

*Inria*

RESEARCH CENTER  
Lille - Nord Europe

FIELD

Activity Report 2019

# Section Partnerships and Cooperations

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## **BONUS Project-Team**

# **9. Partnerships and Cooperations**

## **9.1. Regional Initiatives**

- *CPER Data (2015-2020)*: in this project, that promotes research and software development related to advanced data science, the BONUS team is the scientific leader (N. Melab) of one of the three research lines of the project “Optimization and High-Performance Computing”. In this context, a two-year (2018-2019) engineer (J-Y. Ji) is supported to develop a software demonstrator on decomposition-based big optimization. In addition, the team is co-leader of the workpackage/lever “Research infrastructures” related to the Grid’5000 nation-wide experimental testbed. This allowed to extend the testbed at Lille with a GPU-powered cluster highly important for the BONUS project. In addition, two engineers have been hired for the system & network administration of the testbed, user support and development.
- *CPER ELSAT (2015-2020)*: in this project, focused on ecomobility, security and adaptability in transport, the BONUS team is involved in the transversal research line: planning and scheduling of maintenance logistics in transportation. The team got support for a one-year (2017-2018) post-doc position (M. Rahimi) and a one-year (2019-2020) engineer position (N. Aslimani).

## **9.2. National Initiatives**

### **9.2.1. ANR**

- *Bilateral ANR/RGC France/Hong Kong PRCI (2016-2021)*, “Big Multi-objective Optimization” in collaboration with City University of Hong Kong

## **9.3. European Initiatives**

### **9.3.1. FP7 & H2020 Projects**

Program: H2020

Project acronym: SYNERGY

Project title: Synergy for Smart Multi-Objective Optimisation

Duration: 02 2016 - 03 2019

Coordinator: Jožef Stefan Institute (JSI), Ljubljana, Slovenia

Other partners: University of Lille (France), Cologne University of Applied Sciences (Germany)

Abstract: Many real-world application areas, such as advanced manufacturing, involve optimization of several, often time-consuming and conflicting objectives. For example, they require the maximization of the product quality while minimizing the production cost, and rely on demanding numerical simulations in order to assess the objectives. These, so-called multi-objective optimization problems can be solved more efficiently if parallelization is used to execute the simulations simultaneously and if the simulations are partly replaced by accurate surrogate models.

### **9.3.2. Collaborations in European Programs, Except FP7 & H2020**

Program: COST CA15140

Project acronym: ImAppNIO

Project title: Improving applicability of nature-inspired optimization by joining theory and practice

Duration: 2016-2019

Coordinator: Thomas Jansen

Abstract: The main objective of the COST Action is to bridge this gap and improve the applicability of all kinds of nature-inspired optimisation methods. It aims at making theoretical insights more accessible and practical by creating a platform where theoreticians and practitioners can meet and exchange insights, ideas and needs; by developing robust guidelines and practical support for application development based on theoretical insights; by developing theoretical frameworks driven by actual needs arising from practical applications; by training Early Career Investigators in a theory of nature-inspired optimisation methods that clearly aims at practical applications; by broadening participation in the ongoing research of how to develop and apply robust nature-inspired optimisation methods in different application areas.

### **9.3.3. Collaborations with Major European Organizations**

University of Mons, Belgium, Parallel surrogate-assisted optimization, large-scale exact optimization, two joint PhDs (M. Gobert and G. Briffoteaux).

University of Luxembourg, Q-Learning-based Hyper-Heuristic for Generating UAV Swarming Behaviours.

University of Coimbra and University of Lisbon, Portugal, Exact and heuristic multi-objective search.

University of Manchester, United Kingdom, Local optimality in multi-objective optimization.

University of Elche and University of Murcia, Spain, Matheuristics for DEA.

University of Mohamed V, Morocco, Large scale (multi-objective) optimization.

## **9.4. International Initiatives**

### **9.4.1. Inria International Labs**

#### *9.4.1.1. Other IIL projects*

Title: Frontiers in Massive Optimization and Computational Intelligence (MODO)

International Partner (Institution - Laboratory - Researcher): Shinshu University, Japan

Start year: 2017

See also: <https://sites.google.com/view/lia-modo/>

Abstract: The aim of MODO is to federate French and Japanese researchers interested in the dimensionality, heterogeneity and expensive nature of massive optimization problems. The team receives a yearly support for international exchanges and shared manpower (joint PhD students).

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

Title: Three-fold decomposition in multi-objective optimization (D<sup>3</sup>MO)

International Partner (Institution - Laboratory - Researcher): University of Exeter, UK

Start year: 2018

### **9.4.3. Inria International Partners**

#### *9.4.3.1. Informal International Partners*

- School of Public Health and Preventive Medicine, Monash University, Australia (ranked 73<sup>th</sup> over 1000 in the Shanghai international ranking).
- Instituto Federal de Educação, Ciência e Tecnologia do Ceará, Maracanaú, Brazil.

### **9.4.4. Participation in Other International Programs**

**Title: Evolutionary many-objective optimization: application to smart cities and engineering design**

International Partner (Institution - Laboratory - Researcher): CINVESTAV-IPN, Mexico

Start year: 2016

Abstract: The project is co-funded by ECOS Nord, France and ANUIES, Mexico. It is focused on evolutionary many-objective optimization and its application to smart cities and engineering design.

**Title: Bridging the gap between exact methods and heuristics for multi-objective search (MOCO-Search)**

International Partner (Institution - Laboratory - Researcher): University of Coimbra and University of Lisbon, Portugal

Start year: 2018

Website: <http://sites.google.com/view/moco-search/>

Abstract: This international project for scientific cooperation (PICS), funded by CNRS and FCT, aims to fill the gap between exact and heuristic methods for multi-objective optimization. The goal is to establish the link between the design principles of exact and heuristic methods, to identify features that make a problem more difficult to be solved by each method, and to improve their performance by hybridizing search strategies. Special emphasis is given to rigorous performance assessment, benchmarking, and general-purpose guidelines for the design of exact and heuristic multi-objective search.

## 9.5. International Research Visitors

### 9.5.1. Visits of International Scientists

- Luís Paquete, University of Coimbra, Portugal, April 2019
- Darrell Whitley, Colorado State University, USA, Invited Professor, July 2019
- Minami Miyakawa, Shinshu University, Japan, October 2019
- Renzo Massobrio, Republica University, Uruguay, January to March 2019
- Bernabe Dorransoro, University of Cadiz, Spain, March 2019
- Rachid Ellaia, University of Mohamed V, Morocco, April 2019

#### 9.5.1.1. Internships

- Kazuki Maeda, Shinshu University, Japan, November-December 2019
- Kyo Migishima, Shinshu University, Japan, November-December 2019

### 9.5.2. Visits to International Teams

#### 9.5.2.1. Explorer programme

- T. Carneiro, Cray Inc., Seattle, WA, USA, December 2019
- E-G. Talbi, University of Elche, Spain, November 2019
- E-G. Talbi, University of Luxembourg, Luxembourg, June 2019
- E-G. Talbi, University of Bangkok, Thailand, January 2019
- E-G. Talbi, University of Colorado, USA, November 2019
- E-G. Talbi, University of Mohamed V, Morocco, April 2019
- A. Liefooghe, Shinshu University, Japan, May 2019
- B. Derbel, University of Coimbra, Portugal, October 2019
- A. Liefooghe, University of Coimbra, Portugal, October 2019
- N. Melab, University of Mons, Belgium, working meetings throughout the year

## **INOCS Project-Team**

# **9. Partnerships and Cooperations**

## **9.1. National Initiatives**

### **9.1.1. ANR**

**ANR project AGIRE “Aide à la Gestion Intelligente des Ressources dans les Entrepôts - Decision system for smart management of resources in warehouses”** in collaboration with Ecole des Mines de Saint-Etienne (Gardanne), IFSTTAR (Champs-sur-Marne), HappyChic (Tourcoing). This project addresses human resources management in warehouses which supply either sale points (B2B) or final consumers (B2C). Nowadays, such warehouses are under pressure. This is mainly due to the no inventory policy at the sale points and to the constant growth of e-commerce sales in France and Europe. In terms of logistics, this translates into an increasing number of parcels to prepare and to ship to satisfy an order, which is known typically a few hours before. Moreover, the total number of products to be packed varies very significantly from day-to-day by a factor of at least 3 (<https://fr.wikipedia.org/wiki/HappyChic>).

The novelty of the project is twofold: (1) The human factor is explicitly taken into account. It is integrated in the mathematical models and algorithms that are developed for the project. The aim is to improve the quality of employees' work ensuring the efficiency of the logistic system; (2) Problems at different decision levels are integrated and tackled jointly. At the tactical level, the main problematics are workload smoothing and the management of the storage zone. At operational level, the major issues concern the rearrangement of the picking zone, the picking tours, and the dynamic reorganization of activities to manage uncertainties.

**ANR project PI-Commodality “Co-modal freight transportation chains: an approach based on physical internet”** in collaboration with CGS-ARMINES (Paris), LAAS (Toulouse), DHL (2016 - 2019). The PI-commodality project aims to design new sustainable logistic services between preset origins and destinations. It is based on innovative approaches both in terms of: (1) Logistics and transportation services: by considering the PI-internet approach, specifically: mesh logistics and transportation networks based on available capacities, by designing consistent integrated co-modal chains; (2) Methodology: by addressing the underlying problems according to two approaches: centralized and decentralized, by proposing new realistic models relevant for practitioner taking into account the consistency, by developing state-of-the-art decision making algorithms.

### **9.1.2. F.R.S.-FNRS (Belgium)**

Bilevel optimization is a branch of mathematical optimization that deals with problems whose constraints embed an auxiliary optimization problem. The F.R.S.-FNRS research project “bilevel optimization” (2018-2019) will study such bilevel problems with bilinear objectives and simple second level problems. Each follower chooses one strategy in a given fixed set of limited size. Two classes of such problems will be studied: Pricing Problems and Stackelberg Security Games.

In pricing problems, prices for products must be determined to maximize the revenue of a leader given specific behaviors of customers (followers). More precisely, we will consider the single minded pricing problem and the rank pricing problem.

In Stackelberg games, mixed strategies to cover targets, must be determined in order to maximize the defender expected payoff given that attackers (followers) attack targets that maximize their own payoffs.

## **9.2. Regional Initiatives**

### **9.2.1. Lille**

The ELSAT research program addresses the issues involved in sustainable transportation and mobility. Within ELSAT, INOCS is involved on two projects devoted to hybrid optimization methods in logistics and to city logistics in collaboration with LAMIH (Université de Valenciennes), LGI2A (Université d'Artois) and LEOST (IFSTTAR). ELSAT is supported by the CPER 2015-2020 (State-Region Contract).

### 9.2.2. *Brussels*

ValueBugs is a citizen participatory research project, funded by INNOVIRIS (2018-2020). The objective of ValueBugs is to collectively develop a method for decentralized insect production in cities while enhancing the value of food waste on a small scale. In practical terms, peelings are consumed by insect larvae that have reached the end of their development and offer many promising outlets: feed for hens, farmed fish, pets... and much more! This new, totally innovative sector will be a new tool to be put in the hands of every citizen: we must therefore imagine it collectively.

## 9.3. International Initiatives

### 9.3.1. *Inria International Labs*

#### **Inria Chile**

Associate Team involved in the International Lab:

#### 9.3.1.1. *BIPLOS*

Title: Bilevel Problems in Logistics and Security

International Partner (Institution - Laboratory - Researcher):

University of Chile - Complex Engineering Systems Institute (ISCI) - Ordonez Fernando

Start year: 2017

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

This project is devoted to bilevel optimisation problems with application in the security and logistics domains. Stackelberg games, including one defender and several followers, and competitive location problems will be considered. Mixed integer linear optimisation models and efficient algorithms to solve them will be developed.

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

#### 9.3.2.1. *LOBI*

Title: Learning within Bilevel Optimization

International Partner (Institution - Laboratory - Researcher):

Polytechnique Montréal (Canada) - Research Group in Decision Analysis (GERAD) - Gilles Savard

Start year: 2018

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

The interplay between optimization and machine learning is one of the most important developments in modern computational science. Simultaneously there is a tremendous increase in the availability of large quantities of data in a multitude of applications, and a growing interest in exploiting the information that this data can provide to improve decision-making. Given the importance of big data in business analytics, its explicit integration into an optimization process is a challenge with high potential impact. The innovative project is concerned with the interconnection between machine learning approaches and a particular branch of optimization called bilevel optimization in this “big data” context. More precisely, we will focus on the development of new approaches integrating machine learning within bilevel optimization (LOBI: “learning au sein de l’Optimisation BIniveau”) for two important practical applications, the pricing problem in revenue management and the energy resource aggregation problem in smart grids. The applications arise from current industry collaborations of the teams involved, and will serve as testbeds to demonstrate the potential impact of the proposed approach.

#### 9.3.2.2. *North-European associated team*

Title: Physical-internet services for city logistics



International Partner (Institution - Laboratory - Researcher):

Norwegian School of Economics - Stein Wallace

Start year: 2017

In this project, we consider an urban logistic terminal and new logistics services which could be developed according to a Physical Internet approach. The main objective is to evaluate the services using optimization models created within the project. We are developing optimization models to identify win-win cooperation between carriers based on supply and demand. We aim to explore how to include stochasticity in the description of the supplies and demands, as well as travel times, and to what extent the plans within a day can improve by such knowledge. The second task is to develop solution algorithms for these models. These are real scientific challenges as we are facing stochastic mixed integer problems.

