# Activity Report 2015

# Section Software

ALGORITHMICS, PROGRAMMING, SOFTWARE AND ARCHITECTURE

APPLIED MATHEMATICS, COMPUTATION AND SIMULATION

DIGITAL HEALTH, BIOLOGY AND EARTH

NETWORKS, SYSTEMS AND SERVICES, DISTRIBUTED COMPUTING

PERCEPTION, COGNITION AND INTERACTION

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

# 6. New Software and Platforms

## 6.1. Location Guard

**Participants:**  Konstantinos Chatzikokolakis [correspondant], Marco Stronati.

https://github.com/chatziko/location-guard

The purpose of Location Guard is to protect the user's location during the use of a location-based service, in an easy and intuitive way that makes it available to the general public. Various modern applications, running either on smartphones or on the web, allow third parties to obtain the user's location. A smartphone application can obtain this information from the operating system using a system call, while web application obtain it from the browser using a JavaScript call.

Although both mobile operating systems and browsers require the user's permission to disclose location information, the user faces an "all-or-nothing" choice: either disclose his exact location and give up his privacy, or stop using the application. This forces many users to disclose their location, although ideally they would like to enjoy some privacy.

The API level of a browser or an operating system is an ideal place for integrating a location obfuscation technique, in a way that is easy to understand for the average user, and readily available to all applications. When an application asks for the user's location, the browser or operating system can ask the user's permission, but including the option to provide an obfuscated location instead of the real one! Different levels of obfuscation can be also offered, so that the user can chose to provide more accurate location to applications that really need it, and more noisy location to those that don't.

In 2015, Location Guard matured with several additions and fixes throughout the year, and was selected by Mozilla as the pick of the month for June 2015, confirming the users' general interest in location privacy.

Moreover in 2015 we set the foundations for actively using Location Guard as a platform for performing research on location privacy. Since location data are sensitive, since the creation of Location Guard we chose to collect no data whatsoever from the users. However, such data are invaluable for research purposes. As a consequence, we created a framework for *locally* collecting data at the user's machine, perform an analysis also locally, and collect back only the results of the analysis for research purposes.

## GEOMETRICA Project-Team

# 6. New Software and Platforms

## 6.1. GUDHI

Geometric Understanding in Higher Dimensions

SCIENTIFIC DESCRIPTION

The GUDHI open source library will provide the central data structures and algorithms that underly applications in geometry understanding in higher dimensions. It is intended to both help the development of new algorithmic solutions inside and outside the project, and to facilitate the transfer of results in applied fields.

FUNCTIONAL DESCRIPTION

The current release of the GUDHI library includes: – Data structures to represent, construct and manipulate simplicial complexes. – Algorithms to compute persistent homology and multi-field persistent homology. – Simplification methods via implicit representations. - A graphical user interface and several examples and datasets.

It also has improved performance, portability and documentation.

- Participants: Jean-Daniel Boissonnat, Marc Glisse, Anatole Moreau, Vincent Rouvreau and David Salinas
- Contact: Jean-Daniel Boissonnat
- URL: https://project.inria.fr/gudhi/software/

## 6.2. CGAL dD Triangulations

CGAL module: Triangulations in any dimension

KEYWORDS: Triangulation - Delaunay triangulation
FUNCTIONAL DESCRIPTION

This package of CGAL (Computational Geometry Algorithms Library, http://www.cgal.org) allows to compute triangulations and Delaunay triangulations in any dimension. Those triangulations are built incrementally and can be modified by insertion or removal of vertices.

- Participants: Samuel Hornus, Olivier Devillers and Clément Jamin
- Contact: Clément Jamin
- URL: http://doc.cgal.org/4.6/Triangulation/

## 6.3. CGAL Kernel_d

CGAL module: High-dimensional kernel Epick_d

FUNCTIONAL DESCRIPTION

Several functions were added in release 4.7 in preparation for a future alpha-complex implementation.

- Participants: Marc Glisse
- Contact: Marc Glisse
- URL: http://doc.cgal.org/4.7/Kernel_d/

## 6.4. R package TDA

Topological Data Analysis package for the R software

FUNCTIONAL DESCRIPTION

the R package TDA provides some tools for Topological Data Analysis. In particular, it includes implementations of functions that, given some data, provide topological information about the underlying space, such as the distance function, the distance to a measure, the kNN density estimator, the kernel density estimator, and the kernel distance.

- Participants: Clément Maria, Vincent Rouvreau
- Contact: Vincent Rouvreau
- URL: https://cran.r-project.org/web/packages/TDA/index.html

## 6.5. cgal Periodic Triangulations and Meshes

The CGAL library offers a package to compute the 3D periodic Delaunay triangulation of a point set in $\mathbb{R}^3$, more precisely the Delaunay triangulation of a point set in the 3-dimensional flat torus with cubic domain [49]. The package has been used in various fields. [0]

We have been extending this package in three directions:

First, a few new small functions have been added to the Delaunay triangulation class and integrated in CGAL 4.7.

We have developed and documented some new classes allowing to compute *weighted* periodic Delaunay triangulations. They have been submitted to the CGAL editorial board and accepted for inclusion in CGAL. The code still needs some polishing, and the testsuite must be completed, before a public distribution in CGAL.

We have continued our work to use this package together with the 3D mesh generation package of CGAL [48], in order to propose a construction of meshes of periodic volumes. Although last year's preliminary results were already convincing [50], [51], the work is not ready yet for being submitted to CGAL: the code requires to be completed, documented, and extensively tested.

- Participant : Aymeric Pellé
- Contact: Monique Teillaud (Vegas project-team)
- This work was done in the framework of the Inria ADT *(Action de Développement Technologique)* OrbiCGAL http://www.loria.fr/~teillaud/ADT-OrbiCGAL/

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[0]see http://www.cgal.org/projects.html

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

# 6. New Software and Platforms

## 6.1. Fast Compact Diffie-Hellman

KEYWORD: Cryptography

FUNCTIONAL DESCRIPTION

A competitive, high-speed, open implementation of the Diffie–Hellman protocol, targeting the 128-bit security level on Intel platforms. This download contains Magma files that demonstrate how to compute scalar multiplications on the x-line of an elliptic curve using endomorphisms. This accompanies the EuroCrypt 2014 paper by Costello, Hisil and Smith, the full version of which can be found here: http://eprint.iacr.org/2013/692 . The corresponding SUPERCOP-compatible crypto_dh application can be downloaded from http://hhisil.yasar.edu.tr/files/hisil20140318compact.tar.gz .

- Participant: Benjamin Smith
- Contact: Benjamin Smith
- URL: http://research.microsoft.com/en-us/downloads/ef32422a-af38-4c83-a033-a7aafbc1db55/

## 6.2. Platforms

### 6.2.1. ACTIS: Algorithmic Coding Theory in Sage

FUNCTIONAL DESCRIPTION

The aim of this project is to vastly improve the state of the error correcting library in Sage. The existing library does not present a good and usable API, and the provided algorithms are very basic, irrelevant, and outdated. We thus had two directions for improvement:

1. renewing the APIs to make them actually usable by researchers, and
2. incorporating efficient programs for decoding, like J. Nielsen's CodingLib, which contains many new algorithms.

After a year on the project, which started October 1st, 2014, we have been able to completely rethink and rewrite the API to a new structure able to support many mathematical constructions and integrate it in Sage. We also implemented numerous code classes and decoding algorithms, including cyclic codes over any finite field and list decoding of GRS codes, which are not available in Maple, Magma and Mathematica. As integrating code in Sage is a slow process, which requires external developers, we attended two Sage workshops (Sage Days 66 in Liège and Sage Days 70 in Berkeley) and welcomed one at Inria Saclay http://wiki.sagemath.org/GroupeUtilisateursParis#mercredi-1er-juillet-2015-module-de-codage-actis-pour-sage to spread the word on the project and meet the main Sage developers. We're now trusted members of the community, and we were able to integrate several patches in Sage.

- Contact: David Lucas
- URL: https://bitbucket.org/lucasdavid/sage_coding_project/wiki/Home
- One can check a full list of accepted and pending ACTIS patches for Sage here : http://trac.sagemath.org/ticket/18846.

<span style="color:red">**MEXICO Project-Team**</span>

# 6. New Software and Platforms

## 6.1. General Remark

The team's software and platform are the same as in 2014, namely

- <span style="color:red">COSMOS</span>,
- <span style="color:red">MOLE</span>,
- <span style="color:red">CosyVerif</span>;

no major changes have occurred in 2015.

<span style="color:red">**PARSIFAL Project-Team**</span>

# 6. New Software and Platforms

## 6.1. Abella

FUNCTIONAL DESCRIPTION

Abella is an interactive theorem prover for reasoning about computations given as relational specifications. Abella is particuarly well suited for reasoning about binding constructs.

In 2015, Abella has been extended with

- support for polymorphic definitions and theorems;
- schemas and automatically derived theorems about them;
- the ability to record and replay automated search;
- a number of new examples from process calculi, including a contributed example from Horace Blanc about relating the $\pi$-calculus and the $\lambda$-calculus.

One further development is that Abella can now be compiled into JavaScript and run completely inside any modern browser, thanks to the `js_of_ocaml` compiler from OCaml bytecode to JavaScript. We expect this to become rather crucial in popularization of Abella, particularly in a pedagogical context, since it does not require any local software installation—just a modern web browser.

- Participants: Dale Miller, Kaustuv Chaudhuri, Horace Blanc
- Partner: Department of Computer Science and Engineering, University of Minnesota
- Contact: Kaustuv Chaudhuri
- URL: http://abella-prover.org/
- Online version: http://abella-prover.org/tutorial/try

## 6.2. Bedwyr

Bedwyr - A proof search approach to model checking
FUNCTIONAL DESCRIPTION

Bedwyr is a generalization of logic programming that allows model checking directly on syntactic expression possibly containing bindings. This system, written in OCaml, is a direct implementation of two recent advances in the theory of proof search.

It is possible to capture both finite success and finite failure in a sequent calculus. Proof search in such a proof system can capture both "may" and "must" behavior in operational semantics. Higher-order abstract syntax is directly supported using term-level lambda-binders, the nabla quantifier, higher-order pattern unification, and explicit substitutions. These features allow reasoning directly on expressions containing bound variables.

The distributed system comes with several example applications, including the finite pi-calculus (operational semantics, bisimulation, trace analyses, and modal logics), the spi-calculus (operational semantics), value-passing CCS, the lambda-calculus, winning strategies for games, and various other model checking problems.

- Participant: Roberto Blanco Martinez
- Contact: Quentin Heath
- URL: http://slimmer.gforge.inria.fr/bedwyr/

## 6.3. Checkers

Checkers - A proof verifier

KEYWORDS: Proof - Certification - Verification
FUNCTIONAL DESCRIPTION

Checkers is a tool in Lambda-prolog for the certification of proofs. Checkers consists of a kernel which is based on LKF and is based on the notion of ProofCert.

- Participants: Tomer Libal and Giselle Reis
- Contact: Tomer Libal
- URL: https://github.com/proofcert/checkers

## 6.4. Mætning

KEYWORDS:  Automated Theorem Proving - Intuitionistic Logic

FUNCTIONAL DESCRIPTION

Mætning is an automated theorem prover for first-order intuitionistic logic that is particularly suited for efficiently finding *disproofs*, i.e., for establishing that a given goal query is not provable. It is based on the focused inverse method  [54] [74], but augmented by a mechanism for building finite approximations for infinite search spaces that nevertheless guarantee soundness of a disproof.

Mætning has been released under the terms of the MIT license.

- Participants: Taus Brock-Nannestad, Kaustuv Chaudhuri
- Contact: Kaustuv Chaudhuri
- URL: https://github.com/chaudhuri/maetning

## 6.5. Psyche

KEYWORDS: Proof-search - Correct-by-construction approach - Programmable Theorem Proving
FUNCTIONAL DESCRIPTION

Psyche is a modular platform for automated or interactive theorem proving, programmed in OCaml and built on an architecture (similar to LCF) where a small kernel interacts with plugins and decision procedures. The major effort in 2015 was a complete redesign of its architecture to allow the safe cooperation of various procedures (for e.g. different theories).

- Participants: Assia Mahboubi, Jean-Marc Notin and Stéphane Graham-Lengrand
- Contact: Assia Mahboubi and Stéphane Graham-Lengrand
- URL: http://www.lix.polytechnique.fr/~lengrand/Psyche/

<div align="center">**POSTALE Team**</div>

# 5. New Software and Platforms

## 5.1. Boost.SIMD

FUNCTIONAL DESCRIPTION

Boost.SIMD provides a portable way to vectorize computation on Altivec, SSE or AVX while providing a generic way to extend the set of supported functions and hardwares.

- Contact: Joël Falcou
- URL: http://www.github.com/MetaScale/nt2

## 5.2. CovTrack

FUNCTIONAL DESCRIPTION

CovTrack: agile realtime multi-target tracking algorithm.

- Contact: Lionel Lacassagne

## 5.3. Dohko

FUNCTIONAL DESCRIPTION

Dohko is a goal-oriented cloud architecture that aims to simplify the cloud for the users through a declarative strategy. It implements the autonomic properties: self-configuration, self-healing, and context-awareness. In Dohko, the users specify the applications and the requirements (e.g., number of CPU cores, maximal financial cost per hour, among others), and the system automatically (a) selects the resources (i.e., VMs) that meet the constraints, (b) configures and installs the applications in the clouds, (c) handles resource failures, and (d) executes the applications.

- Contact: Alessandro Ferreira Leite
- URL: http://dohko.io/

## 5.4. Molly

FUNCTIONAL DESCRIPTION

Using Polly extension, the LLVM compiler framework is able to automatically parallelize general programs for shared memory threading for by exploiting the powerful analysis and transformations of the polyhedral model.

Molly adds the ability to manage distributed memory using the polyhedral model and is therefore able to automatically parallelize even for the largest of today's supercomputer. Once the distribution of data between the computer's nodes is known, Molly determines the values that are required to be transferred between the nodes and chunks them into as few messages as possible. It also keeps tracks of the buffers required by the MPI interface. Transfers are asynchronous such that further computations take place while the data is being transferred.

