault Aviation (France) ; Enfeild AB (Sweden); Scilab entreprise (France); Teratec (France); Inria (France); Swedish Defebnse Research Agency - FOI (France); UVSQ (France).

Abstract: The COLOC project aims at providing new models, mechanisms and tools for improving applications performance and supercomputer resources usage taking into account data locality and concurrency.

NESUS: Network for Ultrascale Computing (<http://www.nesus.eu>)

Program: COST

Project acronym: NESUS

Project title: Network for Ultrascale Computing

Duration: April 2014 - April 2018

Coordinator: University Carlos III de Madrid

Other partners: more than 35 countries

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

8.2.2. Collaborations with Major European Organizations

Partner 1: INESC-ID, Lisbon, (Portugal)

Subject 1: Application modeling for hierarchical memory system

Partner 2: ETH Zurich (Switzerland)

Subject 2: Topology mapping

Partner 3: BSC, Barcelona (Spain)

Subject 3: High-performance communication on new architectures; load-balancing and meshing.

8.3. International Initiatives

8.3.1. Inria International Labs

JLPC Inria joint-Lab on Extreme Scale Computing:

Coordinators: Franck Cappello and Marc Snir.

Other partners: Argonne National Lab, Inria, University of Urbanna Champaign, Tokyo Riken, Jülich Supercomputing Center, Barcelona Supercomputing Center.

Abstract: The Joint Laboratory is based at Illinois and includes researchers from Inria, and the National Center for Supercomputing Applications, ANL, Riken, Jülich, and BSC. It focuses on software challenges found in extreme scale high-performance computers.

8.3.2. Inria International Partners

8.3.2.1. Informal International Partners

Partner 1: ICL at University of Tennessee

Subject 1: on instrumenting MPI applications and modeling platforms (works on HWLOC take place in the context of the OPEN MPI consortium) and MPI and process placement

Partner 2: Cisco Systems

Subject 2: network topologies and platform models

Partner 3: UWLAX (Wisconsin)

Subject 3: network topology modeling

Partner 4: Intel

Subject 4: modeling many-core platforms and next-generation memory architectures

Partner 5: University of Tokyo and Riken

Subject 5: Adaptation of MPI and runtime systems to MIC processors.

Partner 6: Lawrence Livermore National Laboratory

Subject 6: Testing of the mapping features of SCOTCH on very large process graphs (more than two billion vertices) and very large target architectures (more than 200,000 parts).

8.4. International Research Visitors

8.4.1. Visits of International Scientists

8.4.1.1. Internships

- Ivan Cores from Universidade da Coruña, Spain, visited us for 4 months and have worked on topology-aware malleability of MPI programs.
- Guillaume Houzeaux and Mariano Vazquez from BSC visited us for several days to work on particule and mesh based applications and new architectures.

ASCOLA Project-Team

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 Voevodsky, 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. Wolfgang 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).

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, DIVERSE addresses 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 renova-tION*) 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 Jyväskylä, 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 tailoring 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. France⁰ 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.

⁰Colorado 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.

FOCUS Project-Team

8. Partnerships and Cooperations

8.1. National Initiatives

- REVER (Programming Reversible Recoverable Systems) is an ANR project that started on 1st December 2011 and with a 4-year duration. REVER aims to study the possibility of defining semantically well-founded and composable abstractions for dependable computing on the basis of a reversible programming language substrate, where reversibility means the ability to undo any distributed program execution, possibly step by step. The critical assumption behind REVER is that by adopting a reversible model of computation, and by combining it with appropriate notions of compensation and modularity, one can develop systematic and composable abstractions for recoverable and dependable systems. Main persons involved: Giachino, Lienhardt, Lanese, Laneve, Zavattaro.
- PACE (Processus non-standard: Analyse, Coinduction, et Expressivité) is an ANR project that started in 2013. The project targets three fundamental ingredients in theories of concurrent processes, namely coinduction, expressiveness, and analysis techniques. The project aims at processes that are beyond the realm of "traditional" processes. Specifically, the models studied exhibit one or more of the following features: probabilities, higher-order, quantum, constraints, knowledge, and confidentiality. These models are becoming increasingly more important for today's applications. Coinduction is intended to play a pivotal role. Indeed, the approaches to expressiveness and the analysis techniques considered in the project are based on coinductive equalities. Main persons involved: Hirschhoff (project coordinator), Dal Lago, Lanese, Sangiorgi, Zavattaro.
- ELICA (Expanding Logical Ideas for Complexity Analysis) is an ANR project which started on October 2014 and that we will finish on September 2018. ELICA is a project about methodologies for the static analysis of programs as for their resource consumption. The project's aim is to further improve on logical methodologies for complexity analysis (type systems, rewriting, etc.). More specifically, one would like to have more powerful techniques with less false negatives, being able at the same time to deal with nonstandard programming paradigms (concurrent, probabilistic, etc.). Main persons involved: Avanzini, Cappai, Dal Lago, Hirschhoff, Martini, Sangiorgi.

8.2. European Initiatives

8.2.1. FP7 & H2020 Projects

- ENVISAGE (Engineering Virtualized Services) is a EU FP7 project, with starting date October 1st, 2013, and with a 3-year duration. The project is about model-based development of virtualized services, including tool support for resource analysis. Most Focus members are involved.

8.2.2. Collaborations in European Programs, except FP7 & H2020

- The ICT COST Action BETTY (Behavioural Types for Reliable Large-Scale Software Systems). initiated in October 2012 and with a 4-year duration, uses behavioural type theory as the basis for new foundations, programming languages, and software development methods for communication-intensive distributed systems. Behavioural type theory encompasses concepts such as interfaces, communication protocols, contracts, and choreographies. Main persons involved: Bravetti, Giachino, Hirschhoff, Lanese, Laneve, Mauro, Sangiorgi, Zavattaro.

- ICT COST Action IC1405 (Reversible computation - extending horizons of computing). Initiated at the end of April 2015 and with a 4-year duration, this COST Action studies reversible computation and its potential applications, which include circuits, low-power computing, simulation, biological modeling, reliability and debugging. Reversible computation is an emerging paradigm that extends the standard forwards-only mode of computation with the ability to execute in reverse, so that computation can run backwards as naturally as it can go forwards.

Main persons involved: Giachino, Lanese (vice-chair of the action), Bernadet

- ICT COST Action IC1402 ARVI (Runtime Verification beyond Monitoring) Initiated in December 2014 and with a 4-year duration, this COST Action studies runtime verification, a computing analysis paradigm based on observing a system at runtime to check its expected behavior.

Main persons involved: Lanese

8.2.3. Collaborations with Major European Organizations

Simone Martini is a member of the Executive Board of EQANIE (European Quality Assurance Network for Informatics Education), from October 2014.

We list here the cooperations and contacts with other groups, without repeating those already listed in previous sections.

- ENS Lyon (on concurrency models and resource control). Contact person(s) in Focus: Dal Lago, Martini, Sangiorgi, Vignudelli. Some visit exchanges during the year, in both directions. One joint PhD supervision (J.-M. Madiot).
- Inria EPI Spades (on models and languages for components, reversibility). Contact person(s) in Focus: Lanese. Some visit exchanges during the year, in both directions.
- Laboratoire d'Informatique, Université Paris Nord, Villetaneuse (on implicit computational complexity). Contact person(s) in Focus: Dal Lago, Martini. An Italian PhD student (Marco Solieri) is working on his PhD thesis with joint supervision (Martini, Guerrini).
- Institut de Mathématiques de Luminy, Marseille (on lambda-calculi, linear logic and semantics). Contact person(s) in Focus: Dal Lago, Martini.
- Team PPS, University of Paris-Diderot Paris 7 (on logics for processes, resource control). Contact person(s) in Focus: Dal Lago, Martini, Sangiorgi. Some short visits in both directions during the year.
- IRILL Lab, Paris (on models for the representation of dependencies in distributed package based software distributions). Contact person(s) in Focus: Mauro, Zavattaro. Some short visits in both directions during the year.
- EPI Carte, Inria-Nancy Grand Est and LORIA (on implicit computational complexity). Contact person(s) in Focus: Dal Lago.
- LMU Munich (M. Hofmann) (on Implicit computational complexity and IntML). Contact person(s) in Focus: Dal Lago.
- IMDEA Software, Madrid (G. Barthe) (on Implicit computational complexity for cryptography). Contact person(s) in Focus: Dal Lago, Sangiorgi. Some visits during 2015.
- Facultad de Informatica, Universidad Complutense de Madrid (on web services). Contact person(s) in Focus: Bravetti. Bravetti is an external collaborator in the project "ESTuDIo: ESpecificacion y Testing de sistemas altamente DIstribuidos" (Specification and Testing of Highly Distributed Systems) January 1, 2013 - December 31, 2015 (3 years), funded by the Spanish Ministerio de Economía y Competitividad.

8.3. International Initiatives

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

8.3.1.1. CRECOGI

Title: Concurrent, Resourceful and Effectful Computation, by Geometry of Interaction

International Partner (Institution - Laboratory - Researcher):

 Todai (Japan) - Graduate School of Information Science and Technology - Ichiro HASUO

Start year: 2015

See also: <http://crecogi.cs.unibo.it>

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

8.3.2. Participation In other International Programs

Complexity Analysis of Higher-Order Rewrite Systems is an FWF (Austrian Science Fund, see <http://www.fwf.ac.at/>) project which is conducted in Bologna from April 2014 to April 2016. The project aim is the development of logical methodologies for the static resource analysis of higher-order rewrite systems, a formal model of computation that closely captures the evaluation semantics of functional programs. Particular attention is paid to automation, so that the developed complexity-techniques can be integrated into the Tyrolean Complexity Tool, a highly modular complexity analyser for rewrite systems.

Main persons involved: Avanzini, Dal Lago.

8.4. International Research Visitors

8.4.1. Visits of International Scientists

The following researchers have visited Focus for short periods; we list them together with the title of the talk they have given during their stay, or the topic discussed during their stay.

- Giovanni Pardini: "Lazy Security Controllers."
- Antonio Ravara: "Towards static deadlock resolution in the pi-calculus."
- Silvia Crafa: "Concurrency theory and concurrent languages: an evolutionary view of programming abstractions."
- Henning Kerstan: "Probabilistic Transition Systems."
- Jean-Bernard Stefani: "Location graphs: yet another global computing model (but with reason)."
- Isabel Oitavem: "P, NP and Pspace from a recursion-theoretic perspective."
- Reinhard Kahle: "Theories for Classes of Computational Complexity."
- Violet Ka I Pun: "Meeting Deadlines, Elastically."
- Volker Stolz: "Search-based composed refactorings."

- Giuseppe De Ruvo: "An Unusual Context for Formal Verification: Wiki Evolution."
- Manuel Mazzara: "Applications of reversibility".
- Claudio Antares Mezzina and Doriana Medic: "Calculi for reversibility".
- Thomas Leventis: " Theories in Probabilistic lambda-calculus."
- Mirko Viroli: "Perspectives on Aggregate Computing".
- Benoit Valiron and Claudia Faggian: "Resource control and linear logics".
- Beniamino Accattoli: "Abstract machines and resource control".
- Georg Moser, Thomas Powell and Stephane Gimenez: "Tools for computational complexity".
- Ichiro Hasuo, Akira Yoshimizu, and Ryo Tanaka: "Game semantics".
- Ales Bizjak: "Step-Indexed Logical Relations for Probability".
- Roberto Di Cosmo: "Preserving Software: challenges and opportunities for reproducibility of Science and Technology".

8.4.2. Visits to International Teams

January 14-28: Ugo Dal Lago visited Shanghai Jiaotong University, and collaborated with Yuxin Deng, as for the PACE project.

8.4.2.1. Sabbatical programme

Maurizio Gabbrielli is, since 15 September 2014, Head of the EIT ICT Labs Doctoral School with Paris as his principal location.

INDES Project-Team

7. Partnerships and Cooperations

7.1. National Initiatives

7.1.1. ANR AJACS

The AJACS project (Analyses of JavaScript Applications: Certification & Security) has been funded by the ANR for 42 months, starting December 2014. The goal of AJACS project is to provide strong security and privacy guarantees on the client side for web application scripts. The Indes members are involved in the tasks WP2 Certified Analyses and WP3 Security of JavaScript Applications. The partners of this project include Inria teams Celtique (coordinator), Toccata, and Prosecco.

7.1.2. FUI UCF

The 3 years long UCF project aims at developing a reactive Web platforms for delivering multimedia contents. The partners of the project are the startups Alterway, OCamlPro, and XWiki, and the academic research laboratories of University Pierre et Marie Curie and Denis Diderot.

7.2. European Initiatives

7.2.1. FP7

7.2.1.1. MEALS

Title: Mobility between Europe and Argentina applying Logics to Systems

Program: FP7

Instrument: International Research Staff Exchange Scheme

Duration: October 2011 - September 2015

Coordinator: Pedro D'Argenio

Partners:

Imperial College of Science, Technology and Medicine (United Kingdom)

Rheinisch-Westfaelische Technische Hochschule Aachen (Germany)

Technische Universiteit Eindhoven (Netherlands)

Technische Universitaet Dresden (Germany)

University of Leicester (United Kingdom)

Universitaet Desarlandes (Germany)

Universidad de Córdoba (Argentina)

Universidad de Buenos Aires (Argentina)

Inria contact: Castuscia Palamidessi

Abstract: The MEALS project (Mobility between Europe and Argentina applying Logics to Systems) goals cover three aspects of formal methods: specification (of both requirement properties and system behavior), verification, and synthesis. The Indes members are involved in the task of Security and Information Flow Properties (WP3). The partners in this task include University of Buenos Aires, University of Córdoba, Inria (together with Castuscia Palamidessi, Kostas Chatzikokolakis, Miguel Andrés) and University of Twente. The web page of the project can be found at <http://www.meals-project.eu>.

7.2.1.2. RAPP

Program: <http://rapp-project.eu>

Title: Robot App Store

Collaborator: Inria Coprin

Abstract: RAPP is a 36 months pan-european FP7 project, started in December 2013. Hop is used in the development of prototypes of the Coprin Ang rollator transfer device, for mobility assistance and activity monitoring.

7.2.2. Collaborations in European Programs, except FP7 & H2020

Program: ICT Cost Action IC1201

Project acronym: BETTY

Project title: Behavioural Types for Reliable Large-Scale Software Systems

Duration: October 2012 - October 2016

Coordinator: Simon Gay, University of Glasgow

Other partners: Several research groups, belonging to 22 european countries

Abstract: The aim of BETTY is to investigate and promote behavioural type theory as the basis for new foundations, programming languages, and software development methods for communication-intensive distributed systems. Behavioural type theory encompasses concepts such as interfaces, communication protocols, contracts, and choreography.

Program: ICT Cost Action IC1405

Project title: Reversible computation - extending horizons of computing

Duration: November 2014 - November 2018

Coordinator: Irek Ulidowski, University of Leicester

Abstract: Reversible computation is an emerging paradigm that extends the standard forwards mode of computation with the ability to execute in reverse. It aims to deliver novel computing devices and software, and to enhance traditional systems. The potential benefits include the design of reversible logic gates and circuits - leading to low-power computing and innovative hardware for green ICT, new conceptual frameworks and language abstractions, and software tools for reliable and recovery-oriented distributed systems.

This Action is the first European network of excellence aimed at coordinating research on reversible computation.

7.3. International Research Visitors

7.3.1. Visits of International Scientists

7.3.1.1. Internships

Vineet Rajani

Date: December 2014 - March 2015

MPI (Germany)

Katyal Rohan

Date: June 2015 - Aug 2015

Institution: IIIT-D (India)

Francis Dolière Some

Date: July 2015 - Sept 2015

University of Ouagadougou (Burkina)

PHOENIX Project-Team

8. Partnerships and Cooperations

8.1. Regional Initiatives

8.1.1. HomeAssist: Platform for Assisted Living

The objective of this project is to provide an open platform of digital assistance dedicated to aging in place. This project is in collaboration with researchers in Cognitive Science (Bordeaux University) and the UDCCAS Gironde (Union Départementale des Centres Communaux d'Action Sociale) managing elderly care. This project includes a need analysis, the development of assistive applications and their experimental validation.

This work is funded by CARSAT Aquitaine (“Caisse d'Assurance Retraite et de la Santé au Travail”), Aquitaine Region and Conseil Général de la Gironde.

8.1.2. HomeAssist 500 – Populational Study

HomeAssist is an assisted living platform developed by the Phoenix research group at Inria. This platform has been applied to the domain of assisted living for the past two years. From the start, computer scientists and researchers in Ageing and Occupational Therapy have conducted this research effort in close collaboration with the stakeholders of aging in place. An initial set of applications has been developed, relying on a basic set of entities (sensors, actuators and web services). HomeAssist has been deployed in the homes of 24 older adults (matched with 24 control counterparts not equipped) and is currently being assessed. Although ongoing, the preliminary results of this field study show that the platform is well adopted (highly accepted and usable) by the older adults and their families or caregivers. Additionally, benefits from HomeAssist intervention have been demonstrated in terms of well-being, autonomy as well as quality of life (psychological health).

8.1.2.1. A Randomized Controlled Trial (RCT) of HomeAssist

This RTC will be conducted with older adults, ranging from autonomous to mildly cognitively impaired (e.g., cognitive or physical frailty) Alzheimer disease (AD) in its early stage). The RCT is considered as the gold standard of a true experimental design. Furthermore, it provides strong evidence for causal relationships, as well as the ability to generalize the results to people outside the study's sample. The study design will thus be a single-blinded RCT. It will include up to 500 participants, matched with non-equipped participants. The HomeAssist intervention will involve monitoring as well as compensation services to support independent living in place. The duration of the HomeAssist intervention is of 12 months.

8.1.2.2. Expected Impact on Elderly Care

Prolonging ageing in place. Our 12-month field study of a large group of participants, combined with a control group, will give a statistical basis to assess the efficacy of our platform to prolong ageing in place for a range of older adults, including participants with mild cognitive impairment. Functional status and nursing needs will be assessed through statistical analyses over the duration of the field study. Subjective and objective measures will be done using such tools as the Multilevel Assessment Instrument or Lawton Scale and the Time-Based IADL. These traditional assessments will be completed by longitudinal in situ actimetric data recorded at home via HomeAssist, for measuring the actual IADL performance.

Secondary criteria of technology efficacy will also be studied, including general cognitive status, memory and executive functioning.

Improving well-being. Socialization activities have proven to be a key factor in well-being. To promote socialization activities, our platform offers a variety of services ranging from the main tablet, running a digital picture frame connected to online albums, to a simplified email client, allowing responses to be voice-recorded, instead of typed on a keyboard. Our platform also supports autonomous realization of daily tasks, which is known to be related to older adult well-being. Additionally, to improve well-being, applications support self-regulation and self-determination in helping the users to conform to their own daily routines via sensor-based activity monitoring and assistive supports (e.g., activity reminders or prompts). Specific assessment tools will be used to measure the well-being and the self-efficacy of the participants over the duration of the study.

Improving the efficiency of the caregiving environment. The actions of the caregiving environment are often limited or impeded by the lack of a proxy at the older adult's home. Such a proxy is needed for a number of actions, including mutualizing the planning of care services, gathering information on older adult activities, reminding of activities and appointments, monitoring potentially unsafe activities and situations. Our online catalog already offers applications materializing a caregiving proxy; the HomeAssist project will expand this catalog with an emphasis on older adults with cognitive impairment. Questionnaires will be administered to caregivers to assess the reassurance impact of our platform in their daily delivery of services (e.g., feeling of burden assessment, Psychological health of caregivers).

8.1.2.3. *Expected Impact on Pervasive Computing*

Robustness. The DiaSuiteBox platform will be deployed at a large scale, serving 500 users. This deployment will allow to further test the robustness of DiaSuiteBox beyond the current 24 users in Bordeaux. Various runtime logs will be collected to measure the performance and the behavior of DiaSuiteBox.

Development of assistive applications. Our existing experience in developing assistive applications will be significantly expanded by considering users with cognitive impairment. This situation will result in taking into account additional parameters in the user interactions. We will formalize and report on a methodology to assess users' need and develop assistive applications, leveraging our current experience and the one of HomeAssist.

A validated assistive platform. An outcome of the HomeAssist project is the validation of the DiaSuiteBox technology as a platform for assisted living. The project will provide a solid basis on which a technology transfer can be achieved. In particular, the following factors will be key measures of the readiness and potential of DiaSuiteBox: diversity of users participating in our field study, the range of applications developed, the variety of devices utilized. The questionnaires administered to the participants will be valuable information for elaborating marketing strategies of the DiaSuiteBox technology.