### **9.3.3. Inria International Partners**

#### *9.3.3.1. Informal International Partners*

Department of Statistics and Operations Research, University of Vienna, Austria

Centre for Quantitative Methods and Operations Management, HEC-Liège, Belgium

Interuniversity Centre on Enterprise Networks, Transportation and Logistics (CIRRELT), Montreal, Canada

Department of Industrial Engineering, University of Talca, Curicó, Chile

Complex Engineering Systems Institute (ISCI), University of Chile, Santiago, Chile

Department of Mathematics, Trier University, Germany

The Centre for Business Analytics, University College Dublin, Ireland

Department of Electrical, Electronic, and Information Engineering, University of Bologna, Italy

Department of Mathematics, University of Padova, Italy

Department of Electrical and Information Engineering, University of Padova, Italy

Department of Mathematics, University of Salerno, Italy

Department of Control and Computer Engineering, Politecnico di Torino, Italy

Department of Mathematics, University of Aveiro, Portugal

Department of Statistics and Operations Research, Universidade de Lisboa, Portugal

Department of Statistics and Operational Research, University of Murcia, Spain

Institute of Mathematics, University of Seville, Spain

Stewart School of Industrial and Systems Engineering, Georgia Tech Institute of Technology, USA

### **9.3.4. Participation in Other International Programs**

#### *9.3.4.1. Inria International Chairs*

##### **IIC ANJOS Miguel**

Title: Power Peak Minimization for the Smart Grid

International Partner (Institution - Laboratory - Researcher):

Polytechnique Montréal (Canada) - Miguel Anjos

Duration: 2016 - 2020

Start year: 2016

## **9.4. International Research Visitors**

### **9.4.1. Visits of International Scientists**

- Yasemin Arda Da Silveira, HEC-Liège, University of Liège, Belgium, Mar 2019
- Maria Del Carmen Gale Pola, University of Zaragoza, Spain, Feb 2019
- Anton Kleywegt, Georgia Institute of Technology, USA, from Apr 2019 until May 2019
- Daniel Pereda Herrera, University of Chile, Chile, from Nov 2019
- Sebastián Dávila, University of Chile, Chile, from June 2019 until Dec 2019
- Natividad Gonzalez Blanco, University of Sevilla, Spain, from May 2019 until July 2019
- Federica Laureanam, University of Salerno, Italy, from Feb 2019 until May 2019

*9.4.1.1. Internships*

Sebastián Dávila, Ph.D. student at University of Chile, June to December 2019

## MEPHYSTO Team

# 6. Partnerships and Cooperations

## 6.1. National Initiatives

### 6.1.1. ANR

A. de Laire is a member of the ANR ODA project.

Title: Dispersive and random waves

ANR reference: ANR-18-CE40-0020-01

Coordinator: Nikolay Tzvetkov, Université de Cergy-Pontoise

A. Hardy is a member of the ANR BoB project.

Title: Inférence bayésienne à ressources limitées - données massives et modèles coûteux

Programme ANR: (DS0705) 2016

ANR reference: ANR-16-CE23-0003

Coordinator: R. Bardenet, CNRS & Université de Lille

Duration: October 2016 - October 2020

M. Simon has been a member of the ANR EDNHS project.

Title: Diffusion de l'énergie dans des système hamiltoniens bruités

Type: Défi de tous les savoirs (DS10) 2014

ANR reference: ANR-14-CE25-0011

Coordinator: C. Bernardin, Université de Nice

Duration: October 2014 - October 2019

## 6.2. European Initiatives

### 6.2.1. FP7 & H2020 Projects

M. Simon is a collaborator of the ERC Starting Grant HyLEF project.

Title: Hydrodynamic Limits and Equilibrium Fluctuations: universality from stochastic systems

Duration: May 2017 - April 2022

Coordinator: P. Gonçalves, Instituto Superior Técnico, Lisbon, Portugal

## MODAL Project-Team

# 9. Partnerships and Cooperations

## 9.1. Regional Initiatives

### 9.1.1. ONCOLille partnership

**Participants:** Sophie Dabo-Niang, Cristian Preda.

ONCOLille is a regional scientific interest group whose purpose is to develop fundamental, translational (pre-clinical) and clinical interdisciplinary cancer research, particularly in the field of resistance to therapies. Sophie Dabo-Niang is member of the executive group.

## 9.2. National Initiatives

### 9.2.1. Programme of Investments for the Future (PIA)

Bilille is a member of the PIA “Infrastructures en biologie-santé” IFB, French Institute of Bioinformatics (<https://www.france-bioinformatique.fr/en>). As the co-head of the platform, Guillemette Marot is thus involved in this network.

### 9.2.2. RHU PreciNASH

**Participant:** Guillemette Marot.

RHU PreciNASH

Acronym: PreciNASH

Project title: Non-alcoholic steato-hepatitis (NASH) from disease stratification to novel therapeutic approaches

Coordinator: F. Pattou

Duration: 5 years

Partners: FHU Integra and Sanofi

Abstract: PreciNASH, project coordinated by Pr. F. Pattou (UMR 859, EGID), aims at better understanding non alcoholic stratohepatitis (NASH) and improving its diagnosis and care. In this RHU, Guillemette Marot supervises a 2 years post-doc, as her team EA 2694 is a member of the FHU Integra. EA 2694 is involved in the WP1 for the development of a clinical-biological model for the prediction of NASH. Other partners of the FHU are UMR 859, UMR 1011 and UMR 8199, these last three teams being part of the labex EGID (European Genomic Institute for Diabetes). Sanofi is the main industrial partner of the RHU PreciNASH. The whole project will last 5 years (2016-2021).

### 9.2.3. CNRS PEPS Blanc – BayesRealForRNN project

**Participants:** Pascal Germain, Vera Shalaeva.

BayesRealForRNN project: PAC-Bayesian theory for recurrent neural networks: a control theoretic approach

Coordinator: Mihaly Petreczky, CNRS, UMR 9189 CRIStAL, Université de Lille

Year: 2019

Abstract: The project proposes to analyze the mathematical correctness of deep learning algorithms by combining techniques from control theory and PAC-Bayesian statistical theory. More precisely, the project proposes to concentrate on recurrent neural networks (RNNs), develop their structure theory using techniques from control theory, and then apply this structure theory to derive PAC-Bayesian error bounds for RNNs.

#### **9.2.4. CNRS AMIES PEPS 2 - DiagChange project**

**Participants:** Cristian Preda, Quentin Grimonprez.

DiagChange

Coordinator: Cristian Preda, Inria MODAL

Year: 2019

Abstract: The project proposes to study the topic of change detection distribution for multivariate signal in a industrial context. The project is in collaboration with the Diagrams start-up.

#### **9.2.5. AMIES PEPS 1 - CADIS2**

**Participants:** Serge Iovleff, Sophie Dabo-Niang, Cristian Preda.

Partners: Société SIRS <https://www.sirs-fr.com/sirs/fr/>

Acronym: CADIS2

Project title: Classification Automatique D'Images Sentinel-2

Coordinator: Serge Iovleff

Year: 2019

Duration: 1 year

Abstract: In the context of several European projects, SIRS is in charge of exploring the improvements to be made to the "High Resolution Layers" as well as future prototypes such as "CORINE Land Cover +", on a European scale using the Sentinel-2 images, through the project H2020 "ECo-LaSS". The CADIS2 project aims to develop, study and implement supervised classification methods to classify trees in predefined forest areas by SIRS.

#### **9.2.6. AMIES PEPS 2 - MadiPa**

**Participants:** Stéphane Girard, Serge Iovleff.

Partners: Société Phimeca <http://phimeca.com/>, Mistis team Inria Grenoble Rhône-Alpes

Acronym: MadiPa

Project title: Modèles Auto-associatifs pour la Dispersion de Polluants dans l'Atmosphère

Coordinator: Stéphane Iovleff

Duration: 18 month (start in december 2019)

Abstract: Our goal is to develop a method for predicting the dispersion of pollutants in the atmosphere from an initial emission map and meteorological data. A map of the probabilities of exceeding a critical threshold of pollutants will be estimated thanks to the construction of a meta-model: the large dimension of the problem is reduced by the use of auto-associative models, a non-linear extension of the Principal Components Analysis.

#### **9.2.7. ANR**

##### **9.2.7.1. ANR APRIORI**

**Participants:** Benjamin Guedj, Pascal Germain, Hemant Tyagi, Vera Shalaeva.

APRIORI 2019–2023, ANR PRC

PAC-Bayesian theory and algorithms for deep learning and representation learning.

Main coordinator of the project: Emilie Morvant, Université Jean Monnet.

Funding: 300k EUR.

2 partners - MODAL (Inria LNE), Hubert Curien Lab. (UMR CNRS 5516).

#### 9.2.7.2. ANR BEAGLE

**Participants:** Benjamin Guedj, Pascal Germain.

BEAGLE 2019–2023, ANR JCJC

PAC-Bayesian theory and algorithms for agnostic learning

Main coordinator of the project: Benjamin Guedj

Funding: 180k EUR

The consortium also includes Pierre Alquier (RIKEN AIP, Japan), Peter Grünwald (CWI, The Netherlands), Rémi Bardenet (UMR CRISAL 9189).

#### 9.2.7.3. ANR SMILE

**Participants:** Christophe Biernacki, Vincent Vandewalle.

SMILE Project-2018-2022

ANR project (ANR SMILE - Statistical Modeling and Inference for unsupervised Learning at Large-Scale)

Main coordinator of the project: Faïcel Chamroukhi, LMNO, Université de Caen

4 partners - MODAL (Inria LNE), LMNO UMR CNRS 6139 (Caen), LMRS UMR CNRS 6085 (Rouen), LIS UMR CNRS 7020 (Toulon).

#### 9.2.7.4. ANR TheraSCUD2022

**Participant:** Guillemette Marot.

Acronym: TheraSCUD2022

Project title: Targeting the IL-20/IL-22 balance to restore pulmonary, intestinal and metabolic homeostasis after cigarette smoking and unhealthy diet

Coordinator: P. Gosset

Duration: 3 years (2017-2020)

Partners: CIIL Institut Pasteur de Lille and UMR 1019 INRA Clermont-Ferrand

Abstract: TheraSCUD2022, project coordinated by P. Gosset (Institut Pasteur de Lille), studies inflammatory disorders associated with cigarette smoking and unhealthy diet (SCUD). Guillemette Marot is involved in this ANR project as head of bilille platform, and will supervise 1 year engineer on integration of omic data. The duration of this project is 3 years (2017-2020).

### 9.2.8. Working groups

Sophie Dabo-Niang belongs to the following working groups:

- STAFAV (STatistiques pour l’Afrique Francophone et Applications au Vivant)
- ERCIM Working Group on computational and Methodological Statistics, Nonparametric Statistics Team

Benjamin Guedj belongs to the following working groups (GdR) of CNRS:

- ISIS (local referee for Inria Lille - Nord Europe)
- MaDICS
- MASCOT-NUM (local referee for Inria Lille - Nord Europe).

Guillemette Marot belongs to the [StatOmique working group](#).

### 9.2.9. Other initiatives

**Participants:** Serge Iovleff, Cristian Preda, Vincent Vandewalle.

Serge Iovleff is the head of the project CloHe granted in 2016 by the [Mastodons CNRS challenge](#) “Big data and data quality”. The project is axed on the design of classification and clustering algorithms for mixed data with missing values with applications to high spatial resolution multispectral satellite image time-series. [Website](#). Cristian Preda and Vincent Vandewalle are also members of the CloHe project.

## 9.3. European Initiatives

### 9.3.1. FP7 & H2020 Projects

PERF-AI project (Nov 2018 - Nov 2020, involving Benjamin Guedj, Vincent Vandewalle - hired Florent Dewez, Arthur Taelpert). Two partners: Inria LNE and the company Safety Line (Paris, France).

Commercial aviation is already responsible for 3% of the total CO2 emissions, and with a constant growth rate of 5% per year, traffic will double within the next decade. With the support of new technologies such as Big Data, Artificial Intelligence, in-flight connectivity, major improvements can be introduced to optimize flight trajectories. PERF-AI focuses on the challenge of minimizing fuel consumption throughout the flight. The aim of PERF-AI is to provide a flight trajectory optimization prototype that implements new machine learning performance models.

The first step of the project that was carried out in the first year was to define, implement and test narrow system identification techniques. Several Machine Learning methods have been tried and have provided very encouraging initial results.

PERF-AI main objective is to provide a computation engine that can be used in two ways:

- support update of FMS that integrate individual aircraft performance models, that allow to perform accurate trajectory prediction;
- perform trajectory optimization on the ground using most accurate aircraft performance models.

### 9.3.2. Collaborations with Major European Organizations

Sophie Dabo-Niang is chair of EMS-CDC (European Mathematical society-Committee of Developing Countries).

Sophie Dabo-Niang is a member of the executive committee of CIMPA (International Centre of Pure and Applied Mathematics)

## 9.4. International Initiatives

### 9.4.1. Inria International Labs

#### 9.4.1.1. 6PAC (IIL CWI-Inria)

Scientific leaders: Benjamin Guedj, Peter Grünwald.

Other members: Emilie Kaufmann (Inria LNE, EPI SequeL), Wouter Koolen (CWI).

Title: Making Probably Approximately Correct Learning Active, Sequential, Structure-aware, Efficient, Ideal and Safe

International Partner (Institution - Laboratory - Researcher):

CWI (Netherlands) - Machine Learning Group - Peter Grünwald (head)

Start year: 2018, renewed for 2019 and 2020

Webpage: <https://bguedj.github.io/6pac/index.html>

This project roots in statistical learning theory, which can be viewed as the theoretical foundations of machine learning. The most common framework is a setup in which one is given  $n$  training examples, and the goal is to build a predictor that would be efficient on new (similar) data. This efficiency should be supported by PAC (Probably Approximately Correct) guarantees, e.g. upper bounds on the excess risk of a predictor that hold with high probability. Such guarantees however often hold under stringent assumptions which are typically never met in real-life application, e.g., independent, identically distributed data. More realistic modelling of data has triggered many research efforts in several directions: first, accommodating possible data (e.g., dependent, heavy-tailed), and second, in the direction of sequential learning, in which the predictor can be built on the fly, while new data is gathered. We believe that an ever more realistic paradigm is active learning, a setup in which the learner actively requests data (possibly facing constraints, such as storage, velocity, cost, etc.)

and adapts its queries to optimize its performance. The 3-years objective of 6PAC (where 6 stands for Sequential, Active, Efficient, Structured, Ideal, Safe - the six research directions we intend to contribute to) is to pave the way to new PAC generalization and sample-complexity upper and lower bounds beyond batch learning. Our ambition is to contribute to several learning setups, ranging from sequential learning (where data streams are collected) to adaptive and active learning (where data streams are requested by the learning algorithm).

## **9.4.2. Inria International Partners**

### **9.4.2.1. Declared Inria International Partners**

A byproduct of Benjamin Guedj's sabbatical position at University College London (UCL) since Dec 2018 is a strengthened link between UCL and Inria. DGDS has established contact with UCL President in April 2019 and a MoU has been signed between UCL and Inria in December 2019. A research group (known as Inria@UCL) has been established by Benjamin Guedj within UCL, Department for Computer Science, Centre for Artificial Intelligence. Inria@UCL initiative is expected to grow in 2020 and possibly evolve into a joint team or more. A strategic partnership between Inria and UCL will be explored in 2020.

#### **SIMERGE**

Title: Statistical Inference for the Management of Extreme Risks and Global Epidemiology

International Partner (Institution - Laboratory - Researcher):

UGB (Senegal) - LERSTAD - Abdou Ka Diongue

Serge Iovleff and Sophie Dabo-Niang are associated members of SIMERGE.

## **9.5. International Research Visitors**

### **9.5.1. Visits of International Scientists**

- Mihai Cucuringu (University of Oxford) visited Hemant Tyagi in January 2019 for a research visit of 1 week.
- Martin Wahl (Humboldt Universität from Berlin) visited Alain Celisse in March 2019 for a research visit of 1 week and November 2019 for a research visit of 1 week.
- Apoorv Vikram Singh is currently visiting Hemant Tyagi to work on a research project which is jointly supervised by Hemant Tyagi and Mihai Cucuringu (University of Oxford). The duration of the visit is 4 months (October 1, 2019 - January 31, 2020) and is partly funded by the Alan Turing Institute, London.
- Abdou Kâ Diongue visited Serge Iovleff in June 2019 for one month.

### **9.5.2. Visits to International Teams**

#### **9.5.2.1. Sabbatical programme**

Since Dec 2018, Benjamin Guedj is on sabbatical at University College London (UCL). He is a PI of the UCL Centre for Artificial Intelligence (UCL AI) and a visiting researcher at the Alan Turing Institute. This has led to the Inria@UCL initiative, see supra.