- Contact: Michael Kruse

## 5.5. MyNRC

FUNCTIONAL DESCRIPTION

MyNRC is multi-plateform library that can handle SSE, AVX, Neon and ST VECx registers.

- Contact: Lionel Lacassagne

## 5.6. NT2

Numerical Template Toolbox
FUNCTIONAL DESCRIPTION

The Numerical Template Toolbox (NT2) is an Open Source C++ library aimed at simplifying the development, debugging and optimization of high-performance computing applications by providing a Matlab like syntax that eases the transition between prototype and actual application.

- Participants: Joël Falcou, Pierre Estérie and Ian Masliah
- Contact: Joël Falcou
- URL: https://github.com/jfalcou/nt2

<span style="color:red">**SPECFUN Project-Team**</span>

# 5. New Software and Platforms

## 5.1. Coq

KEYWORDS: Proof - Certification - Formalisation
FUNCTIONAL DESCRIPTION

Coq provides both a dependently-typed functional programming language and a logical formalism, which, altogether, support the formalisation of mathematical theories and the specification and certification of properties of programs. Coq also provides a large and extensible set of automatic or semi-automatic proof methods. Coq's programs are extractible to OCaml, Haskell, Scheme, ...

- Participants: Benjamin Grégoire, Enrico Tassi, Bruno Barras, Yves Bertot, Pierre Boutillier, Xavier Clerc, Pierre Courtieu, Maxime Denes, Stéphane Glondu, Vincent Gross, Hugo Herbelin, Pierre Letouzey, Assia Mahboubi, Julien Narboux, Jean-Marc Notin, Christine Paulin-Mohring, Pierre-Marie Pédrot, Loïc Pottier, Matthias Puech, Yann Régis-Gianas, François Ripault, Matthieu Sozeau, Arnaud Spiwack, Pierre-Yves Strub, Benjamin Werner, Guillaume Melquiond and Jean-Christophe Filliâtre
- Partners: CNRS - Université Paris-Sud - ENS Lyon - Université Paris-Diderot
- Contact: Hugo Herbelin
- URL: <span style="color:red">http://coq.inria.fr/</span>

## 5.2. DynaMoW

Dynamic Mathematics on the Web
FUNCTIONAL DESCRIPTION

Programming tool for controlling the generation of mathematical websites that embed dynamical mathematical contents generated by computer-algebra calculations. Implemented in OCaml.

- Participants: Frédéric Chyzak, Alexis Darrasse and Maxence Guesdon
- Contact: Frédéric Chyzak
- URL: <span style="color:red">http://ddmf.msr-inria.inria.fr/DynaMoW/</span>

## 5.3. ECS

Encyclopedia of Combinatorial Structures
FUNCTIONAL DESCRIPTION

On-line mathematical encyclopedia with an emphasis on sequences that arise in the context of decomposable combinatorial structures, with the possibility to search by the first terms in the sequence, keyword, generating function, or closed form.

- Participants: Stéphanie Petit, Alexis Darrasse, Frédéric Chyzak and Maxence Guesdon
- Contact: Frédéric Chyzak
- URL: <span style="color:red">http://algo.inria.fr/encyclopedia/</span>

## 5.4. Math-Components

Mathematical Components library
FUNCTIONAL DESCRIPTION

The Mathematical Components library is a set of Coq libraries that cover the mechanization of the proof of the Odd Order Theorem.

- Participants: Andrea Asperti, Jeremy Avigad, Yves Bertot, Cyril Cohen, François Garillot, Georges Gonthier, Stéphane Le Roux, Assia Mahboubi, Sidi Ould Biha, Ioana Pasca, Laurence Rideau, Alexey Solovyev, Enrico Tassi and Russell O'connor
- Contact: Assia Mahboubi
- URL: http://www.msr-inria.fr/projects/mathematical-components-2/

## 5.5. Ring

FUNCTIONAL DESCRIPTION

Coq normalization tool and decision procedure for expressions in commutative ring theories. Implemented in Coq and OCaml. Integrated in the standard distribution of the Coq proof assistant since 2005.

- Contact: Assia Mahboubi

## 5.6. Ssreflect

FUNCTIONAL DESCRIPTION

Ssreflect is a tactic language extension to the Coq system, developed by the Mathematical Components team.

- Participants: Cyril Cohen, Yves Bertot, Laurence Rideau, Enrico Tassi, Laurent Théry, Assia Mahboubi and Georges Gonthier
- Contact: Yves Bertot
- URL: http://ssr.msr-inria.inria.fr/

# TOCCATA Project-Team

# 6. New Software and Platforms

## 6.1. Alt-Ergo

Automated theorem prover for software verification
KEYWORDS: Software Verification - Automated theorem proving
FUNCTIONAL DESCRIPTION

Alt-Ergo is an automatic solver of formulas based on SMT technology. It is especially designed to prove mathematical formulas generated by program verification tools, such as Frama-C for C programs, or SPARK for Ada code. Initially developed in Toccata research team, Alt-Ergo's distribution and support are provided by OCamlPro since September 2013.

- Participants: Sylvain Conchon, Évelyne Contejean, Mohamed Iguernelala, Stéphane Lescuyer and Alain Mebsout
- Partner: OCamlPro
- Contact: Sylvain Conchon
- URL: http://alt-ergo.lri.fr

## 6.2. CFML

Interactive program verification using characteristic formulae
KEYWORDS: Coq - Software Verification - Deductive program verification - Separation Logic
FUNCTIONAL DESCRIPTION

The CFML tool supports the verification of OCaml programs through interactive Coq proofs. CFML proofs establish the full functional correctness of the code with respect to a specification. They may also be used to formally establish bounds on the asymptotic complexity of the code. The tool is made of two parts: on the one hand, a characteristic formula generator implemented as an OCaml program that parses OCaml code and produces Coq formulae, and, on the other hand, a Coq library that provides notation and tactics for manipulating characteristic formulae interactively in Coq.

- Contact: Arthur Charguéraud
- URL: http://www.chargueraud.org/softs/cfml/

## 6.3. Coq

KEYWORDS: Proof - Certification - Formalisation
FUNCTIONAL DESCRIPTION

Coq provides both a dependently-typed functional programming language and a logical formalism, which, altogether, support the formalisation of mathematical theories and the specification and certification of properties of programs. Coq also provides a large and extensible set of automatic or semi-automatic proof methods. Coq's programs are extractible to OCaml, Haskell, Scheme, ...

- Participants: Benjamin Grégoire, Enrico Tassi, Bruno Barras, Yves Bertot, Pierre Boutillier, Xavier Clerc, Pierre Courtieu, Maxime Denes, Stéphane Glondu, Vincent Gross, Hugo Herbelin, Pierre Letouzey, Assia Mahboubi, Julien Narboux, Jean-Marc Notin, Christine Paulin-Mohring, Pierre-Marie Pédrot, Loïc Pottier, Matthias Puech, Yann Régis-Gianas, François Ripault, Matthieu Sozeau, Arnaud Spiwack, Pierre-Yves Strub, Benjamin Werner, Guillaume Melquiond and Jean-Christophe Filliâtre
- Partners: CNRS - Université Paris-Sud - ENS Lyon - Université Paris-Diderot
- Contact: Hugo Herbelin
- URL: http://coq.inria.fr/

## 6.4. CoqInterval

Interval package for Coq
KEYWORDS: Interval arithmetic - Coq
FUNCTIONAL DESCRIPTION

CoqInterval is a library for the proof assistant Coq. CoqInterval provides a method for proving automatically the inequality of two expression of real values.

The Interval package provides several tactics for helping a Coq user to prove theorems on enclosures of real-valued expressions. The proofs are performed by an interval kernel which relies on a computable formalization of floating-point arithmetic in Coq.

The Marelle team developed a formalization of rigorous polynomial approximation using Taylor models inside the Coq proof assistant, with a special focus on genericity and efficiency for the computations. In 2014, this library has been included in CoqInterval.

- Participants: Guillaume Melquiond, Érik Martin-Dorel, Nicolas Brisebarre, Miora Maria Joldes, Micaela Mayero, Jean-Michel Muller, Laurence Rideau and Laurent Théry
- Contact: Guillaume Melquiond
- URL: http://coq-interval.gforge.inria.fr/

## 6.5. Coquelicot

The Coquelicot library for real analysis in Coq
KEYWORDS: Coq - Real analysis
FUNCTIONAL DESCRIPTION

Coquelicot is library aimed for supporting real analysis in the Coq proof assistant. It is designed with three principles in mind. The first is the user-friendliness, achieved by implementing methods of automation, but also by avoiding dependent types in order to ease the stating and readability of theorems. This latter part was achieved by defining total function for basic operators, such as limits or integrals. The second principle is the comprehensiveness of the library. By experimenting on several applications, we ensured that the available theorems are enough to cover most cases. We also wanted to be able to extend our library towards more generic settings, such as complex analysis or Euclidean spaces. The third principle is for the Coquelicot library to be a conservative extension of the Coq standard library, so that it can be easily combined with existing developments based on the standard library.

- Participants: Sylvie Boldo, Catherine Lelay and Guillaume Melquiond
- Contact: Sylvie Boldo
- URL: http://coquelicot.saclay.inria.fr/

## 6.6. Cubicle

The Cubicle model checker modulo theories
KEYWORDS: Model Checking - Software Verification
FUNCTIONAL DESCRIPTION

Cubicle is an open source model checker for verifying safety properties of array-based systems, which corresponds to a syntactically restricted class of parametrized transition systems with states represented as arrays indexed by an arbitrary number of processes. Cache coherence protocols and mutual exclusion algorithms are typical examples of such systems.

- Participants: Sylvain Conchon and Alain Mebsout
- Contact: Sylvain Conchon
- URL: http://cubicle.lri.fr/

## 6.7. Flocq

The Flocq library for formalizing floating-point arithmetic in Coq
KEYWORDS: Floating-point - Arithmetic code - Coq
FUNCTIONAL DESCRIPTION

The Flocq library for the Coq proof assistant is a comprehensive formalization of floating-point arithmetic: core definitions, axiomatic and computational rounding operations, high-level properties. It provides a framework for developers to formally certify numerical applications.

Flocq is currently used by the CompCert certified compiler for its support of floating-point computations.

- Participants: Guillaume Melquiond and Sylvie Boldo
- Contact: Sylvie Boldo
- URL: http://flocq.gforge.inria.fr/

## 6.8. Gappa

The Gappa tool for automated proofs of arithmetic properties
KEYWORDS: Floating-point - Arithmetic code - Software Verification - Constraint solving
FUNCTIONAL DESCRIPTION

Gappa is a tool intended to help verifying and formally proving properties on numerical programs dealing with floating-point or fixed-point arithmetic. It has been used to write robust floating-point filters for CGAL and it is used to certify elementary functions in CRlibm. While Gappa is intended to be used directly, it can also act as a backend prover for the Why3 software verification plateform or as an automatic tactic for the Coq proof assistant.

- Contact: Guillaume Melquiond
- URL: http://gappa.gforge.inria.fr/

## 6.9. Why3

The Why3 environment for deductive verification
KEYWORDS: Formal methods - Trusted software - Software Verification - Deductive program verification
FUNCTIONAL DESCRIPTION

Why3 is an environment for deductive program verification. It provides a rich language for specification and programming, called WhyML, and relies on external theorem provers, both automated and interactive, to discharge verification conditions. Why3 comes with a standard library of logical theories (integer and real arithmetic, Boolean operations, sets and maps, etc.) and basic programming data structures (arrays, queues, hash tables, etc.). A user can write WhyML programs directly and get correct-by-construction OCaml programs through an automated extraction mechanism. WhyML is also used as an intermediate language for the verification of C, Java, or Ada programs.

- Participants: Jean-Christophe Filliâtre, Claude Marché, Guillaume Melquiond, Andriy Paskevych, François Bobot, Martin Clochard and Levs Gondelmans
- Partners: CNRS - Université Paris-Sud
- Contact: Claude Marché
- URL: http://why3.lri.fr/

<span style="color:red">**COMMANDS Project-Team**</span>

# 6. New Software and Platforms

## 6.1. BOCOP

Boite à Outils pour le Contrôle OPtimal

KEYWORDS: Energy management - Numerical optimization - Biology - Identification - Dynamic Optimization - Transportation

FUNCTIONAL DESCRIPTION

Bocop is an open-source toolbox for solving optimal control problems, with collaborations with industrial and academic partners. Optimal control (optimization of dynamical systems governed by differential equations) has numerous applications in transportation, energy, process optimization, energy and biology. Bocop includes a module for parameter identification and a graphical interface, and runs under Linux / Windows / Mac.

- Participants: Joseph Frédéric Bonnans, Pierre Martinon, Olivier Tissot and Benjamin Heymann
- Contact: Pierre Martinon
- URL: <span style="color:red">http://bocop.org</span>

## 6.2. Bocop Avion

KEYWORDS: Optimization - Aeronautics
FUNCTIONAL DESCRIPTION

Optimize the climb speeds and associated fuel consumption for the flight planning of civil airplanes.

- Participants: Joseph Frédéric Bonnans, Pierre Martinon, Stéphan Maindrault, Cindie Andrieu, Pierre Jouniaux and Karim Tekkal
- Contact: Pierre Martinon

## 6.3. Bocop HJB

- Participants: Joseph Frédéric Bonnans, Pierre Martinon, Benjamin Heymann and Olivier Tissot
- Contact: Joseph Frédéric Bonnans
- URL: <span style="color:red">http://bocop.org</span>

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

# 5. New Software and Platforms

## 5.1. FVforBlochTorrey

FUNCTIONAL DESCRIPTION

We developed two numerical codes to solve the multiple-compartments Bloch-Torrey partial differential equation in 2D and 3D to simulate the water proton magnetization of a sample under the influence of diffusion-encoding magnetic field gradient pulses.

We coupled the spatial discretization with an efficient time discretization adapted to diffusive problems called the (explicit) Runge-Kutta-Chebyshev method.