8.1.2.4. *Technology Transfer*

An outcome of the HomeAssist-500 project is the validation of the DiaSuiteBox technology as a platform for assisted living. The project will provide a solid basis for the creation of a startup to market the technology. In particular, the following factors will be key measures of the readiness and potential of DiaSuiteBox: diversity of users participating in our field study, range of applications developed, variety of devices utilized, deployment in 500 homes for a period of 12 months. The questionnaires administered to the participants will be valuable information for elaborating marketing strategies for the DiaSuiteBox technology. Inria, which owns the intellectual property of DiaSuiteBox, is committed to providing the Inria Phoenix group with support to turn this technology into a marketable product.

This work is funded by European Regional Development Funds, CARSAT Aquitaine, (ERDF), Aquitaine Region, Réunica, Conseil Département de Gironde, RPDAD / UDCCAS Gironde, CNSA.

8.1.3. **ANDDI**

Five percent of the population have Intellectual Disabilities (ID). Individuals with ID have significant socio-adaptive limitations in a variety of daily activities, at home (task planification and execution, medication, home safety, etc.) as well as outside (route planning, itinerary in public transportation, etc.). Individuals with ID, their families, health institutions, caregiving services, and dedicated organizations strive to find ways in which these individuals can live as independently as possible, while promoting their social inclusion in every respect of their life (housing, professional training, employment, leisure, culture, etc.).

The research project ANDDI leverages the abilities of individuals with ID and the recent technological advances to develop a variety of assistive services addressing their daily needs. These services draw on our expertise in cognitive science and computer science, dedicated to assisting users with technologies. In particular, we use our platform, named HomeAssist, dedicated to the independently living of older adults. This platform relies on DiaSuite, our suite of tools for developing applications that orchestrate networked objects, and DiaSuiteBox, our platform that runs an open-ended set of applications, sensors, actuators and web services.

ANDDI addresses users with Down syndrome aiming to live independently; it pursues the following goals:

1. determining the key obstacles to perform daily activities autonomously and collecting the needs in assistive support expressed by individuals with ID and their family and caregivers;
2. developing and adapting assistive services available in HomeAssist across an iterative assessment (period of 6 months) of experiences of each individual;
3. evaluating the efficacy of our developed assistive services across the stages experienced by individuals progressively becoming independent in their daily life (pre-post comparison after 12 months of HomAssist intervention).

This project is the outcome of the OPALI project, described in Section 8.3.1.1, and is funded by the Aquitaine Region and “Trisomie 21 France”.

8.1.4. Certification of an open platform

The purpose of this project is to define concepts and tools for developing certifying open platforms. This certification process must ensure a set of critical properties (e.g., safety, confidentiality, security) by certifying each tier application. These guarantees are essential to ensure that openness does not come at the expense of the user’s well-being. To preserve the innovation model of open platforms, this certification process should also be as automatic as possible. Indeed, the success of open platforms is mainly due to the low development cost of a new application. The case study of this thesis will be the domain of home automation. The results of this thesis will be put into practice in the DiaSuiteBox open platform.

This project is funded by Aquitaine Region.

8.2. National Initiatives

8.2.1. Objects’ World: design-driven development of large-scale smart spaces

There are an abundance of research and industry initiatives that have been undertaken with the aim of promoting the emergence of Internet of Things. In line with this goal, the Object’s World project brings together stakeholders from different domains to build and support the emergence of an IoT sector in France and beyond. The project is lead by SIGFOX, the world’s first cellular network operator dedicated to low-bandwidth wireless objects. The cooperation between industry and research partners (e.g., sensor manufacturers, computer science and electrical engineering research labs) is of uttermost importance in overcoming technological barriers. This issue is currently hindering the development of an IoT sector. The main objectives of this project are the development of

- expertise in the low-bandwidth network sector,
- low-cost transmitter/receiver chips,
- low-energy autonomous sensors, and
- software frameworks which cover the entire lifecycle of IoT applications.

Network infrastructures that support huge numbers of objects open up a range of opportunities for innovative services. Critically, these new opportunities rely on the ability to address the software engineering challenges of this new sector. We promote an approach that revolves around software frameworks. In areas such as mobile and web development, this approach has already been shown to facilitate software development by abstracting over implementation details and guiding the programmer.

Our objective is to propose concepts and tools for developing reliable applications orchestrating large-scale smart spaces of networked entities. The industrial partners of the Objects’ World project will provide us with real-size case studies in various application domains (e.g., smart cities, tracking of vehicles, healthcare, energy management).

This work is funded by the OSEO national agency.

8.2.2. School Inclusion for Children with Autism

The objective of this project is to provide children with assistive technologies dedicated to the school routines. This project is in collaboration with the “Handicap et Système Nerveux” research group (EA 4136, Bordeaux University), the PsyCLÉ research center (EA 3273, Provence Aix-Marseille University) and the “Parole et Langage” research laboratory (CNRS, Provence Aix-Marseille University).

This work is funded by the French Ministry of National Education and Orange Foundation.

8.3. International Initiatives

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

8.3.1.1. OPALI

Title: OPen Assistive-technology platform for independent LIving

International Partner (Institution - Laboratory - Researcher):

Université du Québec à Trois Rivières (Canada) - Self-Determination Assistive Technologies Research Chair (TSA Chair) - Dany Lussier-Desrochers

Start year: 2013

See also: <http://phoenix.inria.fr/opali>

The goal of the OPALI project is to develop an Open Platform for Assisted Living targeting users with cognitive disabilities. It is a cross-disciplinary project combining expertise in (1) Computer Science focusing in development of applications orchestrating networked devices and (2) Psychology focusing in assistive technologies for users with cognitive disabilities. Furthermore, this project will leverage a unique research vehicle created by the University of Trois-Rivières consisting of a full-fledged apartment equipped with a range of networked devices and dedicated to experimental studies. The outcome of the project will include a large catalog of assistive applications allowing to match each user’s project life.

8.4. International Research Visitors

8.4.1. Visits of International Scientists

Faustina HWang visited in June 2015. She is a professor at Reading University (UK). Her research interests concern assistive technologies, mainly for older adults and people with learning disabilities.

Matthew Goodwin visited in July 2015. He is a founding and key faculty member of a new doctoral program in Personal Health Informatics (PHI) and Director of the Computational Behavioral Science Laboratory (CBSL) at Northeastern University.

Myra Fernandes visited in September 2015. She is a professor at Waterloo University. Her research interests include memory, aging, Parkinson disorder, and virtual reality.

RMOD Project-Team

9. Partnerships and Cooperations

9.1. Regional Initiatives

We have signed a convention with the CAR team led by Noury Bouraqadi of Ecole des Mines de Douai. In this context we co-supervised three PhD students (Mariano Martinez-Peck, Nick Papoylias and Guillermo Polito). The team is also an important contributor and supporting organization of the Pharo project.

9.2. European Initiatives

9.2.1. FP7 & H2020 Projects

MEALS FP7 Marie Curie Research Staff Exchange Scheme

MEALS (Mobility between Europe and Argentina applying Logics to Systems) is a mobility project financed by the 7th Framework programme under the Marie Curie International Research Staff Exchange Scheme. It involves seven academic institutions from Europe and four from Argentina, and a total of about 80 researchers to be exchanged. The project started on the 1st of October, 2011, and it has a duration of 4 years. Nr: FP7-PEOPEL-2011-IRSES

<http://www.meals-project.eu>

9.2.2. Collaborations in European Programs, except FP7 & H2020

9.2.2.1. ERCIM Software Evolution

We are involved in the ERCIM Software Evolution working group since its inception. We participated at his creation when we were at the University of Bern.

9.3. International Initiatives

9.3.1. Inria International Labs

Inria Chile

Associate Team involved in the International Lab:

9.3.1.1. PLOMO2

Title: Infrastructure for a new generation of development tools

International Partner (Institution - Laboratory - Researcher):

Universidad de Chile (Chile) - Computer Science Department, PLEIAD laboratory (DCC)
- Alexander Bergel

Start year: 2014

See also: <http://pleiad.cl/research/plomo2>

Performing effective software development and maintenance are best achieved with effective tool support. Provided by a variety of tools, each one presenting a specific kinds of information supporting the task at hand. With Plomo2, we want to invent a new generation tools to navigate and profile programs by combining dynamic information with visualization to improve the development environment.

9.3.2. Inria International Partners

9.3.2.1. Declared Inria International Partners

Participants: Marcus Denker [correspondant], Stéphane Ducasse [RMoD], Nicolas Anquetil [RMoD], Diego Garbervetsky [UBA,LAFHIS], Gabriela Arevalo [Universidad Nacional de Quilmes]), Nicolas Passerini [Uqbar].

Uqbar - Argentina

Uqbar is a foundation of researchers teaching in several universities of the Buenos Aires area. Universidad Tecnologica Nacional (FRBA) Universidad Nacional de Quilmes, Universidad Nacional de San Martin, Universidad Nacional del Oeste. LAFHIS is a research laboratory from the University of Buenos Aires. More information at (<http://www.uqbar-project.org>).

9.3.2.2. Informal International Partners

Pharo in Research: We are building an ecosystem around Pharo with international research groups, universities and companies. Several research groups (such as Software Composition Group – Bern, and Pleaid – Santiago) are using Pharo. Many universities are teaching OOP using Pharo and its books. Several companies worldwide are deploying business solutions using Pharo.

University of Mons, Belgium Julien Delplanque is a student in the master M1 program from Mons University. He is working on SQL parsers and code critics.

9.3.3. Participation In other International Programs

9.3.3.1. STIC AmSud

Participants: Damien Cassou [correspondant], Gustavo Santos [RMoD], Martin Dias [RMoD], David Röthlisberger [UDP - Universidad Diego Portales, Santiago, Chile], Marcelo Almeida Maia [UFU - Federal University of Uberlândia, Brasil], Romain Robbes [Departamento de Ciencias de la Computación (DCC), Universidad de Chile, Santiago, Chile], Martin Monperrus [Spirals].

Project Partners: Inria RMOD, Inria Spirals, DCC Universidad de Chile, Universidad Diego Portale Chile, Federal University of Uberlândia, Brasil.

This project aims at facilitating the usage of frameworks and application programming interfaces (APIs) by mining software repositories. Our intuition is that mining reveals how existing projects instantiate these frameworks. By locating concrete framework instantiations in existing projects, we can recommend to developers the concrete procedures for how to use a particular framework for a particular task in a new system. Our project also tackles the challenge of adapting existing systems to new versions of a framework or API by seeking repositories for how other systems adapted to such changes. We plan to integrate recommendations of how to instantiate a framework and adapt to changes directly in the development environment. Those points taken together, considerably distinguish our approach from existing research in the area of framework engineering.

Nicolas Anquetil visited one week the ASERG team of Pr. Marco Tulio Valente at Federal University of Minas Gerais (Brazil), and another week the team of Pr. Alexander Bergel at University of Chile.

9.3.3.2. European Lab with Delft

We have a Lille Nord Europe European Lab with A. Bachelli from Delft University. We are working on infrastructure and tools for code reviewing. We have exchange of staff and presented a paper at SANER 2015.

9.4. International Research Visitors

9.4.1. Visits of International Scientists

In the context of the PLOMO2 associated Team with the University of Chile:

- Johan Fabry (January 2015 for Pharo Days Lille, PLEIAD funded)
- Alexandre Bergel (01/07/2015 until 27/07/2015)
- Johan Fabry (July 2015 for ESUG, PLEIAD funded)
- Pierre Chanson (July 2015 and September 2015)
- Miguel Campusano (20/09/2015-07/10/2015)
- Alexandre Bergel (Dec 2015)

In the context of MEALS:

- Guido Chari visited RMoD in March 2015.

Other visitors:

- Glenn Cavarle, Jun 2015. Pharo MOOC.
- Skip Lentz, Delft University of Technology, Delft, the Netherlands, September 2015 to January 2016. Internship/Research project.
- Matthieu Lacaton, Thales, April 2015.
- Alain Plantec, Univ. Bretagne Occidentale, until June 2015. Bloc UI Project.
- Klérisson Vinícius Ribeiro da Paixão, Federal University of Uberlândia, Uberlândia (MG), Brazil, from September, 2015 to July, 2016. Stic-Amsud MineAPI.
- Markiyán Rizun, Ivan Franko National University of Lviv, Ukraine, From 11 January 2015 to 5 February 2015 and 4 July 2015 7 August 2015. Rewrite Tool.
- Nicolás Passerini, Uqbar / Universidad Nacional de Quilmes, Buenos Aires, Argentina, 24/11/2015 to 27/11/2015.
- Pablo Tesone, Thesis Relay from August 2015.
- Abdelghani ALIDRA, University 20 Aout 55, Skikda. Algeria. One month in June-July and November 2015 to December 2016.
- Leonardo Silva, PhD student from Brazil (Federal University of Minas Gerais), did a 6 months internship within for his PhD. From January 2015 to June 2015. SticAmsud Project Dynarchi.

9.4.2. Visits to International Teams

9.4.2.1. Research stays abroad

- Guillermo Polito: 25.05.2015 SOFT Languages Lab Vrije Universiteit Brussel, Brussels. Visit to present the work of the laboratory and look for collaborations.
- Guillermo Polito: 23.07.2015 Universidad de Quilmes, Buenos Aires. Visit to present the work of the laboratory.
- Nicolas Anquetil visited one week the ASERG team of Pr. Marco Tulio Valente at Federal University of Minas Gerais (Brazil), and another week the team of Pr. Alexander Bergel at University of Chile.
- Marcus Denker: 02.11-02.12.2015 PLEIAD DCC University of Chile, Santiago de Chile. Visit in the context of the Inria Associated Team PLOMO2.
- Marcus Denker: 02.01-20.01.2015 PLEIAD DCC University of Chile, Santiago de Chile. Visit in the context of the Inria Associated Team PLOMO2.
- Damien Cassou and Gustavo Santos. 02.02.2015. Visited for one week the University of Uberlandia (Brazil). Project MineAPI (SticAmSud).
- Olivier Auverlot and Anne Etien 16.12.15. University of Namur, Belgium. Visit to present the SQL project.

TACOMA Team

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.

COATI Project-Team

9. Partnerships and Cooperations

9.1. National Initiatives

9.1.1. ANR

9.1.1.1. ANR Blanc STINT, 2014-2017

Participants: Pierre Aboulker, Jean-Claude Bermond, David Coudert, Frédéric Havet, Luc Hogie, William Lochet, Nicolas Nisse, Stéphane Pérennes, Michel Syska.

The STINT project (*STRUCTURES INTerdites*) is led by the MC2 group (LIP, ENS-Lyon) and involves the G-SCOP laboratory (Grenoble).

The aim of STINT is to answer the following fundamental question: *given a (possibly infinite) family ψ of graphs, what properties does a ψ -free graph have?* To this end, it will firstly establish bounds on some classical graph parameters (e.g., clique number, stability number, chromatic number) for ψ -free graphs. Then, it will design efficient algorithms to recognize ψ -free graphs and to determine or approximate some parameters for those graphs. These studies shall result in the development of new proof techniques.

(<http://www.ens-lyon.fr/LIP/MC2/STINT/>)

9.1.2. PEPS

9.1.2.1. PEPS MoMis SYSTEMIC, 2015

Participant: Frédéric Giroire.

The SYSTEMIC project was led by COATI and involves the LAMA (Paris Est), GREDEG (Sophia Antipolis) and CREM (Rennes) laboratories.

The aim of SYSTEMIC was to bring together the expertises of researchers in economics, graph theory and financial mathematics to propose new models to evaluate the systemic risk of networks of financial institutions, and to propose new methods to mitigate the risk of contagions in such networks. The novelty of the project was in particular to consider strategies for a dynamic control of heterogeneous networks.

9.1.3. GDR Actions

9.1.3.1. Action ResCom, ongoing (since 2006)

Réseaux de communications, working group of GDR RSD, CNRS.

(<http://rescom.asr.cnrs.fr/>)

9.1.3.2. Action Graphes, ongoing (since 2006)

Action Graphes, working group of GDR IM, CNRS.

(<http://gtgraphes.labri.fr/>)

9.2. European Initiatives

9.2.1. Collaborations with Major European Organizations

AOR (Vassilis Zissimopoulos) : University of Athens, Department of Informatics and Telecommunications (Greece)

Combinatorial Optimization, Games and Applications (COGA), June 2015- September 2016

Participants : Jean-Claude Bermond, David Coudert, Frédéric Giroire, Nicolas Nisse, Stéphane Pérennes

9.3. International Initiatives

9.3.1. Inria International Labs

Inria Chile

Associate Team involved in the International Lab:

9.3.1.1. ALDYNET

Title: Algorithm for large and Dynamic Networks

Inria principal investigator: Nicolas Nisse

International Partner (Institution - Laboratory - Researcher):

Universidad Adolfo Ibáñez, Santiago, Chile

Facultad de Ingeniería y Ciencias

Karol Suchan

Duration: 2013 - 2015

See also: <https://team.inria.fr/coati/projects/aldynet/>

The main goal of this Associate Team is to study the structure of networks (modeled by graphs) to design both efficient distributed algorithms and reliable network topologies suitable to applications. We are interested both in large-scale (Facebook, Internet, etc.) and in smaller networks (e.g., WDM) that handle heavy traffic. More precisely, we aim at designing new techniques of distributed and localized computing to test structural properties of networks and to compute structures (e.g., decompositions) to be used in applications. Concerning the applications, we will first focus on routing and subgraph packing problems.

9.3.2. Inria International Partners

9.3.2.1. Informal International Partners

Apart from formal collaboration COATI members maintain strong connections with the following international teams, with regular visits of both sides.

Univ. of Southern Denmark, Prof. Jorgen Bang Jensen

RWTH Aachen Univ., Lehrstuhl II für Mathematik, Germany, Prof. Arie M.C.A. Koster

Concordia Univ. - Montréal, Quebec, Canada, Prof. Brigitte Jaumard

9.3.3. Participation In other International Programs

Action ECOS-SUD: ALgorithmes Distribués pour le calcul de la structure des réseaux, with Chile, 2013-2015.

GAIATO : Graphs and Algorithms Applied to Telecommunications, International Cooperation FUNCAP/FAPs/Inria/INS2i-CNRS, no. INC-0083-00047.01.00/13, with Federal University of Ceará, Brasil, 2014-2016.

9.4. International Research Visitors

9.4.1. Visits of International Scientists

Jorgen Bang Jensen : Jan 31 - June 13, Univ. of Southern Denmark

Sylvain Leguay : Feb 2 - March 27, Univ. Paris XI, LRI, Orsay, France

Mauricio Abel Soto Gomez : Feb 23 - March 20, Univ. Adolfo Ibáñez, Santiago, Chile

Takako Kodate : March 23 - Apr 4, Tokyo Woman's Christian Univ., Japan

Mín-Li (Joseph) Yu : March 3 - Apr 8, Univ. of the Fraser valley, Abbotsford, (BC), Canada

Medji Kaddour : May 4 - 15, Univ. d'Oran, Algérie

Nicolas De Almeida Martins : May 20 - July 30, Univ. Federal do Ceará, Fortaleza, Brazil

Samuel Nascimento de Araujo : June - July, Univ. Federal do Ceará, Fortaleza, Brazil

Esteban H. Roman Catafau : Oct 1 - 10, Univ. Adolfo Ibáñez, Santiago, Chile

Arunabha Sen : Oct 12 - 17, Arizona State Univ., USA

Fabricio Benevides : Oct 19 - 31, Univ. Federal do Ceará, Fortaleza, Brazil

Victor Campos : Oct 19 - 31, Univ. Federal do Ceará, Fortaleza, Brazil

Eduardo Moreno : Nov 1 - 7, Univ. Adolfo Ibáñez, Santiago, Chile

9.4.2. Visits to International Teams

9.4.2.1. Research stays abroad

David Coudert

Univ. Adolfo Ibañez and Univ. Chile, Santiago, Chile, in the context of Inria associated team AIDyNet, April 3-19 and November 21-December 5, 2015;

Department of Information Engineering at University of Florence, Italy, June 23-30, 2015;

Department of Informatics and Telecommunications of the National and Kapodistrian University of Athens, Greece, September 7-11, 2015.

Guillaume Ducoffe

Univ. Adolfo Ibañez and Univ. Chile, Santiago, Chile, in the context of Inria associated team AIDyNet, November 21-December 6, 2015.

Frédéric Giroire

Univ. Adolfo Ibañez and Univ. Chile, Santiago, Chile, in the context of Inria associated team AIDyNet, November 13-29, 2015.

Frédéric Havet

Univ. Federal do Ceará, Fortaleza, Brazil, May 5-10, 2015;

Univ. Orléans - LIFO, July 6-10 2015.