9.5.2.2. *Research Stays Abroad*

- Sophie Dabo-Niang has visited University of Kuala Lumpur, Malaysia in August 2019 and University of Mohamed V, Morocco in December 2019.
- Serge Iovleff has visited University Gaston Berger, Senegal in February 2019 and gave a course entitled "Introduction to Statistical Learning".
- Hemant Tyagi visited Mihai Cucuringu and Benjamin Guedj at the Alan Turing Institute, UK from in October 2019.
- Alain Celisse visited Markus Reiß and Martin Wahl at the Humboldt Universität, Germany in March and December 2019.
- Alain Celisse visited Benjamin Guedj at the University College London, UK in February-March and July-August 2019.
- Pascal Germain visited Benjamin Guedj at University College London, UK on several occasions totalling about 1.5 month in 2019.
- Cristian Preda visited Amarioarei Alexandru at University of Bucharest on several occasions totalling about 1 week in 2019.

## **RAPSODI Project-Team**

# **9. Partnerships and Cooperations**

## **9.1. Regional Initiatives**

### **9.1.1. ERC Generator**

T. Rey has been awarded an ERC Generator grant (116 545 euros) from I-SITE Université Lille - Nord Europe for his project MANAKINEQO (R-ERCGEN-19-007-REY). In the next two years, T. Rey aims at investigating mathematical properties, as well as developing efficient numerical schemes, for multiscale collisional kinetic equations of the Boltzmann type. A 20-months post-doc will be funded using this grant, as well as an international conference. Following this ERC Generator grant, T. Rey will apply for an ERC Consolidator grant.

### **9.1.2. Actions of Technological Development (ADT)**

S. Lemaire is the PI of the ADT project ParaSkel++, which is one of the funded ADT of the Inria Lille - Nord Europe 2019 campaign. The aim of the project is to develop an optimized C++ platform for the arbitrary-order numerical approximation of PDEs by skeletal methods on general 2D/3D meshes, with a particular emphasis on the implementation of HPC facilities. L. Beaudé has been hired as a development engineer for this project. She will start in February 2020.

In the same vein, T. Rey is part of the ADT project SIMPAPH led by the MEPHYSTO-POST team, that has as well been funded as a result of the Inria Lille - Nord Europe 2019 campaign. The aim is to develop robust numerical methods to solve large systems of stochastic differential equations describing (among others) particles in an optic fiber, schools of fish, or microscopic particles. The expected code will attempt to solve these multiscale problems using different approaches, and to be versatile enough to act as an industrial benchmark. A. Roget has been hired as a development engineer for this project.

## **9.2. National Initiatives**

### **9.2.1. ANR**

C. Chainais-Hillairet has been a member of the ANR **MOONRISE** project. The MOONRISE project aimed at exploring modeling, mathematical, and numerical issues originating from the presence of high oscillations in nonlinear PDEs mainly from the physics of nanotechnologies and from the physics of plasmas.

Title: M0dels, Oscillations, and NumeRIcal SchEmes

Type: Fondements du numérique (DS0705) - 2014

ANR reference: ANR-14-CE23-0007

Coordinator: F. Méhats (Université de Rennes 1)

Duration: October 2014 - June 2019

C. Chainais-Hillairet and T. Rey are members of the ANR **MOHYCON** project. The MOHYCON project is related to the analysis and simulation of multiscale models of semiconductors. As almost all current electronic technology involves the use of semiconductors, there is a strong interest for modeling and simulating the behavior of such devices, which was recently reinforced by the development of organic semiconductors used for example in solar panels or in mobile phones and television screens (among others).

Title: Multiscale M0dels and HYbrid numerical methods for semiCONductors

Type: Société de l'information et de la communication (DS07) - 2017

ANR reference: ANR-17-CE40-0027

Coordinator: M. Bessemoulin-Chatard (CNRS and Université de Nantes)

Duration: January 2018 - December 2020

C. Cancès is a member of the ANR **COMODO** project. The COMODO project focuses on the mathematical and numerical study of cross-diffusion systems in moving domains. The targeted application is the simulation of the building of solar plants by the vapour deposition process.

Title: CrOss-diffusion equations in MOving DOmains

Type: Modèles numériques, simulation, applications (CE46) - 2019

ANR reference: ANR-19-CE46-0002

Coordinator: V. Ehrlacher (École des Ponts ParisTech and Inria Paris)

Duration: January 2020 - December 2023

M. Herda is a member of the ANR JCJC MICMOV project. The MICMOV project aims at gathering PDE analysts, probability theorists, and theoretical physicists to work on the derivation of macroscopic properties of physical systems from their microscopic description. The rigorous microscopic description of moving interfaces, the understanding of macroscopic nonlocal effects, and the mathematical apprehension of the underlying atomic mechanisms, are particularly important matters of this project.

Title: MICroscopic description of MOving interfaces

Type: Mathématiques (CE40) - 2019

Coordinator: M. Simon (Inria Lille - Nord Europe)

### 9.2.2. *LabEx CEMPI*

Title: Centre Européen pour les Mathématiques, la Physique et leurs Interactions

Coordinator: S. De Bièvre (LPP, Université de Lille)

Duration: January 2012 - December 2019, extended in 2019

Partners: Laboratoire Paul Painlevé (LPP) and Laser Physics department (PhLAM), Université de Lille

The “Laboratoire d’Excellence” Centre Européen pour les Mathématiques, la Physique et leurs Interactions (**CEMPI**), a project of the Laboratoire de mathématiques Paul Painlevé (LPP) and the laboratoire de Physique des Lasers, Atomes et Molécules (PhLAM), was created in the context of the “Programme d’Investissements d’Avenir” in February 2012.

The association Painlevé-PhLAM creates in Lille a research unit for fundamental and applied research and for training and technological development that covers a wide spectrum of knowledge stretching from pure and applied mathematics to experimental and applied physics.

One of the three focus areas of CEMPI research is the interface between mathematics and physics. This focus area encompasses three themes. The first is concerned with key problems of a mathematical, physical and technological nature coming from the study of complex behavior in cold atoms physics and nonlinear optics, in particular fiber optics. The two other themes deal with fields of mathematics such as algebraic geometry, modular forms, operator algebras, harmonic analysis and quantum groups that have promising interactions with several branches of theoretical physics.

### 9.2.3. *PEPS*

T. Rey has been the laureate in 2019 of a Young Researcher PEPS grant from CNRS’s INSMI (3 500 euros, from March to November 2019). The granted project aimed at investigating high-order (in time and velocity) numerical methods for approximating the solutions to the granular gases equation.

## 9.3. European Initiatives

C. Cancès, C. Chainais-Hillairet and B. Merlet are involved in the H2020 project **EURAD** (European Joint Programme on RADioactive Waste Management). The aim of their project inside EURAD is to establish an energetic formulation of the Diffusion Poisson Coupled Model leading to new large-time robust numerical methods for the simulation of the corrosion processes in an underground repository.

C. Cancès is the leader of the task “Numerical methods for high-performance computing of coupled processes” within the EURAD project.

## 9.4. International Initiatives

C. Cancès is a member of the Indo-French Center for Applied Mathematics (IFCAM) project “Conservation laws:  $BV^s$ , control, interfaces” (PIs: S. Ghoshal, TIFR Centre For Applicable Mathematics, India and S. Junca, Université de Nice).

## 9.5. International Research Visitors

### 9.5.1. Visits of International Scientists

In January-February, E. Daus (TU Vienna, Austria) visited C. Cancès and C. Chainais-Hillairet during two weeks.

In 2019, RAPSODI members also invited several researchers for short visits (a week or less) in Lille.

- R. Bailo (Imperial College London, UK) came in November to work with T. Rey (funded by his Young Researcher PEPS grant).
- R. V. Sabariego (KU Leuven, Electrical Engineering ESAT/Electa, EnergyVille, Belgium) came in May to work with E. Creusé.
- E. Bretin and S. Masnou (Institut Camille Jordan, Lyon) and M. Goldman (CNRS and LJLL/Université Paris Diderot) came in June and December to work with B. Merlet.
- A. Trescases (CNRS and Institut de Mathématiques de Toulouse) came in September to work with M. Herda.
- C. Bataillon (CEA), V. Ehrlicher (École des Ponts ParisTech and Inria Paris) and C. Perrin (CNRS and Université d’Aix-Marseille) came to work with C. Cancès.
- M. Cassier (CNRS and Institut Fresnel, Marseille) came in February-March to work with S. Lemaire.

On a slightly different note, from March to October, G. Robillard has been an AIRLab resident (Artiste en Immersion Recherche dans un Laboratoire) in order to work with C. Calgaro and E. Creusé (with a support from the Communauté d’Universités et d’Établissements Lille Nord-de-France).

### 9.5.2. Visits to International Teams

B. Gaudeul spent two weeks in WIAS Berlin, Germany in November in order to work with J. Fuhrmann on the extension of the results obtained in [48] to Nernst–Planck–Poisson systems with ion size and solvation effects.

M. Herda spent one week at Imperial College London, UK in February to work with P. Degond on a Fokker–Planck approach to the study of robustness in gene expression.

T. Rey visited 3 times J. A. Carrillo and J. Hu at Imperial College London, UK between February and March, for 3 days long stays funded by his Young Researcher PEPS grant, to work (in particular) on the development of a new high-order numerical method for solving the granular gases equation.

C. Cancès and B. Merlet spent one week at the University of Lisbon, Portugal in December to work with L. Monsaingeon.

C. Cancès spent one week at Université de Tours to work with B. Andreianov.

B. Merlet visited E. Bretin and S. Masnou at Institut Camille Jordan in Lyon in February, and visited several times M. Goldman at LJLL/Université Paris Diderot in March, May, October, and November.

F. Chave and S. Lemaire spent 3 days at Université de Montpellier in September to work with D. A. Di Pietro on arbitrary-order polytopal methods for electromagnetism.

### **9.5.3. Research Stays Abroad**

M. Herda was in residence at the Hausdorff Research Institute for Mathematics (University of Bonn, Germany) from May 19 to July 7 in the framework of the **Junior Trimester Program in Kinetic Theory**, that gave young mathematicians the opportunity to carry out collaborative research in kinetic theory. M. Herda was part of a project in collaboration with N. Ayi (Sorbonne Université), M. Breden (École Polytechnique), J. Guerand (University of Cambridge, UK), H. Hivert (Centrale Lyon), and I. Tristani (ENS Paris) on the study of a fractional kinetic Fokker–Planck equation. This collaboration has already led to the article [44], and a second article is in preparation. A collaboration was also initiated with M. Breden and A. Trescases (CNRS and Institut de Mathématiques de Toulouse) on the derivation of cross-diffusion systems from kinetic models.

## SEQUEL Project-Team

# 9. Partnerships and Cooperations

## 9.1. Regional Initiatives

### 9.1.1. *With U. INSERM 1190, CHU Lille*

**Participants:** Odalric-Ambrym Maillard, Philippe Preux, Philippe Preux.

Title: Bandits for Health (B4H)

Type: I-SITE Lille

Coordinator: Philippe Preux

Duration: 2019–2023

Abstract: B4H is a fundamental research project on a certain type of bandit algorithms, tailored to be applied to post-surgical patient follow-up. Bandit in a non-stationary environment will be studied. This work is performed in collaboration with Pr. F. Pattou and his group.

Title: No title

Type: Informal

Coordinator: Philippe Preux

Duration: 2019–2020

Abstract: This is mostly a data analysis work in order to study whether a certain disease may be predicted based on a certain dataset collected by U. INSERM 1190. Estelle Chatelain, a BiLille engineer, is involved in this project. This work is performed in collaboration with Pr. F. Pattou and his group.

### 9.1.2. *With Service de Radiologie et Imagerie Musculosquelettique, CHU Lille*

**Participants:** Philippe Preux, Franck Valentini.

Title: Radiology AI Demonstrator (RAID)

Type: CPER, Région Hauts-de-France

Coordinator: Philippe Preux

Duration: 2019–2020

Abstract: The goal of the RAID project is to assess the potential of deep learning for radio analysis and patient triage. Various applications are investigated.

## 9.2. National Initiatives

### 9.2.1. *ANR BOLD*

**Participants:** Émilie Kaufmann, Michal Valko, Pierre Ménard, Xuedong Shang, Omar Darwiche Domingues.

Title: Beyond Online Learning for better Decision making

Type: National Research Agency

Coordinator: Vianney Perchet (ENS Paris-Saclay / ENSAE)

Duration: 2019–2023

Abstract: Reactive machine learning algorithms adapt to data generating processes, typically do not require large computational power and, moreover, can be translated into offline (as opposed to online) algorithms if needed. Introduced in the 30s in the context of clinical trials, online ML algorithms have been gaining a lot of theoretical interest for the last 15 years because of their applications to the optimization of recommender systems, click through rates, planning in congested networks, to name just a few. However, in practice, such algorithms are not used as much as they should, because the traditional low-level modelling assumptions they are based upon are not appropriate, as it appears.

Instead of trying to complicate and generalise arbitrarily a framework unfit for potential applications, we will tackle this problem from another perspective. We will seek a better understanding of the simple original problem and extend it in the appropriate directions. There are currently three main barriers to a broader development of online learning, that this project aim at overcoming. 1) The classical “one step, one decision, one reward” paradigm is unfit. 2) Optimality is defined with respect to worst-case generic lower bounds and mechanics behind online learning are not fully understood. 3) Algorithms were designed in a non strategic or interactive environment.

The project gathers four parnters: ENS Paris-Saclay, University of Toulouse, Inria Lille and Université Paris Descartes.

### **9.2.2. ANR BoB**

**Participant:** Michal Valko.

Title: Bayesian statistics for expensive models and tall data

Type: National Research Agency

Coordinator: CNRS (Rémi Bardenet)

Duration: 2016–2020

**Abstract:** Bayesian methods are a popular class of statistical algorithms for updating scientific beliefs. They turn data into decisions and models, taking into account uncertainty about models and their parameters. This makes Bayesian methods popular among applied scientists such as biologists, physicists, or engineers. However, at the heart of Bayesian analysis lie 1) repeated sweeps over the full dataset considered, and 2) repeated evaluations of the model that describes the observed physical process. The current trends to large-scale data collection and complex models thus raises two main issues. Experiments, observations, and numerical simulations in many areas of science nowadays generate terabytes of data, as does the LHC in particle physics for instance. Simultaneously, knowledge creation is becoming more and more data-driven, which requires new paradigms addressing how data are captured, processed, discovered, exchanged, distributed, and analyzed. For statistical algorithms to scale up, reaching a given performance must require as few iterations and as little access to data as possible. It is not only experimental measurements that are growing at a rapid pace. Cell biologists tend to have scarce data but large-scale models of tens of nonlinear differential equations to describe complex dynamics. In such settings, evaluating the model once requires numerically solving a large system of differential equations, which may take minutes for some tens of differential equations on today’s hardware. Iterative statistical processing that requires a million sequential runs of the model is thus out of the question. In this project, we tackle the fundamental cost-accuracy trade-off for Bayesian methods, in order to produce generic inference algorithms that scale favorably with the number of measurements in an experiment and the number of runs of a statistical model. We propose a collection of objectives with different risk-reward trade-offs to tackle these two goals. In particular, for experiments with large numbers of measurements, we further develop existing subsampling-based Monte Carlo methods, while developing a novel decision theory framework that includes data constraints. For expensive models, we build an ambitious programme around Monte Carlo methods that leverage determinantal processes, a rich class of probabilistic tools that lead to accurate inference with limited model evaluations. In short, using innovative techniques such as subsampling-based Monte Carlo and determinantal point processes, we propose in this project to push the boundaries of the applicability of Bayesian inference.