The version of the code using Finite Volume discretization on a Cartesian grid is complete (written by Jing-Rebecca Li). The version of the code using linear Finite Elements discretization is complete (written by Dang Van Nguyen and Jing-Rebecca Li).

- Contact: Jing Rebecca Li
- URL: http://www.cmap.polytechnique.fr/~jingrebeccali/

## 5.2. InvGIBC

A FreeFem++ routines for solving inverse Maxwell's problem for 3D shape identification using a gradient descent method.

- Contact: Houssem Haddar
- URL: http://www.cmap.polytechnique.fr/~haddar/

## 5.3. RODIN

FUNCTIONAL DESCRIPTION

In the framework of the RODIN project we continue to develop with our software partner ESI the codes Topolev and Geolev for topology and geometry shape optimization of mechanical structures using the level set method.

- Contact: Grégoire Allaire
- URL: http://www.cmap.polytechnique.fr/~allaire/

## 5.4. samplings-2d

This software solves forward and inverse problems for the Helmholtz equation in 2-D.
FUNCTIONAL DESCRIPTION

This software is written in Fortran 90 and is related to forward and inverse problems for the Helmholtz equation in 2-D. It includes three independent components. The first one solves to scattering problem using integral equation approach and supports piecewise-constant dielectrics and obstacles with impedance boundary conditions. The second one contains various samplings methods to solve the inverse scattering problem (LSM, RGLSM(s), Factorization, MuSiC) for near-field or far-field setting. The third component is a set of post processing functionalities to visualize the results

- Contact: Houssem Haddar
- URL: http://sourceforge.net/projects/samplings-2d/

## 5.5. Samplings-3d

FUNCTIONAL DESCRIPTION

This software is written in Fortran 90 and is related to forward and inverse problems for the Helmholtz equation in 3-D. It contains equivalent functionalities to samplings-2d in a 3-D setting.

- Contact: Houssem Haddar
- URL: http://www.cmap.polytechnique.fr/~haddar/

# DISCO Project-Team

# 6. New Software and Platforms

## 6.1. OreAlgebraicAnalysis

FUNCTIONAL DESCRIPTION

OreAlgebraicAnalysis is a Mathematica implementation of algorithms available in the OreModules and the OreMorphisms packages (developed in Maple). OreAlgebraicAnalysis is based on the implementation of Grobner bases over Ore algebras available in the Mathematica HolonomicFunctions package developed by Christoph Koutschan (RICAM). OreAlgebraicAnalysis can handle larger classes of Ore algebras than the ones accessible in Maple, and thus we can study larger classes of linear functional systems. Finally, Mathematica internal design allows us to consider classes of systems which could not easily be considered in Maple such as generic linearizations of nonlinear functional systems defined by explicit nonlinear equations and systems containing transcendental functions (e.g., trigonometric functions, special functions). This package has been developed within the PHC Parrot project CASCAC.

- Participants: Alban Quadrat and Thomas Cluzeau
- Contact: Alban Quadrat
- URL: http://pages.saclay.inria.fr/alban.quadrat/OreAlgebraicAnalysis/index.html

## 6.2. OreModules

FUNCTIONAL DESCRIPTION

The OreModules package, based on the commercial Maple package Ore-algebra, is dedicated to the study of linear multidimensional systems defined over certain Ore algebras of functional operators (e.g., ordinary or partial differential systems, time-delay systems, discrete systems) and their applications in mathematical systems theory, control theory and mathematical physics.

- Participants: Frédéric Chyzak and Alban Quadrat
- Contact: Alban Quadrat
- URL: http://wwwb.math.rwth-aachen.de/OreModules/

## 6.3. OreMorphisms

FUNCTIONAL DESCRIPTION

The OreMorphisms package of OreModules is dedicated to the implementation of homological algebraic tools such as the computations of homomorphisms between two finitely presented modules over certain noncommutative polynomial algebras (Ore algebras), of kernel, coimage, image and cokernel of homomorphisms, Galois transformations of linear multidimensional systems and idempotents of endomorphism rings. Using the packages Stafford and Quillen-Suslin , the factorization, reduction and decomposition problems can be constructively studied for different classes of linear multidimensional systems. Many linear systems studied in engineering sciences, mathematical physics and control theory have been factorized, reduced and decomposed by means of the OreMorphisms package.

- Participants: Alban Quadrat and Thomas Cluzeau
- Contact: Alban Quadrat
- URL: http://pages.saclay.inria.fr/alban.quadrat/OreMorphisms/index.html

## 6.4. PurityFiltration

FUNCTIONAL DESCRIPTION

The PurityFiltration package, built upon the OreModules package, is an implementation of a new effective algorithm which computes the purity/grade filtration of linear functional systems (e.g., partial differential systems, differential time-delay systems, difference systems) and equivalent block-triangular matrices. This package is used to compute closed form solutions of over/underdetermined linear partial differential systems which cannot be integrated by the standard computer algebra systems such as Maple and Mathematica.

- Contact: Alban Quadrat
- URL: http://pages.saclay.inria.fr/alban.quadrat/OreAlgebraicAnalysis/index.html

## 6.5. QuillenSuslin

FUNCTIONAL DESCRIPTION

QuillenSuslin is a Maple implementation of a constructive version of the Quillen-Suslin Theorem. It provides an algorithm which computes a basis of a free module over a polynomial ring. In terms of matrices, this algorithm completes a unimodular rectangular matrix (e.g. a unimodular row) to an invertible matrix over the given polynomial ring with rational or integer coefficients. The package was also extended with Park's Algorithm to deal with unimodular rows over Laurent polynomial rings and with heuristic methods for localizations of polynomial rings.

- Participants: Alban Quadrat and Anna Fabiańska
- Contact: Alban Quadrat
- URL: http://wwwb.math.rwth-aachen.de/QuillenSuslin/

## 6.6. Stafford

FUNCTIONAL DESCRIPTION

The Stafford package of OreModules contains an implementation of two constructive versions of Stafford's famous but difficult theorem [96] stating that every ideal over the Weyl algebra An(k) (resp., Bn(k)) of partial differential operators with polynomial (resp., rational) coefficients over a field k of characteristic 0 (e.g., k=Q,R) can be generated by two generators. Based on this implementation and algorithmic results developed by the authors of the package, two algorithms which compute bases of free modules over the Weyl algebras An(Q) and Bn(Q) have been implemented. The rest of Stafford's results developed in [96] have recently been made constructive (e.g., computation of unimodular elements, decomposition of modules, Serre's splitting-off theorem, Stafford's reduction, Bass' cancellation theorem, minimal number of generators) and implemented in the Stafford package. The development of the Stafford package was motivated by applications to linear systems of partial differential equations with polynomial or rational coefficients (e.g., computation of injective parametrization, Monge problem, differential flatness, the reduction and decomposition problems and Serre's reduction problem). To our knowledge, the Stafford package is the only implementation of Stafford's theorems nowadays available.

- Participants: Alban Quadrat and Daniel Robertz
- Contact: Alban Quadrat
- URL: http://wwwb.math.rwth-aachen.de/OreModules/index_sub.html

## 6.7. YALTA

FUNCTIONAL DESCRIPTION

The YALTA toolbox is a Matlab toolbox dedicated to the study of classical and fractional systems with delay in the frequency-domain. Its objective is to provide basic but important information such as, for instance, the position of the neutral chains of poles and unstable poles, as well as the root locus with respect to the delay of the system. The corresponding algorithms are based on recent theoretical results and on classical continuation methods exploiting the particularities of the problem.

- Participants: Hugo Cavalera, Catherine Bonnet, Andre Fioravanti, Le Ha Vy Nguyen, Jim Pioche
- Contact: Catherine Bonnet
- URL: http://yalta-toolbox.gforge.inria.fr/

The YALTA toolbox is a Matlab toolbox dedicated to the study of classical and fractional systems with delay in the frequency-domain. Its objective is to provide basic but important information such as, for instance, the position of the neutral chains of poles and unstable poles, as well as the root locus with respect to the delay of the system. The corresponding algorithms are based on recent theoretical results (see, for instance, [78] and [85]) and on classical continuation methods exploiting the particularities of the problem [86], [87].

For classical delay systems, a Pade2 approximation scheme is available as well as a finite-dimensional approximation of the system.

Binaries are freely available at http://yalta-toolbox.gforge.inria.fr/.

The YALTA GUI (graphical user interface) is a graphical application developed in Python that interacts with the Matlab toolbox YALTA. User actions are performed through intuitive graphic elements (dialog boxes, icons, menus, scroll bars) in order to capitalize on the functionalities of YALTA. This software, still in development, is based on PyQt, a Python binding of the cross-platform GUI toolkit Qt (C++).

Recently, some features have been added. YALTA toolbox and YALTA GUI have been designed to support multi-languages settings (English and French languages currently available). Parally, the implementation of the Pade2 approximation scheme has been improved. Finally, continuous integration processes and tools such as Jenkins Hudson have been configured and managed to ensure long-term software quality.

## GECO Project-Team  (section vide)

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

# 6. New Software and Platforms

## 6.1. Boîte à outil Maxplus de SCILAB/Maxplus toolbox of Scilab

Trois chercheurs du groupe (S. Gaubert, J.-P. Quadrat, et G. Cohen) ont développé (à partir d'une première version réalisée par M. Mc Gettrick) la *boîte à outils Maxplus* de Scilab, qui est téléchargeable librement parmi les contributions du site Scilab, et qui est maintenant intégrée par défaut dans Scicoslab. Cette boîte à outils implémente l'ensemble du calcul numérique linéaire max-plus, elle comprend en particulier le stockage creux des matrices, et des algorithmes efficaces pour le calcul de la valeur propre basées sur les itérations sur les politiques. Elle a été utilisées par plusieurs chercheurs, voir notamment  [66], [135]. Il faut aussi noter que le groupe de L. Hardouin, du LISA/Istia, a complété la boîte à outils Maxplus en interfaçant leur propre librairie C++, qui permet le calcul des séries de transfert de graphes d'événements temporisés.

<p style="text-align:center;">*English version*</p>

Three researchers of the team (S. Gaubert, J.-P. Quadrat, and G. Cohen, building on a preliminary version of M. McGettrick) have developed and released the *Maxplus toolbox* of Scilab, which is freely available among the contributions on the Scilab web site, and which is now included by default in Scicoslab. It implements all basic linear algebra functionalities, with a special attention to large sparse matrices, including efficient algorithms for eigenvalue computation based on policy iteration. The software has been used by several researchers in their work, including  [66], [135]. It should be noted that the team of L. Hardouin, from LISA/Istia, has completed the toolbox by interfacing their own C++ library computing the transfer series of a timed event graph.

## 6.2. Itérations sur les politiques pour les jeux stochastiques à somme nulle/Policy iterations for zero sum stochastic games

L'algorithme d'itérations sur les politiques pour les jeux stochastiques à somme nulle pour le cas de paiements ergodiques (gain moyen par unité de temps), et dégénérés de type "multi-chaîne" a été introduit dans  [84]. Plusieurs stages ont permis l'implémentation partielle en Scilab, C ou C++, et le test de ce type d'algorithmes (voir le travail de Vishesh Dhingra  [101]), ou de son couplage avec la résolution de systèmes linéaires par des méthodes multigrilles algébriques (stage de Shantanu Gangal en 2007). Le travail de thèse de Sylvie Detournay a permis le développement d'un programme complet. Le code écrit par Sylvie Detournay (en C) a été déposé sur InriaGForge. Pour le moment il n'est accessible qu'aux membres de l'équipe.

<p style="text-align:center;">*English version*</p>

The policy iteration algorithm for zero sum repeated games with ergodic payoff (i.e. mean payoff per time unit), and in degenerate "multichain" cases, has been introduced in  [84]. Several internships allowed us to implement in Scilab, C or C++, and to test such algorithms (see the work of Vishesh Dhingra  [101]), or its combinaison with the resolution of linear systems by algebraic multigrid methods (internship of Shantanu Gangal in 2007). The PhD thesis work of Sylvie Detournay allowed us to develop a complete program. The program written by Sylvie Detournay (in C language) has been posted on InriaGForge. For the moment it can only be seen by members of the team.

## 6.3. TPLib: bibliothèque pour la manipulation de polyèdres tropicaux/TPLib: tropical polyhedra library

TPLib est une bibliothèque écrite en OCaml qui permet de manipuler des polyèdres tropicaux. Elle est distribuée sous license LGPL https://gforge.inria.fr/projects/tplib.

Cette bibliothèque implémente notamment des algorithmes permettant de passer d'une représentation externe d'un polyèdre à une représentation interne, ou inversement (voir §7.2.1 pour plus de détails). Elle permet aussi de réaliser d'autres opérations fondamentales, comme le calcul du complexe polyédral associé à un polyèdre donné (au sens de Develin et Sturmfels [97]), ou le calcul de cônes tangents tropicaux. Enfin, elle fournit toutes les primitives permettant d'utiliser les polyèdres tropicaux en tant que domaine abstrait numérique, afin de déterminer des invariants de programmes ou systèmes faisant intervenir les opérations min et max (voir [61]).

TPLib est utilisé dans le logiciel Polymake [116], développé à la Technische Universität Berlin (Allemagne). Ce dernier logiciel constitue une boite à outils permettant de manipuler des nombreux objets mathématiques (polytopes convexes, complexes polyédraux, graphes, matroïdes, polytopes tropicaux).

Le développement d'interfaces avec d'autres logiciels est désormais facilité grâce à la présence de *bindings* dans le langage C. Grâce à cela, un prototype d'interface a été réalisé entre TPLib et l'outil VerifyTAPN (https://launchpad.net/verifytapn), qui permet la vérification de réseaux de Pétri avec arcs temporisés. De même, une interface à la bibliothèque de domaines abstraits numériques APRON [127] est également en cours de développement.

### *English version*

TPLib is a library written in OCaml, which allows to manipulate tropical polyhedra. It is distributed under LGPL https://gforge.inria.fr/projects/tplib.

This library implements algorithms allowing to pass from an external representation of a polyhedron to an internal description, or inversely (see §7.2.1 for more details). Besides, the library allows to perform several fundamental operations over tropical polyhedra, such as computing the associated polyhedral complex (see Develin and Sturmfels [97]), or determining the tropical tangent cone at any point. Finally, it provides all the primitives allowing to use tropical polyhedra as an numerical abstract domain, in order to determine program/system invariants involving the operations min and max (see [61]).

