

*Inria*

RESEARCH CENTER  
Saclay - Île-de-France

FIELD

# Activity Report 2019

## Section Software

Edition: 2020-03-21



ALGORITHMICS, PROGRAMMING, SOFTWARE AND ARCHITECTURE	
1. COMETE Project-Team	4
2. DATASHAPE Project-Team	6
3. DEDUCTEAM Project-Team	8
4. GRACE Project-Team	12
5. MEXICO Project-Team	13
6. PARSIFAL Project-Team	14
7. SPECFUN Project-Team	16
8. TOCCATA Project-Team	18
APPLIED MATHEMATICS, COMPUTATION AND SIMULATION	
9. CELESTE Project-Team	22
10. COMMANDS Project-Team	24
11. DEFI Project-Team (section vide)	26
12. DISCO Project-Team (section vide)	27
13. GAMMA Project-Team	28
14. POEMS Project-Team	29
15. RANDOPT Project-Team	30
16. TAU Project-Team	32
17. TROPICAL Project-Team	34
DIGITAL HEALTH, BIOLOGY AND EARTH	
18. LIFEWARE Project-Team	36
19. M3DISIM Project-Team	37
20. OPIS Project-Team	39
21. PARIETAL Project-Team	41
22. XPOP Project-Team	44
NETWORKS, SYSTEMS AND SERVICES, DISTRIBUTED COMPUTING	
23. TRIBE Project-Team	45
PERCEPTION, COGNITION AND INTERACTION	
24. AVIZ Project-Team	47
25. CEDAR Project-Team	49
26. EX-SITU Project-Team	52
27. ILDA Project-Team	56
28. PETRUS Project-Team	61

## COMETE Project-Team

# 6. New Software and Platforms

## 6.1. libqif - A Quantitative Information Flow C++ Toolkit Library

KEYWORDS: Information leakage - Privacy - C++ - Linear optimization

FUNCTIONAL DESCRIPTION: The goal of libqif is to provide an efficient C++ toolkit implementing a variety of techniques and algorithms from the area of quantitative information flow and differential privacy. We plan to implement all techniques produced by Comète in recent years, as well as several ones produced outside the group, giving the ability to privacy researchers to reproduce our results and compare different techniques in a uniform and efficient framework.

Some of these techniques were previously implemented in an ad-hoc fashion, in small, incompatible with each-other, non-maintained and usually inefficient tools, used only for the purposes of a single paper and then abandoned. We aim at reimplementing those – as well as adding several new ones not previously implemented – in a structured, efficient and maintainable manner, providing a tool of great value for future research. Of particular interest is the ability to easily re-run evaluations, experiments and case-studies from all our papers, which will be of great value for comparing new research results in the future.

The library's development continued in 2018 with several new added features. 82 new commits were pushed to the project's git repository during this year. The new functionality was directly applied to the experimental results of several publications of the team (QEST'18, Entropy'18, POST'18, CSF'18).

- Contact: Konstantinos Chatzikokolakis
- URL: <https://github.com/chatziko/libqif>

## 6.2. F-BLEAU

KEYWORDS: Information leakage - Machine learning - Privacy

FUNCTIONAL DESCRIPTION: F-BLEAU is a tool for estimating the leakage of a system about its secrets in a black-box manner (i.e., by only looking at examples of secret inputs and respective outputs). It considers a generic system as a black-box, taking secret inputs and returning outputs accordingly, and it measures how much the outputs "leak" about the inputs.

F-BLEAU is based on the equivalence between estimating the error of a Machine Learning model of a specific class and the estimation of information leakage.

This code was also used for the experiments of a paper under submission, on the following evaluations: Gowalla, e-passport, and side channel attack to finite field exponentiation.

RELEASE FUNCTIONAL DESCRIPTION: First F-BLEAU release. Supports frequentist and k-NN estimates with several parameters, and it allows stopping according to delta-convergence criteria.

- Contact: Konstantinos Chatzikokolakis
- URL: <https://github.com/gchers/fbleau>

## 6.3. Location Guard

KEYWORDS: Privacy - Geolocation - Browser Extensions

SCIENTIFIC DESCRIPTION: The purpose of Location Guard is to implement obfuscation techniques for achieving location privacy, in an easy and intuitive way that makes them 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.

FUNCTIONAL DESCRIPTION: Websites can ask the browser for your location (via JavaScript). When they do so, the browser first asks your permission, and if you accept, it detects your location (typically by transmitting a list of available wifi access points to a geolocation provider such as Google Location Services, or via GPS if available) and gives it to the website.

Location Guard is a browser extension that intercepts this procedure. The permission dialog appears as usual, and you can still choose to deny. If you give permission, then Location Guard obtains your location and adds "random noise" to it, creating a fake location. Only the fake location is then given to the website.

Location Guard is by now a stable tool with a large user base. No new features were added in 2018, however the tool is still actively maintained, and several issues have been fixed during this year (new geocoder API, manual installation method for Opera users, etc).

- Participants: Catuscia Palamidessi, Konstantinos Chatzikokolakis, Marco Stronati, Miguel Andrés and Nicolas Bordenabe
- Contact: Konstantinos Chatzikokolakis
- URL: <https://github.com/chatziko/location-guard>

## 6.4. dspacenet

*Distributed-Spaces Network.*

KEYWORDS: Social networks - Distributed programming

FUNCTIONAL DESCRIPTION: DSpaceNet is a tool for social networking based on multi-agent spatial and timed concurrent constraint language.

I - The fundamental structure of DSpaceNet is that of *\*space\**: A space may contain

(1) spatial-mobile-reactive tcc programs, and (2) other spaces.

Furthermore, (3) each space belongs to a given agent. Thus, a space of an agent  $j$  within the space of agent  $i$  means that agent  $i$  allows agent  $j$  to use a computation sub-space within its space.

II - The fundamental operation of DSpaceNet is that of *\*program posting\**: In each time unit, agents can post spatial-mobile-reactive tcc programs in the spaces they are allowed to do so (ordinary message posting corresponds to the posting of tell processes). Thus, an agent can for example post a watchdog tcc process to react to messages in their space, e.g. whenever (*\*happy b\*frank\**) do tell("thank you!"). More complex mobile programs are also allowed (see below).

The language of programs is a spatial mobile extension of tcc programs:

$$P, Q \dots := \text{tell}(c) | \text{whencdo} P | | \text{next} P | P | | Q | \text{unless} \text{next} P | [P]_i | \uparrow_i P | \text{rec} X.P$$

Computation of timed processes proceeds as in tcc. The spatial construct  $[P]_i$  runs  $P$  in the space of agent  $i$  and the mobile process  $\uparrow_i P$ , extrudes  $P$  from the space of  $i$ . By combining space and mobility, arbitrary processes can be moved from one a space into another. For example, one could send a trojan watchdog to another space for spying for a given message and report back to one's space.

III- Constraint systems can be used to specify advance text message deduction, arithmetic deductions, scheduling, etc.

IV - Epistemic Interpretation of spaces can be used to derive whether they are users with conflicting/inconsistent information, or whether a group of agents may be able to deduce certain message.

V - The scheduling of agent requests for program posts, privacy settings, friendship lists are handled by an external interface. For example, one could use type systems to check whether a program complies with privacy settings (for example checking that the a program does not move other program into a space it is not allowed into).

- Partner: Pontificia Universidad Javeriana Cali
- Contact: Frank Valencia
- URL: <http://www.dspacenet.com>

## DATASHAPE Project-Team

# 4. New Software and Platforms

## 4.1. GUDHI

*Geometric Understanding in Higher Dimensions*

KEYWORDS: Computational geometry - Topology

SCIENTIFIC DESCRIPTION: The current release of the GUDHI library includes: – Data structures to represent, construct and manipulate simplicial and cubical complexes. – Algorithms to compute simplicial complexes from point cloud data. – Algorithms to compute persistent homology and multi-field persistent homology. – Simplification methods via implicit representations.

FUNCTIONAL 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.

NEWS OF THE YEAR: - Cover complex - Representation of persistence diagrams - Cech complex - weighted periodic 3d alpha-complex - sparse Rips complex - debian / docker / conda-forge packages

- Participants: Clément Maria, François Godi, David Salinas, Jean-Daniel Boissonnat, Marc Glisse, Mariette Yvinec, Pawel Dlotko, Siargey Kachanovich, Vincent Rouvreau, Mathieu Carrière and Bertrand Michel
- Contact: Jean-Daniel Boissonnat
- URL: <https://gudhi.inria.fr/>

## 4.2. CGAL module: interval arithmetics

KEYWORD: Arithmetic

FUNCTIONAL DESCRIPTION: This package of CGAL (Computational Geometry Algorithms Library <http://www.cgal.org>) provides an efficient number type for intervals of double and the corresponding arithmetic operations. It is used in the evaluation of geometric predicates for a first quick computation, which either provides the result with guarantees, or rarely answers that more precision is needed.

RELEASE FUNCTIONAL DESCRIPTION: Partial rewrite to take advantage of SIMD instructions on recent x86 processors.