### **9.2.3. ANR Badass**

**Participants:** Odalric-Ambrym Maillard, Émilie Kaufmann.

Title: BAnDits for non-Stationarity and Structure

Type: National Research Agency

Coordinator: Inria Lille (O. Maillard)

Duration: 2016–2020

**Abstract:** Motivated by the fact that a number of modern applications of sequential decision making require developing strategies that are especially robust to change in the stationarity of the signal, and in order to anticipate and impact the next generation of applications of the field, the BADASS project intends to push theory and application of MAB to the next level by incorporating non-stationary observations while retaining near optimality against the best not necessarily constant decision strategy. Since a non-stationary process typically decomposes into chunks associated with some possibly hidden variables (states), each corresponding to a stationary process, handling non-stationarity crucially requires exploiting the (possibly hidden) structure of the decision problem. For the same reason, a MAB for which arms can be arbitrary non-stationary processes is powerful enough to capture MDPs and even partially observable MDPs as special cases, and it is thus important to jointly address the issue of non-stationarity together with that of structure. In order to advance these two nested challenges from a solid theoretical standpoint, we intend to focus on the following objectives: *(i)* To broaden the range of optimal strategies for stationary MABs: current strategies are only known to be provably optimal in a limited range of scenarios for which the class of distribution (structure) is perfectly known; also, recent heuristics possibly adaptive to the class need to be further analyzed. *(ii)* To strengthen the literature on pure sequential prediction (focusing on a single arm) for non-stationary signals via the construction of adaptive confidence sets and a novel measure of complexity: traditional approaches consider a worst-case scenario and are thus overly conservative and non-adaptive to simpler signals. *(iii)* To embed the low-rank matrix completion and spectral methods in the context of reinforcement learning, and further study models of structured environments: promising heuristics in the context of e.g. contextual MABs or Predictive State Representations require stronger theoretical guarantees.

This project will result in the development of a novel generation of strategies to handle non-stationarity and structure that will be evaluated in a number of test beds and validated by a rigorous theoretical analysis. Beyond the significant advancement of the state of the art in MAB and RL theory and the mathematical value of the program, this JCJC BADASS is expected to strategically impact societal and industrial applications, ranging from personalized health-care and e-learning to computational sustainability or rain-adaptive river-bank management to cite a few.

#### **9.2.4. Grant of Fondation Mathématique Jacques Hadamard**

**Participants:** Michal Valko, Ronan Fruit.

**Title:** Theoretically grounded efficient algorithms for high-dimensional and continuous reinforcement learning

**Type:** PGM0-IRMO, funded by Criteo

**PI:** Michal Valko

**Criteo contact:** Marc Abeille

**Duration:** 2018–2020

**Abstract:** While learning how to behave optimally in an unknown environment, a reinforcement learning (RL) agent must trade off the exploration needed to collect new information about the dynamics and reward of the environment, and the exploitation of the experience gathered so far to gain as much reward as possible. A good measure of the agent’s performance is the regret, which measures the difference between the performance of optimal policy and the actual rewards accumulated by the agent. Two common approaches to the exploration-exploitation dilemma with provably good regret guarantees are the optimism in the face of uncertainty principle and Thompson Sampling. While these approaches have been successfully applied to small environments with a finite number of states and action (tabular scenario), existing approach for large or continuous environments either rely on heuristics and come with no regret guarantees, or can be proved to achieve small regret but cannot be implemented efficiently. In this project, we propose to make a significant contribution in the understanding of large and/or continuous RL problems by developing and analyzing new algorithms that perform well both in theory and practice.



This research line can have a practical impact in all the applications requiring continuous interaction with an unknown environment. Recommendation systems belong to this category and, by definition, they can be modeled as a sequence of repeated interaction between a learning agent and a large (possibly continuous) environment.

### 9.2.5. *With CIRAD and CGIAR*

**Participants:** Philippe Preux, Odalric-Ambrym Maillard, Romain Gautron.

Title: Crop management

Duration: 2019–2022

Abstract: We study how reinforcement learning may be used to provide recommendations of practices to small farm holders in under-developed countries. In such countries, agriculture remains mostly a non mechanized activity, dealing with fields of very small surface.

This is a very challenging application for RL: data is scarce, recommendations made to farmers should be of quality: we can not just learn by making millions of bad recommendations to people who use them to live and feed their family. Modeling the problem as an RL is yet another challenge.

We feel that it is very interesting to challenge RL with such complex tasks. Solving games with RL is nice and fun, but we should assess RL abilities to solve real risky tasks.

This pioneering work is done within Romain Gautron's PhD, in collaboration with CIRAD, the CGIAR, and in relation with the Africa Rising program.

### 9.2.6. *Project CNRS-INSERM REPOS*

**Participants:** Émilie Kaufmann, Clémence Réda [INSERM].

Title: Repositionnement de médicaments basé sur leurs effets transcriptionnels par des approches de réseaux géniques

Type: Appel à projet Santé Numérique

PI: Pr. Andrée Delahaye-Duriez (INSERM, UMR1141)

Duration: 2019

Abstract: Drug repurposing consists in studying molecules already commercialized and find other therapies in which they may be efficient. The quality of therapeutic components is often assessed by their affinity to a given protein, but it can also be assessed in terms of their impact at the transcriptomic level. The aim of this project is to develop a method for selecting which drugs could be used for a given disease based on their ability to inverse the transcriptomic signature of a pathological phenotype. We will propose a new method based on algorithms for sequential decision making (bandit algorithms) to adaptively select which drug should be explored, where exploring a drug means performing simulations to propagate the perturbation (using for example gene regulatory networks) and estimate the transcriptomic impact of the perturbation induced by the drug. These simulations will hinge on existing gene expression data that are already available for many drugs, but also on new transcriptomic data generated for a mouse model of a rare disease called the Ondine syndrom.

### 9.2.7. *National Partners*

- ENS Paris-Saclay
  - M. Valko collaborated with V. Perchet on structured bandit problem. They co-supervise a PhD student (P. Perrault) together
  - O-A. Maillard collaborates with V. Perchet on automated feature learning. They co-supervise a PhD student (R. Ouhamma) together
  - E. Kaufmann collaborated with V. Perchet and E. Boursier on Multi-Player bandits
- Institut de Mathématiques de Toulouse, then Ecole Normale Supérieure de Lyon

- E. Kaufmann collaborated with Aurélien Garivier on sequential testing and structured bandit problems
- Centrale-Supélec Rennes:
  - E. Kaufmann co-advises Lilian Besson, who works at CentraleSupélec with Christophe Moy on MAB for cognitive radio and Internet-of-Things communications
- Participation to the Inria Project Lab (IPL) “HPC – Big Data”: Started in 2018, this IPL gathers a dozen Inria team-projects, mixing researchers in HPC with researchers in machine learning and data science. SEQUEL contribution in this project is about how we can take advantage of HPC for our computational needs regarding deep learning and deep reinforcement learning, and also how such learning algorithms might be redesigned or re-implemented in order to take advantage of HPC architectures.
- Participation to the Inria Project Lab (IPL) “HYAIAI”: Started in 2019, this IPL gathers Magnet and SEQUEL in Lille, Tau in Saclay, Lacodam in Rennes, Orpailleur and Multispeech in Nancy. The goal of this IPL is to study machine learning combining symbolic and numeric approaches, to obtain interpretable AI systems.
- PCIM (École Polytechnique)
  - Ph. Preux collaborates with Tanguy Levent (PhD student) on the control of smartgrids with reinforcement learning
- Defrost (Inria Lille)
  - Ph. Preux collaborates with Pierre Schegg (PhD student) on the control of soft robots with reinforcement learning

## 9.3. European Initiatives

### 9.3.1. Collaborations in European Programs, Except FP7 & H2020

#### 9.3.1.1. DELTA

**Participants:** Michal Valko, Émilie Kaufmann, Omar Darwiche Domingues, Pierre Ménard.

Program: CHIST-ERA

Project acronym: DELTA

Project title: Dynamically Evolving Long-Term Autonomy

Duration: October 2017 - December 2021

Coordinator: Anders Jonsson (PI)

Inria Coordinator: Michal Valko

Other partners: UPF Spain, MUL Austria, ULG Belgium

Abstract: Many complex autonomous systems (e.g., electrical distribution networks) repeatedly select actions with the aim of achieving a given objective. Reinforcement learning (RL) offers a powerful framework for acquiring adaptive behaviour in this setting, associating a scalar reward with each action and learning from experience which action to select to maximise long-term reward. Although RL has produced impressive results recently (e.g., achieving human-level play in Atari games and beating the human world champion in the board game Go), most existing solutions only work under strong assumptions: the environment model is stationary, the objective is fixed, and trials end once the objective is met. The aim of this project is to advance the state of the art of fundamental research in lifelong RL by developing several novel RL algorithms that relax the above assumptions. The new algorithms should be robust to environmental changes, both in terms of the observations that the system can make and the actions that the system can perform. Moreover, the algorithms should be able to operate over long periods of time while achieving different objectives. The proposed algorithms will address three key problems related to lifelong RL: planning, exploration, and task

decomposition. Planning is the problem of computing an action selection strategy given a (possibly partial) model of the task at hand. Exploration is the problem of selecting actions with the aim of mapping out the environment rather than achieving a particular objective. Task decomposition is the problem of defining different objectives and assigning a separate action selection strategy to each. The algorithms will be evaluated in two realistic scenarios: active network management for electrical distribution networks, and microgrid management. A test protocol will be developed to evaluate each individual algorithm, as well as their combinations.

## 9.4. International Initiatives

### 9.4.1. Inria International Partners

- É. Kaufmann visited CWI, Amsterdam for one week in February, working with Wouter Koolen, Rémy Degenne and Rianne De Heide. Pierre Ménard also collaborated with them.

## 9.5. International Research Visitors

### 9.5.1. Visits of International Scientists

- Anders Jonsson, Pompeu Fabra University, Spain ,sabbatical year Sep 2019 – Jul 2020
- Kaige Yang, University College London, UK, Oct 9 & Jan 9 2020
- Rianne de Heide, CWI, The Netherlands, April 23 – August 3, 2019
- Chuan-Zheng Lee, Stanford University, USA, June – October 2019
- Arun Verma, IIT Bombay, June 1 – November 30, 2019

#### 9.5.1.1. Internships

- Alessio Della Libera, from Jul 2019 until Sep 2019  
*TD-Gammon*, and his github [with the gym-backgammon code](#)

## VALSE Project-Team

# 8. Partnerships and Cooperations

## 8.1. Regional Initiatives

The team participates in CPER Data programs and projects:

- **ControlHub**, coordinator A. Polyakov, see the dedicated platform description above
- “ContrATech” subprogram of **CPER ELSAT**, coordinator J.-M. Foucaut (LMFL)

## 8.2. National Initiatives

### 8.2.1. ANR

- **Digitslid**, coordinator B. Brogliato (Inria, Grenoble)
- **Finite4SoS**, coordinator W. Perruquetti (École Centrale de Lille)
- **WaQMoS**, coordinator D. Efimov (Inria, Lille)
- **TurboTouch**, coordinator G. Casiez (Inria, Lille)

### 8.2.2. Inria project labs

The team participates in **IPL COSY**, coordinator E. Cinquemani (Inria, Grenoble).

## 8.3. European Initiatives

### 8.3.1. FP7 & H2020 Projects

The team is involved in 1 EU project **UCoCoS**, coordinator W. Michiels (KUL, Belgium).

## 8.4. International Initiatives

### 8.4.1. Inria North European associate teams

- **WeCare** with Uppsala University (Sweden), coordinator R. Ushirobira
- **RECoT** with IBM Research (Ireland), coordinator A. Polyakov

### 8.4.2. Inria International Partners

- UNAM (Mexico), L. Fridman and J. Moreno
- ITMO University (Russia), A. Bobtsov and I. Furtat

## 8.5. International Research Visitors

### 8.5.1. Visits of International Scientists

- A. Aleksandrov, SPbSU (Russia), from Mar 2019 until Apr 2019
- S. Aranovskiy, École supérieure d'électricité, Jun 2019
- J. Epperlein, IBM Research (Ireland), from Dec 2019
- E. Fridman, Tel Aviv University (Israel), from Jul 2019 until Sep 2019, **Inria invited professor**
- A. Medvedev, Uppsalla University (Sweden), from Nov 2019 until Dec 2019
- J. Moreno, UNAM (Mexico), from Dec 2019
- Y. Orlov, CICESE (Mexico), from Dec 2019
- M. Ruderman, University of Agder (Norway), from Dec 2019
- L. Tupak Aguilar Bustos, CICESE (Mexico), from Dec 2019
- J. Zhang, HDU (China), from Aug 2019
- K. Zimenko, ITMO University (Russia), from Sep 2019 until Nov 2019
- S. Zhuk, IBM Research (Ireland), from Dec 2019

#### 8.5.1.1. Internships

- M. Ballesteros Escamilla, Cinvestav (Mexico), until Apr 2019
- D. Cruz Ortiz, Cinvestav (Mexico), until Apr 2019
- J. Franco Jaramillo, Technological Institute of La Laguna (Mexico), from Oct 2019 until Nov 2019
- J. Mendoza Avila, UNAM (Mexico), from Sep 2019 until Dec 2019

## FUN Project-Team

# 8. Partnerships and Cooperations

## 8.1. Regional Initiatives

### 8.1.1. StoreConnect

**Participants:** Nathalie Mitton [contact person], Valeria Loscri, Antonio Costanzo, Ibrahim Amadou.

Title: StoreConnect

Type: FUI

Duration: September 2016 - October 2018

Coordinator: NEOSSENSYS

Others partners: Inria FUN, SPIRALS and STARS, TeVolys, Ubudu, Smile, STIME, Leroy Merlin

The aim of StoreConnect is to provide French large retailers with efficient and powerful tools in the in-store customer interaction.

### 8.1.2. LumiCAR

**Participants:** Valeria Loscri [contact person], Antonio Costanzo, Meysam Mayahi.

Title: LumiCAR

Type: ISITE

Duration: October 2019 - October 2021

Vehicle-to-Vehicle and Vehicle-RSU (Roadside Units) communication (V2X) has become a very active topic of research in recent years as it appears to be a means of improving road safety and make effective and timely intervention of road safety actors. To date, most research activities are based on the use of conventional radio frequency (RF) technology. However, faced with multiple constraints, these vehicular communications are not always effective. In the LumiCar project we will base the V2X communication mainly on the Visible Light Communication (VLC) technology and we will focus on the coexistence of the VLC with other technologies. VLC has already started to work in other indoor applications such as connected stores for geolocation of customers. The properties offered by light (speed, directional, controlled containment ...) suggest that VLC technology is more suitable for vehicular communications and can effectively meet the needs of a reliable, robust and with increasing flow to consider new applications such as virtual reality in future cars. In addition, VLC technology can be recognized as a "green" technology because it is based on the exploitation of LEDs and lamps already used for lighting and visibility. It is therefore a question of optimizing the use (by the transmission of information) of an energy already consumed.