TPLib is used in the software Polymake [116], developed in Technische Universität Berlin (Germany). Polymake is a toolbox allowing to manipulate mathematic objects such as convex polytopes, polyhedral complexes, graphs, matroids, and tropical polytopes.

The development of further interfaces is now easier thanks to the distribution of bindings in C language. Using these bindings, a prototype of interface has been created between TPLib and the model-checker VerifyTAPN (https://launchpad.net/verifytapn), which allows the verification of timed-arc Petri Nets. An interface to the numerical abstract domain APRON [127] is also under development.

## 6.4. MPGLib

FUNCTIONAL DESCRIPTION

MPGLib is a library written in OCaml, which allows to manipulate tropical polyhedra.

This library implements algorithms allowing to pass from an external representation of a polyhedron to an internal description, or inversely. Besides, the library allows to perform several fundamental operations over tropical polyhedra, such as computing the associated polyhedral complex (see Develin and Sturmfels), or determining the tropical tangent cone at any point. Finally, it provides all the primitives allowing to use tropical polyhedra as an numerical abstract domain, in order to determine program/system invariants involving the operations min and max.

- Participant: Xavier Allamigeon
- Contact: Xavier Allamigeon
- https://gforge.inria.fr/projects/tplib

# POEMS Project-Team

# 5. New Software and Platforms

## 5.1. COFFEE

FUNCTIONAL DESCRIPTION

COFFEE is a 3D solver for linear elastodynamics based on fast BEMs (full implementation in Fortran 90). The 3-D elastodynamic equations are solved with the boundary element method accelerated by the multi-level fast multipole method or H-matrix based solvers. The fundamental solutions for the infinite or half-space are used. A boundary element-boundary element coupling strategy is also implemented so multi-region problems (strata inside a valley for example) can be solved.

- Contact: Stéphanie Chaillat
- URL: http://perso.ensta-paristech.fr/ chaillat/index.php?page=softwares

## 5.2. XLiFE++

FUNCTIONAL DESCRIPTION

XLiFE++ is a Finite Element library written in C++ based on a variational approach and standard finite element methods, boundary element methods, spectral approximations. It allows to mix these different methods in a easy way to deal with complex models. A new version (v1.3) has been released in December 2015 but it is still in progress. This year, the main new features are: finite elements at any order (before, they were available up to order 6), some edge elements at any order (Raviart-Thomas, Nedelec), more stable boundary element methods. The performance was highly improved and first tests with multithreading (using OpenMP) have been done. At last, a lot of work to improve and stabilize user interface was done about mesh integrated tools, solvers, and external libraries installation. To make further progress in BEM methods (FMM, H Matrix, SCSD), a DGA project started in October 2015 in collaboration with MyBEM software team at CMAP (François Allouges, Matthieu Aussal, ...). Nicolas Salles has been recruited to enhance the BEM part of XLiFE++.

- Contact: Eric Lunéville
- URL: http://uma.ensta-paristech.fr/soft/XLiFE++/

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

# 5. New Software and Platforms

## 5.1. MIXMOD software

**Participants:** Gilles Celeux [Correspondant], Benjamin Auder, Jonas Renault.

Mixture model, cluster analysis, discriminant analysis MIXMOD is being developed in collaboration with Christophe Biernacki, Florent Langrognet (Université de Franche-Comté) and Gérard Govaert (Université de Technologie de Compiègne). MIXMOD (MIXture MODeling) software fits mixture models to a given data set, with either a clustering or a discriminant analysis purpose. MIXMOD uses a large variety of algorithms to estimate mixture parameters, e.g., EM, Classification EM, and Stochastic EM. They can be combined to create different strategies that lead to a sensible maximum of the likelihood (or completed likelihood) function. Moreover, different information criteria for choosing a parsimonious model, e.g. the number of mixture components, some of them favoring either a cluster analysis or a discriminant analysis point of view, are included. Many Gaussian models for continuous variables and multinomial models for discrete variable are included. Written in C++, MIXMOD is interfaced with MATLAB. The software, statistical documentation, and user guide are available here: http://www.mixmod.org.

Since 2010, MIXMOD has a proper graphical user interface. A version of MIXMOD in R is now available: http://cran.r-project.org/web/packages/Rmixmod/index.html.

Benjamin Auder contributes to the software improvement of MIXMOD. He has implemented an interface to test any mathematical library (Armadillo, Eigen, etc.) to replace NEWMAT. He has contributed to the continuous integration setup using Jenkins tools, and has prepared an automated testing framework for unit and non-regression tests.

This year, MIXMOD has received the support of an ADT (MASSICCC) for three years. This ADT MASSICCC has been obtained conjointly with the MODAL team (Inria Lille). This year, an engineer, Jonas Renault, has been appointed for two years. He is in charge of developing a web version of MIXMOD.

## 5.2. BLOCKCLUSTER software

**Participants:** Gilles Celeux, Christine Keribin.

Mixture model, Block cluster analysis, Blockcluster is software devoted to model-based block clustering. It is developed in parternship with the MODAL team (Inria Lille). This year, some major bugs have been fixed, and the Bayesian point of view has been reinforced by including Gibbs sampling for binary and categorial data. This Gibbs sampler, coupled with the variational Bayes algorithm, provides solutions which are more stable and less dependent on the initial values of the algorithm. An exact expression of the ICL criterion has been provided. This non-asymptotic criterion appears to be more relevant than the BIC-like approximation of ICL.

Vincent Brault, Christine Keribin and Mahindra Mariadassou have shown the consistency and asymptotic normality of the maximum likelihood and variational estimators in stochastic or latent block models.

# TAO Project-Team

# 6. New Software and Platforms

## 6.1. CMA-ES

Covariance Matrix Adaptation Evolution Strategy
KEYWORDS: Numerical optimization - Black-box optimization - Stochastic optimization
SCIENTIFIC DESCRIPTION

The CMA-ES is considered as state-of-the-art in evolutionary computation and has been adopted as one of the standard tools for continuous optimisation in many (probably hundreds of) research labs and industrial environments around the world. The CMA-ES is typically applied to unconstrained or bounded constraint optimization problems, and search space dimensions between three and a hundred. The method should be applied, if derivative based methods, e.g. quasi-Newton BFGS or conjugate gradient, (supposedly) fail due to a rugged search landscape (e.g. discontinuities, sharp bends or ridges, noise, local optima, outliers). If second order derivative based methods are successful, they are usually faster than the CMA-ES: on purely convex-quadratic functions, $f(x)=x^THx$, BFGS (Matlabs function fminunc) is typically faster by a factor of about ten (in terms of number of objective function evaluations needed to reach a target function value, assuming that gradients are not available). On the most simple quadratic function $f(x)=\|x\|^2=x^Tx$ BFGS is faster by a factor of about 30.
FUNCTIONAL DESCRIPTION

The CMA-ES is an evolutionary algorithm for difficult non-linear non-convex black-box optimisation problems in continuous domain.

- Participants: Nikolaus Hansen and Emmanuel Benazera
- Contact: Nikolaus Hansen
- URL: https://www.lri.fr/~hansen/cmaesintro.html

## 6.2. COCO

COmparing Continuous Optimizers
KEYWORDS: Benchmarking - Numerical optimization - Black-box optimization - Stochastic optimization
SCIENTIFIC DESCRIPTION

COmparing Continuous Optimisers (COCO) is a tool for benchmarking algorithms for black-box optimisation. COCO facilitates systematic experimentation in the field of continuous optimization. COCO provides: (1) an experimental framework for testing the algorithms, (2) post-processing facilities for generating publication quality figures and tables, (3) LaTeX templates of articles which present the figures and tables in a single document.

The COCO software is composed of two parts: (i) an interface available in different programming languages (C/C++, Java, Matlab/Octave, R, Python) which allows to run and log experiments on multiple test functions testbeds of functions (noisy and noiseless) are provided (ii) a Python tool for generating figures and tables that can be used in the LaTeX templates.
FUNCTIONAL DESCRIPTION

The Coco Platform provides the functionality to automatically benchmark optimization algorithms for un-bounded, unconstrained optimization problems in continuous domains. Benchmarking is a vital part of algorithm engineering and a necessary path to recommend algorithms for practical applications. The Coco platform releases algorithm developers and practitioners alike from (re-)writing test functions, logging, and plotting facilities by providing an easy-to-handle interface in several programming languages. The Coco platform has been developed since 2007 and has been used extensively within the "Blackbox Optimization Benchmarking (BBOB)" workshop series since 2009. Overall, 123 algorithms and algorithm variants by contributors from all over the world have been benchmarked with the platform so far and all data is publicly available for the research community for the submissions to BBOB-2013).

- Participants: Dimo Brockhoff, Tea Tulsar, Dejan Tulsar, Thanh-Do Tran, Nikolaus Hansen, Anne Auger, Marc Schoenauer, Ouassim Ait Elhara and Asma Atamna
- Partners: Université technique de Dortmund - Université technique de Prague
- Contact: Dimo Brockhoff
- URL: http://coco.gforge.inria.fr/doku.php

## 6.3. PTraces

Personal digital Traces

KEYWORDS: Information retrieval - Taxonomy induction - Personal Big Data - Ontology

SCIENTIFIC DESCRIPTION Personal digital Traces (PTraces) is a platform for fetching and annotating personal data. Ptraces provides us a demonstration platform for personal semantics and ontology induction. Ptraces includes: (1) modules for securely fetching personal data from external applictions (2) an annotation component that annotates personal information with user-chosen taxonomies (facets). These facets arean experimental framework for testing the algorithms, (3) an information retrieval component

The PTraces software is composed of two parts: (i) A Java backbone, built on Elastic Search (ii) a web-browser user interface for configuring the system (choosing data sources, choosing ontologies to activate) and for query retrieved data.

FUNCTIONAL DESCRIPTION

The system accepts taxonomies in the SKOS format. These taxonomies are presented to the user, along with a number of connectors to otuside data sources (gmail, twitter, facebook, fitbit, ...). The user chooses which sources to index, and which taxonomies to apply. After this initialisation, the system accesses the sources using the indentification tokens that the user has supplied, fetches the user data, annotates the data using the activated taxonomies, and sets up a local server that that user can access to search in their own data, using a browser interface.

- Participants: Gregory Grefenstette, Lawrence Muchemi, Mohamed Bouatira
- Contact: Mohamed Bouatira
- URL: https://gforge.inria.fr/scm/browser.php?group_id=7217

## 6.4. Cartolabe

FUNCTIONAL DESCRIPTION

Scientific cartography from articles

- Contact: Philippe Caillou
- URL: (project starting in 2016 - no url yet)

## 6.5. GO

Grid Observatory

KEYWORDS: Green computing - Autonomic computing

FUNCTIONAL DESCRIPTION

The Grid Observatory (GO) software suite collects and publishes traces of the EGI (European Grid Initiative) grid usage. With the release and extensions of its portal, the Grid Observatory has made a database of grid usage traces available to the wider computer science community since 2008. These data are stored on the grid, and made accessible through a web portal without the need of grid credentials. The GO is fully integrated with the evolution of EGI monitoring.

- Participants: Cécile Germain-Renaud, Julien Nauroy and Martine Sebag
- Contact: Cécile Germain-Renaud
- URL: http://grid-observatory.org/

## 6.6. METIS

KEYWORDS: Optimization - Energy
FUNCTIONAL DESCRIPTION

Many works in Energy Optimization, in particular in the case of high-scale sequential decision making, are based on one software per application, because optimizing the software eventually implies losing generality. Our goal is to develop with Artelys a platform, METIS, which can be used for several applications. In 2012 we interfaced existing codes in Artelys and codes developed in the TAO team, experiments have been performed and test cases have been designed. Several codes have been developped, tested on real world problems, and are (depending on which code) under the process of (i) open source diffusion (ii) code protection.

A big work is the development of a new, independent, open source, simulator for the French power grid, currently under extension to other European countries.

- Participants: Olivier Teytaud, Jérémie Decock, Jean-Joseph Christophe, Vincent Berthier, Marie-Liesse Cauwet and Sandra Cecilia Astete Morales
- Partner: Artelys
- Contact: Olivier Teytaud
- URL: http://www.lri.fr/~teytaud

## 6.7. Game Test Bed

KEYWORDS: An open source game test bed.
FUNCTIONAL DESCRIPTION

GTB is an open source library of games, including solvers. It includes an interface to noisy continuous optimization of parametric policies, and noise-free continuous optimization, leading to a preliminary continuous optimization platform with real-world test cases.

- Participants: Olivier Teytaud is the only developer, some feedback from Sandra Astete-Morales, and an interfacing with works by Marcus Gallagher at Univ. Queensland in under discussion.
- URL: https://gforge.inria.fr/projects/gametestbed/

## 6.8. MOGO

KEYWORDS: Computer Go - Monte-Clarlo - UCT
FUNCTIONAL DESCRIPTION

MoGo and its Franco-Taiwanese counterpart MoGoTW is a Monte-Carlo Tree Search program for the game of Go, which made several milestones of computer-Go in the past (first wins against professional players in 19x19, first win with disadvantageous side in 9x9 Go). Recent results include 7 wins out of 12 against professional players (in Brisbane, 2012) in 7x7, and recently an optimization of the random seed which brings a significant improvement in Go and (unpublished) on the difficult case of phantom-Go. However, the work in the UCT-SIG has now shifted to energy management.

- Participants: Sylvain Gelly, Rémi Munos, Olivier Teytaud, Yizao Wang and Jean-Baptiste Hoock
- Contact: Olivier Teytaud
- URL: https://www.lri.fr/~teytaud/taiwanopen2009.html

## 6.9. MultiBoost

multi-purpose boosting package

KEYWORDS: Multi-class - Multi-label classification

FUNCTIONAL DESCRIPTION

The MultiBoost package provides a fast C++ implementation of multi-class/multi-label/multi-task boosting algorithms. It is based on AdaBoost.MH but it also implements popular cascade classifiers, Arc-GV , and FilterBoost . The package contains common multi-class base learners (stumps, trees, products, Haar filters). Further base learners and strong learners following the boosting paradigm can be easily implemented in a flexible framework.