- Contact: Marc Glisse
- URL: <https://www.cgal.org/>

## 4.3. CGAL module: interface to Boost.Multiprecision

KEYWORD: Arithmetic

FUNCTIONAL DESCRIPTION: This package of CGAL (Computational Geometry Algorithms Library <http://www.cgal.org>) makes it possible to use some number types from Boost.Multiprecision in CGAL.

- Author: Marc Glisse
- Contact: Marc Glisse
- URL: <https://www.cgal.org/>

## 4.4. Module CGAL: New dD Geometry Kernel

KEYWORD: Computational geometry

FUNCTIONAL DESCRIPTION: This package of CGAL (Computational Geometry Algorithms Library <http://www.cgal.org>) provides the basic geometric types (point, vector, etc) and operations (orientation test, etc) used by geometric algorithms in arbitrary dimension. It uses filters for efficient exact predicates.

RELEASE FUNCTIONAL DESCRIPTION: New kernel with lazy exact constructions.

- Author: Marc Glisse
- Contact: Marc Glisse
- URL: <http://www.cgal.org/>

## DEDUCTEAM Project-Team

# 5. New Software and Platforms

## 5.1. Autotheo

KEYWORD: Automated deduction

SCIENTIFIC DESCRIPTION: Transformation of axiomatic theories into rewriting systems that can be used by iProverModulo.

FUNCTIONAL DESCRIPTION: Autotheo is a tool that transforms axiomatic theories into polarized rewriting systems, thus making them usable in iProverModulo. It supports several strategies to orient the axioms, some of them being proved to be complete, in the sense that ordered polarized resolution modulo the resulting systems is refutationally complete, some others being merely heuristics. In practice, Autotheo takes a TPTP input file and produces an input file for iProverModulo.

NEWS OF THE YEAR: Maintenance.

- Participant: Guillaume Burel
- Partner: ENSIIE
- Contact: Guillaume Burel
- Publication: [Consistency Implies Cut Admissibility](#)
- URL: [http://www.ensiie.fr/~guillaume.burel/blackandwhite\\_autotheo.html.en](http://www.ensiie.fr/~guillaume.burel/blackandwhite_autotheo.html.en)

## 5.2. CoLoR

*Coq Library on Rewriting and termination*

KEYWORDS: Coq - Formalisation

FUNCTIONAL DESCRIPTION: CoLoR is a Coq library on rewriting theory and termination. It provides many definitions and theorems on various mathematical structures (quasi-ordered sets, relations, ordered semi-rings, etc.), data structures (lists, vectors, matrices, polynomials, finite graphs), term structures (strings, first-order terms, lambda-terms, etc.), transformation techniques (dependency pairs, semantic labeling, etc.) and (non-)termination criteria (polynomial and matrix interpretations, recursive path ordering, computability closure, etc.).

- Authors: Frédéric Blanqui and Sébastien Hinderer
- Contact: Frédéric Blanqui
- Publications: [CoLoR: a Coq library on well-founded rewrite relations and its application to the automated verification of termination certificates - Automated Verification of Termination Certificates](#)  
[- CoLoR: a Coq library on rewriting and termination](#)
- URL: <http://color.inria.fr/>

## 5.3. Coquine

*Coq In dEdukti*

KEYWORDS: Higher-order logic - Formal methods - Proof

FUNCTIONAL DESCRIPTION: CoqInE is a plugin for the Coq software translating Coq proofs into Dedukti terms. It provides a Dedukti signature file faithfully encoding the underlying theory of Coq (or a sufficiently large subset of it). Current development is mostly focused on implementing support for Coq universe polymorphism. The generated output is meant to be type-checkable using the latest version of Dedukti.

- Contact: Guillaume Burel
- URL: [http://www.ensiie.fr/~guillaume.burel/blackandwhite\\_coqInE.html.en](http://www.ensiie.fr/~guillaume.burel/blackandwhite_coqInE.html.en)



## 5.4. Dedukti

KEYWORD: Logical Framework

FUNCTIONAL DESCRIPTION: Dedukti is a proof-checker for the LambdaPi-calculus modulo. As it can be parametrized by an arbitrary set of rewrite rules, defining an equivalence relation, this calculus can express many different theories. Dedukti has been created for this purpose: to allow the interoperability of different theories.

Dedukti's core is based on the standard algorithm for type-checking semi-full pure type systems and implements a state-of-the-art reduction machine inspired from Matita's and modified to deal with rewrite rules.

Dedukti's input language features term declarations and definitions (opaque or not) and rewrite rule definitions. A basic module system allows the user to organize his project in different files and compile them separately.

Dedukti features matching modulo beta for a large class of patterns called Miller's patterns, allowing for more rewriting rules to be implemented in Dedukti.

NEWS OF THE YEAR: There has been a new release 2.6 in 2018. This release provides a better control on module loading, and a better log of rewrite steps.

- Participants: François Thiré, Gaspard Ferey, Guillaume Genestier and Rodolphe Lepigre
- Contact: François Thiré
- Publications: [Dedukti:un vérificateur de preuves universel - Rewriting Modulo  \$\beta\$  in the  \$\lambda\$  II-Calculus Modulo - Expressing theories in the  \$\lambda\$ II-calculus modulo theory and in the Dedukti system](#)
- URL: <https://deducteam.github.io/>

## 5.5. Holide

KEYWORD: Proof

FUNCTIONAL DESCRIPTION: Holide translates HOL proofs to Dedukti[OT] proofs, using the OpenTheory standard (common to HOL Light and HOL4). Dedukti[OT] being the encoding of OpenTheory in Dedukti.

- Contact: Guillaume Burel
- URL: <http://deducteam.gforge.inria.fr/holide/>

## 5.6. HOT

*Higher-Order Termination*

FUNCTIONAL DESCRIPTION: HOT is an automated termination prover for higher-order rewriting, based on the notion of computability closure.

- Contact: Frédéric Blanqui
- URL: <http://rewriting.gforge.inria.fr/hot.html>

## 5.7. iProver Modulo

KEYWORDS: Automated deduction - Automated theorem proving

SCIENTIFIC DESCRIPTION: Integration of ordered polarized resolution modulo theory into the prover iProver.

FUNCTIONAL DESCRIPTION: iProver Modulo is an extension of the automated theorem prover iProver originally developed by Konstantin Korovin at the University of Manchester. It implements ordered polarized resolution modulo theory, a refinement of the resolution method based on deduction modulo theory. It takes as input a proposition in predicate logic and a clausal rewriting system defining the theory in which the formula has to be proved. Normalization with respect to the term rewriting rules is performed very efficiently through translation into OCaml code, compilation and dynamic linking. Experiments have shown that ordered polarized resolution modulo dramatically improves proof search compared to using raw axioms.

NEWS OF THE YEAR: Maintenance of Dedukti output

- Participant: Guillaume Burel
- Partner: ENSIIE
- Contact: Guillaume Burel
- Publications: [A Shallow Embedding of Resolution and Superposition Proofs into the  \$\lambda\$ -Calculus Modulo - Experimenting with deduction modulo](#)
- URL: <https://github.com/gburel/iProverModulo>

## 5.8. mSAT

KEYWORD: Propositional logic

FUNCTIONAL DESCRIPTION: mSAT is a modular, proof-producing, SAT and SMT core based on Alt-Ergo Zero, written in OCaml. The solver accepts user-defined terms, formulas and theory, making it a good tool for experimenting. This tool produces resolution proofs as trees in which the leaves are user-defined proof of lemmas.

- Contact: Guillaume Bury
- Publication: [mSAT: An OCaml SAT Solver](#)
- URL: <https://github.com/Gbury/mSAT>

## 5.9. Rainbow

*Termination certificate verifier*

KEYWORDS: Demonstration - Code generation - Verification

FUNCTIONAL DESCRIPTION: Rainbow is a set of tools for automatically verifying the correctness of termination certificates expressed in the CPF format used in the annual international competition of termination tools. It contains: a tool xsd2coq for generating Coq data types for representing XML files valid with respect to some XML Schema, a tool xsd2ml for generating OCaml data types and functions for parsing XML files valid with respect to some XML Schema, a tool for translating a CPF file into a Coq script, and a standalone Coq certified tool for verifying the correctness of a CPF file.

- Author: Frédéric Blanqui
- Contact: Frédéric Blanqui
- Publications: [Automated verification of termination certificates - Automated verification of termination certificates](#)
- URL: <http://color.inria.fr/rainbow.html>

## 5.10. Krajono

KEYWORD: Proof

FUNCTIONAL DESCRIPTION: Krajono translates Matita proofs into Dedukti[CiC] (encoding of CiC in Dedukti) terms.

- Contact: François Thiré

## 5.11. archsat

KEYWORDS: Automated theorem proving - First-order logic - Propositional logic

FUNCTIONAL DESCRIPTION: Archsat is an automated theorem prover aimed at studying the integration of first-order theorem prover technologies, such as rewriting, into SMT solvers.