## 8.2. National Initiatives

### 8.2.1. Exploratory Action

#### 8.2.1.1. Ethicam

**Participants:** Valeria Loscri [contact person], Carola Rizza.

Duration: October 2019 - October 2022

The evolution of the Internet of Things (IoT) towards the Internet of Everything (IoE) paradigm represents an important and emerging research direction, capable to connect and interconnect massive number of heterogeneous nodes, both inanimate and living entities, encompassing molecules, nanosensors, vehicles and people. This new paradigm demands new engineering communication solutions to overcome miniaturization and spectrum scarcity. Novel pervasive communication paradigms will be conceived by the means of a cutting edge multidisciplinary research approach integrating (quasi) particles (e.g. phonons) and specific features of the (meta)material (e.g. chirality) in the design of the communication mechanisms. In particular, by the means of the meta-materials, it would be possible to control the propagation environment. More specifically, through this paradigm it will be possible to manipulate not only the desired signals, but also the interfering signals.

## 8.2.2. ADT

### 8.2.2.1. Catimex

**Participants:** Matthieu Berthome, Nathalie Mitton [contact person], Julien Vandaele.

Duration: September 2017 -June 2019

Coordinator: Inria FUN

The purpose of this project is to foster research transfer in IoT from ADT members to their industrial partners by widening experimental features and PoC realization. It is lead in closed partnership with Inria Chile and Université of Strasbourg.

## 8.2.3. Equipements d'Excellence

### 8.2.3.1. FIT

**Participants:** Nathalie Mitton [contact person], Julien Vandaele, Matthieu Berthome.

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.

## 8.3. European Initiatives

### 8.3.1. H2020 Projects

#### 8.3.1.1. VESSEDIA

**Participants:** Rehan Malak, Nathalie Mitton, Allan Blanchard [contact person].

Title: Verification Engineering of Safety and Security Critical Dynamic Industrial Applications

Program: H2020

Duration: January 2017 - Dec. 2019

Coordinator: Technikon Forschungs und Planungsgesellschaft MBH (TEC)

The VESSEDIA project will bring safety and security to many new software applications and devices. In the fast evolving world we live in, the Internet has brought many benefits to individuals, organizations and industries. With the capabilities offered now (such as IPv6) to connect billions of devices and therefore humans together, the Internet brings new threats to the software developers and VESSEDIA will allow connected applications to be safe and secure. VESSEDIA proposes to enhance and scale up modern software analysis tools, namely the mostly open-source Framac Analysis platform, to allow developers to benefit rapidly from them when developing connected applications. At the forefront of connected applications is the IoT, whose growth is exponential and whose security risks are real (for instance in hacked smart phones). VESSEDIA will take this domain as a target for demonstrating the benefits of using our tools on connected applications. VESSEDIA

will tackle this challenge by 1) developing a methodology that allows to adopt and use source code analysis tools efficiently and produce similar benefits than already achieved for highly-critical applications (i.e. an exhaustive analysis and extraction of faults), 2) enhancing the Frama-C toolbox to enable efficient and fast implementation, 3) demonstrating the new toolbox capabilities on typical IoT (Internet of Things) applications including an IoT Operating System (Contiki), 4) developing a standardization plan for generalizing the use of the toolbox, 5) contributing to the Common Criteria certification process, and 6) defining a label "Verified in Europe" for validating software products with European technologies such as Frama-C. This project yields to set of publications in 2019: [17], [18], [35].

#### 8.3.1.2. *CyberSANE*

**Participants:** Valeria Loscri, Nathalie Mitton [contact person], Edward Staddon.

Title: Cyber Security Incident Handling, Warning and Response System for the European Critical Infrastructures

Program: H2020

Duration: September 2019 - September 2022

CyberSANE aims to enhance the security and resilience of Critical Information Infrastructures (CIIs) by providing a dynamic collaborative, warning and response system supporting and guiding security officers and operators (e.g. Incident Response professionals) to recognize, identify, dynamically analyze, forecast, treat and respond to advanced persistent threats (APTs) and handle their daily cyber incidents utilizing and combining both structured data (e.g. logs and network traffic) and unstructured data (e.g. data coming from social networks and dark web).

In achieving that aim, CyberSANE will introduce a holistic and privacy-aware approach in handling security incidents, addressing the complexity of these nets consisting of cyber assets hosted in cross-border, heterogeneous Critical Information Infrastructures (CIs). Moreover, CyberSANE is fully in-line with relevant regulations (such as the GDPR and NIS directive), which requires organizations to increase their preparedness, improve their cooperation with each other, and adopt appropriate steps to manage security risks, report and handle security incidents.

## 8.4. International Initiatives

### 8.4.1. *Inria International Labs*

#### 8.4.1.1. *Agrinet*

**Participants:** Christian Salim, Brandon Foubert, Nathalie Mitton [contact person].

Title: Agrinet

International Partner (Institution - Laboratory - Researcher): Stellenbosch University, South Africa, Riaan Wolhuter

Type: LIRIMA Associate team

Duration: 2017-2020

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

The current drought and limited water resources in many parts of Southern Africa and beyond, already have a significant impact on agriculture and hence, food production. Sustainable food security depends upon proper plant and crop management respectful of soils and natural resources, such as water. This includes very important South African farming areas, such as the Western Cape and Northern Cape. In France, agriculture is also hugely important. Not just nationally, but also in Europe. The system proposed can be applied to a variety of crops. The economic- and social consequences are profound and any contribution towards more efficient farming within increasingly onerous natural constraints, should be a priority. To address these constraints, we propose to develop a flexible, rapidly deployable, biological/agricultural data acquisition platform and associated machine learning algorithms to create advanced agricultural monitoring and management techniques, to improve crop management and use of natural resources. The project also addresses an industry with very high socioeconomic impact.

Publications issued from that project in 2019 are: [12], [16].

## 8.4.2. Inria International Partners

### 8.4.2.1. Declared Inria International Partners

**Université Méditerranée di Reggio Calabria (UNIC) (Italy):** The 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, such that is independent of the network topology, in a reliable and flexible way. The result is an 'ecosystem' of self-organized and self-sustained objects, 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.

### 8.4.2.2. Informal International Partners

**Anna-Maria Vegni from Roma Tre University, Italy:** The purpose of this collaboration is to study alternative communication paradigms and investigate their limitations and different effects on performances. In this framework, joint publications have been obtained, among them in 2019 [23], [33], [15], [24], [32].

## 8.4.3. Participation in Other International Programs

### 8.4.3.1. International Initiatives

#### **CroMo**

Title: Crowd data in the mobile cloud

International Partner (Institution - Laboratory - Researcher):

Universidade Federal do Rio de Janeiro (Brazil) - GTA Laboratory - Luis Henrique Costa

Duration: 2015 - 2019

Start year: 2015

CroMo's main goal is to investigate alternatives to efficiently offload multiple data collected from mobile users to the cloud. To achieve this goal, CroMo will focus on three complementary objectives:

- Objective 1 (Data acquisition): In a wireless environment, data can be sourced at a multitude of wireless devices. Hence, the first objective of this project is to identify the most relevant information from all the data available by using local criteria. The notion of local can be concerned with a single wireless device or a set of nearby wireless devices. The goal is to only send relevant data to the cloud or to assign a higher priority to it.
- Objective 2 (Data transmission): The large-scale sensing system forces massive transmission to the cloud. Hence, transmitting the data in a reliable and timely fashion is the purpose of this second objective.
- Objective 3 (Data computation): Mobile clouds must be available for wireless users to receive and process data. Hence, the cloud infrastructure must be efficient enough to process data from users in a efficient fashion. The third objective of this project is to evaluate cloud availability and to propose performance improvements for data computation. Such improvements are concerned with cloud infrastructure adaptation according to users' demands.

In this context, our project is original and ambitious. Indeed, compared to other studies in wireless networking, our project is focused on a global approach from raw data acquisition to information creation at the mobile cloud infrastructure.

## 8.5. International Research Visitors

### 8.5.1. Visits of International Scientists

Several researchers have visited our group in 2019, mainly from our partner universities but not only:

- Gewu Bu, LIP6, France, January 2019
- Noura Mares, University of Sfax, Tunisia, from June 2019 until July 2019
- Marco Di Renzo, Centrale Supélec, France, August 2019
- Riaan Wolhuter, Stellenbosch University, South Africa, September 2019



## RMOD Project-Team

# 9. Partnerships and Cooperations

## 9.1. Regional Initiatives

### 9.1.1. CAR IMT Douai

Participants: Pablo Tesone, Guillermo Polito, Marcus Denker, Stéphane Ducasse with: L. Fabresse and N. Bouraqadi (IMT Douai)

From 2009, ongoing.

We have signed a convention with the CAR team led by Noury Bouraqadi of IMT 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.

Pablo Tesone did a PhD co-supervised by RMOD and Pr. L. Fabresse and N. Bouraqadi (finished in 2018). Currently, three PhD Students are co-supervised:

- PhD in progress: Théo Rogliano, *On multiple language kernel*, started Oct 2019, Stéphane Ducasse, Luc Fabresse
- PhD in progress: Pierre Misse-Chanabier, *Modular, green, versatile Virtual Machines*, started Oct 2019, Stéphane Ducasse, Noury Bouraqadi
- PhD in progress: Carolina Hernández, *Tools for MicroKernels* Guillermo Polito and Luc Fabresse

We are collaborating in the Context of CPER Data since 2018.

### 9.1.2. CPER DATA

Participants: Marcus Denker, Stéphane Ducasse, Alex Oliveira with: L. Fabresse and N. Bouraqadi (IMT Douai)

From 2018, ongoing.

Funding to work one year on the PharoThings Platform. We are creating content for a website and a Demo in collaboration with IMT Douai.

## 9.2. National Initiatives

### 9.2.1. CEA List

Participants: Jason Lecerf, Stéphane Ducasse with Thierry Goubier (CEA List)

From 2016, PhD finished 2019.

Jason Lecerf started a shared PhD Oct 2016 and finished November 2019: *Designing Language-Agnostic Code Transformation Engines*.

## 9.3. European Initiatives

### 9.3.1. Collaborations in European Programs, Except FP7 & H2020

#### University of Novi Sad, Serbia

Participants: Stéphane Ducasse, Anne Etien, Nicolas Anquetil, Vincent Aranega

A collaboration with the University of Novi Sad, Serbia, started in 2018 with the university joining the Pharo Consortium as an academic member.

We have handed in a bilateral project (Campus France) between Novi Sad and RMOD: *An innovative visual environment in service of developer experience*. We expect results by the end of this year.

A Master thesis has been cosupervised. Nina Medic: *Graph library with layout algorithms in Pharo*.

Visitors:

- Sebastijan Kaplar [University of Novi Sad, Serbia, Aug 2019]
- Gordana Rakic [University of Novi Sad, Serbia, from Nov 2019]
- Nina Medic [University of Novi Sad, Serbia, from Jun 2019 until Jul 2019]

#### **University of Prague, Czech Republic**

Participants: Stéphane Ducasse.

From 2015, ongoing.

We are working with Dr. Robert Pergl from the University of Prague. Stéphane Ducasse gave a lecture at the University of Prague in 2018, the next lecture is planned for 2020.

#### **University of Cagliari, Italy**

Participants: Stéphane Ducasse

We are working on software engineering problems in the context of blockchain based software.

Visitor: Giuseppe Antonio Pierro [University of Cagliari, until July 2019].

#### **University of Bern, Switzerland**

Participants: Stéphane Ducasse, Marcus Denker

We are working on dynamic software update to, for example, automatically transform users of deprecated code.

Visitor: Manuel Leuenberger [University of Bern, from Sep 2019 until Nov 2019]

#### **Siemens AG, Germany**

Participants: Stéphane Ducasse, Anne Etien, Nicolas Anquetil

The Siemens Digital Industry Division approached our team to help them restructure a large legacy systems. The joined work resulted in a publication in 2019: *Decomposing God Classes at Siemens* [1].

## **9.4. International Initiatives**

### **9.4.1. Inria International Labs**

Discussions with Inria Chile have started about organizing Pharo lectures in Chile. A first visit to Inria Chile in fall 2019 did not happen due to the political situation in Chile.

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

#### **VUB Brussels, Belgium**

Participants: Guillermo Polito, Stéphane Ducasse, Marcus Denker.

Collaboration with SOFT started 2016, from 2020 Inria Lille North-European associated team funding with SOFT/VUB for 2 years.

Student: Matteo Marra, collaboration with Eliza Gonzalez Boix.

Marcus Denker gave a lecture at VUB in October 2019.

### **9.4.3. Inria International Partners**

#### **9.4.3.1. Informal International Partners**

##### **Uqbar Argentina**

Participants: Pablo Tesone, Esteban Lorenzano, Guillermo Polito, Stéphane Ducasse.

From 2015, ongoing.

We are working with the Uqbar team from different Argentinian universities. We hired three of the people: Nicolas Passerini(engineer), Esteban Lorenzano (engineer) and Pablo Tesone (PhD).

**Pharo in Research:**

Participants: Pablo Tesone, Esteban Lorenzano, Guillermo Polito, Marcus Denker, Stéphane Ducasse.  
From 2009, ongoing.

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.

## 9.5. International Research Visitors

### 9.5.1. Visits of International Scientists

- Abdelhakim Bouremel [University of Skikda, Algeria, Oct 2019]
- Mohamad Chakroun [Mar 2019]
- Victor Martín Dias [University of Chile, Chile, until Sep 2019]
- Christopher Fuhrman [École de technologie supérieure de Montréal, Canada, until Sep 2019]
- Yann-Gaël Guéhéneuc [Concordia University, Canada, from Apr 2019 until May 2019]
- Sebastijan Kaplar [University of Novi Sad, Serbia, Aug 2019]
- Manuel Leuenberger [University of Bern, Switzerland, from Sep 2019 until Nov 2019]
- Milton Mamani Torres [Object Profile SpA, Chile, Aug 2019]
- Nina Medic [University of Novi Sad, Serbia, from Jun 2019 until Jul 2019]
- Hayatou Oumarou [University of Maroua, Cameroun, from Sep 2019 until Oct 2019]
- Giuseppe Antonio Pierro [University of Cagliari, Italy, until July 2019]
- Gordana Rakic [University of Novi Sad, Serbia, from Nov 2019]
- Moussa Saker [University Badji Mokhtar-Annaba, Algeria, from Dec 2019]

#### 9.5.1.1. Internships

- Dayne Lorena Guerra Calle [Inria, from Feb 2019 until Aug 2019]
- Chia Yu Li [Inria, until Jul 2019]
- Iona Thomas [Centrale Lille, from Jul 2019 until Aug 2019]
- Oleksandr Zaitsev [Inria, until Feb 2019]

## SPIRALS Project-Team

# 9. Partnerships and Cooperations

## 9.1. Regional Initiatives

### 9.1.1. Région Hauts-de-France

#### 9.1.1.1. CIRRUS

**Participants:** Stéphanie Challita, Guillaume Fieni, Alexandre Garnier, Christophe Gourdin, Philippe Merle [contact person], Romain Rouvoy, Lionel Seinturier, Faiez Zalila.