- Participants: Balasz Kegl, Robert Busa-Fekete and Djalel Benbouzid
- Contact: Balasz Kegl
- URL: http://www.multiboost.org/

## 6.10. io.datascience

FUNCTIONAL DESCRIPTION

This Data as a Service (DaaS) platform [54] is developed in the context of the Center for Data Science and the TIMCO project. Its overall goals is to exploit the advances in semantic web techniques for efficient sharing and usage of scientific data. A related specific software is the Tester for Triplestore (TFT) software suite [49], which benchmarks the compliance of sparql databases wrt the RDF standard and publishes the results through the SparqlScore service.

- Contact: Cécile Germain
- URL: https://io.datascience-paris-saclay.fr/

# AMIB Project-Team

# 5. New Software and Platforms

## 5.1. VARNA

KEYWORDS: Bioinformatics - Structural Biology
FUNCTIONAL DESCRIPTION

A lightweight Java Applet dedicated to the quick drawing of an RNA secondary structure. VARNA is open-source and distributed under the terms of the GNU GPL license. Automatically scales up and down to make the most out of a limited space. Can draw multiple structures simultaneously. Accepts a wide range of documented and illustrated options, and offers editing interactions. Exports the final diagrams in various file formats (svg,eps,jpeg,png,xfig)

- Participants: Yann Ponty
- Contact: Yann Ponty
- URL: http://varna.lri.fr/

## 5.2. KGS

KEYWORDS: Bioinformatics - Structural Biology -protein kinematics -RNA kinematics
FUNCTIONAL DESCRIPTION

The Kino-Geometric Sampling (KGS) software suite uses advanced, robotics-inspired algorithms to rapidly explore the conformational landscape of folded proteins, RNA, and their complexes. Combined with powerful statistical techniques, it structurally characterizes collective motions and excited substates from sparse, spatiotemporally averaged data.

- Participants: Amélie Héliou.
- Contact: Amélie Héliou
- URL: https://simtk.org/home/kgs/

## 5.3. SV-BAY

KEYWORDS: Bioinformatics - NGS- Cancer
FUNCTIONAL DESCRIPTION

SV-BAY is a software to detect structural variants in cancer genomes. It relies on a Bayesian approach and a correction for GC-content and read mappability is provided. SV-BAY is written in Python with small insertions in C++ code.

- Participants: Daria Iakovishina and M. Régnier
- Contact: M. Régnier
- URL: https://github.com/InstitutCurie/SV-Bay

## 5.4. DeClone

KEYWORDS: Bioinformatics - Comparative Genomics - Genome rearrangements
FUNCTIONAL DESCRIPTION

DECLONE is a software to predict ancestral adjacencies from reconciled gene trees. It offers multiple indicators to assess the robustness of predictions, including individual supports, the (stochastic) generation of (co/sub)-optimal solutions, and the domain of validity of a given prediction in the parameter space.

- Participants: Y. Ponty
- Contact: Y. Ponty
- URL: https://github.com/yannponty/DeClone

# GALEN Project-Team

# 6. New Software and Platforms

## 6.1. DISD

Dense Image and Surface Descriptors

FUNCTIONAL DESCRIPTION

Scale-Invariant Descriptor, Scale-Invariant Heat Kernel Signatures DISD implements the SID, SI-HKS and ISC descriptors. SID (Scale-Invariant Descriptor) is a densely computable, scale- and rotation- invariant descriptor. We use a log-polar grid around every point to turn rotation/scalings into translation, and then use the Fourier Transform Modulus (FTM) to achieve invariance. SI-HKS (Scale-Invariant Heat Kernel Signatures) extract scale-invariant shape signatures by exploiting the fact that surface scaling amounts to multiplication and scaling of a properly sampled HKS descriptor. We apply the FTM trick on HKS to achieve invariance to scale changes. ISC (Intrinsic Shape Context) constructs a net-like grid around every surface point by shooting outwards and tracking geodesics. This allows us to build a meta-descriptor on top of HKS/SI-HKS that takes neighborhood into account, while being invariant to surface isometries.

- Participants: Iasonas Kokkinos and Eduard Trulls
- Contact: Iasonas Kokkinos
- URL: http://vision.mas.ecp.fr/Personnel/iasonas/descriptors.html

## 6.2. DPMS

FUNCTIONAL DESCRIPTION

Dpms implements branch-and-bound object detection, cutting down the complexity of detection from linear in the number of pixels to logarithmic.

- Participant: Iasonas Kokkinos
- Contact: Iasonas Kokkinos
- URL: http://cvn.ecp.fr/personnel/iasonas/dpms.html

## 6.3. DROP

KEYWORDS: Health - Merging - Registration of 2D and 3D multimodal images - Medical imaging

FUNCTIONAL DESCRIPTION

Drop is a software programme that registers images originating from one or more modes by quickly and efficiently calculating a non-rigid / deformable field of deformation. Drop is a new, quick and effective registration tool based on new algorithms that do not require a cost function derivative.

- Partner: Centrale Paris
- Contact: Nikolaos Paragyios
- URL: http://campar.in.tum.de/Main/Drop

## 6.4. FastPD

KEYWORD: Medical imaging

FUNCTIONAL DESCRIPTION

FastPD is an optimization platform in C++ for the computer vision and medical imaging community.

- Contact: Nikolaos Paragyios
- URL: http://www.csd.uoc.gr/~komod/FastPD/

## 6.5. GraPeS

Grammar Parser for Shapes

FUNCTIONAL DESCRIPTION It is a software for parsing facade images using shape grammars. Grapes implement a parsing methods based on Reinforcement Learning principles. It optimizes simultaneously the topology of the parse tree as well as the associated parameters. GraPeS comes along with predefined shape grammars as XML files and defines three kinds of rewards. However, it also offers the possibility to create new grammars and to provide custom rewards in text files, widening the scope of potential applications. The name of the software comes from the aspect of the parse tree of the binary split grammars involved in the process.

- Participant: Iasonas Kokkinos
- Contact: Iasonas Kokkinos
- URL: http://vision.mas.ecp.fr/Personnel/teboul/grapesPage/index.php

## 6.6. HOAP-SVM

High-Order Average Precision SVM
SCIENTIFIC DESCRIPTION

We consider the problem of using high-order information (for example, persons in the same image tend to perform the same action) to improve the accuracy of ranking (specifically, average precision). We develop two learning frameworks. The high-order binary SVM (HOB-SVM) optimizes a convex upper bound of the surrogate 0-1 loss function. The high-order average precision SVM (HOAP-SVM) optimizes a difference-of-convex upper bound on the average precision loss function.

Authors of the research paper: Puneet K. Dokania, A. Behl, C. V. Jawahar and M. Pawan Kumar
FUNCTIONAL DESCRIPTION

The software provides a convenient API for learning to rank with high-order information. The samples are ranked according to a score that is proportional to the difference of max-marginals of the positive and the negative class. The parameters of the score function are computed by minimizing an upper bound on the average precision loss. The software also provides an instantiation of the API for ranking samples according to their relevance to an action, using the poselet features. The following learning algorithms are included in the API:

(1) Multiclass-SVM (2) AP-SVM (3) High Order Binary SVM (HOB-SVM) (4) High Order AP-SVM (HOAP-SVM) (5) M4 Learning (unpublished work)

The API is developed in C/C++ by Puneet K. Dokania.

- Participants: Puneet Dokania and Pawan Kumar
- Contact: Puneet Dokania
- URL: http://puneetkdokania.github.io/projects/ranking-highorder/ranking-highorder.html

## 6.7. LBSD

Learning-Based Symmetry Detection
FUNCTIONAL DESCRIPTION

LBSD implements the learning-based approach to symmetry detection. It includes the code for running a detector, alongside with the ground-truth symmetry annotations that we have introduced for the Berkeley Segmentation Dataset (BSD) benchmark.

- Participant: Stavros Tsogkas
- Contact: Stavros Tsogkas
- URL: https://github.com/tsogkas/oid_1.0

## 6.8. TeXMeG

FUNCTIONAL DESCRIPTION

Texture, modulation, generative models, segmentation, TeXMeG is a front-end for texture analysis and edge detection platform in Matlab that relies on Gabor filtering and image demodulation. Includes frequency- and time- based definition of Gabor- and other Quadrature-pair filterbanks, demodulation with the Regularized Energy Separation Algorithm and Texture/Edge/Smooth classification based on MDL criterion.

- Participant: Iasonas Kokkinos
- Contact: Iasonas Kokkinos
- URL: http://cvsp.cs.ntua.gr/software/texture/

## 6.9. mrf-registration

KEYWORDS: Health - Medical imaging
FUNCTIONAL DESCRIPTION

Deformable image and volume registration, is a deformable registration platform in C++ for the medical imaging community. This is the first publicly available platform which contains most of the existing metrics to perform registration under the same concept. The platform is used for clinical research from approximately 3,000 users worldwide.

- Participant: Nikolaos Paragyios
- Contact: Nikolaos Paragyios
- URL: http://www.mrf-registration.net/

<h1 style="text-align:center">M3DISIM Team</h1>

# 6. New Software and Platforms

## 6.1. FELiScE

Finite Elements for Life SCiences and Engineering problems
KEYWORDS: Health - Cardiac - Finite elements - Cardiac Electrophysiology
FUNCTIONAL DESCRIPTION

FELISCE – standing for "Finite Elements for LIfe SCiences and Engineering" – is a new finite element code. One specific objective of this code is to provide in a unified software environment all the state-of-the-art tools needed to perform simulations of the complex cardiovascular models considered in the teams M3DISIM and REO – namely, involving fluid and solid mechanics, electrophysiology, and the various associated coupling phenomena.

In FELISCE we have prepared a branch called HappyHeart, which aims at providing a user-friendly interface able to deal efficiently with complex cardiovascular simulations. Started in 2013, the code is already quite large (about 55,000 lines of code in almost 700 different files) and its core is about to be complete. It includes among others full HPC functionalities, high-order finite elements, physics coupling and topology capabilities. Our purpose will then be to use the library to implement the sophisticated cardiovascular models of the team and couple them with Verdandi (data assimilation library) to provide patient-specific simulations.

- Participants: Dominique Chapelle, Miguel Angel Fernandez Varela, Jean-Frédéric Gerbeau, Philippe Moireau, Marina Vidrascu, Sébastien Gilles, Sebastien Impériale and Gautier Bureau
- Contact: Sébastien Gilles
- URL: http://felisce.gforge.inria.fr

## 6.2. HeartLab

KEYWORDS: Simulation - Health - Cardiac - Image analysis - Computational geometry
SCIENTIFIC DESCRIPTION

The heartLab software is a library written in (64-bit compatible) Matlab and C (mex functions), designed to perform both simulation and estimation (based on various types of measurements, e.g. images) of the heart mechanical behavior. Started in 2006, it is already quite large (about 60,000 lines), and is used within various collaborations.

FUNCTIONAL DESCRIPTION

The code relies on OpenFEM – to which the team has previously contributed, see http://www.openfem.net – for the finite element computations, and the implementation was performed with a particular concern for modularity, since modeling and estimation use the same finite element operators. This modularity also allows to couple the code with other FEM solvers, such as LifeV and Mistral developed in the Reo team-project. In particular, we are now able to include perfusion and electrical coupling with LifeV using PVM, and fluid-structure interaction using Mistral.

We also included geometric data and tools in the code to define cardiac anatomical models compatible with the simulation requirements in terms of mesh quality, fiber direction data defined within each element, and the referencing necessary for handling boundary conditions and estimation, in particular. These geometries are analytical or come from computerized tomography (CT) or magnetic resonance (MR) image data of humans or animals.

We incorporated numerous non-linear data assimilation observation operators based on medical imaging post-processing to be able to now perform estimation with a large variety of medical imaging modalities. And recently we have worked on generalized micro-macro cardiac law using stochastic formulations.

- Participants: Radomir Chabiniok, Dominique Chapelle and Philippe Moireau
- Contact: Philippe Moireau
- URL: https://raweb.inria.fr/rapportsactivite/RA2013/m3disim/uid14.html

## 6.3. Verdandi

KEYWORDS: HPC - Model - Software Components - Partial differential equation
FUNCTIONAL DESCRIPTION

Verdandi is an open-source (LGPL) library for data assimilation. It includes various such methods for coupling one or several numerical models and observational data. Mainly targeted at large systems arising from the discretization of partial differential equations, the library is devised as generic, which allows for applications in a wide range of problems (biology and medicine, environment, image processing, etc.). Verdandi also includes tools to ease the application of data assimilation, in particular in the management of observations or for a priori uncertainty quantification. Implemented in C++, the library may be used with models implemented in Fortran, C, C++ or Python. Moreover, a Matlab module called VerdandinMatlab is developed in the team for pedagogical and test purposes.

- Participants: Nicolas Claude, Vivien Mallet, Dominique Chapelle, Philippe Moireau, Aurora Armiento and Gautier Bureau
- Contact: Vivien Mallet
- URL: http://verdandi.gforge.inria.fr/

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

**PARIETAL Project-Team**

</div>

# 6. New Software and Platforms

## 6.1. Scikit-learn

KEYWORDS: Classification - Learning - Clustering - Regession - Medical imaging

SCIENTIFIC DESCRIPTION

Scikit-learn is a Python module integrating classic machine learning algorithms in the tightly-knit scientific Python world. It aims to provide simple and efficient solutions to learning problems, accessible to everybody and reusable in various contexts: machine-learning as a versatile tool for science and engineering.

FUNCTIONAL DESCRIPTION

Scikit-learn can be used as a middleware for prediction tasks. For example, many web startups adapt Scikitlearn to predict buying behavior of users, provide product recommendations, detect trends or abusive behavior (fraud, spam). Scikit-learn is used to extract the structure of complex data (text, images) and classify such data with techniques relevant to the state of the art.