- Contact: Guillaume Bury
- URL: <https://gforge.inria.fr/projects/archsat>

## 5.12. **lrat2dk**

KEYWORDS: Automated theorem proving - Proof

FUNCTIONAL DESCRIPTION: Take as input a SAT proof trace in LRAT format, which can be obtained from the de facto standard format DRAT using drat-trim. Output a proof checkable by Dedukti, in a shallow encoding of propositional logic.

- Participant: Guillaume Burel
- Partner: ENSIIE
- Contact: Guillaume Burel
- URL: <https://github.com/gburel/lrat2dk>

## 5.13. **ekstrakto**

KEYWORDS: TPTP - TSTP - Proof assistant - Dedukti

FUNCTIONAL DESCRIPTION: Extracting TPTP problems from a TSTP trace. Proof reconstruction in Dedukti from TSTP trace.

- Contact: Mohamed Yacine El Haddad
- URL: <https://github.com/elhaddadyacine/ekstrakto>

## 5.14. **SizeChangeTool**

KEYWORDS: Rewriting systems - Proof assistant - Termination

FUNCTIONAL DESCRIPTION: A termination-checker for higher-order rewriting with dependent types. Took part in the Termination Competition 2018 ( [http://termination-portal.org/wiki/Termination\\_Competition\\_2018](http://termination-portal.org/wiki/Termination_Competition_2018) ) in the "Higher-Order Rewriting (union Beta)" category.

- Partner: Mines ParisTech
- Contact: Guillaume Genestier
- URL: <https://github.com/Deducteam/SizeChangeTool>

## 5.15. **Logipedia**

KEYWORDS: Formal methods - Web Services - Logical Framework

FUNCTIONAL DESCRIPTION: Logipedia is composed of two distinct parts: 1) A back-end that translates proofs expressed in a theory encoded in Dedukti to other systems such as Coq, Lean or HOL 2) A front-end that prints these proofs in a "nice way" via a website. Using the website, the user can search for a definition or a theorem then, download the whole proof into the wanted system.

Currently, the available systems are: Coq, Matita, Lean, PVS and OpenTheory. The proofs comes from a logic called STTForall.

In the long run, more systems and more logic should be added.

RELEASE FUNCTIONAL DESCRIPTION: This is the beta version of Logipedia. It implements the functionalities mentioned above.

- Contact: François Thiré
- URL: <http://www.logipedia.science>

## GRACE Project-Team

# 5. New Software and Platforms

## 5.1. 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 have two directions for improvement: renewing the APIs to make them actually usable by researchers, and incorporating efficient programs for decoding, like J. Nielsen's CodingLib, which contains many new algorithms.

- Partner: Technical University Denmark
- Contact: Daniel Augot

## 5.2. DECODING

KEYWORD: Algebraic decoding

FUNCTIONAL DESCRIPTION: Decoding is a standalone C library. Its primary goal is to implement Guruswami–Sudan list decoding-related algorithms, as efficiently as possible. Its secondary goal is to give an efficient tool for the implementation of decoding algorithms (not necessarily list decoding algorithms) and their benchmarking.

- Participant: Guillaume Quintin
- Contact: Daniel Augot

## 5.3. 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: Ben Smith
- Contact: Ben Smith
- URL: <http://research.microsoft.com/en-us/downloads/ef32422a-af38-4c83-a033-a7aafbc1db55/>

## 5.4. CADO-NFS

*Crible Algébrique: Distribution, Optimisation - Number Field Sieve*

KEYWORDS: Cryptography - Number theory

FUNCTIONAL DESCRIPTION: CADO-NFS is a complete implementation in C/C++ of the Number Field Sieve (NFS) algorithm for factoring integers and computing discrete logarithms in finite fields. It consists in various programs corresponding to all the phases of the algorithm, and a general script that runs them, possibly in parallel over a network of computers.

NEWS OF THE YEAR: The main program for relation collection now supports composite "special-q". The memory footprint of the central step of linear algebra was reduced. Parallelism of many of the Cado-NFS programs was improved considerably (sieving, relation filtering, as well as the central step of linear algebra).

- Participants: Pierrick Gaudry, Emmanuel Thomé and Paul Zimmermann
- Contact: Emmanuel Thomé
- URL: <http://cado-nfs.gforge.inria.fr/>

## MEXICO Project-Team

# 6. New Software and Platforms

## 6.1. COSMOS

KEYWORD: Model Checker

FUNCTIONAL DESCRIPTION: COSMOS is a statistical model checker for the Hybrid Automata Stochastic Logic (HASL). HASL employs Linear Hybrid Automata (LHA), a generalization of Deterministic Timed Automata (DTA), to describe accepting execution paths of a Discrete Event Stochastic Process (DESP), a class of stochastic models which includes, but is not limited to, Markov chains. As a result HASL verification turns out to be a unifying framework where sophisticated temporal reasoning is naturally blended with elaborate reward-based analysis. COSMOS takes as input a DESP (described in terms of a Generalized Stochastic Petri Net), an LHA and an expression  $Z$  representing the quantity to be estimated. It returns a confidence interval estimation of  $Z$ , recently, it has been equipped with functionalities for rare event analysis.

It is easy to generate and use a C code for discrete Simulink models (using only discrete blocks, which are sampled at fixed intervals) using MathWorks tools. However, it limits the expressivity of the models. In order to use more diverse Simulink models and control the flow of a multi-model simulation (with Discrete Event Stochastic Processes) we developed a Simulink Simulation Engine embedded into Cosmos.

COSMOS is written in C++

- Participants: Benoît Barbot, Hilal Djafri, Marie DufLOT-Kremer, Paolo Ballarini and Serge Haddad
- Contact: Benoît Barbot
- URL: <http://www.lsv.ens-cachan.fr/~barbot/cosmos/>

## 6.2. CosyVerif

FUNCTIONAL DESCRIPTION: CosyVerif is a platform dedicated to the formal specification and verification of dynamic systems. It allows to specify systems using several formalisms (such as automata and Petri nets), and to run verification tools on these models.

- Participants: Alban Linard, Fabrice Kordon, Laure Petrucci and Serge Haddad
- Partners: LIP6 - LSV - LIPN (Laboratoire d'Informatique de l'Université Paris Nord)
- Contact: Serge Haddad
- URL: <http://www.cosyverif.org/>

## 6.3. Mole

FUNCTIONAL DESCRIPTION: Mole computes, given a safe Petri net, a finite prefix of its unfolding. It is designed to be compatible with other tools, such as PEP and the Model-Checking Kit, which are using the resulting unfolding for reachability checking and other analyses. The tool Mole arose out of earlier work on Petri nets.

- Participant: Stefan Schwoon
- Contact: Stefan Schwoon
- URL: <http://www.lsv.ens-cachan.fr/~schwoon/tools/mole/>

## PARSIFAL Project-Team

# 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 particularly well suited for reasoning about binding constructs.

- Participants: Dale Miller, Gopalan Nadathur, Kaustuv Chaudhuri, Mary Southern, Matteo Cimini, Olivier Savary-Bélanger and Yuting Wang
- Partner: Department of Computer Science and Engineering, University of Minnesota
- Contact: Kaustuv Chaudhuri
- URL: <http://abella-prover.org/>

## 6.2. Bedwyr

*Bedwyr - A proof search approach to model checking*

KEYWORD: Model Checker

FUNCTIONAL DESCRIPTION: Bedwyr is a generalization of logic programming that allows model checking directly on syntactic expressions that possibly contain 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.

- Participants: Dale Miller, Quentin Heath and Roberto Blanco Martinez
- Contact: Dale Miller
- 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: Giselle Machado Nogueira Reis, Marco Volpe and Tomer Libal
- Contact: Tomer Libal
- URL: <https://github.com/proofcert/checkers>

## 6.4. Psyche

*Proof-Search factorY for Collaborative HEuristics*

KEYWORD: Automated 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 trusted kernel interacts with plugins. The kernel offers an API of proof-search primitives, and plugins are programmed on top of the API to implement search strategies. This architecture is set up for pure logical reasoning as well as for theory-specific reasoning, for various theories.

**RELEASE FUNCTIONAL DESCRIPTION:** It is now equipped with the machinery to handle quantifiers and quantifier-handling techniques. Concretely, it uses meta-variables to delay the instantiation of existential variables, and constraints on meta-variables are propagated through the various branches of the search-space, in a way that allows local backtracking. The kernel, of about 800 l.o.c., is purely functional.

- Participants: Assia Mahboubi, Jean-Marc Notin and Stéphane Graham-Lengrand
- Contact: Stéphane Graham-Lengrand
- URL: <http://www.csl.sri.com/users/sgl/>

## 6.5. Maetning

**FUNCTIONAL DESCRIPTION:** Mætning is an automated theorem prover for intuitionistic predicate logic that is designed to disprove non-theorems.