Nicolas Nisse

Univ. Federal do Ceará, Fortaleza, Brazil, May 4-17, 2015;

Univ. Aix-Marseille, June 29-July 2015;

Univ. Adolfo Ibañez and Univ. Chile, Santiago, Chile, in the context of Inria associated team AIDyNet, November 13-29, 2015.

DANTE Project-Team

9. Partnerships and Cooperations

9.1. National Initiatives

9.1.1. ANR

9.1.1.1. Equipex FIT (*Futur Internet of Things*)

Participant: Éric Fleury.

FIT is one of 52 winning projects in the Equipex research grant program. It will set up a competitive and innovative experimental facility that brings France to the forefront of Future Internet research. FIT benefits from 5.8 million grant from the French government Running from 22.02.11 – 31.12.2019. The main ambition is to create a first-class facility to promote experimentally driven research and to facilitate the emergence of the Internet of the future.

9.1.1.2. ANR GRAPHSIP

Participants: Paulo Gonçalves Andrade, Éric Fleury, Thomas Begin, Sarra Ben Alaya, Hadrien Hours.

An increasing number of application areas require the processing of massive datasets. These data can often be represented by graphs in order to encode complex interactions. When data vectors are associated with graph vertices, a so-called graph signal is obtained. The processing of such graph signals includes several open challenges because of the nature of the involved information. Indeed graph theory and signal and image processing methodologies do not combine readily. In particular, such a combination requires new developments, allowing classical signal processing methods to work on irregular grids and non Euclidean spaces. Considering the significant success of classical signal processing tools, it appears essential to generalise their use to graph signals. The GRAPHSIP project aims at developing a set of advanced methods and algorithms for the processing of graph signals: multi-scale transforms and solutions of variational problems on graphs. The major outcomes of this project are expected to lead to significant breakthroughs for graph data processing. The project will also focus on two novel applications on instances of graph signals: brain networks and 3D colour point clouds. They will exemplify and illustrate the proposed methodological advances on emerging applications.

9.1.1.3. ANR INFRA DISCO (*DIstributed SDN COntrollers for rich and elastic network services*)

Participants: Thomas Begin [correspondant], Anthony Busson, Isabelle Guérin Lassous, Huu Nghi Nguyen.

The DANTE team will explore the way SDN (Software Designed Network) can change network monitoring, control, urbanisation and abstract description of network resources for the optimisation of services. More specifically, the team will address the issues regarding the positioning of SDN controllers within the network, and the implementation of an admission control that can manage IP traffic prioritization.

9.1.1.4. ANR REFLEXION (*REsilient and FLEXible Infrastructure for Open Networking*)

Participants: Thomas Begin [correspondant], Anthony Busson, Isabelle Guérin Lassous, Guillaume Artero Gallardo.

The DANTE team will work on the monitoring of NFV proposing passive and light-weight metrology tools. They will then investigate the modeling of low-level resources consumptions and finally propose methods to dynamically allocate these resources taking into account performance constraints.

9.1.1.5. ANR CONTINT CODDDE

Participants: Éric Fleury [correspondant], Christophe Crespelle, Márton Karsai, Hadrien Hours.

It is a collaborative project between the ComplexNetwork team at LIP6/UPMC; Linkfluence and Inria Dante. The CODDDE project aims at studying critical research issues in the field of real-world complex networks study:

- How do these networks evolve over time?
- How does information spread on these networks?
- How can we detect and predict anomalies in these networks?

In order to answer these questions, an essential feature of complex networks will be exploited: the existence of a community structure among nodes of these networks. Complex networks are indeed composed of densely connected groups of that are loosely connected between themselves.

The CODDDE project will therefore propose new community detection algorithms to reflect complex networks evolution, in particular with regards to diffusion phenomena and anomaly detection.

These algorithms and methodology will be applied and validated on a real-world online social network consisting of more than 10 000 blogs and French media collected since 2009 on a daily basis (the dataset comprises all published articles and the links between these articles).

9.1.1.6. ANR RESCUE

Participants: Thomas Begin, Isabelle Guérin Lassous [correspondant].

In the RESCUE project, we investigate both the underlying mechanisms and the deployment of a substitution network composed of a fleet of dirigible wireless mobile routers. Unlike many projects and other scientific works that consider mobility as a drawback, in RESCUE we use the controlled mobility of the substitution network to help the base network reduce contention or to create an alternative network in case of failure. The advantages of an on-the-fly substitution network are manifold: Reusability and cost reduction; Deployability; Adaptability.

The RESCUE project addresses both the theoretical and the practical aspects of the deployment of a substitution network. From a theoretical point of view, we will propose a two-tiered architecture including the base network and the substitution network. This architecture will describe the deployment procedures of the mobile routing devices, the communication stack, the protocols, and the services. The design of this architecture will take into account some constraints such as quality of service and energy consumption (since mobile devices are autonomous), as we want the substitution network to provide more than a best effort service. From a practical point of view, we will provide a proof of concept, the architecture linked to this concept, and the necessary tools (*e.g.*, traffic monitoring, protocols) to validate the concept and mechanisms of on-the-fly substitution networks. At last but not least, we will validate the proposed system both in laboratory testbeds and in a real-usage scenario.

9.1.1.7. ANR FETUSES

Participant: Paulo Gonçalves Andrade.

The goals of this ANR project consist in the development of statistical signal processing tools dedicated to per partum fetal heart rate characterization and acidosis detection, and are organized as follows: *(i)* construction of a large dataset of per partum fetal heart rate recordings, which is well documented and of significant clinical value; *(ii)* Developments of adaptive (*e.g.* data driven) algorithms to separate data into trend (deceleration induced by contractions) and fluctuation (cardiac variability) components; *(iii)* Developments of algorithms to characterize the non stationary and multifractal properties of per partum fetal heart rate ; *(iv)* Acidosis detection and assessment using the large datasets; *(v)* Algorithm implementation for performing tests in real clinical situations. ANR is a joint project between DANTE, the Physics Lab of ENS de Lyon (SiSyPhe team) and the *Hôpital Femme-Mère-Enfant* of Bron (Lyon). Fetuses started in january 2012 and ended in june 2015.

9.1.1.8. ANR SoSweet

Participants: Éric Fleury, Márton Karsai.

The SoSweet project focuses on the synchronic variation and the diachronic evolution of the variety of French used on Twitter. The recent rise of novel digital services opens up new areas of expression which support new linguistics behaviors. In particular, social medias such as Twitter provide channels of communication through which speakers/writers use their language in ways that differ from standard written and oral forms. The result is the emergence of new varieties of languages. The main goal of SoSweet is to provide a detailed account of the links between linguistic variation and social structure in Twitter, both synchronically and diachronically. Through this specific example, and aware of its bias, we aim at providing a more detailed understanding of the dynamic links between individuals, social structure and language variation and change.

9.2. European Initiatives

9.2.1. FP7 & H2020 Projects

9.2.1.1. EMBERS

Title: Enabling a Mobility Back-End as a Robust Service

Programm: H2020

Duration: 2015, Dec to 2019

Coordinator: UPMC

Partners: UPMC, LIP6, France; UBIWHERE Lda, Portugal; Fraunhofer Gesellschaft Zur Forderung Der Angewandten Forschung, Germany; Technische Universitaet Berlin, Germany; Inria, France

Inria contact: Eric Fleury

EMBERS will bring to market a back-end for smart city mobility that is developed by a European small enterprise based upon its smart parking and smart traffic management products that two municipalities in Portugal currently deploy. The Mobility Back-end as a Service (MBaaS) replaces such all-in-one systems, in which a municipality purchases the full set of components from a single vendor. Instead, the city manager can purchase best-of-breed devices and apps developed by third parties, with the only constraint being that they interoperate with the back-end via a free, open, smart city mobility API. This domain-specific API lowers barriers to entry for app and device developers, making it easier for innovative SMEs to enter the market. Furthermore, the API is offered via a variety of generic interfaces, including oneM2M, ETSI M2M, OMA LWM2M, and FIWARE NGSI. EMBERS thus clears the way for developers and to municipalities that have adopted any one of these potential emerging machine-to-machine (M2M) communication standards.

9.2.1.2. ARMOUR

Title: Large-Scale Experiments of IoT Security & Trust (Project n°688237)

Programm: H2020

Duration: 2015 Dec to 2018

Coordinator: UPMC

Partners: UPMC, LIP6, France; Synelixis Lyseis Pliroforikis Automatismou & Tilepikoinonion Monoprosopi EPE, Greece; Smartesting Solutions & Services, France; Unparallel Innovation, Lda, Portugal; Easy Global Market, France; ODIN Solutions, Spain;

Inria contact: Eric Fleury

Provide duly tested, benchmarked and certified Security & Trust solutions for large-scale IoT using upgraded FIRE large-scale IoT/Cloud testbeds properly-equipped for Security & Trust experimentations. ARMOUR takes the top large-scale FIT IoT-LAB testbed – a FIRE OpenLAB / FIT IoT LAB facility – and enhances it as to enable experimentally-driven research on a key research dimension: large-scale IoT Security & Trust. Presently, no proper installations exist to experiment IoT Security & Trust on large-scale conditions; ARMOUR will develop and install such capability.

9.3. International Initiatives

9.3.1. Inria International Partners

University of Namur: Department of Mathematics/Naxys (Belgium). Collaboration with Renaud Lambiotte on dynamical processes on dynamical networks and communities detections.

Aalto University: Department of Biomedical Engineering and Computational Science (Finland). Collaboration with Jari Saramaki on modeling temporal networks and community like modular structure

Central European University (Hungary). Collaboration with János Kertész on modeling complex contagion phenomena.

ISI Foundation (Italy). Collaboration with Laetitia Gauvin on multiplex networks and transportation systems

UPC (Spain): Department of Telematic Engineering. Collaboration with Monica Aguilar Igartua and Luis J. de la Cruz Llopis on vehicular and community networks.

University of Bergen: Institute of Computer Science (Norway). Collaboration with Pinar Heggernes on graph editing problems for analysis and modeling of complex networks.

Ecole Polytechnique Fédérale de Lausanne (Switzerland). Collaboration with Pierre Vandergheynst on Graph Signal Processing

LNCC, Petropolis (Brazil). Collaboration with Arthur Ziviani on Temporal Graph modeling and algorithms.

Algorithms group: University of Bergen, Institute of Computer Science (Norway).

Collaboration with Pinar Heggernes on graph editing problems for analysis and modeling of complex networks.

Algorithmics group: University of Konstanz, Department of Computer and Information Science (Germany).

Collaboration with Ulrik Brandes on graph editing problems for analysis and modeling of complex networks.

9.3.1.1. Declared Inria International Partners

Taiwan, ACADEMIA SINICA & IIIS. Signature of a MoU in the framework of IoT-LAB.

9.3.2. Participation In other International Programs

9.3.2.1. PHC Peridot

Participants: Mohammed Amer, Thomas Begin, Anthony Busson, Isabelle Guérin Lassous.

Framework for Control and Monitoring of Wireless Mesh Networks (WMN) using Software-Defined Networking (SDN). The main objective of this project is propose mechanisms and modifications in the SDN architecture, specifically in the OpenFlow, which allow SDN mechanisms to operate over WMN considering the dynamic network topology that WMN may experience and some other relevant characteristics. The project will involve devising mechanisms for controlling mesh switches through controllers in a wireless environment, which will require developing novel and WMN-specific rules, actions and commands. The project will involve proposing mechanism that consider dynamic environment of WMN along with providing redundancy in the network. Besides, there is a requirement to have an adaptive measurement API for WMN. This is the second objective of our research project. The proposed measurement API will enable the network operators to monitor network traffic over WMN which may be content-specific or host-specific. This is a joint project between DANTE and M. A. Jinnah University, Islamabad. It started in June 2015 and will end in June 2018.

9.3.2.2. STIC AMSUD UCOOL: Understanding and predictin human demanded COntent and mObiLity

Participants: Éric Fleury, Márton Karsai, Christophe Crespelle.

Finding new ways to manage the increased data usage and to improve the level of service required by the new wave of applications for smartphones is an essential issue nowadays. The improved understanding of user mobility (i.e. the context they experience) and the content they demand is of fundamental importance when looking for solutions for this problem in the modern communication landscape. The resulting knowledge can help at the design of more adaptable networking protocols or services as well as can help determining, for instance, where to deploy networking infrastructure, how to reduce traffic congestion, or how to fill the gap between the capacity granted by the infrastructure technology and the traffic load generated by mobile users.

9.4. International Research Visitors

9.4.1. Visits of International Scientists

Sahoo Prasan Kumar

Date: July 2015

Institution: Chang Gung University (Taiwan)

9.4.2. Visits to International Teams

9.4.2.1. Sabbatical programme

Begin Thomas

Date: Sep 2015 - Aug 2016

Institution: **University of Ottawa** (Canada)

Thomas Begin is on a research leave at DIVA lab - University of Ottawa - Canada for the 2015 - 2016 academic year. This leave is funded through a CNRS grant (délégation CNRS) & Inria grant (Sabbatic grant).

Christophe Crespelle

Date: Sep 2015 - Aug 2016

Institution: **Institute of Mathematics, Vietnam Academy of Science and Technology** (Vietnam)

Christophe Crespelle is in CNRS delegation for academic year 2015-2016 at the Institute of Mathematics, Vietnam Academy of Science and Technology, Hanoi

DIANA Project-Team

8. Partnerships and Cooperations

8.1. Regional Initiatives

- **Plate-forme Telecom (Com4innov)** (2011-2017) is a DGCIS funded project, in the context of the competitiveness cluster SCS, that aims at providing to PACA region industrials wishing to develop or validate new products related to future mobile networks and services and M2M application, a networking infrastructure and tools helpful for development, test and validation of those products. Other partners : 3Roam, Audilog Groupe Ericsson, Ericsson, Eurecom, Inria, iQsim, MobiSmart, Newsteo, OneAccess, Orange Labs, SCS cluster, ST Ericsson, Telecom Valley. Our contribution is centred around providing a test methodology and tools for wireless networks experimentation. In the context of this project we have realized a study on MPTCP performance in a wireless-wired environment with Orange Labs Sophia. The software tools that were developed in the project have been integrated in the R²lab anechoic chamber.

8.2. National Initiatives

8.2.1. ANR

- **ANR FIT** (2011-2018): FIT (Future Internet of Things) aims at developing an experimental facility, a federated and competitive infrastructure with international visibility and a broad panel of customers. It will provide this facility with a set of complementary components that enable experimentation on innovative services for academic and industrial users. The project will give French Internet stakeholders a means to experiment on mobile wireless communications at the network and application layers thereby accelerating the design of advanced networking technologies for the Future Internet. FIT is one of 52 winning projects from the first wave of the French Ministry of Higher Education and Research's "Équipements d'Excellence" (Equipex) research grant programme. The project will benefit from a 5.8 million euro grant from the French government. Other partners are UPMC, IT, Strasbourg University and CNRS. See also <http://fit-equipex.fr/>.
- **ANR DISCO** (2014-2016): DISCO (DIstributed SDN COntrollers for rich and elastic network services) aims at exploring the way how Software Defined Networking changes network monitoring, control, urbanisation and abstract description of network resources for the optimisation of services. The project works throughout experimentations and application use cases on the next generation of Software-Defined Networking solutions for large and critical distributed systems. The project will study the distribution of the current SDN control plane and the optimization of network operations that the integrated system view of cloud computing-based architectures allows. See also <http://anr-disco.ens-lyon.fr/>.
- **ANR REFLEXION** (2015-2017): REFLEXION (REsilient and FLEXible Infrastructure for Open Networking) research project will study the robustness and scalability of the current SDN architectures and the flexibility leveraged by SDN for provisioning resources and virtualized network functions (VNF). The project will address four main scientific objectives: (1) Fault and disruption management for virtualized services, (2) Robust and scalable control plane for next generation SDN, (3) Dynamic performance management of low level resources in SDN/NFV environments and (4) Distribution and optimization of virtual network functions in SDN environments. Our contribution in this project will be focused on fault and disruption management for virtualized services. See also <http://anr-reflexion.telecom-paristech.fr/>.

- **ANR BottleNet** (2016-2019): BottleNet aims to deliver methods, algorithms, and software systems to measure Internet Quality of Experience (QoE) and diagnose the root cause of poor Internet QoE. This goal calls for tools that run directly at users' devices. The plan is to collect network and application performance metrics directly at users' devices and correlate it with user perception to model Internet QoE, and to correlate measurements across users and devices to diagnose poor Internet QoE. This data-driven approach is essential to address the challenging problem of modeling user perception and of diagnosing sources of bottlenecks in complex Internet services. ANR BottleNet will lead to new solutions to assist users, network and service operators as well as regulators in understanding Internet QoE and the sources of performance bottleneck.

8.3. European Initiatives

8.3.1. FP7 & H2020 Projects

Program: FP7 FIRE programme

Project acronym:

Project title: Fed4Fire

Duration: October 2012 - October 2016

Coordinator: iMinds (Belgium)

Other partners: 17 european partners including iMinds (Belgium), IT Innovation (UK), UPMC (Fr), Fraunhofer (Germany), TUB (Germany), UEDIN (UK), NICTA (Australia), etc.

Web site: <http://www.fed4fire.eu/>

Abstract: Fed4FIRE will deliver open and easily accessible facilities to the FIRE experimentation communities, which focus on fixed and wireless infrastructures, services and applications, and combinations thereof. The project will develop a demand-driven common federation framework, based on an open architecture and specification. It will be widely adopted by facilities and promoted internationally. This framework will provide simple, efficient, and cost effective experimental processes built around experimenters' and facility owners' requirements. Insight into technical and socio-economic metrics, and how the introduction of new technologies into Future Internet facilities influences them, will be provided by harmonized and comprehensive measurement techniques. Tools and services supporting dynamic federated identities, access control, and SLA management will increase the trustworthiness of the federation and its facilities. A FIRE portal will offer brokering, user access management and measurements. Professional technical staff will offer first-line and second-line support to make the federation simple to use. The project will use open calls to support innovative experiments from academia and industry and to adapt additional experimentation facilities for compliance with Fed4FIRE specifications. A federation authority will be established to approve facilities and to promote desirable operational policies that simplify federation. A Federation Standardization Task Force will prepare for sustainable standardization beyond the end of the project. The adoption of the Fed4FIRE common federation framework by the FIRE facilities, the widespread usage by both academic and industrial experimenters, and the strong links with other national and international initiatives such as the FI-PPP, will pave the way to sustainability towards Horizon 2020.

8.3.2. EIT KIC funded activities

Program: FNS Future Networking Solutions Action Line

Project acronym: NFMD

Project title: Networks for Future Media Distribution (14082)

Duration: January 2015 to December 2015

Coordinator: Acreo, Sweden

Other partners: VTT (Finland), Ericsson, Lund University, SICS (Sweden).

Abstract: The EIT ICT Labs' Networks for Future Media Distribution (NFMD)' activity 14082 has as a specific innovation object set out in the application. The caching algorithm are evaluated and implemented as a proof-of-concept and integrated in the NetInf Information Centric Networking prototype. The field test at the Nordic Ski Championship in Falun was used to gain experience with the NetInf technology in a larger setting to be able to improve the implementations towards production quality. We furthermore in detail analyse and evaluate the test with the purpose to understand the benefits and limitations of the technology. The work on QoE metrics and tools aims to further develop and launch a service "streamingkollen.se" and "ACQUA" that enable consumers to measure the expected media quality that can be achieved with the user's current network connection and equipment. One result of the development is in open source code contributions. Related standardisation activities and business model analysis are also carried out in the activity. Of particular interest for this year is the business interest of INDRA in transferring the results in the area of QoE to a new line of monitoring systems.

8.4. International Initiatives

8.4.1. Inria International Labs

We collaborate with Javier Bustos from Inria Chile and his group on the measurements and analysis of users' quality of experience. This collaboration fits within our respective projects Adkinton Mobile and ACQUA, and aims at collecting measurements of both network and experience, and at using these measurements for the analysis and calibration of users' experience new models and for the design of network troubleshooting techniques in case of service degradation. In 2015, we hosted a student from Inria Chile who worked with us on setting up an experimental platform for Quality of Experience Measurement instantiated to the particular case of YouTube streaming. We also worked together on the Skype use case and published the results in [16].

8.4.2. Inria International Partners

8.4.2.1. Informal International Partners

We have collaborated with researchers at NICT, Japan to propose the Contrace tool for measuring and tracing Content-Centric Networks (CCNs). The tool allows to estimate the content popularity and can help in designing more effective cache control mechanisms.

We have an ongoing collaboration with Katia Obraczka's team at UCSC on the decentralization of the SDN control plane, following our previous COMMUNITY associated team.

We have collaborated with researchers at Universidad Diego Portales (UDP) and Universidad de Chile to design PcapWT, an efficient packet extraction tool for large experimentation traces.