Easy to use, efficient and accessible to non datascience experts, Scikit-learn is an increasingly popular machine learning library in Python. In a data exploration step, the user can enter a few lines on an interactive (but non-graphical) interface and immediately sees the results of his request. Scikitlearn is a prediction engine . Scikit-learn is developed in open source, and available under the BSD license.

- Participants: Olivier Grisel, Gaël Varoquaux, Bertrand Thirion, Michael Eickenberg, Loïc Estève, Alexandre Gramfort and Fabian Pedregosa Izquierdo
- Partners: CEA - Logilab - Nuxeo - Saint Gobain - Tinyclues - Telecom Paris
- Contact: Olivier Grisel
- URL: http://scikit-learn.org

## 6.2. Nilearn

KEYWORDS: Health - Neuroimaging - Medical imaging

FUNCTIONAL DESCRIPTION

NiLearn is the neuroimaging library that adapts the concepts and tools of scikit-learn to neuroimaging problems. As a pure Python library, it depends on scikit-learn and nibabel, the main Python library for neuroimaging I/O. It is an open-source project, available under BSD license. The two key components of NiLearn are i) the analysis of functional connectivity (spatial decompositions and covariance learning) and ii) the most common tools for multivariate pattern analysis. A great deal of efforts has been put on the efficiency of the procedures both in terms of memory cost and computation time.

- Participants: Gaël Varoquaux, Bertrand Thirion, Loïc Estève, Alexandre Abraham, Michael Eickenberg, Alexandre Gramfort, Fabian Pedregosa Izquierdo, Elvis Dohmatob.
- Contact: Bertrand Thirion
- URL: http://nilearn.github.io

## 6.3. Mayavi

FUNCTIONAL DESCRIPTION

Mayavi is the most used scientific 3D visualization Python software. Mayavi can be used as a visualization tool, through interactive command line or as a library. It is distributed under Linux through Ubuntu, Debian, Fedora and Mandriva, as well as in PythonXY and EPD Python scientific distributions. Mayavi is used by several software platforms, such as PDE solvers (fipy, sfepy), molecule visualization tools and brain connectivity analysis tools (connectomeViewer).

- Contact: Gaël Varoquaux
- URL: http://mayavi.sourceforge.net/

## 6.4. PyHRF

KEYWORDS: FMRI - Statistic analysis - Neurosciences - IRM - Brain - Health - Medical imaging
FUNCTIONAL DESCRIPTION

As part of fMRI data analysis, PyHRF provides a set of tools for addressing the two main issues involved in intra-subject fMRI data analysis : (i) the localization of cerebral regions that elicit evoked activity and (ii) the estimation of the activation dynamics also referenced to as the recovery of the Hemodynamic Response Function (HRF). To tackle these two problems, PyHRF implements the Joint Detection-Estimation framework (JDE) which recovers parcel-level HRFs and embeds an adaptive spatio-temporal regularization scheme of activation maps.

- Participants: Thomas Vincent, Solveig Badillo, Lotfi Chaari, Christine Bakhous, Florence Forbes, Philippe Ciuciu, Laurent Risser, Thomas Perret, Aina Frau Pascual and Lotfi Chaari
- Partners: CEA - NeuroSpin
- Contact: Florence Forbes
- URL: http://pyhrf.org

<span style="color:red">**POPIX Team**</span>

# 6. New Software and Platforms

## 6.1. Clinical Trial Simulator

KEYWORDS: Statistics - Bioinformatics - Drug development
FUNCTIONAL DESCRIPTION

A clinical trial simulator (CTS) enables effective implementation of the learn-and-confirm paradigm in drug development. Through simulations the anticipated success rate of a future trial can be estimated. For various reasons industry has not embraced currently available software for trial simulation. A new tool is essential for Model Based Drug Development (MBDD).

POPIX is developing the mlxR R package for the model based simulation of clinical trials.

- Participants: Marc Lavielle
- URL: <span style="color:red">http://simulx.webpopix.org</span>

## 6.2. Monolix

KEYWORDS: Statistics - Bioinformatics - Health - Drug development
FUNCTIONAL DESCRIPTION

MONOLIX is an easy, fast and powerful tool for parameter estimation in nonlinear mixed-effect models, model diagnosis and assessment, and advanced graphical representation. It is a platform of reference for model-based drug development. Pharmacometricians and biostatisticians can rely on MONOLIX for population analysis and to model PK/PD and other complex biochemical and physiological processes.

MONOLIX was developed by Inria until June 2011. The start-up Lixoft now develops and supports MONO-LIX. POPIX collaborates closely with Lixoft to convert research results into new user features available in MONOLIX.

A first extension of MONOLIX for partial differential equations (PDEs) based models was developed by POPIX in 2015.

- Participants: Marc Lavielle, Raphael Kuate

## 6.3. MLXtran

KEYWORDS: Statistics - Bioinformatics - Health - Drug development
FUNCTIONAL DESCRIPTION

Monolix is associated with MLXtran, a powerful and immediately readable declarative language for describing complex pharmacometric and statistical models. MLXtran can be used and interfaced with various environments, e.g., R, Matlab, etc.

POPIX collaborates closely with Lixoft on the definition of the specifications and the syntax of MLXtran. Implementation is then ensured by Lixoft.

- Participants: Marc Lavielle

<span style="color:red">**INFINE Team**</span>

# 5. New Software and Platforms

## 5.1. RIOT

KEYWORDS: Internet of things - Operating system - Internet protocols - Sensors - IoT - Wireless Sensor Networks

SCIENTIFIC DESCRIPTION

While requiring as low as 1,5kB of RAM and 5kB or ROM, the RIOT operating system offers both advanced capabilities such as real time and energy efficiency capabilities, as well as standard capabilities, such as a single API (partially POSIX compliant) across heterogeneous IoT hardware (8-bit, 16-bit and 32-bit low-power hardware). This API is developer-friendly in that it enables Linux-like developer experience which was not possible so far for embedded programming: multi-threading, standard C and C++ application programming and the use of standard debugging tools (gbd, valgrind etc.). On top of this, as expected from a modern OS, RIOT also provides standard connectivity capabilities, by means of several networks stacks that are readily available, such as a standard IPv6/6LoWPAN stack and a information-centric network stack (based on CCN).

FUNCTIONAL DESCRIPTION

RIOT is an open source operating system that provides an API and SDK for energy-, memory- and CPU-constrained IoT devices and similar communicating embedded systems. This API builds upon standard systems concepts (e.g. POSIX) and standard communication protocols (e.g. IPv6). RIOT thus allows the development of applications that collect sensor data and transmit it to the cloud over the Internet, using end-to-end communication means e.g. IPv6 communication from sensor to cloud servers, that can be protected by transport layer security (e.g. DTLS). This data can then be used for smart energy management for example.

An important part of the design of RIOT is that it can easily be ported to different hardware devices (tens of types of heterogeneous IoT devices are already supported), and it can easily be extended to support the latest evolution of communication standards (a wide range of protocols are already supported).

For example, RIOT already enables tests and experiements of arbitrary IoT applications and protocols on FIT IoT-Lab, which provides a large-scale infrastructure facility with 2700 nodes for testing remotely small wireless devices. Once validated, the code for such applications and protocols can then run on any other IoT device hardware supported by RIOT.

- Participants: Emmanuel Baccelli and Oliver Hahm
- Partner: Freie Universitaet Berlin
- Contact: Emmanuel Baccelli
- URL: <span style="color:red">http://www.riot-os.org</span>

## 5.2. GardiNet (previously known as DragonNet)

FUNCTIONAL DESCRIPTION

GardiNet (previously known as DragonNet) is a generic framework for network coding in wireless networks. It is a initially result of the GETRF project of the Hipercom2 team.

It is based on intra-flow coding where the source divides the flow in a sequence of payloads of equal size (padding may be used). The design keys of DragonNet are simplicity and universality, GardiNet does not use explicit or implicit knowledge about the topology (such as the direction or distance to the source, the loss rate of the links, ...). Hence, it is perfectly suited to the most dynamic wireless networks. The protocol is distributed and requires minimal coordination. DragonNet architecture is modular, it is based on 5 building blocks (LIB, SIG, Protocol, SEW and DRAGON). Each block is almost independent. This makes DragonNet generic and hence adaptable to many application scenarios. DragonNet derives from a prior protocol called DRAGONCAST. Indeed, DragonNet shares the same principles and theoretical overview of DRAGONCAST. It enriches DRAGONCAST by the information base and signaling required to perform broadcast in wireless networks and in wireless sensor networks in particular.

- Participants: Cédric Adjih, Ichrak Amdouni, Hana Baccouch and Antonia Masucci
- Contact: Cédric Adjih
- URL: http://getrf.gforge.inria.fr/https://github.com/GardiNet/gardinet

# 5.3. MACACO

Mobile context-Adaptive CAching for COntent-centric networking

FUNCTIONAL DESCRIPTION

MACACOapp is developed in the context of the EU CHIST-ERA MACACO project. It consists in a mobile phone application that periodically samples phoneâs information on the mobility (through, e.g., GPS sensor, accelerometer and WiFi/Bluetooth/Cellular environment, connectivity type) and on the data traffic it generates (through, e.g., Internet browser history and applications data consumption). The information collected will be time-stamped and will be periodically sent to the central servers for analysis and visualization. We expect that (1) the collected information will allow us studying the correlation between mobility and content demand patterns and that (2) the results of this analysis will allow us inferring the best times and places to transfer content from/to usersâ phones location and/or from/to the wireless infrastructure closest to the usersâ phones location. Users will be also invited to fill a non-mandatory questionnaire relevant to this study. Our questionnaire collects information about the personality traits and application preferences of people. We expect that the information collected from questionnaire will allow us to analyse the correlation between users personality traits and their application preferences and interests. Userâs application preferences and interests will be inferred from the Internet browsing history and running app information obtained from the MACACO App.

- Participants: Aline Carneiro Viana, Katia Jaffres and Marco Fiore
- Contact: Aline Carneiro Viana
- URL: https://macaco.inria.fr/macacoapp/

<div align="center">**AVIZ Project-Team**</div>

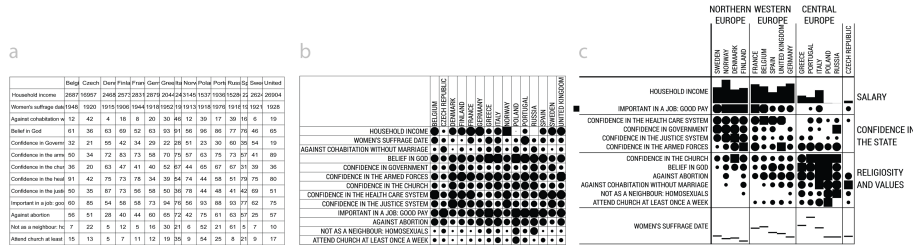# 6. New Software and Platforms

## 6.1. Bertifier



*Figure 3. Image of Bertifier, a web application for creating tabular visualizations from spreadsheets.*

FUNCTIONAL DESCRIPTION

Bertifier is a web application for rapidly creating tabular visualizations from spreadsheets (see Figure 3 ). Bertifier draws from Jacques Bertin's matrix analysis method, whose goal was to "simplify without destroying" by encoding cell values visually and grouping similar rows and columns. Although there were several attempts to bring this method to computers, no implementation exists today that is both exhaustive and accessible to a large audience. Bertifier remains faithful to Bertin's method while leveraging the power of today's interactive computers. Tables are formatted and manipulated through crossets, a new interaction technique for rapidly applying operations on rows and columns. Bertifier also introduces visual reordering, a semi-interactive reordering approach that lets users apply and tune automatic reordering algorithms in a WYSIWYG manner. We showed in an evaluation that Bertifier has the potential to bring Bertin's method to a wider audience of both technical and non-technical users, and empower them with data analysis and communication tools that were so far only accessible to a handful of specialists.

- Participants: Jean-Daniel Fekete, Charles Perin and Pierre Dragicevic
- Partner: Université Paris-Sud
- Contact: Jean-Daniel Fekete
- URL: http://www.bertifier.com

## 6.2. CENDARI Note-Taking-Environment

SCIENTIFIC DESCRIPTION

CENDARI (http://www.aviz.fr/Research/CENDARI) Is a European Infrastructure project funded by the EU for 4 years: 2012-2016. Aviz is in charge of the Human-Computer Interface for the project, and develops a tool to allow historians and archivists to take notes, enter them online, manage their images in relations with the notes and documents, and visualize the entities they find in the documents and notes. This system is an extension of the original EditorsNotes project, integrating several innovative components asked by the historians: visualizations, relations with the Semantic Web, and a management of access rights respecting the researchers' desire of privacy for their notes, as well as desire of sharing entities and relations gathered throught the notes and documents.

FUNCTIONAL DESCRIPTION

The Note-Taking-Environment [24] is an open-source, web-based tool for recording, organizing, preserving, and opening access to research notes, built with the needs of documentary editing projects, archives, and library special collections in mind.

- Participants: Evanthia Dimara, Nadia Boukhelifa Sari Ali, Emmanouil Giannisakis, and Jean-Daniel Fekete
- Contact: Jean-Daniel Fekete
- URL: https://github.com/CENDARI/editorsnotes

## 6.3. GraphCoiffure

SCIENTIFIC DESCRIPTION

Node-link infographics are visually very rich and can communicate messages effectively, but can be very difficult to create, often involving a painstaking and artisanal process. We have investigated node-link visualizations for communication, and have explored how to better support their creation. We have developed a set of techniques aimed at improving their creation workflow by bringing more flexibility and power to users, letting them manipulate all aspects of a node-link diagram (layout, visual attributes, etc.) while taking into account the context in which it will appear. We then implemented these techniques in a proof-of-concept prototype called GraphCoiffure, which we designed as an intermediary step between graph drawing/editing software and image authoring applications.