- Contact: Kaustuv Chaudhuri
- URL: <https://github.com/chaudhuri/maetning/>

## 6.6. OCaml

**KEYWORDS:** Functional programming - Static typing - Compilation

**FUNCTIONAL DESCRIPTION:** The OCaml language is a functional programming language that combines safety with expressiveness through the use of a precise and flexible type system with automatic type inference. The OCaml system is a comprehensive implementation of this language, featuring two compilers (a bytecode compiler, for fast prototyping and interactive use, and a native-code compiler producing efficient machine code for x86, ARM, PowerPC and System Z), a debugger, a documentation generator, a compilation manager, a package manager, and many libraries contributed by the user community.

- Participants: Damien Doligez, Xavier Leroy, Fabrice Le Fessant, Luc Maranget, Gabriel Scherer, Alain Frisch, Jacques Garrigue, Marc Shinwell, Jeremy Yallop and Leo White
- Contact: Damien Doligez
- URL: <https://ocaml.org/>

## SPECFUN Project-Team

# 5. New Software and Platforms

## 5.1. 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: Alexis Darrasse, Frédéric Chyzak and Maxence Guesdon
- Contact: Frédéric Chyzak
- URL: <http://ddmf.msr-inria.inria.fr/DynaMoW/>

## 5.2. 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: Alexis Darrasse, Frédéric Chyzak, Maxence Guesdon and Stéphanie Petit
- Contact: Frédéric Chyzak
- URL: <http://ecs.inria.fr/>

## 5.3. DDMF

*Dynamic Dictionary of Mathematical Functions*

FUNCTIONAL DESCRIPTION: Web site consisting of interactive tables of mathematical formulas on elementary and special functions. The formulas are automatically generated by OCaml and computer-algebra routines. Users can ask for more terms of the expansions, more digits of the numerical values, proofs of some of the formulas, etc.

- Participants: Alexandre Benoit, Alexis Darrasse, Bruno Salvy, Christoph Koutschan, Frédéric Chyzak, Marc Mezzarobba, Maxence Guesdon, Stefan Gerhold and Thomas Gregoire
- Contact: Frédéric Chyzak
- URL: <http://ddmf.msr-inria.inria.fr/1.9.1/ddmf>

## 5.4. Mgfun

*multivariate generating functions package*

FUNCTIONAL DESCRIPTION: The Mgfun Project is a collection of packages for the computer algebra system Maple, and is intended for the symbolic manipulation of a large class of special functions and combinatorial sequences (in one or several variables and indices) that appear in many branches of mathematics, mathematical physics, and engineering sciences. Members of the class satisfy a crucial finiteness property which makes the class amenable to computer algebra methods and enjoy numerous algorithmic closure properties, including algorithmic closures under integration and summation.

- Contact: Frédéric Chyzak
- URL: <http://specfun.inria.fr/chyzak/mgfun.html>



## 5.5. Ssreflect

KEYWORD: Proof assistant

SCIENTIFIC DESCRIPTION: Ssreflect is tactic language that helps writing concise and uniform tactic based proof scripts for the Coq system. It was designed during the proofs of the 4 Color Theorem and the Feit-Thompson theorem.

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

NEWS OF THE YEAR: In 2019, we extended the intro pattern functionality of SSreflect and added support for working under binders using the "under" tactical.

- Participants: Assia Mahboubi, Cyril Cohen, Enrico Tassi, Georges Gonthier, Laurence Rideau, Laurent Théry and Yves Bertot
- Contact: Yves Bertot
- URL: <http://math-comp.github.io/math-comp/>

## 5.6. Math-Components

*Mathematical Components library*

KEYWORD: Proof assistant

FUNCTIONAL DESCRIPTION: The Mathematical Components library is a set of Coq libraries that cover the prerequisite for the mechanization of the proof of the Odd Order Theorem.

RELEASE FUNCTIONAL DESCRIPTION: This releases is compatible with Coq 8.9 and Coq 8.10 it adds many theorems for finite function, prime numbers, sequences, finite types, bigo operations, natural numbers, cycles in graphs.

- Participants: Alexey Solovyev, Andrea Asperti, Assia Mahboubi, Cyril Cohen, Enrico Tassi, François Garillot, Georges Gonthier, Ioana Pasca, Jeremy Avigad, Laurence Rideau, Laurent Théry, Russell O'Connor, Sidi Ould Biha, Stéphane Le Roux and Yves Bertot
- Contact: Assia Mahboubi
- URL: <http://math-comp.github.io/math-comp/>

---

## 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.

RELEASE FUNCTIONAL DESCRIPTION: the "SAT solving" part can now be delegated to an external plugin, new experimental SAT solver based on mini-SAT, provided as a plugin. This solver is, in general, more efficient on ground problems, heuristics simplification in the default SAT solver and in the matching (instantiation) module, re-implementation of internal literals representation, improvement of theories combination architecture, rewriting some parts of the formulas module, bugfixes in records and numbers modules, new option "-no-Ematching" to perform matching without equality reasoning (i.e. without considering "equivalence classes"). This option is very useful for benchmarks coming from Atelier-B, two new experimental options: "-save-used-context" and "-replay-used-context". When the goal is proved valid, the first option allows to save the names of useful axioms into a ".used" file. The second one is used to replay the proof using only the axioms listed in the corresponding ".used" file. Note that the replay may fail because of the absence of necessary ground terms generated by useless axioms (that are not included in .used file) during the initial run.

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

## 6.2. CoqInterval

*Interval package for Coq*

KEYWORDS: Interval arithmetic - Coq

FUNCTIONAL DESCRIPTION: CoqInterval is a library for the proof assistant Coq.

It provides several tactics for proving 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 in Coq. In 2014, this library has been included in CoqInterval.

- Participants: Assia Mahboubi, Érik Martin-Dorel, Guillaume Melquiond, Jean-Michel Muller, Laurence Rideau, Laurent Théry, Micaela Mayero, Mioara Joldes, Nicolas Brisebarre and Thomas Sibut-Pinote
- Contact: Guillaume Melquiond
- Publications: [Proving bounds on real-valued functions with computations - Floating-point arithmetic in the Coq system](#) - [Proving Tight Bounds on Univariate Expressions with Elementary Functions in Coq](#) - [Formally Verified Approximations of Definite Integrals](#) - [Formally Verified Approximations of Definite Integrals](#)
- URL: <http://coq-interval.gforge.inria.fr/>

### 6.3. 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: Catherine Lelay, Guillaume Melquiond and Sylvie Boldo
- Contact: Sylvie Boldo
- URL: <http://coquelicot.saclay.inria.fr/>

### 6.4. 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: Alain Mebsout and Sylvain Conchon
- Contact: Sylvain Conchon
- URL: <http://cubicle.lri.fr/>

### 6.5. 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 verify numerical applications.

Flocq is currently used by the CompCert verified compiler to support floating-point computations.

- Participants: Guillaume Melquiond, Pierre Roux and Sylvie Boldo
- Contact: Sylvie Boldo
- Publications: [Flocq: A Unified Library for Proving Floating-point Algorithms in Coq - A Formally-Verified C Compiler Supporting Floating-Point Arithmetic - Verified Compilation of Floating-Point Computations - Innocuous Double Rounding of Basic Arithmetic Operations - Formal Proofs of Rounding Error Bounds : With application to an automatic positive definiteness check - Computer Arithmetic and Formal Proofs : Verifying Floating-point Algorithms with the Coq System](#)
- URL: <http://flocq.gforge.inria.fr/>

### 6.6. 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 formally verifying 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 verify 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 platform or as an automatic tactic for the Coq proof assistant.

- Participant: Guillaume Melquiond
- Contact: Guillaume Melquiond
- Publications: [Generating formally certified bounds on values and round-off errors](#) - [Formal certification of arithmetic filters for geometric predicates](#) - [Assisted verification of elementary functions](#) - [From interval arithmetic to program verification](#) - [Formally Certified Floating-Point Filters For Homogeneous Geometric Predicates](#) - [Combining Coq and Gappa for Certifying Floating-Point Programs](#) - [Handbook of Floating-Point Arithmetic](#) - [Certifying the floating-point implementation of an elementary function using Gappa](#) - [Automations for verifying floating-point algorithms](#) - [Automating the verification of floating-point algorithms](#) - [Computer Arithmetic and Formal Proofs : Verifying Floating-point Algorithms with the Coq System](#)
- URL: <http://gappa.gforge.inria.fr/>

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

## 6.8. Coq

*The Coq Proof Assistant*

KEYWORDS: Proof - Certification - Formalisation

SCIENTIFIC DESCRIPTION: Coq is an interactive proof assistant based on the Calculus of (Co-)Inductive Constructions, extended with universe polymorphism. This type theory features inductive and co-inductive families, an impredicative sort and a hierarchy of predicative universes, making it a very expressive logic. The calculus allows to formalize both general mathematics and computer programs, ranging from theories of finite structures to abstract algebra and categories to programming language metatheory and compiler verification. Coq is organised as a (relatively small) kernel including efficient conversion tests on which are built a set of higher-level layers: a powerful proof engine and unification algorithm, various tactics/decision procedures, a transactional document model and, at the very top an IDE.