We are collaborating with Augustin Chaintreau from Columbia University on the use of social networks to attract traffic on news media sites.

We are collaborating with David Choffnes from Northeastern University on the detection, analysis, and prevention of privacy leaks from mobile devices.

We have designed and demonstrated a solution for virtual Service Providers in SOHO networks in collaboration with Ericsson and LISPERs.net (<http://www.lispers.net>). The principle is to allow homenets and SOHO networks to use services normally available only for large networks. This, thanks to the virtualization of the Internet connections by the mean of overlay routing. We implemented a demonstrator using LISP implementation provided by LISPERs.net and deployed it in Google Cloud. The key element of the concept is a virtual CPE that has been implemented on a Raspberry Pi demonstrating the potential of the solution for IoT. A demonstration of the fully functional system can be watched at <https://www.youtube.com/watch?v=Gzk-h5UK54E>.

We collaborate with the CRISTAL Lab at ENSI in Tunisia on memory optimizations for content routing. See [17] for more details.

8.5. International Research Visitors

8.5.1. Visits of International Scientists

8.5.1.1. Internships

Nicolas Aguilera Miranda

Date: from October 2014 February 2015

Institution: University of Chile, CIRIC

Supervisor: Chadi Barakat

Subject: Measurements of users' quality of experience over Adkintun Mobile

Brahim Bellaoui

Date: from Mar 2015 until Aug 2015

Institution: University of Nice Sophia Antipolis

Supervisor: Thierry Turletti, Damien Saucez and Walid Dabbous

Subject: Optimization Framework and Fault Management for NFV and SDN

Yuri Bushnev

Date: from June 2015 until Aug 2015

Institution: Saint Petersburg State University

Supervisor: Thierry Turletti and Damien Saucez

Subject: Robust programmable communication networks

Anuvabh Dutt

Date: from Aug 2015 until Sep 2015

Institution: University of Nice Sophia Antipolis, International Master 1

Supervisor: Arnaud Legout

Subject: Analysis of Hashtag Relations to Identify Unusual User Activities on Twitter

Anastasia Kuznetsova

Date: from July 2015 until Aug 2015

Institution: University of Nice Sophia Antipolis, International Master 1

Supervisor: Arnaud Legout

Subject: Analysis of Hashtag Relations to Identify Unusual User Activities on Twitter

Mohamed Naoufal Mahfoudi

Date: from Mar 2015 until Aug 2015

Institution: University of Nice Sophia Antipolis, Ubinet Master

Supervisor: Walid Dabbous and Thierry Turletti

Subject: Reproducible and Realistic wireless Experiments in an Anechoic Chamber

Thierry Spetebroot

Date: from March 2015 until August 2015

Institution: Polytech Nice Sophia, Ubinet Master

Supervisor: Chadi Barakat

Subject: From network-level measurements to expected Quality of Experience for Video applications

8.5.2. Visits to International Teams

Walid Dabbous visited NICT in Tokyo Japan in the context of the Simulbed associated team. He also participated to the French-Japanese workshop dedicated to Cybersecurity in Tokyo, on April 1st to 3rd 2015.

Arnaud Legout visited Columbia University from August 31st to September in the context of the collaboration with Augustin Chaintreau.

8.5.2.1. Research stays abroad

Maksym Gabielkov visited Columbia University for 6 months (from June 15 to December 15). He collaborated with Augustin Chaintreau and his team on the topic "Social Clicks: What and Who Gets Read on Twitter?"

Xuan Nam Nguyen visited Aalto University for 3 months (from June to August). He collaborated with Jose Costa Requena team on "Versatile Caching Framework for LTE".

DIONYSOS Project-Team

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

DYOGENE Project-Team

9. Partnerships and Cooperations

9.1. National Initiatives

9.1.1. GdR GeoSto

Members of Dyogene participate in Research Group GeoSto (Groupement de recherche, GdR 3477) <http://gdr-geostoch.math.cnrs.fr/> on Stochastic Geometry led by Pierre Calka [Université de Rouen]. This is a collaboration framework for all French research teams working in the domain of spatial stochastic modeling, both on theory development and in applications.

9.1.2. ANR

9.1.2.1. ANR GAP

Graphs, Algorithms and Probability - PI: Marc Lelarge; started in Jan 2012 - 48 months. <http://www.di.ens.fr/~lelarge/ANR-GAP.html>

Over the last few years, several research areas have witnessed important progress through the fruitful collaboration of mathematicians, theoretical physicists and computer scientists. One of them is the cavity method. Originating from the theory of mean field spin glasses, it is key to understanding the structure of Gibbs measures on diluted random graphs, which play a key role in many applications, ranging from statistical inference to optimization, coding and social sciences.

The objective of this project is to develop mathematical tools in order to contribute to a rigorous formalization of the cavity method:

- From local to global, the cavity method on diluted graphs. We will study the extent to which the global properties of a random process defined on some graph are determined by the local properties of interactions on this graph. To this end, we will relate the cavity method to the analysis of the complex zeros of the partition function, an approach that also comes from statistical mechanics. This will allow us to apply new techniques to the study of random processes on large diluted graphs and associated random matrices.
- Combinatorial optimization, network algorithms, statistical inference and social sciences. Motivated by combinatorial optimization problems, we will attack long-standing open questions in theoretical computer science with the new tools developed in the first project. We expect to design new distributed algorithms for communication networks and new algorithms for inference in graphical models. We will also analyze networks from an economic perspective by studying games on complex networks.

9.1.2.2. ANR MARMOTE

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

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

9.2. International Initiatives

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

9.2.1.1. PARIS

Title: Probabilistic Algorithms for Renewable Integration in Smart Grid

International Partner (Institution - Laboratory - Researcher):

University of Florida (United States) - Department of Electrical and Computer Engineering
- Sean Meyn

Start year: 2015

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

The importance of statistical modeling and probabilistic control techniques in the power systems area is now evident to practitioners in both the U.S. and Europe. Increased introduction of renewable generation has brought unforeseen volatility to the grid that require new techniques in distributed and probabilistic control. This Associate Team brings together the complementary skills in optimization, Markov modeling, simulation, and stochastic networks with aim to help solving some pressing open problems in this area. This collaboration also opens many exciting new scientific questions in the broad area of stochastic modeling and control.

9.3. International Research Visitors

9.3.1. Visits of International Scientists

- Venkatachalam Anantharam [Professor, University of California, Jul 2015]
- Bruce Hajek [Professor, CSL, from Feb 2015 until Mar 2015]
- Holger Keeler [Post-Doctoral Fellow, Weierstrass Institute, Mar 2015]
- Armand Makowski [Professor, University of Maryland, Jul 2015]
- Peter Marbach [Professor, University of Toronto, from Jan until Jul 2015]
- Piotr Markowski [PhD Student, University of Wroclaw, Jun 2015]
- Sean Meyn [Professor, University of Florida, Feb 2015 and Jul 2015]

9.3.2. Visits to International Teams

9.3.2.1. Research stays abroad

Bartek Blaszczyszyn was visiting Mathematical Department of Wroclaw University for two weeks in April and October 2015 giving a series of lectures on stochastic geometry and modeling of communication networks.

EVA Team

9. Partnerships and Cooperations

9.1. National Initiatives

9.1.1. Competitiveness Clusters

9.1.1.1. SAHARA

Participants: Pascale Minet, Erwan Livolant.

Period: 2011 - 2015.

Partners: EADS (coordinator), Astrium, BeanAir, CNES, ECE, EPMI, Eurocopter, GlobalSys, Inria, LIMOS, Oktal SE, Reflex CES, Safran Engineering Systems.

SAHARA is a FUI project, labelled by ASTECH and PEGASE, which aims at designing a wireless sensor network embedded in an aircraft. The proposed solution should improve the embedded mass, the end-to-end delays, the cost and performance in the transfers of non critical data.

During year 2015, we provided support to the SMEs in the SAHARA project for the implementation of network algorithms and protocols.

9.1.1.2. CONNEXION

Participants: Pascale Minet, Ines Khoufi, Erwan Livolant.

Period: 2012 - 2016.

Partners: EDF (coordinator), All4Tec, ALSTOM, AREVA, Atos WorldGrid, CEA, CNRS / CRAN, Corys TESS, ENS Cachan, Esterel Technologies, Inria, LIG, Predict, Rolls-Royce Civil Nuclear, Telecom ParisTech.

The Cluster CONNEXION (Digital Command Control for Nuclear EXport and renovatION) project aims to propose and validate an innovative architecture platforms suitable control systems for nuclear power plants in France and abroad. This architecture integrates a set of technological components developed by the academic partners (CEA, Inria, CNRS / CRAN, ENS Cachan, LIG, Telecom ParisTech) and based on collaborations between major integrators such as ALSTOM and AREVA, the operator EDF in France and “techno-providers” of embedded software (Atos WorldGrid, Rolls-Royce Civil Nuclear, Corys TESS, Esterel Technologies, All4Tec, Predict). With the support of the competitiveness clusters System@tic, Minalogic and Burgundy Nuclear Partnership, the project started in April 2012. The key deliverables of the project covered several topics related demonstration concern-driven engineering models for the design and validation of large technical systems, design environments and evaluation of HMI, the implementation of Wireless Sensor Network context-nuclear, buses business object or real-time middleware facilitating the exchange of heterogeneous data and distributed data models standardized to ensure consistency of digital systems.

The EVA team focuses more particularly on the interconnection of the OCARI wireless sensor network with the industrial facility backbone and deployment algorithms of wireless sensors. In May and June 2015, we contributed with our Connexion partners to a demonstration showing that OCARI:

- supports wireless sensors of various types (e.g. temperature sensor PT100, smoke detector produced by CEA, fire alarm produced by ADWAVE, various types of flowmeters by Krohne);
- supports mobile nodes and collects their data using router nodes depending on the location of the node embedded in a mobile robot.

All the chain ranging from the physical sensors, the OCARI wireless network, the OPC/UA bus to the KASEM software was integrated to build a Service-Oriented Architecture where new services are created when new sensor nodes are deployed. Services corresponding to sensor nodes that are no longer available, are suppressed. After a service discovery, clients can select the types of measurements made by the sensor nodes they want to visualize.

In June 2015, the CONNEXION project organized an open workshop where EXERA (group of users of instrumentation and systems) was invited. **Pascal Minet** and Erwan Livolant contributed to a demonstration illustrating the integration of the OCARI wireless sensor network, the OPC-UA/ROSA middleware and the KASEM predictive maintenance system in an industrial application. A video presenting this integration was made with the participation of EDF, Inria, Telecom ParisTech, KASEM and CEA.

We also focused on deployment algorithms for mobile wireless sensor networks in temporary worksites or after a disaster. These deployments must meet coverage and connectivity requirements. In 2015 we studied solutions to ensure full coverage of the area to monitor as well as network connectivity. We proposed the OA-DVFA distributed algorithm to deploy autonomous and mobile wireless sensor nodes in a 2D area in the presence of unknown obstacles that are progressively discovered. This distributed algorithm combines the advantages of virtual forces for a fast spreading of sensor nodes and those of a virtual grid avoiding node oscillations and allowing a simple detection of redundant nodes. We also tackled the problem of deploying static sensor nodes, assisted by mobile robots that place the sensor nodes at the positions computed. The solution proposed, called MRDS, solves a multi-objective optimization problem by using a genetic algorithm.

We also studied network connectivity, more particularly how to ensure a reliable connectivity of the sink with each sensor node located at some point of interest (PoI). Our goal was to find the best trade-off between the number of relay nodes deployed and the length of the paths connecting each PoI to the sink.

9.1.2. Other collaborations

EVA has a collaboration with Vedecom. **Paul Muhlethaler** supervises Younes Bouchaala's PhD funded by Vedecom. This PhD aims at studying vehicle-to-vehicle communication to improve roads safety.

9.2. European Initiatives

9.2.1. FP7 & H2020 Projects

9.2.1.1. F-INTEROP

Type: H2020

Objective: Design and implement a cloud-based interoperability testing platform for low-power wireless standards.

Duration: Nov 2015 - Oct 2017

Coordinator: UPMC (FR)

Other partners: iMinds (BE), ETSI (FR), EANTC (DE), Mandat International (CH), DigiCat (UK), UL (LU), Inria (FR), Device Gateway (CH)

Inria contact: **Thomas Watteyne**

9.2.1.2. ARMOUR

Type: H2020

Objective: Security for the IoT

Duration: Dec 2015 – Nov 2017

Coordinator: UPMC (FR)

Other partners: Inria (FR), Synelixis (EL), Smartesting (FR), Unparallel (PT), JRC (BE), Ease Global Market (FR), Odin Solutions (ES)

Inria-EVA contact: **Thomas Watteyne**

9.2.1.3. Project Reviewing

- **Paul Muhlethaler** was reviewer for the TROPIC (Distributed computing, storage and radio resource allocation over cooperative femtocells) project.

9.2.2. Collaborations with Major European Organizations

European Telecommunications Standards Institute (ETSI)

Co-organization First ETSI 6TiSCH plugtest (interop event) in Prague, Czech Republic, 17-18 July 2015.

9.3. International Initiatives

9.3.1. Inria International Labs

9.3.1.1. REALMS

Type: Associate Team

Inria International Lab: Inria@SiliconValley

Associate teams: Inria-EVA, Prof. Glaser's team (UC Berkeley), Prof. Kerkez's team (University of Michigan, Ann Arbor)

Duration: 2015-2017

Objective: Prof. Glaser's and Prof. Kerkez's teams are revolutionizing environmental monitoring by using low power wireless TSCH networks to produce continuous environmental data accessible in real time. They are successfully deploying these networks to study mountain hydrology, observe water quality in urban watersheds, and build intelligent urban stormwater grids. The REALMS associate team conducts research across the environmental engineering and networking research domains. Its 3-year goal is to develop easy-to-use real-world network monitoring solutions to provide real-time data for environmental and urban applications. This goal leads to the following objectives: building a long-term large-scale public connectivity dataset of the networks deployed; using that dataset to model TSCH networks; and building an ecosystem of tools around this technology.

website: <https://realms-team.github.io/>

Inria contact: **Thomas Watteyne**

9.3.2. Inria International Partners

9.3.2.1. Declared Inria International Partners

Inria-EVA has a strong relationship with ENSI (Tunisia) and ENSIAS (Morocco). A significant part of our PhD students come from these engineering schools.

University of California, Berkeley, CA, USA

- Collaboration with Prof. Steven Glaser, Ziran Zhang, Carlos Oroza, Sami Malek and Zeshi Zheng through the REALMS associate team, see Section 9.3.1.1 .

University of Michigan, Ann Arbor, MI, USA

- Collaboration with Prof. Branko Kerkez through the REALMS associate team, see Section 9.3.1.1 .

KU Leuven, Belgium

- Collaboration with Prof. Danny Hughes, Prof. Wouter Joosen, Dr. Nelson Matthys, Fan Yang, Wilfried Daniels on MicroPnP and on security for the IoT.
- Dr. Malisa Vucinic, postdoctoral researcher at KU Leuven, works part time in the Inria-EVA team.
- We won Third Place in the IPSO CHALLENGE 2015 for common project MicroPnP, see Section 5.1 .
- Joint publication(s) in 2015: [35].

Linear Technology/Dust Networks, Silicon Valley, USA

- Collaboration with Prof. Kris Pister, Dr. Brett Warneke, Dr. Lance Doherty, Dr. Jonathan Simon and Joy Weiss on SmartMesh IP and 6TiSCH standardization.

- We won the IPSO CHALLENGE 2015 People's Choice Award for common project HeadsUp!, see Section 5.1 .
- Joint publication(s) in 2015: [44].

9.3.2.2. Informal International Partners

University of California, Berkeley, CA, USA

- Collaboration with Prof. Kris Pister, Dr. Nicola Accettura, Dr. Kazuki Muraoka and David Burnett on OpenWSN and 6TiSCH standardization.
- Joint publication(s) in 2015: [5], [16], [10].

Universitat Oberta de Catalunya, Barcelona, Spain

- Collaboration with Prof. Xavi Vilajosana and Dr. Pere Tuset on OpenWSN, 6TiSCH standardization and OpenMote technologies.
- We organized two OpenWSN/OpenMote tutorials together, see Section 5.1 .
- Joint publication(s) in 2015: [16], [17], [41], [15].

University of Luxembourg, Luxembourg

- Collaboration with Prof. Thomas Engel and Dr. Maria-Rita Palattella on 6TiSCH standardization.
- Joint publication(s) in 2015: [10], [13], [15]. Joint publications in 2015: TODO.

Universidad Diego Portales, Chile

- Collaboration with Prof. Diego Dujovne on OpenWSN and 6TiSCH standardization.
- Joint publication(s) in 2015: [10].

University of Science and Technology, Beijing, China

- Collaboration with Prof. Qin Wang and Tengfei Chang on 6TiSCH standardization and OpenWSN.
- Joint publication(s) in 2015: [5], [10].

University of Southern California, CA, USA

- Collaboration with Prof. Bhaskar Krishnamachari, Pedro Henrique Gomes and Pradipta Gosh on OpenWSN and 6TiSCH-based research.
- Joint publication(s) in 2015: [40].

University of Bari, Italy

- Collaboration with Prof. Alfredo Grieco, Prof. Gennaro Boggia, Dr. Giuseppe Piro and Savio Sciancalepore on security for the IoT.
- Joint publication(s) in 2015: [10].

Swedish Institute of Computer Science (SICS), Sweden

- Collaboration with Prof. Olaf Landsiedel, Dr. Simon Duquennoy and Beshr Al Nahas on distributed scheduling for TSCH networks.
- Joint publication(s) in 2015: [28].

University of Trento, Italy

- Collaboration with Dr. Oana Iova on routing in the IoT.
- Joint publication(s) in 2015: [9].

IMEC, Netherlands

- Collaboration with Dr. Pouria Zand on 6TiSCH standardization.
- Joint publication(s) in 2015: .

9.3.3. Participation In other International Programs

9.3.3.1. PEACH

Program: STIC-AmSud 2015

Title: PEACH - PrEcision Agriculture through Climate research

Inria principal investigator: **Thomas Watteyne**

International Partners (Institution - Laboratory - Researcher):

Escuela de Informática y Telecomunicaciones, Universidad Diego Portales, Santiago, Chile. Coordinator: Prof. Diego Dujovne

Universidad Tecnológica Nacional - Facultad Regional Mendoza, Grupo de I&D en Tecnologías de la Información y Comunicaciones (GridTICS). Coordinator: Prof. Gustavo Mercado

DHARMa Lab, Universidad Tecnológica Nacional, Facultad Regional Mendoza, Argentina.

Cátedra de Fisiología Vegetal, Facultad de Ciencias Agrarias, Universidad Nacional de Cuyo, Mendoza, Argentina.

Duration: 2016-2017

Goal: TPropose a design methodology for a lowpower wireless IoT sensing network, given the requirements and restrictions of a Machine Learning model to predict frost events in peach orchards and vineyards.

9.3.3.2. AWSN

Program: **Euromediterranean 3+3**

Title: Adaptive Wireless Sensor Networks

Inria principal investigator: **Pascale Minet**

International Partners (Institution - Laboratory - Researcher):

University of Catania (Italy) - DIEEI - Lucia Lo Bello

Ecole Nationale Supérieure d'Informatique et d'Analyse des Systèmes (Morocco) - ND-SRG - Mohamed Erradi

Ecole Nationale des Sciences de l'Informatique (Tunisia) - CRISTAL - Leila Azouz Saidane

Duration: Jan 2012 - Dec 2015

Wireless sensor networks (WSNs) allow the development of numerous applications in various domains, such as security and surveillance, environment protection, precision agriculture, intelligent transportation, homecare of elderly and disabled people... Communication in such WSNs has to cope with limited capacity resources, energy depletion of sensor nodes, important fluctuations of traffic in the network, changes in the network topology (radio link breakage, interferences ...) or new application requirements. In the AWSN project, we focus on the different techniques to be introduced in the WSNs to make them auto-adaptive with regard to these various changes, while meeting the application requirements. Thus, we address:

- network deployment and redeployment in order to fulfill the application requirements,
- QoS (Quality of Service) optimization taking into account real-time traffic and dynamic bandwidth allocation,
- energy efficiency and replacement of failed sensor node,
- component generation and dynamic adaptation of the application.

After the mid-term evaluation, the last topic has been replaced by the use of game theory in WSNs, where the Moroccan team is leader.

Three applications have been identified to apply the results obtained within the AWSN project: e-health, precision agriculture and Industrial WSNs with cooperative mobile robot applications. The first three topics previously defined have to be addressed in all these applications. A hierarchical architecture with different types of networks is present: WBAN and/or WSN, wireless or wired LAN, interconnected to the Internet. In addition, mobile nodes exist in these applications (e.g. mobile sinks with nurses and doctors as well tractors and farm machines, mobile robots).