FUNCTIONAL DESCRIPTION

GraphCoiffure [21] is a proof-of-concept prototype designed to bridge the gap between graph editors and image authoring software by supporting graph beautification, i. e., the touching up of a node-link diagram to enhance its communicative power, or to make it conform to a desired aesthetics. GraphCoiffure is not meant to replace graph editors and graph drawing software, but rather to extend them by letting users import and beautify diagrams that have been created in these programs. GraphCoiffure does not itself enhance these diagrams, but it empowers users to do so. Its features include tools for interactive graph manipulation, a CSS-like stylesheet system, and a possibility of using page layout schemas to tailor a diagram for a specific context of use. Unlike graphics editors, it preserves visual mappings and makes it easier for users to make modifications based on the semantics of the graphs and their context of use.

- Participants: Andre Suslik Spritzer, Jeremy Boy, Pierre Dragicevic, Jean-Daniel Fekete, and Carla Maria dal Sasso Freitas
- Contact: Andre Suslik Spritzer

## 6.4. Hybrid Image Visualisation

Hybrid-image visualizations blend two different visual representations into a single static view, such that each representation can be perceived at a different viewing distance. Our work is motivated by data analysis scenarios that incorporate one or more displays with sufficiently large size and resolution to be comfortably viewed by different people from various distances. Hybrid-image visualizations can be used, in particular, to enhance overview tasks from a distance and detail-in-context tasks when standing close to the display. By taking advantage of humans' perceptual capabilities, hybrid-image visualizations do not require tracking of viewers in front of a display. Moreover, because hybrid-images use a perception-based blending approach, visualizations intended for different distances can each utilize the entire display. We contribute a design space, discuss the perceptual rationale for our work, provide examples and a set of techniques for hybrid-image visualizations, and describe tools for designing hybrid-image visualizations. An example can be found in Figure 4 .

KEYWORDS: Wall-Sized Displays, Perception, Hybrid Images

FUNCTIONAL DESCRIPTION

- Participants: Jean-Daniel Fekete, Petra Isenberg, Pierre Dragicevic, Wesley Willett, Romain Primet.
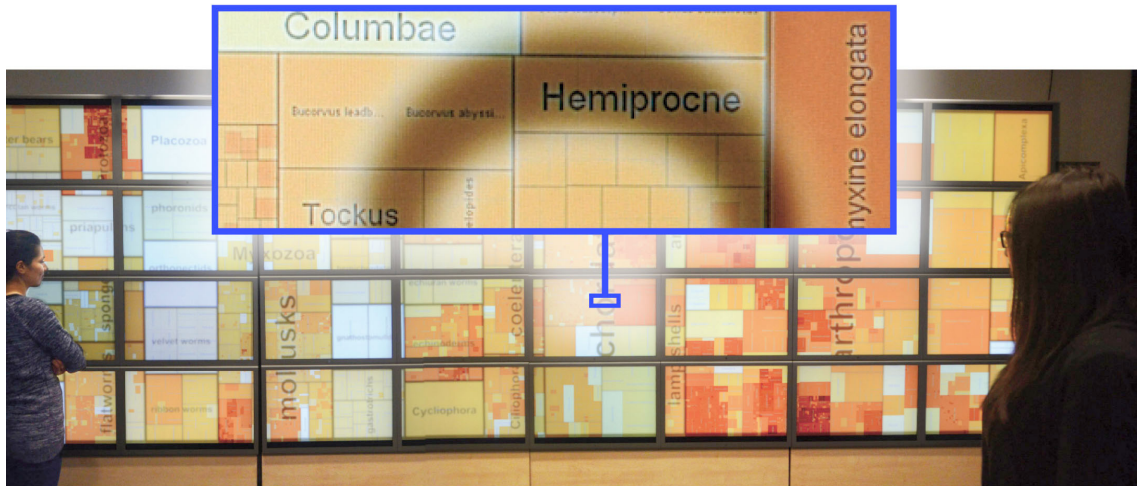- Contact: Petra Isenberg
- URL: http://aviz.fr/Research/HybridImageVisualizations

*Figure 4. Hybrid image visualization software for the creation of visualizations for distant and close viewing on large displays.*
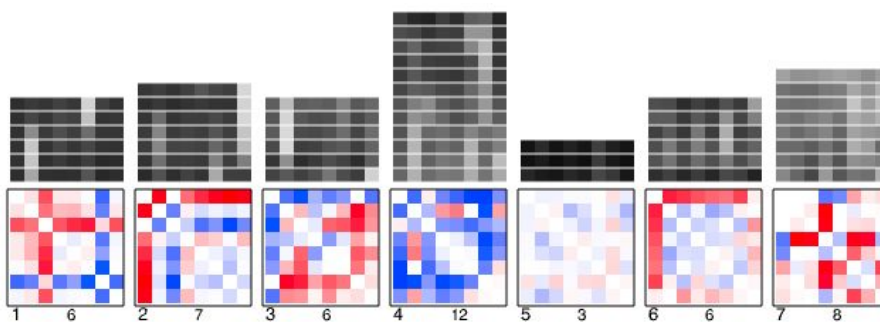


*Figure 5. Small Multipiles is software for visualizing temporal networks such as for brain connectivity analysis.*

## 6.5. Small Multipiles

SCIENTIFIC DESCRIPTION

MultiPiles [11] is a visualization to explore time-series of dense, weighted networks (see Figure 5 ). The interface is based on the physical analogy of piling adjacency matrices, each one representing a single temporal snapshot. Common interfaces for visualizing dynamic networks use techniques such as: flipping/animation; small multiples; or summary views in isolation. Our proposed 'piling' metaphor presents a hybrid of these techniques, leveraging each one's advantages, as well as offering the ability to scale to networks with hundreds of temporal snapshots. While MultiPiles is applicable to many domains, our prototype was initially designed to help neuroscientists investigate changes in brain connectivity networks over several hundred snapshots. The piling metaphor and associated interaction and visual encodings allowed neuroscientists to explore their data, prior to a statistical analysis. They detected high-level temporal patterns in individual networks and this helped them to formulate and reject several hypotheses.

FUNCTIONAL DESCRIPTION

MultiPiles is a visualization interface for the exploration of dense dynamic networks with changing edge weights. Dynamic networks are networks which change topology over time and/or edge weights change over time.

- Participants: Benjamin Bach, Nathalie Henry-Riche, Tim Dwyer, Tara Madhyastha, Jean-Daniel Fekete, Thomas Grabowski
- Contact: Benjamin Bach
- URL: http://visualizingbrainconnectivity.org/multipiles

## 6.6. Network Cube

SCIENTIFIC DESCRIPTION

Network visualizations support research in a range of scientific domains from biology to humanities. We created a platform to bridge the gap between domain scientists and visualisation researchers; NetworkCube [42] aims in being a fast way to deploy experimental visualizations from research to domain experts analyzing dynamic networks. In turn, InfoVis researchers benefit from studying how their visualizations are used in the wild.

FUNCTIONAL DESCRIPTION

NetworkCube is implemented in Java and JavaScript and will be available shortly online.

- Participants: Benjamin Bach, Nathalie Henry Riche, Roland Fernandez, Emmanoulis Giannisakis, Bongshin Lee, Jean-Daniel Fekete
- Contact: Benjamin Bach

## 6.7. Time Curves

SCIENTIFIC DESCRIPTION

Time curves [12], as seen in Figure 6 , are a general approach for visualizing patterns of evolution in temporal data. Examples of such patterns include slow and regular progressions, large sudden changes, and reversals to previous states. These patterns can be of interest in a range of domains, such as collaborative document editing, dynamic network analysis, and video analysis. Time curves employ the metaphor of folding a timeline visualization into itself so as to bring similar time points close to each other. This metaphor can be applied to any dataset where a similarity metric between temporal snapshots can be defined, thus it is largely datatype-agnostic. We illustrate how time curves can visually reveal informative patterns in a range of different datasets.
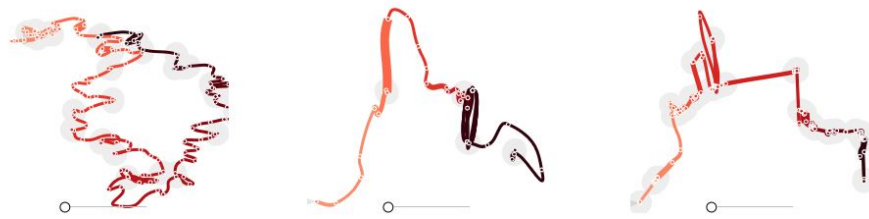
FUNCTIONAL DESCRIPTION

*Figure 6. Time Curves is software for visualizing the evolution of patterns in temporal data.*

Time Curves are implemented in Java and JavaScript.

- Participants: Benjamin Bach, Conglei Shi, Nicolas Heulot, Tara Madhyastha, Tom Grabowski, Pierre Dragicevic
- Contact: Benjamin Bach
- URL: http://www.aviz.fr/~bbach/timecurves/

## 6.8. SmartTokens



*Figure 7. SmartTokens are small-sized tokens supporting touch and motion sensing, and wireless communication with a coordinator.*

SCIENTIFIC DESCRIPTION

SmartTokens are small-sized tangible tokens that can sense multiple types of motion, multiple types of touch/grip, and send input events wirelessly as state-machine transitions. By providing an open platform for embedding basic sensing capabilities within small form-factors, SmartTokens extend the design space of tangible user interfaces. We describe the design and implementation of SmartTokens and illustrate how they can be used in practice by introducing a novel TUI design for event notification and personal task management.

FUNCTIONAL DESCRIPTION

SmartTokens are simple and cost-effective, but smart enough to be used as handles for digital information. SmartTokens allow to make generic, scalable and affordable user interfaces. They embed custom electronics, including touch and motion sensors as well as wireless communication functionalities.

- Participants: Mathieu Le Goc, Pierre Dragicevic, Samuel Huron, Jeremy Boy, Jean-Daniel Fekete
- Contact: Mathieu Le Goc
- URL: http://www.aviz.fr/smarttokens

## 6.9. Sparklificator

FUNCTIONAL DESCRIPTION

Sparklificator is a general open-source jQuery library that eases the process of integrating word-scale visualizations into HTML documents. It provides a range of options for adjusting the position (on top, to the right, as an overlay), size, and spacing of visualizations within the text. The library includes default visualizations, including small line and bar charts, and can also be used to integrate custom word-scale visualizations created using web-based visualization toolkits such as D3.

- Participants: Pascal Goffin, Wesley Willett and Petra Isenberg
- Contact: Jean-Daniel Fekete
- URL: http://inria.github.io/sparklificator/

# DAHU Project-Team (section vide)

# EX-SITU Team

# 6. New Software and Platforms

## 6.1. New Software

### 6.1.1. WildOS

**Participant:**  Michel Beaudouin-Lafon [correspondant].

*WildOS* is middleware designed to support applications that run in an interactive room, such as our WILD and WILDER rooms, with various interaction resources, including a tiled wall display, a motion tracking system, interactive tabletops, tablets, smartphones and custom-made or 3d printed interactive devices. The conceptual model of WildOS is a *platform*, such as the WILD or WILDER room, that can be described as a set of devices on which one or more applications can be run.

*WildOS* consists of a server running on a machine that has network access to all the machines involved in the platform, and a set of clients running on the various interaction resources, such as a display cluster or a tablet. Once *WildOS* is running, applications can be started and stopped and devices can be added to or removed from the platform.

*WildOS* relies on Web technologies, most notably Javascript and node.js, as well as node-webkit and HTML5. This makes it inherently portable (it is currently tested on Mac OS X and Linux). While applications can be developed only with these Web technologies, it is also possible to bridge to existing applications developed in other environments if they provide sufficient access for remote control. Sample applications include a web browser, an image viewer, a window manager, and the BrainTwister application developed in collaboration with neuroanatomists at NeuroSpin.

*WildOS* is used for several research projects at ExSitu and by other partners of the Digiscope project. It was also deployed on several of Google's interactive rooms in Mountain View, Dublin and Paris. It is available under on Open Source licence at https://bitbucket.org/mblinsitu/wildos.

- ACM: H.5.2 [User Interfaces]: Graphical user interfaces (GUI)
- Software benefit: helps development of multisurface applications.
- OS/Middleware: Crossplatform
- Required library or software: node.js, node-webkit
- Programming language: Javascript

### 6.1.2. Unity Cluster

**Participants:**  Cédric Fleury [correspondant], Jean-Baptiste Louvet.

*Unity Cluster* is middleware to distribute any Unity 3D (https://unity3d.com/) application on a cluster of computers that run in interactive rooms, such as our WILD and WILDER rooms, or immersive CAVES (Computer-Augmented Virtual Environments). Users can interact the the application with various interaction resources.

*Unity Cluster* provides an easy solution for running existing Unity 3D applications on any display that requires a rendering cluster with several computers. *Unity Cluster* is based on a master-slave architecture: The master computer runs the main application and the physical simulation as well as manages the input; the slave computers receive updates from the master and render small parts of the 3D scene. *Unity Cluster* manages data distribution and synchronization among the computers to obtain a consistent image on the entire wall-sized display surface.

*Unity Cluster* can also deform the displayed images according to the user's position in order to match the viewing frustum defined by the user's head and the four corners of the screens. This respects the motion parallax of the 3D scene, giving users a better sense of depth.

*Unity Cluster* is composed of a set of C Sharp scripts that manage the network connection, data distribution, and the deformation of the viewing frustum. In order to distribute an existing application on the rendering cluster, all scripts must be embedded into a Unity package that is included in an existing Unity project.

- ACM: C.2.4 [Distributed Systems]: Distributed applications, I.3.7 [3D Graphics and Realism]: Virtual reality
- Software benefit: adapts existing Unity 3D application to a rendering cluster of an interactive room.
- OS/Middleware: Crossplatform
- Required library or software: Unity 3D
- Programming language: C Sharp

## 6.2. Platforms

### 6.2.1. WILDER

**Participants:**  Michel Beaudouin-Lafon [correspondant], Cédric Fleury, Olivier Gladin, Rémi Hellequin, Stéphane Huot, Amani Kooli, Monireh Sanaei, Gabriel Tezier, Jonathan Thorpe.

WILDER (Figure 1 ) is our second experimental ultra-high-resolution interactive environment, which follows the WILD platform developed in 2009 [2]. It features a wall-sized display with seventy-five 20" LCD screens, i.e. a 5m50 x 1m80 (18' x 6') wall displaying 14 400 x 4 800 = 69 million pixels, powered by a 10-computer cluster and two front-end computers. The platform also features a camera-based motion tracking system that lets users interact with the wall, as well as the surrounding space, with various mobile devices. The display uses a multitouch frame (the largest of its kind in the world) to make the entire wall touch sensitive.