CIRRUS is a 3-year (2017–20) joint team with the Scalair cloud operator and architect company funded by the Hauts-de-France region. The CIRRUS joint team is developing novel solutions in the domains of the on demand configuration of heterogeneous cloud resources, the management of cloud elasticity for all deployed services (SaaS, PaaS, IaaS) in order to guarantee quality of service and user quality of experience, and the taming of financial costs of cloud infrastructures.

#### 9.1.1.2. Alloy@Scale

**Participants:** Abderrahman Lahiaoui, Philippe Merle [contact person], Romain Rouvoy, Lionel Seinturier.

Alloy@Scale is a 12-month (2018–19) project funded in the context of CPER Data program. Alloy@Scale aims at overcoming the limits of the formal verification of large software systems specified with the Alloy formal specification language. For that, the program combines the Grid’5000 infrastructure and the Docker container technology.

#### 9.1.1.3. Rigorous Component-Based Design of Correct-by-Construction Software and Systems: Application to Cloud Computing

**Participants:** Simon Bliudze [contact person], Larisa Safina.

This 24-month (2019–20) project is funded in the context of the STaRS program. It aims at the development of methods and tools for rigorous design of cloud computing platforms and applications, which can be proven to be correct by construction. First results have been published in [17], [31], [3].

#### 9.1.1.4. Indoor Analytics

**Participants:** Pierre Bourhis, Remy Raes, Romain Rouvoy [contact person], Lionel Seinturier.

Indoor Analytics is a 32-month (2019–21) project funded in the context of CPER Data program. Indoor Analytics aims at collaborating with the Mapwize company on the development of novel analytics for indoor location systems. In particular, Mapwize and Spirals target the joint delivery of an open-source software solution devoted to the acquisition, storage and processing of location events at scale.

#### 9.1.1.5. COMMODE

**Participants:** Pierre Bourhis, Laurence Duchien, Clément Quinton [contact person].

COMMODE (Knowledge COMpilation for feature MODEls) is a 24-month (2019–21) project funded in the context of CPER Data program. COMMODE aims at using techniques from knowledge compilation, a subarea of artificial intelligence, for feature models, a representation of software products used in software engineering.

### 9.1.2. Inria Lille - Nord Europe

#### 9.1.2.1. North European Lab LLEX

**Participants:** Benjamin Danglot, Martin Monperrus, Lionel Seinturier [contact person].

North European Lab LLEX (2017–19) is an international initiative supported by the Inria Lille - Nord Europe Center that takes place in the context of a collaboration between Inria and KTH. LLEX deals with research on automated diagnosis and repair of software bugs. Automated software repair is the process of fixing software bugs automatically. An automated software repair system fixes software bugs with no human intervention. The goal of automated 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. This initiative led to several results that have been published [24], [21], [45], [36], [10] and to the PhD thesis of Benjamin Danglot [11] that have been defended in November 2019.

#### 9.1.2.2. ADT FingerKit

**Participants:** Antoine Canda, Walter Rudametkin Ivey [contact person], Antoine Vastel.

ADT FingerKit (2018–20) is a technology development initiative supported by the Inria Lille - Nord Europe Center that focuses on the design and development of a new and enhanced version of the **AmIUnique** platform. AmIUnique is a data collection and analysis platform to better understand, analyze and vulgarize the uses and threats of browser fingerprinting. This initiative led by Inria is a key asset to better understand novel techniques that threatens the user privacy on Internet. This ADT builds on our first results with the PhD thesis of Antoine Vastel [14].

#### 9.1.2.3. ADT e-Lens

**Participants:** Arthur d’Azémar, Guillaume Fieni, Romain Rouvoy [contact person].

ADT e-Lens (2018–20) is a technology development initiative supported by the Inria Lille - Nord Europe Center that aims at extending the **PowerAPI** energy monitoring library that we develop in the team since 2011. The extension deals with the integration of new power models (for GPU, disk, network interface), the implementation of a self-optimization algorithm, the port of the platform to embedded systems running with Raspberry Pi, ROS and Android, and the implementation of an active learning algorithm for power models. This ADT builds on our results with the defended PhD theses of Adel Nouredine [68] and Maxime Colmant [52], and with the ongoing PhD thesis of Guillaume Fieni.

## 9.2. National Initiatives

### 9.2.1. ANR

#### 9.2.1.1. ANR BottleNet

**Participants:** Romain Rouvoy [contact person], Walter Rudametkin Ivey, Lionel Seinturier.

BottleNet is a 48-month project (2015–19) funded by ANR. 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. Several results and publications have been obtained in the context of this project [6], [5], [76]. The paper [5] won the Best Paper award at the 19th International Conference on Distributed Applications and Interoperable Systems (DAIS 2019). The PhD thesis of Lakhdar Meftah [13], supervised by Romain Rouvoy and Isabelle Chrisment (Inria Nancy), was defended in December 2019 in the context of this project. This project is in relation with the Inria IPL BetterNet.

#### 9.2.1.2. ANR SATAS

**Participants:** Alexandre Garnier, Philippe Merle [contact person], Romain Rouvoy, Lionel Seinturier.

SATAS is a 48-month project (2015–20) funded by ANR. 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 their 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. Our results from this project have been published in the following papers [53], [60].

#### 9.2.1.3. ANR Headwork

**Participants:** Pierre Bourhis [contact person], Marion Tommasi.

Headwork is a 48-month project (2016–21) funded by ANR. The main objective of Headwork is to develop data-centric workflows for programming crowd sourcing systems in a flexible declarative manner. The problem of crowd sourcing systems is to fill a database with knowledge gathered by thousands or more human participants. A particular focus is to be put on the aspects of data uncertainty and for the representation of user expertise. This project is coordinated by D. Gross-Amblard from the Druid Team (Rennes 1). Other partners include the Dahu team (Inria Saclay), Sumo (Inria Bretagne), and Links (Inria Lille) with J. Nierhen and M. Sakho. Our results from this project have been published in the following paper [1].

#### 9.2.1.4. ANR Delta

**Participant:** Pierre Bourhis [contact person].

Delta is a 48-month project (2016–21) funded by ANR. The project focuses on the study of logic, transducers and automata. In particular, it aims at extending classical framework to handle input/output, quantities and data. This project is coordinated by M. Zeitoun from LaBRI. Other partners include LIF (Marseille), IRIF (Paris-Diderot), and D. Gallois from the Inria Lille Links team. Several results and publications have been obtained in the context of this project [18], [16], [28], [27].

#### 9.2.1.5. ANR CQFD

**Participant:** Pierre Bourhis [contact person].

CQFD is a 48-month project (2018–22) funded by ANR. The project focuses on the complex ontological queries over federated heterogeneous data. The project targets to set the foundations, to provide efficient algorithms, and to provide query rewriting oriented evaluation mechanisms, for ontology-mediated query answering over heterogeneous data models. This project is coordinated by Federico Ulliana from Inria Sophia Antipolis. Other partners include LaBRI, Inria Saclay, IRISA, LTCI, and LIG.

#### 9.2.1.6. ANR FP-Locker

**Participants:** Vikas Mishra, Walter Rudametkin Ivey [contact person].

FP-Locker is a 42-month project (2019–23) funded by ANR in the context of the JCJC program. This project proposes to investigate advanced browser fingerprinting as a configurable authentication mechanism. We argue that it has the potential to be the only authentication mechanism when used in very low-security, public websites; it can be used to block bots and other fraudulent users from otherwise open websites. It also has the potential to be used as a second factor authentication mechanism, or as an additional factor in Multi-Factor Authentication (MFA) schemes. Besides strengthening a session's initial authentication, it can also be used for continuous session authentication to protect against session hijacking. In many contexts, fingerprinting is fully transparent to users, meaning that contrary to authentication processes that rely on external verification cards, code generating keys, special apps, SMS verification codes, users do not have to do anything to improve their security. In more restricted contexts, administrators can enforce different policies, for example, enrolling fingerprints from devices that connect from trusted IP addresses (e.g., an internal network), and then verifying these fingerprints when the same users connect from untrusted IP addresses. Consequently, we plan to design an architecture and implement it to be able to plug the browser fingerprinting authentication process to an existing authentication system.

#### 9.2.1.7. ANR Koala

**Participants:** Pierre Bourhis, Clément Quinton [contact person].

Koala is a 42-month project (2019–23) funded by ANR in the context of the JCJC program. The project aims to deliver a series of innovative tools, methods and software to deal with the complexity of fog computing environments configurations and adaptations. In particular, we take a step back on the current limitations of existing approaches (e.g., lack of expressiveness and scalability) and address them placing knowledge as a first-class citizen. We plan to tackle configuration issues from a novel perspective in the field of variability management, using recent techniques from the area of knowledge compilation. Specifically, we will investigate the best-suited d-DNNF representation for each reasoning operation, and we plan to provide new variability modeling mechanisms (e.g., dimensions, priorities and scopes) required in a fog context. Regarding adaptation concerns, we want to leverage machine learning techniques to improve adaptation management and evolution under uncertainty, relying on a continuously enriched and reusable knowledge base. In particular, we plan to propose an approach for suggesting evolution scenarios in a predictive manner, relying on an evolution-aware knowledge base acquired at run-time through machine learning feedback.

## 9.2.2. Competitivity Clusters

### 9.2.2.1. FUI StoreConnect

**Participants:** Romain Rouvoy, Lionel Seinturier [contact person].

StoreConnect is a 36-month project (2016–19) funded by FUI and labelled by the PICOM (**Pôle des Industries du COMmerce**) competitiveness cluster. The partners are Tevolys, UbuDu (leader), Smile, STIME, Leroy Merlin, Insiteo, Inria Spirals, **Inria Fun**, **Inria Stars**. The goal of the project is to define a modular multi-sensors middleware platform for indoor geolocation. Several results and publications have been obtained in the context of this project [5], [38], [66].

## 9.2.3. Inria National Initiatives

### 9.2.3.1. Inria IPL BetterNet

**Participants:** Lakhdar Meftah, Romain Rouvoy [contact person].

BetterNet (2016–19) aims at building and delivering a scientific and technical collaborative observatory to measure and improve the Internet service access as perceived by users. In this Inria Project Lab, we will propose new original user-centered measurement methods, which will associate social sciences to better understand Internet usage and the quality of services and networks. Our observatory can be defined as a vantage point, where: (1) tools, models and algorithms/heuristics will be provided to collect data, (2) acquired data will be analyzed, and shared appropriately with scientists, stakeholders and civil society, and (3) new value-added services will be proposed to end-users. IPL BetterNet is led by Isabelle Chrisment (Inria Madynes), with the participation of the **Diana**, **Dionysos**, **Inria Chile**, **Muse**, and Spirals Inria project-teams, as well as the ARCEP French agency and the ip-label company. Our results in the context of this project have been published in [66].

## 9.2.4. CNRS Momentum

### 9.2.4.1. Manage Your Data Without Information Leakage

**Participants:** Pierre Bourhis [contact person], Louis Jachiet.

"Gérer vos données sans fuite d'information" is a 3-year (2018–20) project granted in the context of the CNRS-Momentum call for projects. Data manipulated by modern applications are stored in large databases. To protect these pieces of data, security policies limit a user's access to what she is allowed to see. However, by using the semantics of the data, a user can deduce information that she was not supposed to have access to. The goal of this project is to establish methods and tools for understanding and detecting such data leaks. Several results and publications have been obtained in the context of this project [32], [29], [30].

## 9.3. European Initiatives

### 9.3.1. FP7 & H2020 Projects

Program: H2020 ICT-10-2016.

Project acronym: STAMP.

Project title: Software Testing Amplification.

Duration: 36 months (2016–19).

Coordinator: Inria.

Other partners: ActiveEon (France), Atos (Spain), Engineering (Italy), OW2 (France), SINTEF (Norway), TellU (Norway), TU Delft (The Netherlands), XWiki (France).

Abstract: By leveraging advanced research in automatic test generation, STAMP aims at pushing automation in DevOps one step further through innovative methods of test amplification. It will reuse existing assets (test cases, API descriptions, dependency models), in order to generate more test cases and test configurations each time the application is updated. Acting at all steps of development cycle, STAMP techniques aim at reducing the number and cost of regression bugs at unit level, configuration level and production stage.

**Participants:** Benjamin Danglot, Martin Monperrus [contact person].

Program: H2020 JU Shift2Rail.

Project acronym: X2Rail-1.

Project title: Start-up activities for Advanced Signalling and Automation System.

Duration: 36 months (2016–19).

Coordinator: Siemens.

Other partners: 19 partners, among others Bombardier, Siemens, Thales, IRT Railenium.

Abstract: Our contribution to the project is focused on adaptive communication middleware for cyber-physical railway systems.

**Participants:** Lionel Seinturier [contact person].

### 9.3.2. Collaborations in European Programs, Except FP7 & H2020

Program: EUREKA Celtic-Plus.

Project acronym: SENDATE.

Project title: SEcure Networking for a DATa Center Cloud in Europe.

Duration: 36 months (2016–19).

Coordinator: Nokia.

Other partners: 50+ partners in Finland, France, Germany, Norway, and Sweden. Selected partners involved: Nokia, Orange.

Abstract: The project addresses the convergence of telecommunication networks and IT in the context of distributed data centers. We are involved in the TANDEM subproject that targets the infrastructure of such a distributed system. More specifically, we are studying new approaches in terms of software engineering and component-based solutions for enabling this convergence of network and IT.

**Participants:** Lionel Seinturier [contact person].

## 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: 2017

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 a 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. Participation in Other International Programs**

#### *9.4.2.1. Partnership for joint Curriculum Development and Research in Energy Informatics (PACE)*

**Participants:** Mohammed Chakib Belgaid, Arthur d’Azémar, Guillaume Fieni, Alexandre Garnier, Zakaria Ournani, Clément Quinton, Romain Rouvoy [contact person], Lionel Seinturier.

PACE is a 3-year (2019–21) project funded by the Research Council of Norway. The goal of the project is to establish a sustained education and research-oriented collaboration between four partner universities in energy informatics and green computing that will strengthen quality academic relations and mutually improve each other’s quality of research and researcher training both at PhD and master level. Partner universities are: University of Oslo (Norway), University of Stavanger (Norway), TU Munich (Germany), Université de Lille.

## **9.5. International Research Visitors**

### **9.5.1. Visits of International Scientists**

#### *9.5.1.1. Internships*

Jonatan Enes, PhD Student in Computer Science from University of A Coruña, visited us for 3 months from April to July.

Alejandro Grez, from Pontifical Catholic University of Chile, visited us for 1 month in April.