**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, ...

**RELEASE FUNCTIONAL DESCRIPTION:** Coq version 8.10 contains two major new features: support for a native fixed-precision integer type and a new sort `SProp` of strict propositions. It is also the result of refinements and stabilization of previous features, deprecations or removals of deprecated features, cleanups of the internals of the system and API, and many documentation improvements. This release includes many user-visible changes, including deprecations that are documented in the next subsection, and new features that are documented in the reference manual.

Version 8.10 is the fifth release of Coq developed on a time-based development cycle. Its development spanned 6 months from the release of Coq 8.9. Vincent Laporte is the release manager and maintainer of this release. This release is the result of 2500 commits and 650 PRs merged, closing 150+ issues.

See the Zenodo citation for more information on this release: <https://zenodo.org/record/3476303#.Xe54f5NKjOQ>

**NEWS OF THE YEAR:** Coq 8.10.0 contains:

- some quality-of-life bug fixes, - a critical bug fix related to template polymorphism, - native 63-bit machine integers, - a new sort of definitionally proof-irrelevant propositions: `SProp`, - private universes for opaque polymorphic constants, - string notations and numeral notations, - a new simplex-based proof engine for the tactics `lia`, `nia`, `lra` and `nra`, - new introduction patterns for `SSReflect`, - a tactic to rewrite under binders: `under`, - easy input of non-ASCII symbols in CoqIDE, which now uses GTK3.

All details can be found in the user manual.

- Participants: Yves Bertot, Frédéric Besson, Maxime Denes, Emilio Jesús Gallego Arias, Gaëtan Gilbert, Jason Gross, Hugo Herbelin, Assia Mahboubi, Érik Martin-Dorel, Guillaume Melquiond, Pierre-Marie Pédro, Michael Soegtrop, Matthieu Sozeau, Enrico Tassi, Laurent Théry, Théo Zimmermann, Theo Winterhalter, Vincent Laporte, Arthur Charguéraud, Cyril Cohen, Christian Doczkal and Chantal Keller
- Partners: CNRS - Université Paris-Sud - ENS Lyon - Université Paris-Diderot
- Contact: Matthieu Sozeau
- URL: <http://coq.inria.fr/>

## CELESTE Project-Team

# 5. New Software and Platforms

## 5.1. BlockCluster

### *Block Clustering*

KEYWORDS: Statistic analysis - Clustering package

SCIENTIFIC DESCRIPTION: Simultaneous clustering of rows and columns, usually designated by biclustering, co-clustering or block clustering, is an important technique in two way data analysis. It consists of estimating a mixture model which takes into account the block clustering problem on both the individual and variables sets. The blockcluster package provides a bridge between the C++ core library and the R statistical computing environment. This package allows to co-cluster binary, contingency, continuous and categorical data-sets. It also provides utility functions to visualize the results. This package may be useful for various applications in fields of Data mining, Information retrieval, Biology, computer vision and many more.

FUNCTIONAL DESCRIPTION: BlockCluster is an R package for co-clustering of binary, contingency and continuous data based on mixture models.

RELEASE FUNCTIONAL DESCRIPTION: Initialization strategy enhanced

- Participants: Christophe Biernacki, Gilles Celeux, Parmeet Bhatia, Serge Iovleff, Vincent Brault and Vincent Kubicki
- Partner: Université de Technologie de Compiègne
- Contact: Serge Iovleff
- URL: <http://cran.r-project.org/web/packages/blockcluster/index.html>

## 5.2. MASSICCC

### *Massive Clustering with Cloud Computing*

KEYWORDS: Statistic analysis - Big data - Machine learning - Web Application

SCIENTIFIC DESCRIPTION: The web application let users use several software packages developed by Inria directly in a web browser. Mixmod is a classification library for continuous and categorical data. MixtComp allows for missing data and a larger choice of data types. BlockCluster is a library for co-clustering of data. When using the web application, the user can first upload a data set, then configure a job using one of the libraries mentioned and start the execution of the job on a cluster. The results are then displayed directly in the browser allowing for rapid understanding and interactive visualisation.

FUNCTIONAL DESCRIPTION: The MASSICCC web application offers a simple and dynamic interface for analysing heterogeneous data with a web browser. Various software packages for statistical analysis are available (Mixmod, MixtComp, BlockCluster) which allow for supervised and supervised classification of large data sets.

- Contact: Christophe Biernacki
- URL: <https://massiccc.lille.inria.fr>

## 5.3. Mixmod

### *Many-purpose software for data mining and statistical learning*

KEYWORDS: Data mining - Classification - Mixed data - Data modeling - Big data

FUNCTIONAL DESCRIPTION: Mixmod is a free toolbox for data mining and statistical learning designed for large and highdimensional data sets. Mixmod provides reliable estimation algorithms and relevant model selection criteria.

It has been successfully applied to marketing, credit scoring, epidemiology, genomics and reliability among other domains. Its particularity is to propose a model-based approach leading to a lot of methods for classification and clustering.

Mixmod allows to assess the stability of the results with simple and thorough scores. It provides an easy-to-use graphical user interface (mixmodGUI) and functions for the R (Rmixmod) and Matlab (mixmodForMatlab) environments.

- Participants: Benjamin Auder, Christophe Biernacki, Florent Langrognet, Gérard Govaert, Gilles Celeux, Remi Lebreton and Serge Iovleff
- Partners: CNRS - Université Lille 1 - LIFL - Laboratoire Paul Painlevé - HEUDIASYC - LMB
- Contact: Gilles Celeux
- URL: <http://www.mixmod.org>

## COMMANDS Project-Team

# 6. New Software and Platforms

## 6.1. BOCOP

*Boite à Outils pour le Contrôle Optimal*

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

RELEASE FUNCTIONAL DESCRIPTION: Handling of delay systems Alternate automatic differentiation tool: CppAD Update for CMake and MinGW (windows version)

- Participants: Benjamin Heymann, Virgile Andréani, Jinyan Liu, Joseph Frédéric Bonnans and Pierre Martinon
- Contact: Pierre Martinon
- URL: <http://bocop.org>

## 6.2. Bocop HJB

KEYWORDS: Optimal control - Stochastic optimization - Global optimization

FUNCTIONAL DESCRIPTION: Toolbox for stochastic or deterministic optimal control, dynamic programming / HJB approach.

RELEASE FUNCTIONAL DESCRIPTION: User interface State jumps for switched systems Explicit handling of final conditions Computation of state probability density (fiste step to mean field games)

- Participants: Benjamin Heymann, Jinyan Liu, Joseph Frédéric Bonnans and Pierre Martinon
- Contact: Joseph Frédéric Bonnans
- URL: <http://bocop.org>

## 6.3. Bocop Avion

KEYWORDS: Optimization - Aeronautics

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

NEWS OF THE YEAR: Improved atmosphere model 2D interpolations for temperature and wind data

- Participants: Gregorutti Baptiste, Cindie Andrieu, Anamaria Lupu, Joseph Frédéric Bonnans, Karim Tekkal, Pierre Jouniaux and Pierre Martinon
- Partner: Safety Line
- Contact: Pierre Martinon
- URL: <http://www.safety-line.fr>

## 6.4. Bocop HJB Avion

KEYWORDS: Optimization - Aeronautics



FUNCTIONAL DESCRIPTION: Optimize the climb and cruising trajectory of flight by a HJB approach.

NEWS OF THE YEAR: First demonstrator for cruise flight deployed at Safety Line

- Participants: Pierre Martinon, Joseph Frédéric Bonnans, Jinyan Liu, Gregorutti Baptiste and Anamaria Lupu
- Partner: Safety Line
- Contact: Pierre Martinon
- URL: <http://www.safety-line.fr>

**DEFI Project-Team (section vide)**

**DISCO Project-Team (section vide)**

## **GAMMA Project-Team**

### **3. New Software and Platforms**

#### **3.1. Metrix**

*Metrix: Error Estimates and Mesh Control for Anisotropic Mesh Adaptation*

KEYWORDS: Meshing - Metric - Metric fields

FUNCTIONAL DESCRIPTION: Metrix is a software that provides by various ways metric to govern the mesh generation. Generally, these metrics are constructed from error estimates (a priori or a posteriori) applied to the numerical solution. Metrix computes metric fields from scalar solutions by means of several error estimates: interpolation error, iso-lines error estimate, interface error estimate and goal oriented error estimate. It also contains several modules that handle meshes and metrics. For instance, it extracts the metric associated with a given mesh and it performs some metric operations such as: metric gradation and metric intersection.

- Participants: Adrien Loseille and Frédéric Alauzet
- Contact: Frédéric Alauzet
- URL: [https://www.rocq.inria.fr/gamma/Frederic.Alauzet/code\\_eng.html](https://www.rocq.inria.fr/gamma/Frederic.Alauzet/code_eng.html)

## **POEMS Project-Team**

# **5. New Software and Platforms**

## **5.1. COFFEE**

**KEYWORDS:** Numerical simulations - Wave propagation - Boundary element method

**FUNCTIONAL DESCRIPTION:** COFFEE is an adapted fast BEM solver to model acoustic and elastic wave propagation (full implementation in Fortran 90). The 3-D acoustic or elastodynamic equations are solved with the boundary element method accelerated by the multi-level fast multipole method or a hierarchical-matrices based representation of the system matrix. The fundamental solutions for the infinite space are used in this implementation. A boundary element-boundary element coupling strategy is also implemented so multi-region problems (strata inside a valley for example) can be solved. In order to accelerate the convergence of the iterative solver, various analytic or algebraic preconditioners are available. Finally, an anisotropic mesh adaptation strategy is used to further reduce the computational times.