In 2015, the AWSN project organized two workshops open to students and researchers:

- Workshop in Rabat in November 2015.
- Workshop in Rocquencourt in December 2015.

The AWSN project organized also open international workshops and conferences:

- RAWSN 2015: Agadir, May 2015, organized by the Moroccan team, <http://www.fsdmfes.ac.ma/rawsn/>
- WINCOM 2015: Marrakech, October 2015, organized by the Moroccan team, <http://www.wincom-conf.org/>
- the PEMWN 2015 conference in Hammamet in November 2015, 4th edition organized by the Tunisian and French teams, see the program on <https://sites.google.com/site/pemwn2015/final-program>

The outcomes of the AWSN project are multiple:

- Degrees obtained: 2 HDR, 5 PhD and 11 Masters.
- Hiring: 6 Assistant Professors in Tunisia.
- Internships: 5 internships of Tunisian students at Inria.
- Invited Professor: Leila saidane was invited at Inria for a month in 2015.
- Publications: 13 international journals and 49 international conferences

9.4. International Research Visitors

9.4.1. Visits of International Scientists

- **Carlos Oroza**, PhD student, UC Berkeley, USA, 19-30 October 2015
- **Prof. Diego Dujovne**, Professor, Universidad Diego Portales, Chile, 28-31 July 2015
- **Sami Malek**, PhD student, UC Berkeley, USA, 26 May - 12 June 2015
- **Leila Saidane**, ENSI, Tunis, Tunisia, October, November and December 2015
- **Mohammed Erradi**, ENSIAS, Rabat, Morocco, September 2015
- **Abdellatif Kobbane**, ENSIAS, Rabat, Morocco, September 2015

9.4.1.1. Internships

- **Kevin Tewouda**, internship on simulation of wireless networks with NS3, March-August 2015.

9.4.2. Visits to International Teams

9.4.2.1. Research stays abroad

- **Thomas Watteyne**, visits to Prof. Glaser's team at UC Berkeley, as part of the REALMS associate team (Section 9.3.1.1), 10-16 May, 1-17 August, 30 November-4 December 2015.

FUN Project-Team

9. Partnerships and Cooperations

9.1. Regional Initiatives

9.1.1. Tracaverre

Participants: Nathalie Mitton [correspondant], Gabriele Sabatino.

Title: Tracaverre

Type: FUI

Duration: November 2012 - Avril 2015

Coordinator: Saver Glass

Others partners: Inria FUN IEMN Courbon Camus La Grande Marque LIRIS DISP

Tracaverre studies the use of RFID for traceability of prestigious bottles. Tracaverre has yielded to the implementation of the T-Scan software.

9.1.2. PIPA

Participant: Nathalie Mitton [correspondant].

Title: Partager de l'Info PARTout à bas coût

Type: Chercheur citoyen

Duration: Dec 2015 - Dec 2017

Coordinator: Inria FUN

Others partners: SpotTrotter

PIPA project aims to provide an innovative low cost solution to share information in places where communication infrastructure are lacking, insufficient or not adapted, going beyond technical, economical or political limitations.

9.2. National Initiatives

9.2.1. Inria Project Lab

9.2.1.1. CityLab@Inria

Participants: Valeria Loscri, Aziz Mbacke, Nathalie Mitton [correspondant].

Title: CityLab@Inria

Type: IPL

Duration: 2015 - 2019

Coordinator: Valerie Issarny

CityLab@Inria studies ICT solutions toward smart cities that promote both social and environmental sustainability. A strong emphasis of the Lab is on the undertaking of a multi-disciplinary research program through the integration of relevant scientific and technology studies, from sensing up to analytics and advanced applications, so as to actually enact the foreseen smart city Systems of Systems. Obviously, running urban-scale experiments is a central concern of the Lab, so that we are able to confront proposed approaches to actual settings. The Lab's research leverages relevant effort within Inria project-teams that is further revisited as well as integrated to meet the challenges of smart cities. Research themes span: energy-efficient wireless communication protocols, urban-scale social and physical sensing, privacy by design, cloud-based urban data management, data assimilation, visual analysis, and urban system software engineering.

In addition, CityLab Inria research builds upon collaborative effort at the International level, and especially collaboration in the context of the Inria SiliconValley program.

This project has yielded to the set up of a full course on Smart Cities via a MOOC.

9.2.2. ADT

9.2.2.1. RFunID

Participants: Clement Fumey, Nathalie Mitton [correspondant], Julien Vandaele.

Duration: September 2015 - August 2017

Coordinator: Inria FUN

The purpose of this project is to deploy a large scale experimental RFID platform that enables remote programming of RFID scenario on heterogeneous devices.

9.2.2.2. ARUNTA

Participants: Emilio Compagnone, Valeria Loscri [correspondant], Julien Vandaele.

Title: Arduino-based Robots for Ubiquitous Network (ARUNTA)

Type: ADT

Duration: September 2014 - August 2016

Coordinator: Inria FUN

Abstract: This ADT focuses on the use of Arduino, an open-source electronics prototyping platform, really flexible and easy-to-use [1] to allow a fleet of robots to perform specific tasks. The goal of the ADT is to make experiments on Arduino-based robotic platforms, by implementing two robot cooperation algorithms that have been already tested through simulation tools. In order to extend the users' community and to allow more people to benefit from this research on robot cooperation, this ADT will output a tutorial and a test-bed will be developed. Moreover, the final project will be shared with the Arduino community and every interested user.

9.2.3. Equipements d'Excellence

9.2.3.1. FIT

Participants: Raymond Borenstein, Nathalie Mitton [correspondant], Julien Vandaele.

Title: Future Internet of Things

Type: EquipEx

Duration: March 2010 - December 2019

Coordinator: UPMC

See also: <http://fit-equipex.fr/>

Abstract: FIT (Future Internet of Things) aims to develop an experimental facility, a federated and competitive infrastructure with international visibility and a broad panel of customers. It will provide this facility with a set of complementary components that enable experimentation on innovative services for academic and industrial users. The project will give French Internet stakeholders a means to experiment on mobile wireless communications at the network and application layers thereby accelerating the design of advanced networking technologies for the Future Internet.

FIT is one of 52 winning projects from the first wave of the French Ministry of Higher Education and Research's "Equipements d'Excellence" (Equipex) research grant program. Coordinated by Professor Serge Fdida of UPMC Sorbonne Universités and running over a nine-year period, the project will benefit from a 5.8 million euro grant from the French government.

This project has yielded to several publications in 2015: [2], [8], [17], [19], [27].

9.3. European Initiatives

9.3.1. FP7 & H2020 Projects

9.3.1.1. VITAL

Participants: Salvatore Guzzo Bonifacio, Valeria Loscri, Nathalie Mitton [correspondant], Riccardo Petrolo.

Title: Virtualized programmable InTerfAces for innovative cost-effective IoT depLoYments in smart cities

Programm: FP7

Duration: September 2013 - August 2016

Coordinator: National University of Ireland Galway (NUIG)

Partners:

Research and Education Laboratory in Information Technologies (Greece)

Atos Spain (Spain)

Camden Town Center (United Kingdom)

Images & Co (United Kingdom)

Istanbul Metropolitan Municipality (Turkey)

Istanbul Teknik Universitesi (Turkey)

National University of Ireland, Galway (Ireland)

Santer Reply Spa (Italy)

Singularlogic Anonymi Etairia Pliroforiakon Sistimaton Kai Efarmogon Pliroforikis (Greece)

Inria contact: Nathalie Mitton

Internet-of-Things (IoT) applications are currently based on multiple architectures, standards and platforms, which have led to a highly fragmented IoT landscape. This fragmentation is evident in the area of smart cities, which typically comprise several technological silos (i.e. IoT systems that have been developed and deployed independently). Nowadays there is a pressing need to remove these silos in order to allow cities to share data across systems and coordinate processes across domains, thereby essentially improving sustainability and quality of life. In response to this need, VITAL will realize a radical shift in the development, deployment and operation of IoT applications, through introducing an abstract virtualized digital layer that will operate across multiple IoT architectures, platforms and business contexts. Specifically, VITAL will provide platform and business context agnostic access to Internet-Connected-Objects (ICO). Moreover, it will research virtualized filtering, complex event processing (CEP) and business process management mechanisms, which will be operational over a variety of IoT architectures/ecosystems. The mechanisms will compromise the diverse characteristics of the underlying ecosystems, thereby boosting interoperability at the technical and business levels. VITAL will also provide development and governance tools, which will leverage the project's interfaces for virtualized access to ICOs. VITAL will allow solution providers to (re)use a wider range of data steams, thereby increasing the scope of potential applications. It will also enable a more connected/integrated approach to smart city applications development, which will be validated in realistic deployments in London and Istanbul. The partners will contribute and adapt a host of readily available urban infrastructures, IoT platforms and novel IoT applications, which will ease the accomplishment of the project's goals based on an optimal value for EC money. Publications in 2015 in the framework of this project are: [7], [16], [18].

9.4. International Initiatives

9.4.1. Inria International Labs

9.4.1.1. PREDNET

Participants: Nathalie Mitton [correspondant], Viktor Toldov, Julien Vandaele.

Title: Predator network

Type: LIRIMA

Duration: January 2013 - December 2016

See also: <https://iww.inria.fr/prednet/en/>

Abstract: PREDNET (PREDator adhoc NETwork) proposes to do research on the most suitable topology and subsequent deployment of a wireless sensor network for sparsely populated outlying rural and wilderness areas, for effective monitoring and protection of resources and ecosystems. This collaboration gave birth to joint project submission, joint conference organization and several publications, among them for 2015.

9.4.2. Inria International Partners

9.4.2.1. Declared Inria International Partners

Università Mediterranea di Reggio Calabria (UNIC) (Italy)

Objective of this collaboration is the design of an innovative architecture that enables autonomic and decentralized fruition of the services offered by the network of smart objects in many heterogeneous and dynamic environments, in a way that is independent of the network topology, reliable and flexible. The result is an 'ecosystem' of objects, self-organized and self-sustained, capable of making data and services available to the users wherever and whenever required, thus supporting the fruition of an 'augmented' reality thanks to a new environmental and social awareness. This collaboration gave birth to the PALMARES project (see section International programs), students and researchers exchanges (see section international visits) and joint publications, among them for 2015: [4], [3].

9.4.2.2. Informal International Partners

Southern University, China

The purpose of this collaboration is to study the green (or energy-efficient) communication problem in vehicular ad hoc networks (VANETs) and the application of vehicular network communication in green transportation. It gave birth to joint project submission, joint conference organization (UIC 2016) and several publications, among them for 2015: [9].

9.4.2.3. PhD co-supervision

Participants: Nathalie Mitton [correspondant], Mouna Rekik.

Since January 2013, Nathalie Mitton co-supervises Mouna Rekik as a PhD student with Pr Zied Chtourou from Université de Sfax, Tunisia. Her topic is about swarm intelligence based multi-path geographic routing for wireless sensor and actuator networks.

This work has led to the following publications in 2015: [22], [23], [24], [25].

9.4.3. Participation In other International Programs

9.4.3.1. CROMO

Participants: Valeria Loscri, Nathalie Mitton [correspondant], Riccardo Petrolo, Tahiry Razafindralambo.

Title: Crowd Data In the mobile cloud)

Duration: January 2015 - December 2019

CroMo (Crowd Data In the mobile cloud) is a submission to the CAPES-COFECUB project call lead by Inria from the French side and University of Rio de Janeiro from Brazilian Side. Other partner institutions are Université Pierre et Marie Curie and Université de la Rochelle.

Mobile cloud computing is an emerging paradigm to improve the quality of mobile applications by transferring part of the computational tasks to the resource-rich cloud. The multitude data sources combined with the known difficulties of wireless communications represent an important issue for mobile cloud computing. Therefore, the additional computational power added by the cloud has to deal with the constraints of the wireless medium. One could imagine a situation where different sensors collect data and require intensive computation. This data must be transmitted at high rates before becoming stale. In this case, the network becomes the main bottleneck, not the processing power or storage size. To circumvent this issue, different strategies can be envisioned. As usual alternatives, wireless data rates must be increased or the amount of data sent to the cloud must be reduced. CROMO tackles challenges from all these three components of the mobile clouds (data generation, collect and processing) to then integrate them as a whole enhanced mobile cloud with improved network performances in terms of delay, energy consumption, availability, and reliability.

9.5. International Research Visitors

9.5.1. Visits of International Scientists

Several researchers have visited our group in 2015, mainly from our partner universities but not only:

- Zied Chtourou, Univ. Sfax, Tunisia, March 2015
- Sajid Mubashir Sheikh, Univ. Stellenbosch, South Africa, July-August 2015
- Arun Sen, Arizona State University, USA, June-Nov 2015
- OP Vyas, Indian Institute of Information Technology, India July 2015
- Riaan Wolhuter, Univ. Stellenbosch, South Africa, July 2015

9.5.1.1. Internships

We have hosted and supervised several master students. Some came to run their master internship in our lab, like

Ana Garcia Alcala from University of Lille (4 months), Mohamed El Amine Seddik from Telecom Lille (6 months), Ayoub El Yagoubi (4 months).

Other students have visited us from our partner universities in the framework of the joint project we run together. This is the case for Solomon Peterus Le Roux (2 months) who came from Stellenbosch university, South Africa, in the framework of the PredNET program and Anup Bhattacharjee from IIIT Allahabad, India (2 months).

9.5.2. Visits to International Teams

9.5.2.1. Research stays abroad

- Nathalie Mitton visited IIIT Allahabad, India for 2 weeks in March 2015.
- Riccardo Petrolo visited UFRJ, Brasil for 2 months (Oct-dec 2015).

GANG Project-Team

9. Partnerships and Cooperations

9.1. National Initiatives

9.1.1. ANR Displexity

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

Managed by University Paris Diderot, C. Delporte and H. Fauconnier lead this project that grants 1 Ph. D.

Distributed computation keep raising new questions concerning computability and complexity. For instance, as far as fault-tolerant distributed computing is concerned, impossibility results do not depend on the computational power of the processes, demonstrating a form of undecidability which is significantly different from the one encountered in sequential computing. In the same way, as far as network computing is concerned, the impossibility of solving certain tasks locally does not depend on the computational power of the individual processes.

The main goal of DISPLEXITY (for DIStributed computing: computability and COMPLEXITY) 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 the different sub-communities corresponding to a variety of classes of distributed computing models. The current distributed computing community may indeed be viewed as two not necessarily disjoint sub-communities, one focusing on the impact of temporal issues, while the other focusing on the impact of spatial issues. The different working frameworks tackled by these two communities induce different objectives: computability is the main concern of the former, while complexity is the main concern of the latter.

Within DISPLEXITY, the reconciliation between the two communities will be achieved by focusing on the same class of problems, those for which the distributed outputs are interpreted as a single binary output: yes or no. Those are known as the yes/no-problems. The strength of DISPLEXITY is to gather specialists of the two main streams of distributed computing. Hence, DISPLEXITY will take advantage of the experience gained over the last decade by both communities concerning the challenges to be faced when building up a complexity theory encompassing more than a fragment of the field.

In order to reach its objectives, DISPLEXITY aims at achieving the following tasks:

- Formalizing yes/no-problems (decision problems) in the context of distributed computing. Such problems are expected to play an analogous role in the field of distributed computing as that played by decision problems in the context of sequential computing.
- Formalizing decision problems (yes/no-problems) in the context of distributed computing. Such problems are expected to play an analogous role in the field of distributed computing as that played by decision problems in the context of sequential computing.
- Revisiting the various explicit (e.g., failure-detectors) or implicit (e.g., a priori information) notions of oracles used in the context of distributed computing allowing us to express them in terms of decidability/complexity classes based on oracles.
- Identifying the impact of non-determinism on complexity in distributed computing. In particular, DISPLEXITY aims at a better understanding of the apparent lack of impact of non-determinism in the context of fault-tolerant computing, to be contrasted with the apparent huge impact of non-determinism in the context of network computing. Also, it is foreseen that non-determinism will enable the comparison of complexity classes defined in the context of fault-tolerance with complexity classes defined in the context of network computing.

- Last but not least, DISPLEXITY will focus on new computational paradigms and frameworks, including, but not limited to distributed quantum computing and algorithmic game theory (e.g., network formation games).

The project will have to face and solve a number of challenging problems. Hence, we have built the DISPLEXITY consortium so as to coordinate the efforts of those worldwide leaders in Distributed Computing who are working in our country. A successful execution of the project will result in a tremendous increase in the current knowledge and understanding of decentralized computing and place us in a unique position in the field.

The project has been extended until June 2016.

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

Participants: François Durand, The-Dang Huynh, Leonardo Linguaglossa, Laurent Viennot.

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

9.2. European Initiatives

9.2.1. FP7 & H2020 Projects

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

9.3. International Initiatives

9.3.1. Inria International Partners

9.3.1.1. Informal International Partners

Ofer Feinerman (Physics department of complex systems, Weizmann Institute of Science, Rehovot, Israel), is a team member in Amos Korman’s ERC project DBA.

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

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

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

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

9.3.2. Participation In other International Programs

Involvement in the bilateral Franco-Israeli project MAIMONIDE (2014-2015) on “Resource Allocation in the Cloud”. Pierre Fraigniaud was the project’s co-coordinator for the French side. Financed by Partenariats Hubert Curien.

Involvement in the bilateral Franco-Mexican project ECOS NORD (2013-2016) on “Distributed Verification”. Pierre Fraigniaud was the project’s co-coordinator for the French side. Partners: LIAFA and LaBRI (France), UNAM (Mexico).

9.4. International Research Visitors

9.4.1. Visits of International Scientists

Zvi Lotker (Ben Gurion University, Israel) is a long-term visitor of the team. He has also been awarded the Junior Chair of Fondation Sciences Mathématiques de Paris (FSMP) for 2015/2016.

Andrea Pietracaprina (Univ. Padova, Italy), 1 month’s visit, Fall 2015.

Geppino Pucci (Univ. Padova, Italy), 1 month’s visit, Fall 2015.

Eli Gafni (UCLA, USA), 2 months’ visit, June-July 2015.

Sam Toueg (Univ. Toronto, Canada), 1 month’s visit, January 2015.

Flavia Bonomo (Universidad de Buenos Aires, Argentina), 1 month’s visit, June 2015.

9.4.1.1. Internships

Rai Nishant

Date: May 2015 - Jul 2015

Institution: IITK (India)

Shah Parth

Date: May 2015 - Jul 2015

Institution: Indian Institute of Technology Bombay (India)

Ricardo De La Paz Guala

Date: Feb 2015 - May 2015

Institution: Universidad de Concepción (Chile)

Marc Heinrich

Date: Mar 2015 - Jun 2015

Institution: ENS Paris

Simon Collet

Date: Mar 2015 - Jun 2015

Institution: Paris VII

9.4.2. Visits to International Teams

9.4.2.1. Research stays abroad

Amos Korman made several monthly visits to Israel, collaborating with Weizmann Institute of Science and Tel-Aviv University.

INFINE Team

8. Partnerships and Cooperations

8.1. Regional Initiatives

8.1.1. LiveGrid

Participants: Cedric Adjih, Emmanuel Baccelli.

Infine is one of the teams from Inria participating to LiveGrid: LiveGrid is a consortium of the main actors of industry, research organisations, local authorities and competitive cluster from the Paris-Saclay campus. The goal of LiveGrid is make the Paris-Saclay campus one of the leader regions of smart grids. Infine expertise is in infrastructure: testbeds, communication protocols, embedded open source OS.

8.2. National Initiatives

8.2.1. Equipex FIT

Participants: Cedric Adjih, Emmanuel Baccelli, Ichrak Amdouni, Alaeddine Weslati, Vincent Ladeveze.

Partners: Inria (Lille, Sophia-Antipolis, Grenoble), INSA, UPMC, Institut Telecom Paris, Institut TÃ©lÃ©com Evry, LSIIT Strasbourg.

FIT (Future Internet of Things) aims to develop an experimental facility, a federated and competitive infrastructure with international visibility and a broad panel of customers. It provides this facility with a set of complementary components that enable experimentation on innovative services for academic and industrial users. The project gives french internet stakeholders a means to experiment on mobile wireless communications at the network and application layers thereby accelerating the design of advanced networking technologies for the future internet. FIT was one of 52 winning projects from the first wave of the French Ministry of Higher Education and Researchâ€™s "Ã©quipements dâ€™Excellence" (Equipex) research grant program, in 2011.