## DEFROST Project-Team

# 9. Partnerships and Cooperations

## 9.1. Regional Initiatives

- **INVENTOR** Innovative tool for soft robot design and its application for surgery. This project is financed by **I-Site ULNE EXPAND**, supported by “le programme d’Investissements d’Avenir” and “la Métropole Européenne de Lille”. The objective of this project is to develop an innovative tool for the facilitation of soft robot design.
- **COMOROS** Control of deformable robots for surgery Duration april 2017 to march 2020 Program: FEDER Coordinator: C. Duriez Abstract: Surgical procedures are often carried out using instruments made of stiff materials that interact with delicate biological tissues such as internal organs, blood vessel walls and small cavities. This incompatibility of stiffness is one of the sources of danger in many surgical procedures. The use of robots made of soft materials, also called soft robots, would limit such risks by reducing contact pressures and stress concentrations. Their intrinsic deformability would also increase the ability to manoeuvre in confined spaces. However, the promising concept of using soft robots for surgical procedures cannot be practically implemented, due to the lack of precise modelling and control methods for soft robots. This scientific obstacle, identified as a pending issue by major surveys in this field, becomes particularly challenging when interacting with an environment as complex as the human anatomy. Drawing on our background in soft tissue simulation, contact models, surgical applications and soft robotics, our ambition in this project is to:
  - Develop accurate and generic numerical methods for continuum mechanics, adapted to strong real-time constraints in order to demonstrate the ability to model soft mechatronics systems.
  - Reconsider parametrization methodologies of digital models of the patient anatomy through the observation of mechanical interactions with soft robots via embedded sensors and medical imaging
  - Rethink motion generation and teleoperation control with force feedback so as to be compatible with the large number of degrees of freedom of soft robots and be based on accurate, rapidly-computed deformable models and interaction models.

The project also targets the development of software with the required performance and features, as well as the experimental validation of models and methods using prototypes in realistic environments.

- The PhD Thesis of Félix Vanneste is half-funded by the Hauts-de-France region.

## 9.2. National Initiatives

- **ROBOCOP**: Robotization of Cochlear implant. This is a 4-year project, supported by the ANR (French National Agency for Research) in the framework of PRCE, starting from 1 October 2019 until 30 September 2023. ROBOCOP aims at creating a new prototype of cochlear implant, and robotize (i.e. actuate and control) its insertion process to facilitate the work of surgeon, to increase the success ratio, and to decrease the probability of trauma.
- **SIMILAR** Soft robotIcs framework for modeling, simulation and control. This project is supported by **Inria ADT**, and the objective is to design new 3D interactive software to design soft-robots. This new software will be on the top of our existing software stack relying on SOFA for all numerical simulation aspects and 3D rendering aspects.

- **Tremplin ERC** Christian Duriez received a ANR grant “tremplin ERC” (150k€) given the result obtained last year on the ERC proposal (evaluated at “grade A”). The project has allowed to allocate new resources on the developments that were presented in this ERC.

## 9.3. European Initiatives

### 9.3.1. Collaborations in European Programs, Except FP7 & H2020

Meichun Lin was doing a project belonged to Interreg - 2 Seas Mers Zeeën on Cooperate Brachytherapy(CoBra), it is a 4 years project which gathers the experts from the countries between English Channel and southern North Sea aiming on finding an advance method for curing prostate cancer. (see more details on <https://cobra-2seas.eu/>) The project is divided by several fields which are - MR compatible robot design, radiation dose measurement, steerable needle design, mimic soft-tissue (phantom) design and virtual reality real-time training tool development etc. Meichun was working on developing virtual reality real-time training tool with Defrost team. The aim is to have a interactive platform for human and the robot. By using SOFA framework to simulate the soft tissue's deformation and the interaction with needle insertion under the real-time, also with the Image modelling of MRI and soft-tissue modelling and so on and so forth.

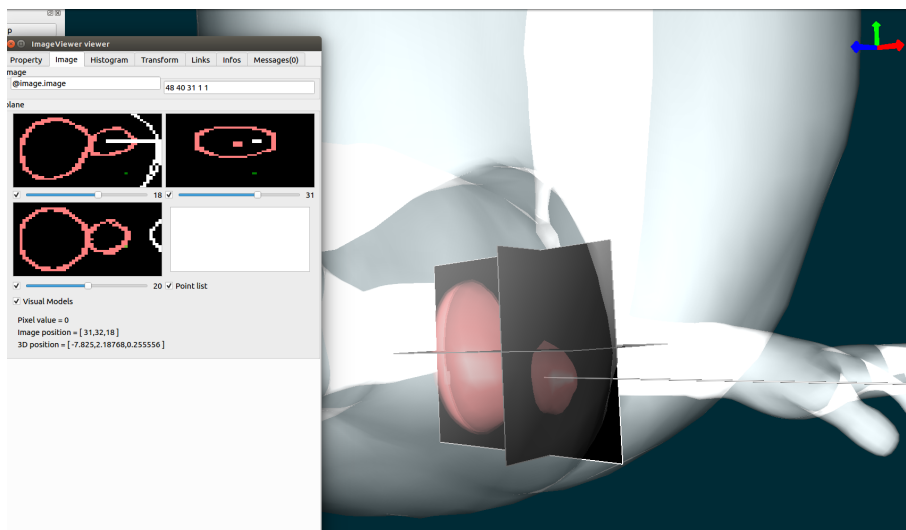


Figure 8. The virtual reality real-time simulation of the CoBra project

## 9.4. International Initiatives

### 9.4.1. Inria International Labs

#### 9.4.1.1. AC/DC: A Charm lab / Defrost team Collaboration

**Inria@SiliconValley** Associate Team

Defrost team (Deformable Robotic Software, Inria Lille – Nord Europe) and the Charm Lab (Collaborative Haptics and Robotics in Medicine Lab, Stanford University, USA) on the topic of soft robots. On this topic, these two entities are very complementary because the Charm Lab is interested in the new design, the realization, the planning and the experimentation and the Defrost team is more centered on mechanical modeling, simulation and the algorithms of control. The collaboration is based on two axes: (1) the creation of flexible robots whose position and rigidity can be controlled, (2) the mechanical modeling and simulation of a robot that navigates in an environment through growth.

- Partner: Allison Okamura at the Department of Mechanical Engineering of Stanford University, USA
- Start year: 2019
- See also: <https://team.inria.fr/defrost/collaboration-with-charm-lab-stanford/>

## **9.5. International Research Visitors**

### ***9.5.1. Visits of International Scientists***

Federico Renda from Khalifa University of Abu Dhabi visited the DEFROST team for a month to work on the implementation of a Cosserat Implementation for Beam simulation in the SOFA framework.

### ***9.5.2. Internships***

- Van Pho Nguyen, PhD Candidate from Japan Advanced Institute of Science and Technology (JAIST), visited the team for 6 months to work on the topic of underwater robots.
- Margaret Koehler from the Charm Lab, Stanford University, USA, visited the team for a month to work on the simulation of a soft haptic device.

### ***9.5.3. Visits to International Teams***

#### ***9.5.3.1. Research Stays Abroad***

- Gang Zheng has visited Nanjing University of Science and Technology (China) for 1 month in July 2019.

## LINKS Project-Team

# 9. Partnerships and Cooperations

## 9.1. Regional Initiatives

- Links is member of the CPER Data (2016-19)
- Lozano's PhD project (2016-19) is co-funded by the Region Nord-Pas de Calais
- Sakho's PhD project is co-funded by the Region Nord-Pas de Calais
- Gallot's PhD project (2017-20) is co-funded by the Region Nord-Pas de Calais
- Crosetti's PhD project (2018-21) is co-funded by the Region Haut de France. This is joined work with J. Ramon from the Inria project Magnet

## 9.2. National Initiatives

**ANR Aggreg** (2014-19): Aggregated Queries.

**Participants:** Joachim Niehren [correspondent], Aurélien Lemay, Adrien Boiret [University of Mons, Belgium], Florent Capelli.

- The coordinator is J. Niehren and the partners are the Université Paris 7 (A. Durand) including members of the Inria project DAHU (L. Ségoufin), the Université de Marseille (N. Creignou) and Université de Caen (E. Grandjean).
- Objective: the main goal of the Aggreg project is to develop efficient algorithms and to study the complexity of answering aggregate queries for databases and data streams of various kinds.

**ANR Colis** (2015-20): Correctness of Linux Scripts.

**Participants:** Joachim Niehren [correspondent], Aurélien Lemay, Sophie Tison, Adrien Boiret [University of Mons, Belgium], Vincent Hugot [INSA Centre-Val de Loire], Nicolas Bacquey [Twig], Paul Gallot, Sylvain Salvati.

- The coordinator is R. Treinen from the Université Paris 7 and the other partner is the Tocata project of Inria Saclay (C. Marché).
- Objective: This project aims at verifying the correctness of transformations on data trees defined by shell scripts for Linux software installation. The data trees here are the instance of the file system which are changed by installation scripts.

**ANR DataCert** (2015-20):

**Participants:** Iovka Boneva [correspondent], Sophie Tison, Jose Martin Lozano.

- Partners: The coordinator is E. Contejean from the Université Paris-Sud and the other partner is the Université de Lyon.
- Objective: the main goals of the Datacert project are to provide deep specification in Coq of algorithms for data integration and exchange and of algorithms for enforcing security policies, as well as to design data integration methods for data models beyond the relational data model.

**ANR Headwork** (2016-21):

**Participants:** Joachim Niehren [correspondent], Momar Sakho, Nicolas Crosetti, Florent Capelli.

- Scientific partners: The coordinateur is D. Gross-Amblard from the Druid Team (Rennes 1). Other partners include the Dahu team (Inria Saclay) and Sumo (Inria Bretagne).
- Industrial partners: Spipoll, and Foulefactory.

- Objective: The main object is to develop data-centric workflows for programming crowd sourcing systems in flexible declarative manner. The problem of crowd sourcing systems is to fill a database with knowledge gathered by thousands or more human participants. A particular focus is to be put on the aspects of data uncertainty and for the representation of user expertise.

**ANR Delta (2016-21):**

**Participants:** Joachim Niehren [correspondent], Sylvain Salvati, Aurélien Lemay, Nicolas Bacquey [Twig], Lily Gallois.

- Partners: The coordinator is M. Zeitoun from LaBRI, other partners are LIF (Marseille) and IRIF (Paris-Diderot).
- Objective: Delta is focused on the study of logic, transducers and automata. In particular, it aims at extending classical framework to handle input/output, quantities and data.

**ANR Bravas (2017-22):**

**Participant:** Sylvain Salvati [correspondent].

- Scientific Partners: The coordinator is Jérôme Leroux from LaBRI, Université de Bordeaux. The other partner is LSV, ENS Cachan.
- Objective: The goal of the BraVAS project is to develop a new and powerful approach to decide the reachability problems for Vector Addition Systems (VAS) extensions and to analyze their complexity. The ambition here is to crack with a single hammer (ideals over well-orders) several long-lasting open problems that have all been identified as a barrier in different areas, but that are in fact closely related when seen as reachability.

### 9.3. European Initiatives

**Oxford, UK:** An exchange project with the computer science lab of the University of Oxford is funded by the Université de Lille via the CRISAL Lab. Links' members produced many common publications over the years with Oxford. Links' contact is C. Paperman.

**Wroclaw, Poland:** S. Staworko has regular exchange with the University of Wroclaw. This has led to a publication at *PODS* [10] together with P. Wiecezorek.

**Saint-Petersburg, Russia:** S. Salvati and J. Niehren started a cooperation with the Saint-Petersburg State University, via a month-long visit by R. Azimov and S. Grigorev.

**Oviedo, Spain:** I. Boneva has an active cooperation with the University of Oviedo.

### 9.4. International Initiatives

#### 9.4.1. Informal International Partners

**Santiago de Chile, Chile:** S. Staworko and I. Boneva have a collaboration with C. Riveros from the Pontifical Catholic University of Chile since 2018.

## LOKI Project-Team

# 9. Partnerships and Cooperations

## 9.1. Regional Initiatives

### 9.1.1. *GeneaLire (CPER MAuVE, 2018-2020)*

**Participants:** Stéphane Huot, Thomas Pietrzak [contact person].

*Interactive tools for the interpretation of manuscripts*

The goal of this project is to design, implement and evaluate interactive tools for helping transcription of scanned handwritten documents. Current solutions focus on automatic recognition, with recent advances thanks to deep learning methods. However these solutions still require a significant learning base that has to be made by hand. Not only this means that part of the work cannot be done automatically, but it also means that this technique is not a solution for small collections of documents. The tools we propose to create will ingeniously take advantage of interactive and automatic techniques. The interactive tools include a text selection technique [32], as well as advanced annotation techniques that will support collaborative work. This tool will be invaluable for bootstrapping the transcription of large collections, as well as helping transcribing small collections. We will use user-centered design, in order to make sure the tool fits historians and genealogists activities and workflow.

Partners: Inria Saclay's AVIZ team, École Polytechnique de l'Université de Tours, Laboratoire de Démographie et d'Histoire Sociale at l'École des hautes études en sciences sociales, and Geneanet.

## 9.2. National Initiatives

### 9.2.1. ANR

#### 9.2.1.1. *TurboTouch (PRC, 2014-2019)*

**Participants:** Géry Casiez [contact person], Sylvain Malacria, Mathieu Nancel, Thomas Pietrzak.

*High-performance touch interactions*

Touch-based interactions with computing systems are greatly affected by two interrelated factors: the transfer functions applied on finger movements, and latency. This project aims at transforming the design of touch transfer functions from black art to science to support high-performance interactions. We are working on the precise characterization of the functions used and the latency observed in current touch systems. We are developing a testbed environment to support multidisciplinary research on touch transfer functions and will use this testbed to design latency reduction and compensation techniques, and new transfer functions.

Partners: Inria Lille's VALSE team (formerly NON-A) and the "Perceptual-motor behavior group" from the Institute of Movement Sciences.

Web site: <http://mjolnir.lille.inria.fr/turbotouch/>

Related publications in 2019: [13], [12]

#### 9.2.1.2. *Causality (JCJC, 2019-2023)*

**Participants:** Géry Casiez, Stéphane Huot, Sylvain Malacria, Mathieu Nancel [contact person], Philippe Schmid.

*Integrating Temporality and Causality to the Design of Interactive Systems*

The project addresses a fundamental limitation in the way interfaces and interactions are designed and even thought about today, an issue we call *procedural information loss*: once a task has been completed by a computer, significant information that was used or produced while processing it is rendered inaccessible regardless of the multiple other purposes it could serve. It hampers the identification and solving of identifiable usability issues, as well as the development of new and beneficial interaction paradigms. We will explore, develop, and promote finer granularity and better-described connections between the causes of those changes, their context, their consequences, and their timing. We will apply it to facilitate the real-time detection, disambiguation, and solving of frequent timing issues related to human reaction time and system latency; to provide broader access to all levels of input data, therefore reducing the need to "hack" existing frameworks to implement novel interactive systems; and to greatly increase the scope and expressiveness of command histories, allowing better error recovery but also extended editing capabilities such as reuse and sharing of previous actions.

Web site: <http://loki.lille.inria.fr/causality/>

#### 9.2.1.3. Discovery (JCJC, 2020-2024)

**Participant:** Sylvain Malacria [contact person].

*Promoting and improving discoverability in interactive systems*

This project addresses a fundamental limitation in the way interactive systems are usually designed, as in practice they do not tend to foster the discovery of their input methods (operations that can be used to communicate with the system) and corresponding features (commands and functionalities that the system supports). Its objective is to provide generic methods and tools to help the design of discoverable interactive systems: we will define validation procedures that can be used to evaluate the discoverability of user interfaces, design and implement novel UIs that foster input method and feature discovery, and create a design framework of discoverable user interfaces. This project investigates, but is not limited to, the context of touch-based interaction and will also explore two critical timings when the user might trigger a reflective practice on the available inputs and features: while the user is carrying her task (discovery in-action); and after having carried her task by having informed reflection on her past actions (discovery on-action). This dual investigation will reveal more generic and context-independent properties that will be summarized in a comprehensive framework of discoverable interfaces. Our ambition is to trigger a significant change in the way all interactive systems and interaction techniques, existing and new, are thought, designed, and implemented with both performance and discoverability in mind.