- Contact: Stéphanie Chaillat

## **5.2. XLiFE++**

**KEYWORDS:** Numerical simulations - Finite element modelling - Boundary element method

**FUNCTIONAL DESCRIPTION:** XLiFE++ is an FEM-BEM C++ code developed by POEMS laboratory and IRMAR laboratory, that can solve 1D/2D/3D, scalar/vector, transient/stationary/harmonic problems. Description: <https://uma.ensta-paristech.fr/soft/XLiFE++/>

- Contact: Eric Lunéville

---

## RANDOPT Project-Team

# 6. New Software and Platforms

## 6.1. 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, including the easy integration of data from benchmarking experiments of 300+ algorithm variants, (3) LaTeX templates for scientific articles and HTML overview pages which present the figures and tables.

The COCO software is composed of two parts: (i) an interface available in different programming languages (C/C++, Java, Matlab/Octave, Python, external support for R) which allows to run and log experiments on several function test suites (unbounded noisy and noiseless single-objective functions, unbounded noiseless multiobjective problems, constrained problems) are provided (ii) a Python tool for generating figures and tables that can be looked at in every web browser and that can be used in the provided LaTeX templates to write scientific papers.

FUNCTIONAL DESCRIPTION: The Coco platform aims at supporting the numerical benchmarking of blackbox optimization algorithms 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, 300+ algorithms and algorithm variants by contributors from all over the world have been benchmarked on the platform’s supported test suites so far. The most recent extension has been towards large-scale problems and was used for the BBOB-2019 workshop at the ACM-GECCO conference.

- Participants: Anne Auger, Asma Atamna, Dejan Tutar, Dimo Brockhoff, Marc Schoenauer, Nikolaus HANSEN, Ouassim Ait Elhara, Raymond Ros, Tea Tutar, Thanh-Do Tran, Umut Batu and Konstantinos Varelas
- Partners: TU Dortmund University - Charles University Prague - Jozef Stefan Institute (JSI)
- Contact: Dimo Brockhoff
- URL: <https://github.com/numbbo/coco>

## 6.2. 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,  $f(x)=x^T H x$ , 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  $f(x)=\|x\|^2=x^T x$  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.

- Participant: Nikolaus HANSEN
- Contact: Nikolaus HANSEN
- URL: [http://cma.gforge.inria.fr/cmaes\\_sourcecode\\_page.html](http://cma.gforge.inria.fr/cmaes_sourcecode_page.html)

## TAU Project-Team

# 6. New Software and Platforms

## 6.1. io.datascience

### *Input Output Data Science*

KEYWORDS: Open data - Semantic Web - FAIR (Findable, Accessible, Interoperable, and Reusable)

FUNCTIONAL DESCRIPTION: io.datascience (Input Output Data Science) is the instance of the Linked Wiki platform developed specifically in Paris-Saclay University as part of its Center for Data Science.

The goal of io.datascience: to facilitate the sharing and use of scientific data. The technological concept of io.datascience: the exploitation of semantic web advances, and in particular wiki technologies.

(Findable, Accessible, Interoperable, and Reusable) (Wilkinson, M., and The FAIR Guiding Principles for Scientific Data Management and Stewardship, Nature Scientific Data 2016)

io.datascience is both a data sharing platform and a framework for further development. It realizes a practical implementation of FAIR (Findable, Accessible, Interoperable, and Reusable - Wilkinson, M., Nature Scientific Data 2016) principles through a user-centric approach.

- Partners: Border Cloud - Paris Saclay Center for Data Science - Université Paris-Sud
- Contact: Cécile Germain
- Publications: [Data acquisition for analytical platforms: Automating scientific workflows and building an open database platform for chemical analysis metadata](#) - [A platform for scientific data sharing](#) - [TFT, Tests For Triplestores : Certifying the interoperability of RDF database systems using a continuous delivery workflow](#) - [Une autocomplétion générique de SPARQL dans un contexte multi-services](#) - [Certifying the interoperability of RDF database systems](#) - [Transforming Wikipedia into an Ontology-based Information Retrieval Search Engine for Local Experts using a Third-Party Taxonomy](#) - [The Grid Observatory 3.0](#) - [Towards reproducible research and open collaborations using semantic technologies](#)
- URL: <https://io.datascience-paris-saclay.fr/>

## 6.2. Codalab

KEYWORDS: Benchmarking - Competition

FUNCTIONAL DESCRIPTION: Challenges in machine learning and data science are competitions running over several weeks or months to resolve problems using provided datasets or simulated environments. Challenges can be thought of as crowdsourcing, benchmarking, and communication tools. They have been used for decades to test and compare competing solutions in machine learning in a fair and controlled way, to eliminate "inventor-evaluator" bias, and to stimulate the scientific community while promoting reproducible science. See [our slide presentation](#).

As of June 2019 Codalab exceeded 40,000 users, 1000 competitions (300 public), and had over 300 submissions per day. Some of the areas in which Codalab is used include Computer vision and medical image analysis, natural language processing, time series prediction, causality, and automatic machine learning. Codalab was selected by the Région Ile de France to organize its challenges in the next three years.



TAU is going to continue expanding Codalab to accommodate new needs. One of our current focus is to support use of challenges for teaching (i.e. include a grading system as part of Codalab) and support for hooking up data simulation engines in the backend of Codalab to enable Reinforcement Learning challenges and simulate interactions of machines with an environment. For the fifth year, **we are using Codalab for student projects**. M2 AIC students create mini data science challenges in teams of 6 students. L2 math and informatics students then solve them as part of their mini projects. We are collaborating with RPI (New York, USA) and Université de Grenoble to use this platform as part of a curriculum of medical students. We created a special application called ChaGrade to grade homework using challenges. Our PhD. students are involved in co-organizing challenges to expose the research community at large with the topic of their PhD. This helps them formalizing a task with rigor and allows them to disseminate their research.

- Contact: Isabelle Guyon
- URL: <http://competitions.codalab.org>

### 6.3. Cartolabe

KEYWORD: Information visualization

FUNCTIONAL DESCRIPTION: The goal of Cartolabe is to build a visual map representing the scientific activity of an institution/university/domain from published articles and reports. Using the HAL Database, Cartolabe provides the user with a map of the thematics, authors and articles. ML techniques are used for dimensionality reduction, cluster and topics identification, visualisation techniques are used for a scalable 2D representation of the results.

NEWS OF THE YEAR: This year, Cartolabe was applied to the Grand Debat dataset (3M individual propositions from french Citizen, see <https://cartolabe.fr/map/debat>). The results were used to test both the scaling capabilities of Cartolabe and its flexibility to non-scientific and non-english corpuses. We also Added sub-map capabilities to display the result of a year/lab/word filtering as an online generated heatmap with only the filtered points to facilitate the exploration.

- Participants: Philippe Caillou, Jean-Daniel Fekete, Jonas Renault and Anne-Catherine Letournel
- Partners: LRI - Laboratoire de Recherche en Informatique - CNRS
- Contact: Philippe Caillou
- URL: <http://www.cartolabe.fr/>

## TROPICAL Project-Team

# 6. New Software and Platforms

## 6.1. Coq-Polyhedra

KEYWORDS: Coq - Polyhedra - Automated theorem proving - Linear optimization

SCIENTIFIC DESCRIPTION: Coq-Polyhedra is a library providing a formalization of convex polyhedra in the Coq proof assistant. While still in active development, it provides an implementation of the simplex method, and already handles the basic properties of polyhedra such as emptiness, boundedness, membership. Several fundamental results in the theory of convex polyhedra, such as Farkas Lemma, duality theorem of linear programming, and Minkowski Theorem, are also formally proved.

The formalization is based on the Mathematical Components library, and makes an extensive use of the boolean reflection methodology.

FUNCTIONAL DESCRIPTION: Coq-Polyhedra is a library which aims at formalizing convex polyhedra in Coq

NEWS OF THE YEAR: Coq-Polyhedra now provides most of the basic operations on polyhedra. They are expressed on a quotient type that avoids reasoning with particular inequality representations. They include : \* the construction of elementary polyhedra (half-spaces, hyperplanes, affine spaces, orthants, simplices, etc) \* basic operations such as intersection, projection (thanks to the formalization of the Fourier-Motzkin algorithm), image under linear functions, computations of convex hulls, finitely generated cones, etc. \* computation of affine hulls of polyhedra, as well as their dimension

Thanks to this, we have made huge progress on the formalization of the combinatorics of polyhedra. The poset of faces, as well as its fundamental properties (lattice, gradedness, atomicity and co-atomicity, etc) are now formalized. The manipulation of the faces is based on an extensive use of canonical structures, that allows to get the most appropriate inequality representations for reasoning. In this way, we arrive at very concise and elegant proofs, closer to the pen-and-paper ones.