One component of the FIT platform is the sets of IoT-LAB testbeds (see [site IoT-LAB](#)). These were motivated by the observation that the world is moving towards an "Internet of Things", in which most communication over networks will be between objects rather than people.

The Infine team is more specifically managing the FIT IoT-LAB site formerly at Rocquencourt, which recently moved to Saclay (on-going re-deployment), and is participating in the deployment of an additional IoT-lab testbed in Berlin (at Freie Universitaet Berlin).

The Infine team is actively collaborating with UPEC on wireless sensor network testbeds (and protocols): in 2015, the testbed from UPEC with 45 Arduino nodes has been [integrated with the FIT IoT-LAB testbed](#).

8.3. European Initiatives

8.3.1. FP7 & H2020 Projects

8.3.1.1. AGILE (H2020 project)

Participants: Emmanuel Baccelli, Cedric Adjih.

Program: H2020 ICT-30-2015 Topic: Internet of Things and Platforms for Connected Smart Objects

Project acronym: AGILE

Project title: Adoptive Gateways for dIverse muLtipLe Environments

Duration: 2015-2017

Coordinator: Emmanuel Baccelli

Other partners: Canonical (UK), Eclipse IoT Foundation (IE), Mobistar (BE), Libelium (ES), Startupbootcamp IoT (SP), CREATE-NET (IT), iMinds (BE), Atos (SP), Rulemotion (UK), Jolocom (DE), Passau University (DE), Sky-Watch (DN), BioAssist (GR), Graz Technical University (AT), Eurotech (IT), IoTango (US).

Abstract:

The AGILE project is a 3-year H2020 project started in January 2016, which will deliver an integrated framework of open source tools and platforms that interoperate for enabling the delivery of adaptive, self-configurable and secure IoT elements (both software and hardware) that can be utilized in a variety of scenarios. Such tools target actors with heterogeneous skills, including entrepreneurs, researchers, and individuals, aiming to enable the realization of IoT applications respecting user privacy and data ownership.

8.3.2. Collaborations in European Programs, except FP7 & H2020

8.3.2.1. EU CHIST-ERA MACACO

Participants: Aline Carneiro Viana, Emmanuel Baccelli, Eduardo Mucelli.

Program: EU CHIST-ERA, topic Context- and Content-Adaptive Communication Networks

Project acronym: MACACO

Project title: Mobile context-Adaptive Caching for Content-centric networking

Duration: 2013-2016

Coordinator: Aline Carneiro Viana

Other partners: INPT-ENSEEIH at University of Toulouse, University of Birmingham (UK), SUPSI (Switzerland), CNR (Italy) and Federal University of Minas Gerais (Brazil)

Abstract:

MACACO (Mobile context-Adaptive Caching for Content-centric networking) is a 3-year CHIST-ERA European Project addressing the topic Context- and Content-Adaptive Communication Networks. It is funded by ANR in France, SNSF in Switzerland, and ESPRC in UK. It focus on data offloading mechanisms that take advantage of context and content information. Our intuition is that if it is possible to extract and forecast the behaviour of mobile network users in the three-dimensional space of time, location and interest (i.e. *what*, *when* and *where* users are pulling data from the network), it is possible to derive efficient data offloading protocols. Such protocols would pre-fetch the identified data and cache it at the network edge at an earlier time, preferably when the mobile network is less charged, or offers better quality of service. This project has officially started in November 2013. The first annual report will be delivered before January 25, 2015.

8.3.2.2. ANR/BMBF SAFEST

Participants: Emmanuel Baccelli, Cedric Adjih, Oliver Hahn.

Program: ANR/BMBF French-German partnership within CSOSG Framework

Project acronym: SAFEST

Project title: Social Area Framework for Early Security Triggers

Duration: 2012-2015

Coordinators: Emmanuel Baccelli (France), Jochen Schiller (Germany)

Other partners: Freie Universitat Berlin, Fraunhofer, Hamburg University, Sagem, Daviko, FOS

Abstract: Public spaces, such as airports, railway stations, or stadiums bring together large numbers of people on limited space to use security-sensitive infrastructure. These spaces pose two distinct challenges to public security: (a) detecting unauthorized intrusions and (b) monitoring large crowds in order to provide guidance in case of unexpected events (e.g., mass panic). To ensure the safety of the general public as well as individuals, we thus require a flexible and intelligent method for area surveillance. One example in which current monitoring systems proved to be dangerously inefficient is the Love Parade music festival in Duisburg, Germany, July 2010. Crowd control failed to provide guidance to a large crowd, resulting in a mass panic with 21 deaths and several hundred injured. In this particular case, overloaded communication infrastructure led to a lack of information about the density and the movement of the crowd, which in turn resulted in misjudgments on appropriate strategies to resolve the situation. This incident highlights the need for more sophisticated and

reliable methods for area surveillance. The SAFEST project aims to analyse the social context of area surveillance and to develop a system that can fulfill this task, both in terms of technology as well as acceptance by the general public. The system will operate in distributed way, collect anonymised data, securely transfer this data to a central location for evaluation, and if necessary notify the operator and/or issue alerts directly to the general public. SAFEST addresses the following topics: (i) it proposes a solution for crisis management, addressing social, technical, and economic issues, (ii) it enhances the protection of the population against risks and dangers, including the evaluation of acceptance of said solution, and (iii) it addresses the protection of critical infrastructures by the means of a comprehensive technical solution. Project completed in 2015. One of its main result was the emergence of RIOT.

8.4. International Initiatives

8.4.1. Inria International Partners

8.4.1.1. Declared Inria International Partners

1. On-going formal collaboration with Freie Universitaet Berlin around the long-term stay of Emmanuel Baccelli in Berlin, around the topics of the Internet of Things and Information-Centric Networking.
2. The Inria teams Infine and Eva are part of the "D2D Communication for LTE Advanced Cellular Network" , a project funded by the Indo-French Centre for the Promotion of Advanced Research (CEFIPRA). With industrial partners, and also with Indian partners, this project is focusing on the evolution of cellular networks towards 5G: this includes exploration of device-to-device (D2D) communication, and more generally IoT communication in a cellular context. Research directions include efficient access for IoT devices (massive numbers of devices with low volume communication); combination of random access protocols/error coding/physical layer ; efficient neighbor discovery, ldots.

8.4.1.2. Informal International Partners

1. On-going collaboration with Hamburg University of Applied Science around RIOT.
2. Informal collaborations with UIUC and UMass.

8.4.2. Participation In other International Programs

8.4.2.1. STIC AmSud UCOOL

Participants: Aline Carneiro Viana, Eduardo Mucelli.

Program: STIC AmSud

Project acronym: UCOOL

Project title: Understanding and predicting human demanded Content and mObiLity

Duration: 2013-2015

Coordinator: Aline Carneiro Viana

Other partners: National Laboratory for Scientific Computing (Brazil), Facultad de IngenierÃ- a, Universidad de Buenos Aires (Argentina), Universidad Tecnica Federico Santa Maria (Chile), Telecom Sud Paris, and Inria (with INFINE at Saclay and DANTE at Rhone-Alpes)

Abstract: The UCOOL (Understanding and predicting human demanded Content and mObiLity, <https://macaco.inria.fr/>) project is granted by STIC-AmSUD, it is a 2-year project, and has officially started in January 2014. The main goal of this project is to define solutions for the identification and modelling of correlations between the user mobility â describing changes in the user positioning and the current environment he/she is in â and the traffic demand he/she generates.

8.4.2.2. PHC PESSOA 2015

Participant: Aline Carneiro Viana.

PHC PESSOA 2015 with University of Coimbra (2015-2016).

Program: -FCT - Programa PESSOA

Project title: Routine-based Enhanced Connectivity under User Mobility

Duration: 2015-2016

Coordinator: Aline Carneiro Viana and João Paulo da Silva Machado Garcia Vilela (University of Coimbra)

Abstract: The main goal of this project is to improve WiFi connectivity of users under mobility. The steady growth of smart-phones usage has put cellular networks under great strain, justifying the need for WiFi offloading as a solution that transfers part of the demand on cellular networks to WiFi hotspots that are in many cases already available. However, this must be performed in a way that provides benefits to the cellular operator while ensuring users a similar level of connectivity that they would achieve with cellular networks, even under user mobility (e.g. walking, taking a bus/train, etc). In this work we aim at (1) developing prediction mechanisms for selection of best hotspots by users under mobility, and (2) develop lightweight security schemes to reduce the burden of the association/authentication process of WiFi networks, therefore making WiFi offloading an effective and secure alternative to the growing demand on cellular networks.

8.5. International Research Visitors

8.5.1. Visits of International Scientists

1. Artur Ziviani, National Laboratory for Scientific Computing (LNCC), Brazil, October 2015.
2. José Ignacio Alvarez-Hamelin, Facultad de Ingeniería, Universidad de Buenos Aires, Argentina, November 2015.
3. Joao P. Vilela, University of Coimbra, July 2015

8.5.2. Visits to International Teams

8.5.2.1. Research stays abroad

Emmanuel Baccelli has been visiting Freie Universitaet (FU) Berlin in 2015, within the context of the SAFEST project. The closer collaboration enabled by this stay allowed the initial development of the RIOT community (<http://www.riot-os.org>), and the development of new activities around Information-centric networking in the Internet of Things.

MADYNES Project-Team

9. Partnerships and Cooperations

9.1. Regional Initiatives

9.1.1. 6PO Research Region Lorraine and UL project

Participants: Emmanuel Nataf, Ye-Qiong Song, Laurent Ciarletta [contact].

Funded by Region Lorraine and Université de Lorraine since 2013. Adel Belkadi (CRAN & LORIA) is co-directed by L. Ciarletta and Didier Theilliol (CRAN correspondant).

6PO (“Systèmes Cyber-Physiques et Commande Coopérative Sûre de Fonctionnement pour une Flotte de Véhicules sans Pilote”) is a joint research project between the Loria and CRAN laboratories. As a part of the Aetournos ecosystem, it also aims at researching solutions for safe formation flying of collaborative UAVs seen as part of a collection of Cyber Physical Systems mixing computer science and automation solutions.

It is reinforced by a PhD grant from this federation that started in october 2014 (*Conception de méthodes de diagnostic et de tolérance aux fautes des systèmes multi-agents: Application à une flotte de véhicules autonomes*, Adel Belkadi).

This led to common publications, notably on the subjects of control of a fleet of UAV (with or without leader, using particle swarm optimisation [25] and [24]) and the organisation of a Federation Charles Hermite research day in may 2015.

The project provides common use cases and scientific challenges that serve as catalysts for collaboration between teams from different research topics :

- Cyber Physical Systems, Real Time, Quality of service, Performance and Energy in Wireless Sensors and Activator Networks
- Collaborative, communicating autonomous systems and Unmanned Vehicles
- Safety, Dependability, Reliability, Diagnosis, Fault-Tolerance

9.1.2. Hydradrone FEDER Région Lorraine project

Participants: Adrien Guenard, Laurent Ciarletta [contact].

Funded by the Region Lorraine under the R&D program.

The Madynes team has been working on the Hydradrone project since July 2014. It started as a collaborative R&D initiative funded by *Région Lorraine* and is now FEDER funded. This project started as a joint work between Madynes and PEMA (*Pedon Environnement et Milieux Aquatiques*), an SME/VSE (small and medium size Enterprise, PME/TPE). The consortium now includes Alerion another VSE, spinoff form Loria.

It consists in developing a new solution for the surveillance of aquatic environment, the Hydradrone:

- starting with an actual need for automated and remote operation of environmental sensing expressed by PEMA
- based on an hybrid UxV (Unmanned Air, Surface... Vehicle),
- some Cyber Physical bricks in coherence with the Alerion’s concepts (ease of use, safety, autonomy)
- and an integration in the Information System of the company

PEMA, as an environmental company, is providing the use cases and terrain (and business) validation, while Alerion is working on the integration and engineering of the solution.

This first year has been dedicated to the development of :

- a couple of small scale hydradrones / proofs of concept (the UxV) for both hardware and software (embedded / remote)
- a larger 1:1 scale hydradrone for heavy sensor payload
- evaluation of the needed sensor payload, and the requirements to turn them into "cyber physical" components.

9.1.3. *Satelor AME Lorraine regional project*

Participants: Mandar Harshe, Lei Mo, Mohamed Tlig, Bernardetta Addis, Evangelia Tsiontsiou, Ye-Qiong Song [contact].

The Madynes team is involved in Satelor, a regional research and development project funded by the AME (Agence de Mobilisation Economique) of Lorraine (October 2013 – September 2016). The consortium includes academic (Univ. of Lorraine, Inria), medical (OHS) and industrial (Diatelic-Pharmagest (lead), ACS, Kapelse, Salendra, Neolinks) partners. It aims at developing innovative and easily deployable ambient assisted living solutions for their effective use in the tele-homecare systems. The Madynes team is mainly involved in the data collection system development based on wireless sensors networks and IoT technology. The first topic consists in defining the basic functions of the future SATEBOX – a gateway box for interconnecting in-home sensors to the medical datacenter, based on our previously developed MPIGate software. A beta-version prototype of the future Satebox gateway has been released. It now includes Zigbee wireless sensors, EnOcean battery-free sensors and Bluetooth Low Energy sensors. It provides a low-cost and easily deployable solution for the daily activity monitoring. After its first real-world deployment at a OHS hospital room, a second prototype testbed has been prepared for a further test deployment including several rooms. The second topic is related to improving the data transfer reliability while still keeping minimum energy consumption. This has led us to focus on the multi-hop mesh network topology with multi-constrained QoS routing problem (PhD thesis of Evangelia Tsiontsiou) [28]. The third topic is related to the wireless charging of sensor nodes (PhD work of Lei MO) in order to keeping sensors in perpetual working state [38]. A new direction has been also investigated which consists in using the CSI (channel signal information) of the omnipresent WiFi (IEEE802.11n) as a new generation of contactless sensors. A first test bed of using CSI to measure the respiration rate has been set up.

9.2. National Initiatives

9.2.1. *ANR Doctor*

Participants: Thibault Cholez [contact], Thomas Silverston [contact], Xavier Marchal, Cédric Enclos, Elian Aubry, Daishi Kondo, Olivier Festor.

The DOCTOR project <http://www.doctor-project.org> is an applied research project funded by the French National Research Agency (ANR), grant <ANR-14-CE28-000>, and supported by the French Systematic cluster. The project started on December 2014 for three years. It involves five partners specialized in network monitoring and security: Orange Labs (lead), Thales, Montimage, Université de technologie de Troyes and LORIA/CNRS. The DOCTOR project advocates the use of virtualized network equipment (Network Functions Virtualization), to enable the co-existence of new Information-Centric Networking stacks (e.g.: NDN) with IP, and the progressive migration of traffic from one stack to the other while guaranteeing the good security and manageability of the network. Therefore in DOCTOR, the main goals of the project are: (1) the efficient deployment of emerging networks functions or protocols in a virtualized networking environment; (2) the monitoring and security of virtually deployed networking architectures.

This year, we mainly worked on the WP1 which goal is to define the global architecture of DOCTOR and select the most relevant technologies solutions [66], [27]. We focused on performance of different virtualization solutions. We also contributed to WP4, dedicated to the testbed infrastructure [71]. We also provided a routing scheme for NDN based on a softwarization approach (Software-Defined Networking, SDN) [22], [21].

9.2.2. PIA LAR

Participants: Kévin Roussel, Ye-Qiong Song [contact].

LAR (Living Assistant Robot) is a PIA (Projet investissement d'avenir) national project getting together Inria (MAIA and MADYNES projects), *Crédit Agricole* (lead), Diatelic and Robotsoft. The aim is to develop an ambient assisted living system for elderly including both sensors and assistant robots. The task of Madynes team is the development of a WSN-based system integrating both sensors of the environment and sensors and actuators embedded on a mobile robot. The research issues include the QoS, energy and mobility management. This year we have intensively tested the S-CoSenS MAC protocol under RIOT OS by using ARM Cortex-M3 motes of IoT-LAB (Grenoble) and especially contributed to the improvement of the robustness (see section 7.7.1). Another achievement is the connection of our MPIGate-based sensor data collect system to the application server, by the mean of properly defined JSON message formats.

9.2.3. FUI HUMA

Participants: Jonathan Arnault, Giulia de Santis, Pierre-Olivier Brissaud, Jérôme François [contact], Abdelkader Lahmadi, Isabelle Chrisment.

The HUMA project (*L'HUmain au cœur de l'analyse de données MAssives pour la sécurité*) is funded under the national FUI Framework (Fonds Unique Interministeriel) jointly by the BPI (Banque Publique d'Investissement) and the Région Lorraine. It has been approved by two competitive clusters: Systematic and Imaginove. The consortium is composed of three academic (ICube, Citi, Inria) and five industrial (Airbus Defence and Space, Intrinsec, Oberthur, Wallix, Sydo) partners. The leader is Intrinsec.

This project started in September 2015 and targets the analysis of Advanced Persistent Threat. APT are long and complex attacks which thus cannot be captured with standard techniques focused on short time windows and few data sources. Indeed, APTs may be several months long and involve multiple steps with different types of attacks and approaches. The project will address such an issue by leveraging data analytics and visualization techniques to guide human experts, which are the only one able to analyze APT today, rather than targeting a fully automated approach. Academic partners will be mainly focused on defining those techniques while industrial partners will build an experimental platform to design a testing platform and data collectors.

9.2.4. Inria-Orange Joint Lab

Participants: Jérôme François [contact], Rémi Badonnel, Olivier Festor, Maxime Compastié.

The challenges addressed by the Inria-Orange joint lab relate to the virtualization of communication networks, the convergence between cloud computing and communication networks, and the underlying software-defined infrastructures. This lab aims at specifying and developing a GlobalOS (Global Operating System) approach as a platform or a software infrastructure for all the network and computing resources required by the Orange network operator. Our work, started in November 2015, concerns in particular monitoring methods for software-defined infrastructures, and management strategies for supporting software-defined security in multi-tenant cloud environments.

9.2.5. Technological Development Action (ADT)

9.2.5.1. ADT Métroscope

This ADT is linked to the consortium Metroscope <http://metroscope.eu/>, whose goal is to understand the behavior of the Internet and its uses within a mobile environment. Through this ADT, funded by Inria, an engineer (Mohammad-Irfan Khan) was hired for 2 years (2013-2015). He is participating in the design and deployment of a distributed platform. This platform is composed of a services providing measurement tools that collect a set of data and interact with probes located at various points of the network.

9.2.5.2. ADT SEA

The goal of this ADT is to provide an novel security solution for Android platforms where the users will be able to evaluate the security level of their devices. The solution relies on the analysis and collection of logs and network activities of running Android applications to detect malicious activities and also the detection of vulnerable configurations of the device using an OVAL-based approach. Through this ADT, funded by Inria an engineer (Eric Finickel) was hired for 2 years (2013-2015). The work was focused on the development of Android devices embedded probes to export logs and network activities, and also the design and setup of collector and analysis applications using a Hadoop based framework. The resulting platform from this ADT is currently deployed in the High Security Lab and it will be extended during the year 2016.

9.2.5.3. ADT R2D2

The goal of this ADT is to provide assistance in developing the Aetournos platform. Through this ADT, funded by Inria, Ceilidh Hoffmann stayed until february 2015 and then Raphaël Cherfan was hired for the rest of the year (2015). They both have been helping maintaining the Aetournos platform, coordinating students work on the platform and tutoring the Aetournos team for the 2014 and 2016 Outback Joe Search and Rescue / Medical Express Challenge.

9.2.5.4. ADT LAPLACE

This ADT started on 2014 and will end on 2016. The Madynes project is a major partner funded at the level of 120k€. ADT LAPLACE builds upon the foundations of the Grid'5000 testbed to reinforce and extend it towards new use cases and scientific challenges. Several directions are being explored: networks and Software Defined Networking, Big Data, HPC, and production computation needs. Already developed prototypes are also being consolidated, and the necessary improvements to user management and tracking are also being performed.

9.2.5.5. ADT COSETTE

This ADT started on 2013 and will end on 2016. The Madynes project is the only partner funded at the level of 120k€. ADT COSETTE, for *COherent SET of Tools for Experimentation* aims at developing or improving a tool suite for experimentation at large scale on testbeds such as Grid'5000. Specifically, we will work on (1) the development of Ruby-CUTE, a library gathering features useful when performing such experiments; (2) the porting of Kadeploy, Distem and XPFlow on top of Ruby-CUTE; (3) the release of XPFlow, developed in the context of Tomasz Buchert's PhD; (4) the improvement of the Distem emulator to address new scientific challenges in Cloud and HPC. E. Jeanvoine (SED) is delegated in the Madynes team for the duration of this project.