Web site: <http://ns.inria.fr/discovery/>

Related publications in 2019: [21].

### 9.2.2. Inria Project Labs

#### 9.2.2.1. BCI-LIFT (2015-2019)

**Participant:** Géry Casiez [contact person].

*Brain Computer Interfaces: Learning, Interaction, Feedback, Training*

The goal of this large-scale initiative is to design a new generation of non-invasive Brain-Computer Interfaces (BCI) that are easier to appropriate, more efficient, and suited for a larger number of people.

Partners: Inria's ATHENA, NEUROSYS, POTIOC, HYBRID & DEMAR teams, *Centre de Recherche en Neurosciences de Lyon* (INSERM) and INSA Rouen.

Web site: <https://bci-lift.inria.fr/>

Related publication in 2019: [24]

#### 9.2.2.2. AVATAR (2018-2022)

**Participants:** Géry Casiez, Stéphane Huot, Thomas Pietrzak [contact person].

*The next generation of our virtual selves in digital worlds*



This project aims at delivering the next generation of virtual selves, or *avatars*, in digital worlds. In particular, we want to push further the limits of perception and interaction through our avatars to obtain avatars that are better embodied and more interactive. Loki's contribution in this project consists in designing novel 3D interaction paradigms for avatar-based interaction and to design new multi-sensory feedbacks to better feel our interactions through our avatars.

Partners: Inria's GRAPHDECO, HYBRID, MIMETIC, MORPHEO & POTIOC teams, Mel Slater (Event Lab, University Barcelona, Spain), Technicolor and Faurecia.

Web site: <https://avatar.inria.fr/>

Related publication in 2019: [19], [14]

### 9.2.3. Others

#### 9.2.3.1. ParkEvolution (Carnot Inria - Carnot STAR, 2015-2019)

**Participant:** Géry Casiez [contact person].

*Longitudinal analysis of fine motor control for patients with Parkinson disease*

This project studies the fine motor control of patients with Parkinson disease in an ecological environment, at home, without the presence of experimenters. Through longitudinal studies, we collect raw information from pointing devices to create a large database of pointing behavior data. From the analysis of this big dataset, the project aims at inferring the individual's disease progression and influence of treatments.

Partners: the "Perceptual-motor behavior group" from the Institute of Movement Sciences and Hôpital de la Timone.

Web site: <http://parkevolution.org/>

#### 9.2.3.2. IRDICS (Projets Exploratifs Premier Soutien CNRS, 2018-2019)

**Participants:** Géry Casiez, Stéphane Huot, Sylvain Malacria, Thomas Pietrzak [contact person].

*Interface de recueil de données imparfaites pour le crowd-sourcing*

Many crowdsourcing studies involve asking hundreds of participants to answer questionnaires. There is typically a trade-off between precision and certitude of participants. Usually, investigators prefer participants to be certain, at the cost of precision. The idea is that the lack of precision can be compensated by the high number of answers. In this project we are interested in studying this trade-off. We performed a first study, in which we asked participants to rate their confidence in their answer. In the next studies, we will allow participants to give several answers, but make sure the right answer is among them. In the last study, participants will be able to rank their answers based on confidence.

Partners: IRISA's DRUID team.

Related publication in 2019: [31]

## 9.3. International Initiatives

### 9.3.1. Inria International Partners

#### 9.3.1.1. Informal International Partners

Andy Cockburn, University of Canterbury, Christchurch, NZ [25], [23]

Carl Gutwin, University of Saskatchewan, Saskatoon, CA [25]

Nicolai Marquardt, University College London, London, UK [18]

Antti Oulasvirta, Aalto University, Helsinki, FI

Daniel Vogel, University of Waterloo, Waterloo, CA

Audrey Girouard, Carleton University, Ottawa, CA

### 9.3.2. Participation in Other International Programs

#### 9.3.2.1. Inria International Chairs

**Expert interaction with devices for musical expression**

Marcelo M. Wanderley – *Professor at Schulich School of Music/IDMIL, McGill University (Canada)*

Period: 2017 - 2021

The main topic of this project is the expert interaction with devices for musical expression and consists of two main directions: *the design of digital musical instruments (DMIs)* and *the evaluation of interactions with such instruments*. It will benefit from the unique, complementary expertise available at the Loki Team, including the design and evaluation of interactive systems, the definition and implementation of software tools to track modifications of, visualize and haptically display data, as well as the study of expertise development within human-computer interaction contexts. The project's main goal is to bring together advanced research on devices for musical expression (IDMIL – McGill) and cutting-edge research in Human-computer interaction (Loki Team).

### **Rich, Reliable Interaction in Ubiquitous Environments**

Edward Lank – *Professor at Cheriton School of Computer Science, University of Waterloo (Canada)*

Period: 2019 - 2023

The objectives of the research program are:

1. Designing Rich Interactions for Ubiquitous and Augmented Reality Environments
2. Designing Mechanisms and Metaphors for Novices, Experts, and the Novice to Expert Transition
3. Integrating Intelligence with Human Action in Richly Augmented Environments.

#### 9.3.2.2. *Université de Lille - International Associate Laboratory*

### **Reappearing Interfaces in Ubiquitous Environments (Réapp)**

*with Edward Lank, Daniel Vogel & Keiko Katsuragawa at University of Waterloo (Canada) - Cheriton School of Computer Science*

Duration: 2019 - 2023

The LIA Réapp is an International Associated Laboratory between Loki and Cheriton School of Computer Science from the University of Waterloo in Canada. It is funded by the University of Lille to ease shared student supervision and regular inter-group contacts. The University of Lille will also provide a grant for a co-tutelle PhD thesis between the two universities.

We are at the dawn of the next computing paradigm where everything will be able to sense human input and augment its appearance with digital information without using screens, smartphones, or special glasses—making user interfaces simply disappear. This introduces many problems for users, including the discoverability of commands and use of diverse interaction techniques, the acquisition of expertise, and the balancing of trade-offs between inferential (AI) and explicit (user-driven) interactions in aware environments. We argue that interfaces must reappear in an appropriate way to make ubiquitous environments useful and usable. This project tackles these problems, addressing (1) the study of human factors related to ubiquitous and augmented reality environments, and the development of new interaction techniques helping to make interfaces reappear; (2) the improvement of transition between novice and expert use and optimization of skill transfer; and, last, (3) the question of delegation in smart interfaces, and how to adapt the trade-off between implicit and explicit interaction.

## **9.4. International Research Visitors**

### **9.4.1. Visits of International Scientists**

**Edward Lank**, Professor at the University of Waterloo, who has been awarded an Inria International Chair in our team in 2019, spent 4 months in our group this year (September to December).

**Marcelo M. Wanderley**, Professor at McGill University, who has been awarded an Inria International Chair in our team in 2017, spent 2 months in our group this year (July to August).

#### 9.4.1.1. *Internships*

**Carola Trahms**, PhD student, Christian-Albrecht University of Kiel, Sep. 2019.

## MAGNET Project-Team

# 8. Partnerships and Cooperations

## 8.1. Regional Initiatives

We participate to the *Data Advanced data science and technologies* project (CPER Data). This project is organized following three axes: internet of things, data science, high performance computing. MAGNET is involved in the data science axis to develop machine learning algorithms for big data, structured data and heterogeneous data. The project MyLocalInfo is an open API for privacy-friendly collaborative computing in the internet of things.

MAGNET also has various collaborations with research groups in linguistics and psycholinguistics at Université de Lille, in particular UMR STL (with an ongoing joint ANR project) and UMR SCALab (co-supervision of students).

## 8.2. National Initiatives

### 8.2.1. ANR Pamela (2016-2020)

**Participants:** MARC TOMMASI [correspondent], AURÉLIEN BELLET, RÉMI GILLERON, JAN RAMON, MAHSA ASADI

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

<https://project.inria.fr/pamela/>

### 8.2.2. ANR JCJC GRASP (2016-2020)

**Participants:** PASCAL DENIS [correspondent], AURÉLIEN BELLET, RÉMI GILLERON, MIKAELA KELLER, MARC TOMMASI

The GRASP project aims at designing new graph-based Machine Learning algorithms that are better tailored to Natural Language Processing structured output problems. Focusing on semi-supervised learning scenarios, we will extend current graph-based learning approaches along two main directions: (i) the use of structured outputs during inference, and (ii) a graph construction mechanism that is more dependent on the task objective and more closely related to label inference. Combined, these two research strands will provide an important step towards delivering more adaptive (to new domains and languages), more accurate, and ultimately more useful language technologies. We will target semantic and pragmatic tasks such as coreference resolution, temporal chronology prediction, and discourse parsing for which proper Machine Learning solutions are still lacking.

<https://project.inria.fr/grasp/>

### 8.2.3. ANR DEEP-Privacy (2019-2023)

**Participants:** MARC TOMMASI [correspondent], AURÉLIEN BELLET, PASCAL DENIS, JAN RAMON, BRIJ SRIVASTAVA

DEEP-PRIVACY proposes a new paradigm based on a distributed, personalized, and privacy-preserving approach for speech processing, with a focus on machine learning algorithms for speech recognition. To this end, we propose to rely on a hybrid approach: the device of each user does not share its raw speech data and runs some private computations locally, while some cross-user computations are done by communicating through a server (or a peer-to-peer network). To satisfy privacy requirements at the acoustic level, the information communicated to the server should not expose sensitive speaker information.

### 8.2.4. ANR-NFS REM (2016-2020)

**Participants:** PASCAL DENIS [correspondent], BO LI, MATHIEU DEHOUCK

With colleagues from the linguistics departments at Université de Lille and University of Neuchâtel (Switzerland), PASCAL DENIS is a member of another ANR project (REM), funded through the bilateral ANR-NFS Scheme. This project, co-headed by I. Depreatere (Université de Lille) and M. Hilpert (Neufchâtel), proposes to reconsider the analysis of English modal constructions from a multidisciplinary perspective, combining insights from theoretical, psycho-linguistic, and computational approaches.

## 8.3. European Initiatives

### 8.3.1. FP7 & H2020 Projects

**Participants:** Aurelien Bellet, Marc Tommasi, Brij Mohan Lal Srivastava.

Program: H2020 ICT-29-2018 (RIA)

Project acronym: COMPRISE

Project title: Cost-effective, Multilingual, Privacy-driven voice-enabled Services

Duration: Dec 2018 - Nov 2021

Coordinator: Emmanuel Vincent [Inria Nancy - Grand Est]

Other partners: Inria Multispeech, Ascora GmbH, Netteffective Technology SA, Rooter Analysis SL, Tilde SIA, University of Saarland

Abstract: COMPRISE will define a fully private-by-design methodology and tools that will reduce the cost and increase the inclusiveness of voice interaction technologies.

### 8.3.2. Collaborations in European Programs, Except FP7 & H2020

Program: Bilateral ANR project with Luxembourg

Project acronym: SLANT

Project title: Spin and Bias in Language Analyzed in News and Texts

Duration: Dec 2019 - June 2023

Coordinator: Philippe Muller [Université Paul Sabatier]

Other partners: IRIT (Toulouse), SnT (Luxembourg)

Abstract: There is a growing concern about misinformation or biased information in public communication, whether in traditional media or social forums. While automating fact-checking has received a lot of attention, the problem of fair information is much larger and includes more insidious forms like biased presentation of events and discussion. The SLANT project aims at characterizing bias in textual data, either intended, in public reporting, or unintended in writing aiming at neutrality. An abstract model of biased interpretation using work on discourse structure, semantics and interpretation will be complemented and concretized by finding relevant lexical, syntactic, stylistic or rhetorical differences through an automated but explainable comparison of texts with different biases on the same subject, based on a dataset of news media coverage from a diverse set of sources. We will also explore how our results can help alter bias in texts or remove it from automated representations of texts.

## 8.4. International Initiatives

### 8.4.1. Inria International Labs

#### **Inria@SiliconValley**

Associate Team involved in the International Lab:

#### 8.4.1.1. LEGO

Title: LEarning GOod representations for natural language processing

International Partner (Institution - Laboratory - Researcher):

University of Southern California (United States) - Theoretical and Empirical Data Science (TEDS) research group Department of Computer Science - Fei Sha

Start year: 2019

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

LEGO lies in the intersection of Machine Learning and Natural Language Processing (NLP). Its goal is to address the following challenges: what are the right representations for text data and how to learn them in a robust and transferable way? How to apply such representations to solve real-world NLP tasks, specifically in scenarios where linguistic resources are scarce? The past years have seen an increasing interest in learning continuous vectorial embeddings, which can be trained together with the prediction model in an end-to-end fashion, as in recent sequence-to-sequence neural models. However, they are unsuitable to low-resource languages as they require massive amounts of data to train. They are also very prone to overfitting, which makes them very brittle, and sensitive to bias present in the original text as well as to confounding factors such as author attributes. LEGO strongly relies on the complementary expertise of the two partners in areas such as representation learning, structured prediction, graph-based learning, multi-task/transfer learning, and statistical NLP to offer a novel alternative to existing techniques. Specifically, we propose to investigate the following two research directions: (a) optimize the representations to make them robust to bias and adversarial examples, and (b) learn transferable representations across languages and domains, in particular in the context of structured prediction problems for low-resource languages. We will demonstrate the usefulness of the proposed methods on several NLP tasks, including multilingual dependency parsing, machine translation, question answering and text summarization.

### 8.4.2. Inria Associate Teams Not Involved in an Inria International Labs

North-European Associate Team PAD-ML: Privacy-Aware Distributed Machine Learning.

International Partner: the PPDA team at the Alan Turing Institute.

Start year: 2018

In the context of increasing legislation on data protection (e.g., the recent GDPR), an important challenge is to develop privacy-preserving algorithms to learn from datasets distributed across multiple data owners who do not want to share their data. The goal of this joint team is to devise novel privacy-preserving, distributed machine learning algorithms and to assess their performance and guarantees in both theoretical and practical terms.

## 8.5. International Research Visitors

### 8.5.1. Visits of International Scientists

Several international researchers have been invited to give a talk at the MAGNET seminar:

- A. Korba (University College London, UK): Two families of (non-parametric) methods for label ranking
- M. Perrot (Max Planck Institute, Germany): Comparison-Based Learning: Hierarchical Clustering and Classification

## **8.5.2. Visits to International Teams**

### *8.5.2.1. Research Stays Abroad*

- FABIO VITALE was on leave at Department of Computer Science of Sapienza University (Rome, Italy) in the Algorithms Randomization Computation group with Prof. Alessandro Panconesi and Prof. Flavio Chierichetti. His current work on machine learning in graphs and published the following papers [6], [12], [10].
- AURÉLIEN BELLET and CÉSAR SABATER visited the Alan Turing Institute (London, UK) for one week in March 2019. They worked with Adrià Gascón, Brooks Paige, Daphne Ezer and Matt Kusner on privacy-preserving machine learning and privacy attacks in genomics.