- Participants: Xavier Allamigeon, Vasileios Charisopoulos, Ricardo Katz and Pierre-Yves Strub
- Partners: CIFASIS - Ecole Polytechnique
- Contact: Xavier Allamigeon
- Publications: [A Formalization of Convex Polyhedra Based on the Simplex Method - A Formalization of Convex Polyhedra Based on the Simplex Method - First steps in the formalization of convex polyhedra in Coq](#)
- URL: <https://github.com/nhojem/Coq-Polyhedra>

## 6.2. EmergencyEval

KEYWORDS: Dynamic Analysis - Simulation - Ocaml - Emergency - Firefighters - Police

SCIENTIFIC DESCRIPTION: This software aims at enabling the definition of a Petri network execution semantic, as well as the instantiation and execution of said network using the predefined semantic.

The heart of the project dwells in its kernel which operates the step-by-step execution of the network, obeying rules provided by an oracle. This user-defined and separated oracle computes the information necessary to the kernel for building the next state using the current state. The base of our software is the framework for the instantiation and execution of Petri nets, without making assumptions regarding the semantic.

In the context of the study of the dynamics of emergency call centers, a second part of this software is the definition and implementation of the semantic of call centers modeled as Petri nets, and more specifically timed prioritized Petri nets. A module interoperating with the kernel enables to include all the operational specificities of call centers (urgency level, discriminating between operators and callers ...) while guaranteeing the genericity of the kernel which embeds the Petri net formalism as such.

**FUNCTIONAL DESCRIPTION:** In order to enable the quantitative study of the throughput of calls managed by emergency center calls and the assessment of various organisational configurations considered by the stakeholders (firefighters, police, medical emergency service of the 75, 92, 93 and 94 French departments), this software modelizes their behaviours by resorting to extensions of the Petri net formalism. Given a call transfer protocol in a call center, which corresponds to a topology and an execution semantic of a Petri net, the software generates a set of entering calls in accord with the empirically observed statistic distributions (share of very urgent calls, conversation length), then simulates its management by the operators with respect to the defined protocol. Transitional regimes phenomena (peak load, support) which are not yet handled by mathematical analysis could therefore be studied. The output of the software is a log file which is an execution trace of the simulation featuring extensive information in order to enable the analysis of the data for providing simulation-based insights for decision makers.

The software relies on a Petri net simulation kernel designed to be as modular and adaptable as possible, fit for simulating other Petri-net related phenomena, even if their semantic differ greatly.

- Participants: Baptiste Colin and Xavier Allamigeon
- Contact: Baptiste Colin

## LIFEWARE Project-Team

# 6. New Software and Platforms

## 6.1. BIOCHAM

*The Biochemical Abstract Machine*

KEYWORDS: Systems Biology - Bioinformatics

FUNCTIONAL DESCRIPTION: The Biochemical Abstract Machine (BIOCHAM) is a software environment for modeling, analyzing and synthesizing biochemical reaction networks (CRNs) with respect to a formal specification of the observed or desired behavior of a biochemical system. BIOCHAM is compatible with the Systems Biology Markup Language (SBML) and contains some unique features about formal specifications in quantitative temporal logic, sensitivity and robustness analyses and parameter search in high dimension w.r.t. behavioral specifications, static analyses, and synthesis of CRNs.

RELEASE FUNCTIONAL DESCRIPTION: – notebooks of Master classes – graphical user interface on top of Jupyter – synthesis of at most binary reactions with minimisation of the variables for negative values – detection of model reduction by subgraph epimorphism – option for partial tropical equilibrations

- Participants: François Fages, David Coudrin, Sylvain Soliman and Mathieu Hemery
- Contact: François Fages
- URL: <http://lifeware.inria.fr/biocham4/>

## 6.2. casq

*CellDesigner as SBML-Qual*

KEYWORDS: SBML - Logical Framework - Knowledge representation

FUNCTIONAL DESCRIPTION: CaSQ transforms a big knowledge map encoded as an SBGN-compliant SBML file in CellDesigner into an executable Logical Model in SBML-Qual

- Authors: Sylvain Soliman and Anna Niarakis
- Partner: Université d'Evry-Val d'Essonne
- Contact: Sylvain Soliman
- URL: <https://gitlab.inria.fr/soliman/casq/>

## 6.3. Platforms

### 6.3.1. Smart experimental platforms to automate microbiology experiments

Models play a central role in our work, either to test our understanding or to guide the design of novel systems. Model development and parameter calibration necessitate informative experiments. We develop methods to assist with the optimal design of experiments. In consequence, we have to perform, in sequence or in parallel, experiments with possibly complex input profiles. This led us to develop experimental platforms that allow for flexible and automated stimulations and measurements. Three platforms are being developed, based on (i) a microplate photometer, (ii) a bioreactor platform coupled with a flow cytometer, and (iii) a microscope equipped with microfluidic systems, respectively. In all cases, the real-time measurement and actuation capabilities allow for making reactive experiments, notably including real-time control experiments.

## M3DISIM Project-Team

# 5. New Software and Platforms

## 5.1. HeartLab

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

FUNCTIONAL DESCRIPTION: The heartLab software is a library designed to perform both simulation and estimation of the heart mechanical behavior (based on various types of measurements, e.g. images).

Also included are 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.

- Participants: Radomir Chabiniok, Gautier Bureau, Martin Genet, Federica Caforio, Ustim Khristenko, Dominique Chapelle and Philippe Moireau
- Contact: Philippe Moireau
- URL: <https://raweb.inria.fr/rapportsactivite/RA2013/m3disim/uid14.html>

## 5.2. Verdandi

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

FUNCTIONAL DESCRIPTION: Verdandi is a free and 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.

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

## 5.3. CardiacLab

KEYWORDS: Cardiovascular and respiratory systems - Matlab - Real time

FUNCTIONAL DESCRIPTION: CardiacLab is a MATLAB toolbox allowing to perform “real-time” cardiac simulations using 0D models of the cardiovascular systems. Its modular development includes (1) a module integrating the mechanical dynamics of the cavity taking into account its particular geometry, (2) a module allowing to choose a micro-model of the cardiac contraction, (3) a module of phase management, (4) a circulation module based on Windkessel models or more advanced 1D flows models, and (5) a perfusion module. The objective of this code is threefold: (1) demonstrate to students, engineers, medical doctors, the interest of modeling in cardiac applications, (2) unify our original modeling developments with the possibility to evaluate them with previous team developments before integrating them into 3D complex formulations, and (3) explore some avenues pertaining to real-time simulation

- Participants: Sebastien Impériale, Martin Genet, Federica Caforio, Ustim Khristenko, Peter Baumgartner, Radomir Chabiniok, François Kimmig and Arthur Le Gall
- Contact: Philippe Moireau
- URL: <https://gitlab.inria.fr/M3DISIM/CardiacLab>

## 5.4. MoReFEM

*Modeling Research with the Finite Element Method*

KEYWORDS: HPC - Multiphysics modelling - Data assimilation

FUNCTIONAL DESCRIPTION: MoReFEM is a HPC finite element library for simulating multiphysics evolution problems like the ones encounter in cardiac modeling (electrophysiology, structure and fluid mechanics, transport-diffusion, wave equations)

- Participants: Philippe Moireau, Patrick Le Tallec, Antoine Olivier, Dominique Chapelle, Ustim Khristenko, François Kimmig, Gautier Bureau and Sébastien Gilles
- Contact: Sébastien Gilles
- URL: <https://gitlab.inria.fr/MoReFEM>

## OPIS Project-Team

# 6. New Software and Platforms

## 6.1. Platforms

### 6.1.1. *The Proximity Operator Repository*

**Participants:** Emilie Chouzenoux and Jean-Christophe Pesquet (in collaboration with Giovanni Chierchia, Univ. Paris Est, and Patrick Combettes, North Carolina State University).

**link:** <http://proximity-operator.net/>

Proximity operators have become increasingly important tools as basic building blocks of proximal splitting algorithms, a class of algorithms that decompose complex composite convex optimization methods into simple steps involving one of the functions present in the model. This website provides formulas for efficiently computing the proximity operator of various functions, along with the associated codes.

### 6.1.2. *FIGARO*

**Participants:** Emilie Chouzenoux and Jean-Christophe Pesquet (in collaboration with Claire Lefort, XLIM, Limoges).

**link:** [https://imagejdocu.tudor.lu/plugin/analysis/figaro\\_psf\\_3d\\_optical\\_microscopy/start](https://imagejdocu.tudor.lu/plugin/analysis/figaro_psf_3d_optical_microscopy/start)

The plugin FIGARO, for ImageJ software, helps tracking resolution of microscope systems by extracting dimensions and orientation of standardized microbeads images, acquired from test samples. In the development of optical microscopes for biomedical imaging, the evaluation of resolution is a fundamental parameter achieved by Point Spread Function (PSF) measurements. Sometimes, PSF measurement procedure is not easy or impossible in case of microspheres images presenting a high noise level. The current method proposed into the plugin FIGARO is based on a variational approach for PSF modeling through multivariate Gaussian fitting, adapted to images acquired in a high noise context [12].