9.2.5.6. ADT RIOT

RIOT ADT is a multi-site project with Infine and Madynes teams, which started in December 2015 for a duration of two years. The high-level objective is to (1) contribute open source code, upstream, to the RIOT code base, (2) coordinate RIOT development within Inria, with other engineers and researchers using/developing RIOT, (3) coordinate RIOT development outside Inria, help maintain the RIOT community at large (see www.riot-os.org and www.github.com/RIOT-OS/RIOT) which aims to become the equivalent of Linux for IoT devices that cannot run Linux because of resource constraints.

Specific objectives of Madynes team include (a) implementation, on RIOT, of new MAC protocols issuing from the latest research, as well as the design of the MAC layer interfaces both with the upper network layer and directly with applications (API), (b) RIOT drivers development to allow efficiently interfacing with both radio transceivers and sensors (via UART, SPI, I2C, GPIO, ...), according to the chosen hardware platforms (e.g., Zolertia Z1, AVR, ARM Cortex), (c) implementation of the previous solutions in a smart home environment, (d) development of an MCU emulator, (e) integration of the developed MCU emulator into a network simulation tool (e.g. Cooja).

9.2.6. Other Initiative

Participants: Ciarletta Laurent, Gurriet Thomas, Xu Yang, Amza Catalin, Guenard Adrien, Nataf Emmanuel [contact].

Alerion is an "e-falconry" startup created by a member of Madynes in June 2015. Its goal is to provide novel solutions and services in the field of UxV (Unmanned Air, Ground, Surface ... Vehicles) and in moving and interacting objects of the "Internet of Things". The concept is to enhance such existing systems or design new ones by combining well-designed (i.e with regards to efficiency, safety, ease of use) components and containers seen as Cyber Physical bricks. This has also given some publications [53], [52] and [30]. The Alerion project is also actively supporting the international UAV Challenge team that is participating to the "Medical Express", the new "Outback Joe Challenge".

9.3. European Initiatives

9.3.1. FP7 & H2020 Projects

9.3.1.1. Flamingo

Title: Management of the Future Internet

Programm: FP7

Duration: November 2012 - October 2016

Coordinator: University Twente

Partners: Iminds Vzw (Belgium), Jacobs University Bremen Gmbh (Germany), University College London (United Kingdom), Université de Lorraine (France), Universitaet Der Bundeswehr Muenchen (Germany), Universitat Politecnica de Catalunya (Spain), Universiteit Twente (Netherlands), Universitaet Zuerich (Switzerland)

Inria contact: Jérôme François

The goals of FLAMINGO are (a) to strongly integrate the research of leading European research groups in the area of network and service management, (b) to strengthen the European and worldwide research in this area, and (c) to bridge the gap between scientific research and industrial application.

In 2015, our activities of Flamingo have been focused on automated configuration using service function chaining for mobile device (section 7.2.3), sensor network monitoring to counter-fight attacks in cooperation with the Jacobs University Bremen (§7.1.4), leading the standardization activities of the project (WP leader), enhancing our flow-based monitoring specification to be standardized at the IETF in a close future (§6.3) and Online training material on network management (§10.2.1).

9.4. International Initiatives

9.4.1. Inria International Labs

- LIRIMA (*Laboratoire international de recherche en informatique et mathématiques appliquées*): Madynes is associated with the MASECNESS research team of the Yaoundé University, Cameroun. The collaboration is about wireless sensors networks and was the support for funding student mobility (4 months this year). The LIRIMA has also supported the purchase of thirty sensors used in our common work. Some results have been presented this year at the scientific workshop of the LIRIMA held in St-Louis of Senegal.
- Since September 2015, Thomas Silverston is on leave at JFLI (*délégation CNRS*), an international joint-laboratory between CNRS, Inria, UPMC, Univ. Paris Sud, Keio University, NII and the University of Tokyo located in Tokyo, Japan. He is currently hosted at the University of Tokyo. His main research objectives are on virtualization on new network architecture (e.g.: ICN/NDN) through the use of software-defined networking or Network Function Virtualization.

Dash Kondo, a PhD student from Madynes, is currently doing an internship at JFLI at the University of Tokyo with Prof. Asami Tohru and Thomas Silverston, on virtualization and security in NDN.

9.4.2. Inria International Partners

9.4.2.1. Informal International Partners

- University of Luxembourg: Jérôme François is a Fellow at SnT (Interdisciplinary Center for Security, Reliability and Trust) to empower our collaboration with the University of Luxembourg. This collaboration is now focused on network virtualization, which also includes the co-advising of S. Signorello.
- University of Waterloo: we pursue our collaboration with the team of Prof. Raouf Boutaba especially on using SDN for scheduling flows generated by *Big Data* applications. This work lead to a survey [55].

9.4.3. Participation In other International Programs

9.4.3.1. STIC-AmSud AKD Project

Participants: Remi Badonnel [contact], Olivier Festor, Gaetan Hurel, Amedeo Napoli.

The AKD project, funded by the STIC-AmSud Program, addresses the challenge of autonomic knowledge discovery for security vulnerability prevention in self-governing systems. The partners include Federal University of Rio Grande do Sul (UFRGS, Brazil), Republic University of Uruguay (INCO, Uruguay), Technical University of Federico Santa Maria (UTFSM, Chile), and Inria (Orpailleur, Madynes). Computer vulnerabilities constitute one of the main entry points for security attacks, and therefore, vulnerability management mechanisms are crucial for any computer systems. However autonomic mechanisms for assessing and remediating vulnerabilities can degrade the performance of the system and might contradict existing operational policies. In that context, this project started in January 2015 focuses on the design of solutions able to pro-actively understand the behavior of systems and networks, in order to prevent vulnerable states. For that purpose, our work concerns more specifically the exploitation and integration of knowledge discovery techniques within autonomic systems for providing intelligent self-configuration and self-protection. It also investigates the building of flexible and dynamic security management mechanisms taking benefits from software-defined methods and techniques.

9.5. International Research Visitors

9.5.1. Visits of International Scientists

9.5.1.1. Internships

Nesrine Khelifi, 18/06/2015-18/09/2015, Université de Manouba - Tunisie. See §7.4.1

Seetaraman Savita, 10/07/2015-31/10/2015, University of Trento (Italy), Benchmarking of virtualized network functions [62]

9.5.1.2. Scientific visits

Dr. Jian Li, associate professor at Shanghai Jiaotong University (China) visited the team for two weeks in December and given a talk on the recent research results of his group on network virtualization and cloud applications.

9.5.2. Visits to International Teams

9.5.2.1. Research stays abroad

Thomas Silverston is currently on leave (Delegation CNRS) at the University of Tokyo within JFLI, an international joint-lab between CNRS, Inria, UPMC, Univ. Paris Sud, Keio University, NII and the University of Tokyo. Daishi Kondo, co-advised with Prof. Olivier Perrin (UL) and Thomas Silverston, is also doing an internship at the JFLI from September 2015 to February 2016.

MAESTRO Project-Team

9. Partnerships and Cooperations

9.1. National Initiatives

9.1.1. ANR Marmote

Participants: Alain Jean-Marie, Issam Rabhi.

ANR Program: Modèles Numériques (MN) 2012, number ANR-12-MONU-0019

Project title: MARKovian MOdeling Tools and Environments

Duration: January 2013 - June 2017

Coordinator: Alain Jean Marie (Inria)

Partners: Inria (project-teams DYOGENE, MAESTRO and MESCAL), Univ. Versailles-Saint-Quentin (DAVID lab.), Telecom SudParis (SAMOVAR lab.), Univ. Paris-Est Créteil (LACL), and Univ. Pierre-et-Marie-Curie (LIP6)

Abstract: ANRMARMOTE aims, among other goals, at realizing the prototype of a software environment dedicated to modeling with Markov chains. It brings together seven partner teams, expert in Markovian analysis, who will develop advanced solution algorithms and applications in different scientific domains: reliability, distributed systems, biology, physics and economics.

<https://wiki.inria.fr/MARMOTE/Welcome>

9.2. European Initiatives

9.2.1. FP7 & H2020 Projects

9.2.1.1. CONGAS

Participants: Eitan Altman, Konstantin Avrachenkov, Yonathan Portilla, Alexandre Reiffers-Masson.

Title: Dynamics and COevolution in Multi-Level Strategic INteraction GAMEs

Programm: FP7

Duration: October 2012 - September 2015

Coordinator: Create-Net

Partners:

iNSPIRE, Create-Net (center for Research and Telecommunication Experimentation for Networked Communities) (Italy)

Mathematics department, Imperial College of Science, Technology and Medicine (United Kingdom)

Electrical Engineering, Technion Israel Institute of Technology

Telecommunications Department, Technische Univ. Delft (Netherlands)

Computer Science Laboratory, Univ. d'Avignon et des Pays de Vaucluse (France)

Department of Information Engineering, Univ. di Pisa (Italy)

Inria contact: Konstantin Avrachenkov

Many real world systems possess a rich multi-level structure and exhibit complex dynamics that are the result of a web of interwoven interactions among elements with autonomous decision-making capabilities. CONGAS will develop new mathematical models and tools, rooted in game theory, for the analysis, prediction and control of dynamical processes in such complex systems. It will provide a coherent theoretical framework for understanding the emergence of structure and patterns in such systems, accounting for interactions spanning various scales in time and space, and acting at different structural and aggregation levels. This framework will be built around game theoretical concepts, in particular evolutionary and multi-resolution games, and will include also techniques drawn from graph theory, statistical mechanics, control and optimization theory. Specific attention will be devoted to systems that are prone to intermittency and catastrophic events due to the effect of collective dynamics. The theory developed in the project will be validated by considering three use cases, one on the growth of the Internet, one on business ecosystems and one on viral marketing dynamics in Internet marketplaces. The CONGAS Consortium comprises seven universities and research institution and includes leading scientists in game theory, evolutionary games, complex systems science, network science and data-driven analysis of socio-technical systems.

MAESTRO's task is to develop game theoretic models to model (a) the formation of technological and social network; (b) the routing for competing agents; and (c) the competition of information in social networks.

<http://www.congas-project.eu/>

9.2.2. Collaborations in European Programs, except FP7 & H2020

Participants: Konstantin Avrachenkov, Abdulhalim Dandoush.

Program: EU COST

Project acronym: ACROSS

Project title: Autonomous Control for a Reliable Internet of Services

Duration: November 2013 - November 2017

Coordinator: Rob Van Der Mei (CWI) and J.L. Van Den Berg (TNO), The Netherlands

Other partners: see <http://www.cost-across.nl/>

Abstract: Currently, we are witnessing a paradigm shift from the traditional information-oriented Internet into an Internet of Services (IoS). This transition opens up virtually unbounded possibilities for creating and deploying new services. Eventually, the ICT landscape will migrate into a global system where new services are essentially large-scale service chains, combining and integrating the functionality of (possibly huge) numbers of other services offered by third parties, including cloud services. At the same time, as our modern society is becoming more and more dependent on ICT, these developments raise the need for effective means to ensure quality and reliability of the services running in such a complex environment. Motivated by this, the aim of this Action is to create a European network of experts, from both academia and industry, aiming at the development of autonomous control methods and algorithms for a reliable and quality-aware IoS.

9.3. International Initiatives

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

9.3.1.1. THANES

Participants: Eitan Altman, Konstantin Avrachenkov, Jithin Kazhuthuvelil Sreedharan, Philippe Nain, Giovanni Neglia, Alexandre Reiffers-Masson.

Title: THEory and Application of NETwork Science

International Partners (Institution - Laboratory - Researcher):

Purdue Univ. (USA) - Department of Computer Science - Bruno Ribeiro

UFRJ (Brazil) - Department of Computer and Systems Engineering - Edmundo de Souza e Silva, Daniel Ratton Figueiredo, Daniel Sadoc

Duration: 2014 – 2017

See also: <https://team.inria.fr/thanes/>

Our goal is to study how services in Online Social Networks (OSN) can be efficiently designed and managed. This research requires to answer 3 main questions: 1) How can the topology of an OSN be discovered? Many services need or can take advantage of some knowledge of the network structure that is usually not globally available and in any case changes continuously due to structural dynamics. 2) How does services' adoption spread across the OSN? On the one hand the popularity of a service is determined by word-of-mouth through the links of the OSN and, on the other end, the service may contribute to reshape the structure of the OSN (e.g. by creating new connections). 3) How do different services compete for the finite attention and money of OSN users? In particular our purpose is to provide analytical models (corroborated by simulations and experiments on real networks) to understand such complex interactions.

9.3.2. Inria International Partners

9.3.2.1. Informal International Partners

MAESTRO has continued collaborations with researchers from GERAD, Univ. Montreal (Canada), Flinders Univ. (Australia), National Univ. of Rosario (Argentina), Technion - Israel Institute of Technology (Israel), Univ. of Arizona (USA), Univ. of Illinois at Urbana-Champaign (USA), Univ. of Liverpool (UK), Univ. of Massachusetts at Amherst (USA), Univ. of Florence (Italy), Univ. of Palermo (Italy), Univ. of Twente (The Netherlands) and Petrozavodsk State Univ. (Russia); Ghent Univ. (Belgium); see Sections 9.4.1.1 and 9.4.2 .

9.3.3. Participation In other International Programs

MAESTRO has continued collaborations with researchers from IIT Mumbai and IISc Bangalore. In 2015, these collaborations were partly supported by IFCAM and Cefipra.

9.4. International Research Visitors

9.4.1. Visits of International Scientists

9.4.1.1. Professors / Researchers

Giuseppe Bianchi

Date: 9-10 December 2015

Institution: Univ. of Roma (Italy)

Vivek Borkar

Date: 10-18 October 2015

Institution: IIT Mumbai (India)

Jerzy Filar

Date: 6-10 July 2015

Institution: Flinders Univ. (Australia)

Vaishnav Janardhan

Date: 4 March 2015

Institution: Akamai Technologies (USA)

Moshe Haviv

Date: 28 September - 8 October 2015

Institution: Univ. of Jerusalem (Israel)

Jie Li

Date: 13 January - 15 April 2015

Institution: Univ. of Tsukuba (Japan)

Vladimir Mazalov

Date: 14-28 February and 18-24 November 2015

Institution: Russian Academy Of Sciences (Russia)

Leon Petrosjan

Date: 29 July 2015

Institution: St Petersburg Univ. (Russia)

Bruno Ribeiro

Date: 8-26 June 2015

Institution: Carnegie Mellon Univ. (USA)

Matteo Sereno

Date: October 2015 - March 2016

Institution: Univ. of Torino (Italy)

9.4.1.2. Post-doc / Ph.D. students

Tejas Bodas

Date: 15-30 March and 12 October - 11 December 2015

Institution: IIT Mumbai (India)

Rajib Ranjan Maiti

Date: 9-12 March 2015

Institution: CNR Pisa (Italy)

9.4.1.3. Internships

Andrea Cantore

Date: 1 March - 31 August 2015

Institution: Univ. Nice Sophia-Antipolis (France)

Supervisor: Giovanni Neglia

Amal Chaker

Date: 1 March - 31 August 2015

Institution: Univ. Nice Sophia-Antipolis (France)

Supervisor: Giovanni Neglia

Ashish Chandra

Date: 21 May - 20 July 2015

Institution: IIT Mumbai (India)

Supervisor: Konstantin Avrachenkov

Baptiste Goujaud

Date: 1 June - 31 August

Institution: ENS Cachan (France)

Supervisor: Eitan Altman

Mikhail Grigorev

Date: 15 September - 31 October 2015

Institution: MIPT (Russia)

Supervisor: Alain Jean-Marie

Lenar Iskhakov

Date: 15 September - 31 October 2015

Institution: MIPT (Russia)

Supervisor: Konstantin Avrachenkov

Wafa Khlif

Date: 1 March - 31 August 2015

Institution: Univ. Nice Sophia-Antipolis (France)

Supervisor: Sara Alouf

Maksim Mironov

Date: 15 September - 31 October 2015

Institution: MIPT (Russia)

Supervisor: Konstantin Avrachenkov

Dimitra Politaki

Date: 1 March - 31 August 2015

Institution: Univ. Nice Sophia-Antipolis (France)

Supervisor: Sara Alouf

Dimitra Tsigkari

Date: 15 October 2015 - 31 July 2016

Institution: Univ. of Thessaloniki (Greece)

Supervisor: Giovanni Neglia

Alina Tuholukova

Date: 1 March - 31 August 2015

Institution: Univ. Nice Sophia-Antipolis (France)

Supervisor: Konstantin Avrachenkov, Giovanni Neglia

9.4.2. Visits to International Teams

9.4.2.1. Sabbatical programme

Philippe Nain

Date: 1 March 2015 - 29 February 2016

Institution: MIT, Laboratory for Information & Decision Systems - LIDS (USA)

Activities: Besides conducting research with colleagues at MIT, Univ. of Massachusetts in Amherst, MA, and Raytheon BBN Technologies in Cambridge, MA, P. Nain has been asked by Inria to launch new scientific collaborations between Inria and universities of the East Coast and to strengthen existing ones. He attended the Inria-Industry Meeting (San Francisco, May 11, 2015) and the fifth BIS (Berkeley-Inria-Stanford) workshop (Berkeley May 12-14, 2015).

9.4.2.2. Research stays abroad

Eitan Altman

Date: 16-20 February, 21-31 October, 21-28 December 2015

Institution: Technion (Israel)

Date: 27 April - 8 May 2015

Institution: New York Univ. - Tandon School of Engineering (USA)

Date: 20-30 May 2015

Institution: IISc Bangalore and IIT Mumbai (India)

Konstantin Avrachenkov

Date: 2-10 March 2015

Institution: IIT Mumbai (India)

Date: 11-19 May 2015

Institution: Yandex Research (Russia)

Ilaria Brunetti

Date: 5 January - 15 April 2015

Institution: Macquaire Univ. (Australia)

Alain Jean-Marie

Date: 3-25 October 2015

Institution: Univ. of Montreal (Canada)

Date: 7-18 December 2015

Institution: Univ. of Rosario (Argentina)

Jithin Kazhuthuveetil Sreedharan

Date: 1-14 August 2015

Institution: Univ. Federal do Rio de Janeiro (Brazil)

Arun Kadavankandy

Date: 25-29 May 2015

Institution: IIT Mumbai (India)

Philippe Nain

Date: 10-15 May 2015

Institution: Univ. of California, Berkeley (USA)

Date: June 4-6, 14-20, July 13-17, September 20-26, November 15-21, December 6-11 2015

Institution: Univ. of Massachusetts at Amherst (USA)

Giovanni Neglia

Date: 19 and 26 January; 2, 9 and 23 February; 2 and 9 March; 4-7 and 29 May; 13-17 July; 11-14 and 21 September; 22-23 October; 12-17 November 2015

Institution: Univ. of Florence (Italy)

Date: August 1-19 2015

Institution: Univ. Federal do Rio de Janeiro (Brazil)

Alexandre Reiffers-Masson

Date: 1-15 August 2015

Institution: New York Univ. - Tandon School of Engineering (USA)

MUSE Team

8. Partnerships and Cooperations

8.1. European Initiatives

8.1.1. User-Centric Networking (UCN)

Type: FP7

Instrument: Specific Targeted Research Project

Duration: October 2013 - September 2016

Coordinator: Technicolor

Other partners: Eurecom, Fraunhofer FOKUS, Intamac, University of Cambridge, University of Nottingham, Martel, NICTA, Portugal Telecom

Inria contact: Renata Teixeira

Abstract: This project introduces the concept of User Centric Networking (UCN), which is a new paradigm leveraging user information at large to deliver novel content recommendation systems and content delivery frameworks. UCN recommendation and content delivery systems will leverage in-depth knowledge about users to help them find relevant content, identify nearby network resources and plan how to deliver the actual content to the appropriate device at the desired time. These systems will additionally account for influences from users' social networks on their content consumption. The goal of this project is to design a UCN system architecture for user-centric connected media services. We will build UCN upon three complementary research pillars:

1. understanding user context: This data can be broadly categorized into three groups. First, the physical and environmental context A second category of data is that which can be extracted from social network interactions. The third category of data is behavioural
2. profiling and predicting user interests: By gaining a deep understanding of the user, we may be able to cast a much wider net in the content ocean and locate a richer catalogue of interesting content for the user
3. personalizing content delivery: Rather than the user (or the service provider) having to worry about the mode of connectivity, device, service, location, etc., the network intelligently directs and adapts the transport stream, or perhaps pre-fetches and replicates content chunks, to the particular and immediate needs of the user.