WILDER was inaugurated in June, 2015. It is one of the ten platforms of the Digiscope Equipment of Excellence and, in combination with WILD and the other Digiscope rooms, provides a unique experimental environment for collaborative interaction.

In addition to using WILD and WILDER for our research, we have also developed software architectures and toolkits, such as WildOS and Unity Cluster, that enable developers to run applications on these multi-device, cluster-based systems.
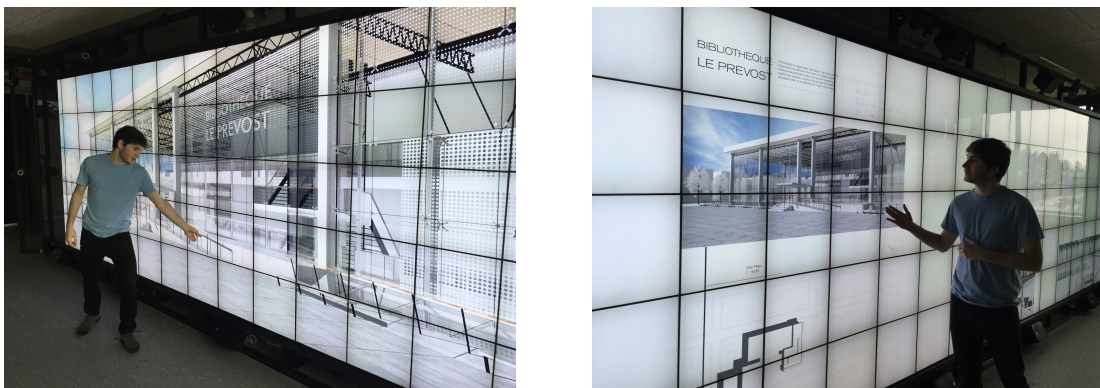


*Figure 1. The WILDER platform.*

<h2 style="text-align:center;color:red">ILDA Team</h2>

# 6. New Software and Platforms

## 6.1. Smarties

FUNCTIONAL DESCRIPTION

The Smarties system provides an easy way to add mobile interactive support to collaborative applications for wall displays.

It consists of (i) a mobile interface that runs on mobile devices for input, (ii) a communication protocol between the mobiles and the wall application, and (iii) libraries that implement the protocol and handle synchronization, locking and input conflicts. The library presents the input as an event loop with callback functions and handles all communication between mobiles and wall application. Developers can customize the mobile interface from the wall application without modifying the mobile interface code.

On each mobile we find a set of cursor controllers associated with keyboards, widgets and clipboards. These controllers (pucks) can be shared by multiple collaborating users. They can control simple cursors on the wall application, or specific content (objects or groups of them). The developper can decide the types of widgets associated to pucks from the wall application side.

- Contact: Olivier Chapuis
- URL: http://smarties.lri.fr/

## 6.2. ZVTM

Zoomable Visual Transformation Machine
KEYWORDS: Information visualization - Data visualization - Geovisualization - Visualization - Big data - Graph visualization
FUNCTIONAL DESCRIPTION

ZVTM is a toolkit enabling the implementation of multi-scale interfaces for interactively navigating in large datasets displayed as 2D graphics.

ZVTM is used for browsing large databases in multiple domains: geographical information systems, control rooms of complex facilities, astronomy, power distribution systems.

The toolkit also enables the development of applications running on ultra-high-resolution wall-sized displays.

- Participants: Caroline Appert, Olivier Chapuis, Bruno Fruchard, Maria Jesus Lobo Gunther, Arnaud Prouzeau, Hande Ozaygen and Can Liu
- Contact: Emmanuel Pietriga
- URL: http://zvtm.sf.net

## 6.3. Platforms

### 6.3.1. Platform: WILDER

Ultra-high-resolution wall-sized displays [27] feature a very high pixel density over a large physical surface. Such platforms have properties that make them well-suited to the visualization of very large datasets. They can represent the data with a high level of detail while at the same time retaining context: users can transition from an overview of the data to a detailed view simply by physically moving in front of the wall display. Wall displays also offer good support for collaborative work, enabling multiple users to simultaneously visualize and interact with the displayed data. To make them interactive, wall-sized displays are increasingly coupled with input devices such as touch frames, motion-tracking systems and wireless multitouch devices, in order to enable multi-device and multi-user interaction with the displayed data. Application areas for such visualization platforms range from the monitoring of complex infrastructures and crisis management situations to tools for the exploratory visualization of scientific data.
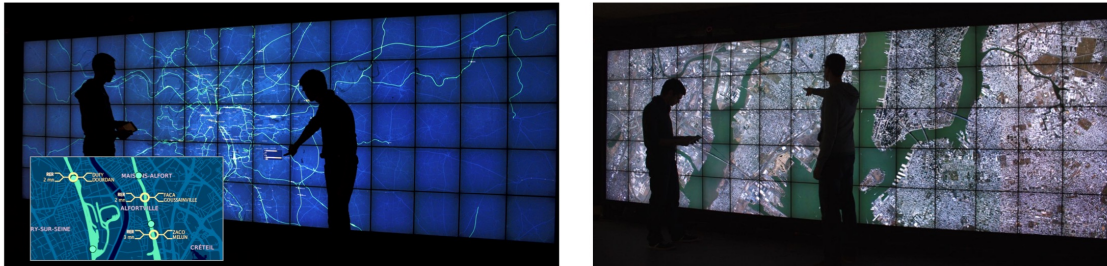
*Figure 2. Geovisualization applications running on the WILDER platform. Real-time monitoring of railroad trafic in France (left), large-scale high-resolution orthoimagery visualization (right).*

WILDER is the latest ultra-high-resolution wall-sized display set up at Inria Saclay, and is one of the nodes of the Digiscope EquipEx. We use this platform for multiple projects, both fundamental HCI research, and research and development activities for specific application areas such as geographical informations systems (Figure 2 ) and astronomy (see Figure 3 ).
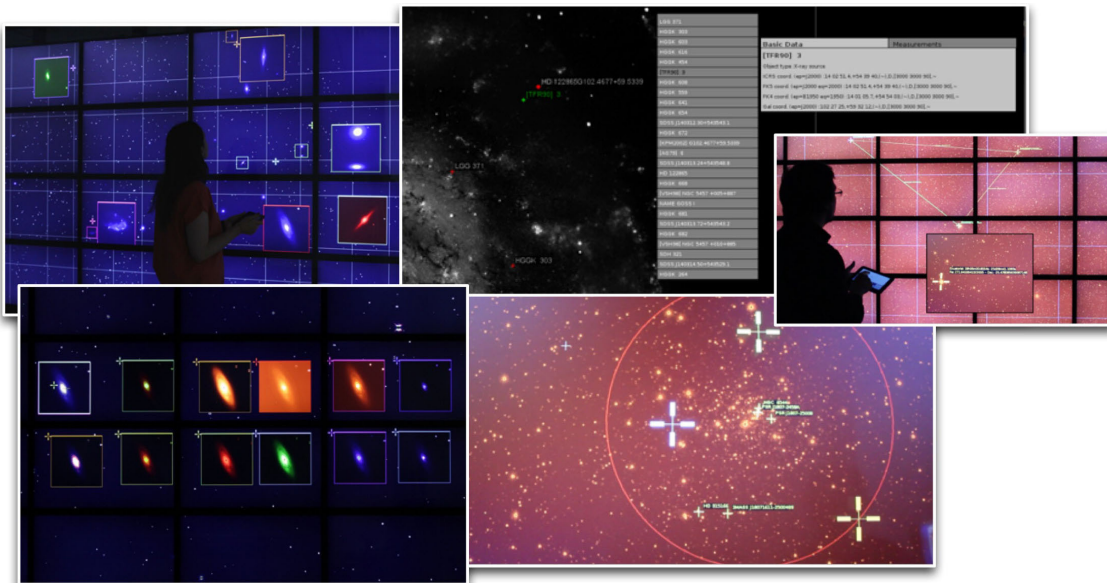
### 6.3.2. Platform: ANDES



*Figure 3. Visualization of high-dynamic-range FITS images and associated data catalogs in the domain of Astronomy on ANDES (collaboration with Inria Chile, Millenium Institute of Astrophysics, and Institut d'Astrophysique Spatiale).*

ANDES is a platform similar to WILDER, set up at Inria in Santiago de Chile, that we use both as a research platform and as a showroom of our research and development activities. ANDES is the main platform used for

our collaborative research project with the Millenium Institute of Astrophysics on the visualization of large FITS images (see Figure 3 ).

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## OAK Project-Team

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# 6. New Software and Platforms

## 6.1. Amada

FUNCTIONAL DESCRIPTION

AMADA is a platform for storing Web data (in particular, XML documents and RDF graphs) based on the Amazon Web Services (AWS) cloud infrastructure. AMADA operates in a Software as a Service (SaaS) approach, allowing users to upload, index, store, and query large volumes of Web data.

- Participants: Jesùs Camacho-Rodriguez, Manolescu Ioana, Dario Colazzo and François Goasdoué
- Contact: Ioana Manolescu
- URL: https://team.inria.fr/oak/projects/amada/

## 6.2. Clique Square

RDF data management platform based on Hadoop architecture
KEYWORDS: Map-Reduce - Hadoop - RDF - Big data
SCIENTIFIC DESCRIPTION

CliqueSquare is a system for storing and querying large RDF graphs relying on Hadoop's distributed file system (HDFS) and Hadoop's MapReduce open-source implementation. CliqueSquare is equipped with a unique optimization algorithm capable of generating highly parallelizable flat query plans relying on n-ary equality joins. In addition, it provides a novel partitioning and storage scheme that permits first-level joins to be evaluated locally using efficient map-only joins.

FUNCTIONAL DESCRIPTION

RDF (Ressource Description Framework) is the data format for the semantic web. CliqueSquare allows storing and querying very large volumes of RDF data in a massively parralel fashion in a Hadoop cluster. The system uses its own partitioning and storage model for the RDF triples in the cluster.

CliqueSquare evaluates queries expressed in a dialect of the SPARQL query language. It is particularly efficient when processing complex queries, because it is capable of translating them into MapReduce programs guaranteed to have the minimum number of successive jobs. Given the high overhead of a MapReduce job, this advantage is considerable.

- Participants: Ioana Manolescu, Benjamin Djahandideh, Stamatios Zampetakis, Zoi Kaoudi, François Goasdoué and Jorge Arnulfo Quiane Ruiz
- Partners: Université de Rennes 1 - Qatar Computing Research Institute
- Contact: Ioana Manolescu
- URL: https://team.inria.fr/oak/projects/cliquesquare/

## 6.3. FactMinder

KEYWORDS: Web - Fact-checking - Data Journalism - Open data
FUNCTIONAL DESCRIPTION

FactMinder is a browser extension targeted at online fact checkers and data journalists. It enables users to analyze web pages with entity extractors and create, in a separate panel, views to cross these annotations with background knowledge from trusted XML or RDF sources such as data sets from the Linked Open Data or governmental agencies.

FactMinder is the basis of the ANR project ContentCheck and was awarded a Google Computational Journalism Research Award in June 2015.

- Participants: Ioana Manolescu, Stamatios Zampetakis and François Goasdoué
- Partner: Université Paris-Sud
- Contact: Ioana Manolescu
- URL: https://team.inria.fr/oak/projects/xr-an-xml-rdf-hybrid-model-for-annotated-documents/

## 6.4. PAXQuery

FUNCTIONAL DESCRIPTION

The PAXQuery engine seamlessly parallelizes the execution of XQuery queries. By applying on-the-fly translation and optimization procedures, PAXQuery runs user queries over massive collections of XML documents in a distributed fashion. PAXQuery runs on top of Apache Flink, a distributed execution platform that relies on the PACT model.

- Participants: Jesùs Camacho-Rodriguez, Ioana Manolescu, Dario Colazzo and Juan Alvaro Munoz Naranjo
- Contact: Ioana Manolescu
- URL: https://team.inria.fr/oak/projects/paxquery/

## 6.5. RDFSummary

RDF Summary
FUNCTIONAL DESCRIPTION

RDF Summary is a standalone Java software capable of building summaries of RDF graphs. Summaries are compact graphs (typically several orders of magnitude smaller than the original graph), which can be used to get acquainted quickly with a given graph, they can also be used to perform static query analysis, infer certain things about the answer of a query on a graph, just by considering the query and the summary.

- Contact: Sejla Cebiric
- URL: https://team.inria.fr/oak/projects/rdfsummary/

## 6.6. WaRG

Warehousing RDF Graphs
KEYWORDS: Data mining - Semantic Web - Data management - Decision - Big data
SCIENTIFIC DESCRIPTION

WaRG is a warehouse-style analytics platform on RDF graphs. The tool stores data in kdb+ with a Java frontend based on the Prefuse Visualization toolkit. The novelty of WaRG is to redesign the full stack of Data Warehouse abstractions and tools for heterogeneous, semantics-rich RDF data, this enables a WaRG RDF DW to be an RDF graph itself, heterogeneous and semantics-rich in its turn. Thus, WaRG benefits both from powerful analytics and the rich interoperability and semantic features of Semantic Web databases.
FUNCTIONAL DESCRIPTION

WaRG (Warehousing RDF graph) is an analytical platform specially designed for the analysis of RDF data.

WaRG allows defining RDF analytical schemas, comprising classes and properties interesting for the analysis. The analytical schema can then be materialized, leading to an instance (RDF graph) refined for the needs of the analysis.

The analytical schema can also be automatically built from the input RDF instance. Finally, RDF analytical queries can be specified and lead to RDF analysis cubes.

- Participants: Roatis Alexandra, Ioana Manolescu, Sejla Cebiric and François Goasdoué
- Partners: Université de Rennes 1 - Université Paris-Sud
- Contact: Ioana Manolescu
- URL: https://team.inria.fr/oak/projects/warg/