See also: <http://usercentricnetworking.eu/>

8.2. International Initiatives

8.2.1. Inria International Partners

8.2.1.1. Informal International Partners

- Princeton (Prof. Nick Feamster): We have a long-term collaboration on measuring the performance of residential broadband Internet access networks and more recently on home network diagnosis.
- ICSI (Dr. Srikanth Sundaresan, Dr. Christian Kreibich, Dr. Robin Sommer): With C. Kreibich, we have been developing Fathom, a browser-based network measurement platform. We are now adding home network diagnosis capabilities to Fathom. We are collaborating with S. Sundaresan on detecting last-mile bottlenecks. In addition, with Robin Sommer we are working on the potential of matching the profiles of a user across multiple online social networks.

- Northwestern University (Prof. Fabian Bustamante and his doctoral student Zachary Bischof): we are working on identifying user activity from network traffic.

8.3. International Research Visitors

8.3.1. Visits of International Scientists

8.3.1.1. Internships

- S. Mohammadyari, master intern, Politecnico di Torino, Italy, March to July 2015.
- Zachary Bischof, doctoral intern, Northwestern University, USA, July to September 2015.

RAP Project-Team

6. Partnerships and Cooperations

6.1. International Initiatives

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

6.1.1.1. RNA

An Associate Team between RAP and McGill university provides funding for a project on the theoretical and applied aspects of connectivity in random networks. The co-funding at McGill financed by the via the CARP FQRNT team grant of L. Addario-Berry, L. Devroye and B. Reed (2013-2015)

The bilateral project PHD Procope funded by Campus France (formerly Egide) obtained in 2014 jointly between the LIX at Ecole Polytechnique (PI Marie Albenque) and the Mathematics institute of Frankfurt's university is still running for 2015. The team RAP is associated to the LIX for this contract.

Title: Connectivity and distances in models of random networks and applications

International Partner (Institution - Laboratory - Researcher):

Start year: 2013

See also: <http://algo.inria.fr/broutin/aap-rna.html>

The projet will shed some new light on two complementary aspects of connectivity and the structure of distances in models of random networks. - We will first explore the nature and universality of phase transition and critical phenomena in random graphs, and more generally for high-dimensional percolation systems. Phase transitions are crucial in statistical physics, but also in the theory of computing where one observes that constraints satisfaction problem exhibit such a sudden change whose understanding is believed to yield important information about hardness of computation. - We will also investigate the connectivity of geometric models of random graphs which are at the core of modelling of wireless networks. In particular we will focus on some global aspects such as the quantification of connectivity, sparsity, and the behavior of diffusion algorithms. We will also design of distributed algorithms to initiate the network which guarantee efficiency and scalability.

6.2. International Research Visitors

6.2.1. Visits of International Scientists

- Louigi Addario-Berry (McGill)
- Cecile Mailler (Bath)
- Jean-Francois Marckert (LaBRI, Bordeaux)
- Leonardo Rolla (Buenos Aires)

6.2.1.1. Internships

- Plinio Santini Dester, M1 student at Polytechnique (Avril-July 2015).

6.2.2. Visits to International Teams

- *Nicolas Broutin* has visited the mathematics department of the University of Bath, the School of Computer Science at McGill University, the computer science laboratory in Bordeaux (LaBRI) and the NYU-ECNU institute for mathematical sciences at NYU Shanghai.

SOCRATE Project-Team

8. Partnerships and Cooperations

8.1. National Initiatives

8.1.1. Equipex FIT- Future Internet of Things (2011-..., 1.064 keuros)

The FIT projet is a national equipex (*équipement d'excellence*), headed by the Lip6 laboratory. As a member of Inria, Socrate is in charge of the development of an Experimental Cognitive Radio platform that should be used as test-bed for SDR terminals and cognitive radio experiments. This should be operational in 2013 for a duration of 7 years. To give a quick view, the user will have a way to configure and program through Internet several SDR platforms (MIMO, SISO, and baseband processing nodes).

8.1.2. ANR - Cormoran - "Cooperative and Mobile Wireless Body Area Networks for Group Navigation" (2012-2015, 150 keuros)

Cormoran project targets to figure out innovative communication functionalities and radiolocation algorithms that could benefit from inter/intra-BAN cooperation. More precisely, the idea is to enable accurate nodes/body location, as well as Quality of Service management and communications reliability (from the protocol point of view), while coping with inter-BAN coexistence, low power constraints and complying with the IEEE 802.15.6 standard. The proposed solutions will be evaluated in realistic applicative scenarios, hence necessitating the development of adapted simulation tools and real-life experiments based on hardware platforms. For this sake, Cormoran will follow an original approach, mixing theoretical work (e.g. modelling activities, algorithms and cross-layer PHY/MAC/NWK design) with more practical aspects (e.g. channel and antennas measurement campaigns, algorithms interfacing with real platforms, demonstrations).

8.1.3. ANR - MetalibM - "Automatic Generation of Function and Filters" (2014-2017, 200 keuros)

The goal of the Metalibm project is to provide a tool for the automatic implementation of mathematical (libm) functions. A function f is automatically transformed into machine-proven C code implementing an polynomial approximation in a given domain with given accuracy. This project is led by Inria, with researchers from Socrate and AriC; PEQUAN team of Laboratoire d'Informatique de Paris 6 (LIP6) at Université Pierre et Marie Curie, Paris; DALI team from Université de Perpignan Via Domitia and Laboratoire d'Informatique, Robotique et Microélectronique de Montpellier (LIRMM); and SFT group from Centre Européen de Recherche Nucléaire (CERN).

8.1.4. FUI SMACS - "SMart And Connected Sensors" (2013-2016, 267 keuros)

The SMACS projet targets the deployment of an innovating wireless sensor network dedicated to many domains sport, health and digital cities. The projet involves Socrate (Insavalor), HIKOB and wireless broadcasting company Euro Media France. The main goal is to develop a robust technologie enabling real-time localization of mobile targets (like cyclist for instance), at a low energy (more generally low cost). The technology will be demonstrated at real cycling races (Tour de France 2013 and 2014). One of the goal is to include localisation information with new radio technology. Another subject of study is distributed wireless consensus algorithms for maintaining a neighborhood knowledge with a low energy budget that scales (more than 200 cycles together)

8.1.5. ADT Sytare (Développement d'un SYSTème embArqué faible consommation à mémoiRE persistante) ADT Inria 2015-2017

The SYTARE project aims to develop and study novel operating system mechanisms for NVRAM-based embedded systems. The term NVRAM collectively describes an emerging generation of memory technologies which are both non-volatile and byte-addressable. These two properties together make the classical RAM+ROM memory architecture obsolete, and enable the design of embedded systems running on intermittent power. This is very attractive in the context of energy-constrained scenarios, for instance systems harvesting their power from the environment. But working with NVRAM also poses novel challenges in terms of software programming. For instance, application state consistency must be guaranteed accross reboots, even though the system includes both NVRAM and volatile elements (e.g. CPU, hardware peripherals). The SYTARE project is funded by Inria via the ADT program.

8.1.6. ADT CorteXlab, ADT Inria 2015-2017

The Socrate project-team is in charge of the FIT/CorteXlab platform (section 5.6). This platform makes use of many complex technologies from signal processing to computer science through micro-electronics and FPGA. The objectiv of the CorteXlab ADT is to maintain a support to the user of the FPGA-based platform of CorteXlab and to provide tutorial and running experiment that will help them in builing experimentation using the PicoSDR machines.

8.1.7. Taiwan III - research proposal on 5G M2M 2015-2016

In the context of the MoU signed between Inria and The National Science Council of Taiwan. Taiwan's Institute for Information Industry (III) and Socrate signed a one-year contract for a research proposal containing two items: a first to study the OFDMA-based RACH access from theoretical or mathematical models and a second to set up an experiment in CorteXlab that will emulate a given number of M2M device using a narrow band radio protocol and record the resulting radio environment. This document described in more detail the research proposal.

8.2. European Initiatives

8.2.1. FP7 & H2020 Projects

8.2.1.1. CYBERNETS

Title: Cybernetic Communication Networks: Fundamental Limits and Engineering Challenges

Programm: H2020 - Marie Skłodowska-Curie Actions - Individual Fellowships

Duration: June 2015 - June 2017

Coordinator: Inria

Recipient: Samir Perlaza

This Reintegration Panel proposal, CYBERNETS, focuses on the study of Cybernetic Communication Networks (CCN). CCNs are wireless networks that are context-aware, possess learning capabilities and artificial intelligence to guarantee reliability, efficiency and resilience to changes, failures or attacks via autonomous, self-configuring and self-healing individual and network behavior. Typical examples of CCNs are beyond-5G cellular systems and critical communication systems, e.g., law enforcement, disaster relief, body- area, medical instruments, space, and indoor/outdoor commercial applications. A practical implementation of a CCN requires extending classical communication systems to embrace the dynamics of fully decentralized systems whose components might exhibit either cooperative, non-cooperative or even malicious behaviors to improve individual and/or global performance. In this context, CYBERNETS aims to develop a relevant understanding of the interactions between information theory, game theory and signal processing to tackle two particular problems from both theoretical and practical perspectives: (I) use of feedback and (II) behavior adaptation in fully decentralized CCNs. In the former, the main objectives are: (i) to determine the fundamental

limits of data transmission rates in CCNs with feedback; and (ii) to develop and test in real-systems, transmit-receive configurations to provide a proof-of-concept of feedback in CCNs. For the achievement of these practical objectives, CYBERNETS relies on the world-class testbed infrastructure of Inria at the CITI Lab for fully closing the gap between theoretical analysis and real-system implementation. In the latter, the main objectives are: (i) to identify and explore alternatives for allowing transmitter-receiver pairs to learn equilibrium strategies in CCNs with and without feedback; (ii) to study the impact of network-state knowledge on scenarios derived from the malicious behavior of network components.

8.3. International Initiatives

8.3.1. CoWIN

Title: CoWin: Cognitive Wireless Networks from Theory to Implementation

International Partners:

Princeton University (N.J., United States) - School of Engineering and Applied Science - Prof. H. Vincent Poor

Rutgers University (N.J., United States) - Winlab - Dr. Ivan Seskar.

Start year: 2015

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

The objective of this team is to strengthen the research efforts on emerging software radio and cognitive radio technologies. The team will count on: first, the cognitive radio test-bed CorteXlab recently set up by the Socrate team within the FIT Equipex, second the leading position of Vincent Poor's team in the field of network information theory and third the Orbit Platform of Rutgers university. The goal is to lead research in both the information theory community and the applied research community so as to reinforce the link between both communities. This work will concern architecture and programs of software radio equipments, distributed and cognitive algorithms for radio resource allocation, cognitive radio scenario experimentations, fundamental limits of cooperative wireless channels and the set up of common experimental infrastructure and protocols for research on cognitive wireless networks.

8.3.2. Inria International Partners

8.3.2.1. Informal International Partners

Socrate has strong collaborations with several international partners.

- **Princeton University**, School of Applied Science, Department of Electrical Engineering, NJ, USA. This cooperation with Prof. H. Vincent Poor is on topics related to decentralized wireless networks. Samir Perlaza has been appointed as Visiting Research Collaborator at the EE Department for the academic period 2016-2017. Scientific-Leaders at Inria: Samir Perlaza and Jean-Marie Gorce.
- **Rutgers University**, Winlab, Orbit testbed. This cooperation with Ivan Seskar is related to experimental wireless testbed. Orbit has been one of the first wireless testbeds of its type. Tanguy Risset and Leonardo Sampaio Cardoso have visited Winlab and I. Seskar visited the Socrate team for one week. Their collaboration is on the development of tools to ease experiment handling on wireless testbeds: visualisation, synchronization etc. Scientific-Leader at Inria: Tanguy Risset
- **University of Sheffield**, Department of Automatic Control and Systems Engineering, Sheffield, UK. This cooperation with Prof. Inaki Esnaola is on topics related to information-driven energy systems and multi-user information theory. Scientific-in-charge at Inria: Samir Perlaza.
- **University of Arizona**, Department of Electrical and Computer Engineering, Tucson, AZ, USA. This cooperation with Prof. Ravi Tandon is on topics related to channel-output feedback in wireless networks. Scientific-Leader at Inria: Samir Perlaza.

- **University of Cyprus**, Department of Electrical and Computer Engineering, University of Cyprus, Nicosia, Cyprus. This cooperation with Prof. Ioannis Krikidis is on topics related to energy-harvesting and wireless communications systems. Scientific-Leaders at Inria: Guillaume Villemaud and Samir Perlaza.
- **Universidade Federal do Ceará**, GTEL, Departamento de Teleinformática, Fortaleza, Brazil. This recently started cooperation with Prof. Tarcisio Ferreira Maciel is on topics related to the optimization of radio resources for massive MIMO in 5G and 5G-like wireless communications systems. Scientific-in-charge at Inria: Leonardo Sampaio Cardoso.
- **Universidad Nacional del Sur**, LaPSyC laboratory, Bahía Blanca, Argentina. This cooperation with Prof. Juan Cousseau is on topics related to Full-Duplex communications and Interference Alignment. Scientific-in-charge at Inria: Guillaume Villemaud.

8.4. International Research Visitors

8.4.1. Visits of International Scientists

Prof. Ioannis Krikidis from the Department of Electrical and Computer Engineering, University of Cyprus, was appointed as Visiting Professor at the Department of Telecommunications at the INSA de Lyon hosted at the CITI Lab by Samir Perlaza.

Prof. Guiseppe Durisi from the Chalmers University of Technology, Sweden was visiting our group and delivered the following talk: "Towards Low-Latency Wireless Communications: The Art of Sending Short Packets".

Prof. Michèle Wigger from Télécom ParisTech, France, was visiting our group and delivered the following talk: "New Results on Cache-Aided One-to-Many Compression and Communication"

Prof. Albert Guillén i Fabregas from Universitat Pompeu Fabra, Spain, was visiting our group and delivered the following talk: "Hypothesis Testing and Error Probability in Information Theory"

Prof. Iñaki Esnaola from University of Sheffield, UK was visiting our group and delivered the following talk: "The Impact of Prior Knowledge in Data Injection Attacks"

Ivan Seskar from Rutgers University, USA was visiting our group and delivered the following talk: "ORBIT Testbed"

8.4.2. Visits to International Teams

Samir Perlaza was visiting the Department of Automatic Control and Systems Engineering at the University of Sheffield, UK, hosted by Prof. Iñaki Esnaola.

Samir Perlaza was visiting the Department of Electrical and Electronic Engineering at Imperial College London, UK hosted by Prof. Deniz Gunduz.

Yasser Fadlallah was visiting the Department of Electrical and Telecommunications Engineering at the University of Naples Federico II, hosted by Prof. Antonia M. Tulino .

Jean-Marie Gorce was visiting the Electrical Department at Princeton university, hoster by Prof. Vincent Poor Dean of School of Engineering and Applied Science of Princeton University.

Tanguy Risset and Leonardo Sampaio Cardoso were visiting the Winlab research lab at Rutgers University, hosted by Ivan Seskar Associate Director of Information Technology of Winlab.

URBANET Team

9. Partnerships and Cooperations

9.1. Regional Initiatives

- BQR INSA CROME 12/2013-12/2016
Participants: Fabrice Valois
The partners in this project are the CITI DynaMid team and LIRIS. The project studies the coordination of a fleet of mobile robots for the multi-view analysis of complex scenes.
- Labex IMU Priva'Mov 10/2013-10/2016
Participants: Patrice Raveneau, Hervé Rivano, Razvan Stanica
The partners in this project are DRIM LIRIS, Inria Privatics, INSA EVS, and LET ENTPE. The aim of this project is to develop and deploy a crowdsensing platform to collect mobility traces from a sample of real users equipped with android devices, while carrying research on privacy preservation issues. Our contribution consists on developing the platform and using the collected data to analyze cellular network offloading strategies.
- Labex IMU UrPolSens 10/2015-10/2018
Participants: Ahmed Boubrima, Leo Le Taro, Walid Bechkit, Hervé Rivano
The partners in this project are Ifsttar, LMFA, EVS, and TUBA, with Inria Urbanet leading the project. UrPolSens deals with the monitoring of air pollution using low-cost sensors interconnected by a wireless networks. Although they are less accurate than the high-end sensors used today, low-cost autonomous air quality sensors allow to achieve a denser spatial granularity and, hopefully, a better monitoring of air pollution. The main objectives of this project are to improve the modeling of air pollution dispersion; propose efficient models to optimize the deployment the sensors while considering the pollution dispersion and the impact of urban environment on communications; deploy a small-scale network for pollution monitoring as a proof of concept; compare the measured and estimated levels of exposure; study the spatial disparities in exposure between urban areas.

9.2. National Initiatives

9.2.1. ANR

- ANR ABCD 10/2013-04/2017.
Participants: Diala Naboulsi, Marco Fiore, Razvan Stanica
The partners in the ANR ABCD project are: Orange Labs, Ucopia, Inria UrbaNet, UPMC LIP6 PHARE, Telecom ParisTech. The objective of ABCD is to characterize large-scale user mobility and content consumption in urban areas via mobile data mining, so as to achieve efficient deployment and management of cloud resources via virtual machines. Our contribution in the project consists on the characterization of human mobility and service consumption at a city scale, and the design of appropriate resource allocation techniques at the cellular network level.
- ANR IDEFIX 10/2013-04/2017.
Participants: Soukaina Cherkaoui, Hervé Rivano, Fabrice Valois
The partners in the ANR IDEFIX project are: Orange Labs, Alcatel Lucent - Bell Labs, Telecom Paris Tech, Inria UrbaNet, Socrate and Dyogene.

9.2.2. Pôle ResCom

- Ongoing participation (since 2006)
Communication networks, working groups of GDR ASR/RSD, CNRS (<http://rescom.inrialpes.fr>).
Hervé Rivano is member of the scientific committee of ResCom.

9.2.3. EquipEx

- SenseCity
We have coordinated the participation of several Inria teams to the SenseCity EquipEx. Within the SenseCity project, several small reproduction of 1/3rd scale city surroundings will be built under a climatically controlled environment. Micro and nano sensors will be deployed to experiment on smart cities scenarios, with a particular focus on pollution detection and intelligent transport services. Urbanet will have the opportunity to tests some of its capillary networking solutions in a very realistic but controlled urban environment. The first deployment is scheduled early 2015.

9.2.4. Inria Project lab

- CityLab
Urbanet is involved in the CityLab Inria Project Lab lead by Valérie Issarny. Within this project, Hervé Rivano is the networking referent for the PhD thesis of Raphael Ventura, advised by Vivien Mallet, in the Clime Inria team.

9.3. International Initiatives

9.3.1. Inria International Partners

9.3.1.1. Declared Inria International Partners

- DTN for IOT - Bilateral contract with III Taiwan 2015.
This collaboration, funded by III, focuses on the feasibility to implement Delay Tolerant Network protocols within the Internet Of Things context. The motivation for using generic protocols able to handle the constraints of the Intenet of Things is highlighted with the choice of the Bundle Protocol. A study of existing implementations of this protocol is realized within a sensor context and a tailored implementation is proposed. This collaboration has partially funded the postdoc of Patrice Raveneau.

9.3.1.2. Informal International Partners

- **Ecole Polytechnique de Montréal, QC, Canada.** Cooperation on subjects related to mobile networks with the group of Prof. Samuel Pierre.
- **University of Waterloo, ON, Canada.** Joint publications and visits to/from the group of Prof. Catherine Rosenberg.

9.4. International Research Visitors

9.4.1. Visits of International Scientists

- Dennis Chen, Research Engineer, III, Taiwan: one week visit (June 2015).
- Ling-Jyh Chen, Associate Research Fellow, Academia Sinica, Taiwan: one week visit (December 2015).
- Mario Gerla, Professor, UCLA, USA: one day visit (March 2015).
- Roch Glitho, Associate Professor, Concordia University, Montreal, Canada: one week visit (September 2015).
- Catherine Rosenberg, Professor, University of Waterloo, Canada: two days visit (July 2015).

9.4.1.1. Internships

- F. Bernardo Duarte, intern, University of Lisbon, Portugal: Comfortable workplace using sensor motes (3 months).
- A. Boubrima, MS thesis, ESI Algiers, Algeria: Optimal deployment of wireless sensor networks for air pollution monitoring (6 months).
- A. Dobre, intern, Polytechnic University of Bucharest, Romania: Comfortable workplace using sensor motes (3 months).

- A. Hanganu, intern, Polytechnic University of Bucharest, Romania: Comfortable workplace using sensor motes (3 months).
- J. Lallana, intern, Universidad Politécnica de Madrid, Spain: Performance evaluation of RPL resiliency using Cooja (5 months)
- D. Martella, intern, Politecnico di Torino, Italy: Coordination of robots fleet (6 months).
- M. Iliushkina, intern, University of Saint Petersburg, Russia: Comfortable workplace using sensor motes (3 months).
- Z. Plokhovska, intern, University of Pittsburgh, PA, USA: Combining DSRC and VLC in Safety Vehicular Networks (3 months).