### 6.1.3. *Kymatio*

**Participant:** Edouard Oyallon.

**link:** <http://www.kymatio.io>

The website shares the software *Kymatio* for Scattering Transform, that computes cascade of wavelets and modulus non-linearity. The codes have been optimized for GPUs and work on the open-source framework *PyTorch*.

### 6.1.4. *BiasedWalk: Learning latent node features with biased random walks*

**Participants:** Fragkiskos Malliaros and Duong Nguyen (UC San Diego)

**link:** <https://github.com/duong18/BiasedWalk/>

The BiasedWalk network representation learning algorithm, computes latent node features on graphs based on biased random walks. The framework has been implemented in Python and has been built upon widely used modules, including *networkx*, *numpy*, *gensim* and *scikit-learn*.

### 6.1.5. *DiffuGreedy: Influence maximization in complex networks based on diffusion cascades*

**Participants:** Fragkiskos Malliaros, Georgios Panagopoulos and Michalis Vazirgiannis (École Polytechnique)

**link:** <https://goo.gl/GpfCVZ>

The DiffuGreedy is an algorithm for influence maximization in complex networks, that is based on diffusion cascades. It has been implemented in Python and has been built upon widely used modules, including *networkx*, *igraph*, *numpy* and *pandas*.

### 6.1.6. Graph-based text categorization

**Participants:** Fragkiskos Malliaros, Konstantinos Skianis and Michalis Vazirgiannis (École Polytechnique)

**link:** <https://github.com/y3nk0/Graph-Based-TC/>

Graph-based TC is a framework for text categorization that relies on a graph representation of documents. The framework uses various graph centrality criteria to determine the importance of a term within a document. It also makes use of word embeddings to further boost the performance of graph-based methods. It has been implemented in Python and has been built upon widely used modules, including networkx, igraph, numpy and scikit-learn.

### 6.1.7. KernelNE - Topical Node Embeddings

**Participants:** Abdulkadir Çelikkanat, Fragkiskos Malliaros

**link:** <https://abdcelikkanat.github.io/projects/kernelNE/>

KernelNE learns node representations on graphs based on a weighted matrix factorization model which encodes random walk-based information about the nodes, as described in [53].

### 6.1.8. EFGE - Exponential Family Graph Embeddings

**Participants:** Abdulkadir Çelikkanat, Fragkiskos Malliaros

**link:** <https://abdcelikkanat.github.io/projects/EFGE/>

EFGE learns node embeddings generalizing random walk-based network representation learning techniques to exponential family conditional distributions, as described in [54].

### 6.1.9. Semi-supervised Fake News Detection

**Participants:** Adrien Benamira, Benjamin Devillers, Etienne Lesot, Ayush K. Ray, Manal Saadi, and Fragkiskos Malliaros

**link:** <https://github.com/bdvlrs/misinformation-detection-tensor-embeddings>

We propose a graph-based semi-supervised fake news detection method, based on graph neural networks, as described in [34].

### 6.1.10. The PINK image library

**Participant:** Hugues Talbot

**link:** <http://ibipio.hu/joomla/>

The PINK image library is a general-purpose, open-source, portable image processing library specializing in discrete geometry and mathematical morphology. It is the result of several decades of research in these domains and features state-of-the-art algorithmic implementation of both classical and leading edge DG and MM operators. These include nD parallel thinning and skeletonization methods and efficient hierarchical morphological transforms.

### 6.1.11. The Vivabrain AngioTK toolkit

**Participant:** Hugues Talbot

**link:** <https://github.com/vivabrain/angiotk>

AngioTK is a toolkit supported by Kitware (the authors of VTK) for the filtering, segmentation, generation and simulation of blood vessels. It was started in the context of the Vivabrain ANR project in 2012, but continues with the same as well as new partners. Applications are numerous, from the simulation and understanding of perfusion (see associated theme) to the simulation of realistic blood flow MRI images with associated ground truth, via the generation of blood vessel atlases.

### 6.1.12. The PET/CT FIJI Viewer

**Participant:** Hugues Talbot

**link:** <http://petctviewer.org/>

Quantitative Positron Emission Tomography is a new area for which software is not readily available. With our partners from Toulouse and Beth Israel hospitals, we have proposed a free open-source plugin allowing clinicians to view, interact and perform automated and interactive lesion segmentation in the context of PET/CT.



## PARIETAL Project-Team

# 6. New Software and Platforms

## 6.1. 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/>

## 6.2. Nilearn

*NeuroImaging with scikit learn*

**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: Alexandre Abraham, Alexandre Gramfort, Bertrand Thirion, Elvis Dohmatob, Fabian Pedregosa Izquierdo, Gaël Varoquaux, Loïc Estève, Michael Eickenberg and Virgile Fritsch
- Contact: Bertrand Thirion
- URL: <http://nilearn.github.io/>

## 6.3. Scikit-learn

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

## 6.4. MODL

*Massive Online Dictionary Learning*

KEYWORDS: Pattern discovery - Machine learning

FUNCTIONAL DESCRIPTION: Matrix factorization library, usable on very large datasets, with optional sparse and positive factors.

- Participants: Arthur Mensch, Gaël Varoquaux, Bertrand Thirion and Julien Mairal
- Contact: Arthur Mensch
- Publications: [Subsampled online matrix factorization with convergence guarantees - hal-01431618v3](#)
- URL: <http://github.com/arthurmensch/modl>

## 6.5. MNE

*MNE-Python*

KEYWORDS: Neurosciences - EEG - MEG - Signal processing - Machine learning

FUNCTIONAL DESCRIPTION: Open-source Python software for exploring, visualizing, and analyzing human neurophysiological data: MEG, EEG, sEEG, ECoG, and more.

RELEASE FUNCTIONAL DESCRIPTION: [http://martinos.org/mne/stable/whats\\_new.html](http://martinos.org/mne/stable/whats_new.html)

- Partners: HARVARD Medical School - New York University - University of Washington - CEA - Aalto university - Telecom Paris - Boston University - UC Berkeley
- Contact: Alexandre Gramfort
- URL: <http://martinos.org/mne/>

## 6.6. Dmipy

*Diffusion MRI Multi-Compartment Modeling and Microstructure Recovery Made Easy*

KEYWORDS: Diffusion MRI - Multi-Compartment Modeling - Microstructure Recovery

FUNCTIONAL DESCRIPTION: Non-invasive estimation of brain microstructure features using diffusion MRI (dMRI) – known as Microstructure Imaging – has become an increasingly diverse and complicated field over the last decades. Multi-compartment (MC)-models, representing the measured diffusion signal as a linear combination of signal models of distinct tissue types, have been developed in many forms to estimate these features. However, a generalized implementation of MC-modeling as a whole, providing deeper insights in its capabilities, remains missing. To address this fact, we present Diffusion Microstructure Imaging in Python (Dmipy), an open-source toolbox implementing PGSE-based MC-modeling in its most general form. Dmipy allows on-the-fly implementation, signal modeling, and optimization of any user-defined MC-model, for any PGSE acquisition scheme. Dmipy follows a “building block”-based philosophy to Microstructure Imaging, meaning MC-models are modularly constructed to include any number and type of tissue models, allowing simultaneous representation of a tissue’s diffusivity, orientation, volume fractions, axon orientation dispersion, and axon diameter distribution. In particular, Dmipy is geared toward facilitating reproducible, reliable MC-modeling pipelines, often allowing the whole process from model construction to parameter map recovery in fewer than 10 lines of code. To demonstrate Dmipy’s ease of use and potential, we implement a wide range of well-known MC-models, including IVIM, AxCaliber, NODDI(x), Bingham-NODDI, the spherical mean-based SMT and MC-MDI, and spherical convolution-based single- and multi-tissue CSD. By allowing parameter cascading between MC-models, Dmipy also facilitates implementation of advanced approaches like CSD with voxel-varying kernels and single-shell 3-tissue CSD. By providing a well-tested, user-friendly toolbox that simplifies the interaction with the otherwise complicated field of dMRI-based Microstructure Imaging, Dmipy contributes to more reproducible, high-quality research.

- Authors: Rutger Fick, Demian Wassermann and Rachid Deriche
- Contact: Rachid Deriche

## 6.7. PySAP

*Python Sparse data Analysis Package*

KEYWORDS: Image reconstruction - Image compression

FUNCTIONAL DESCRIPTION: The PySAP (Python Sparse data Analysis Package, <https://github.com/CEA-COSMIC/pysap>) open-source image processing software package has been developed for the 3 years between the Compressed Sensing group at Inria-CEA Parietal team led by Philippe Ciuciu and the CosmoStat team (CEA/IRFU) led by Jean-Luc Starck. It has been developed for the COMpressed Sensing for Magnetic resonance Imaging and Cosmology (COSMIC) project. This package provides a set of flexible tools that can be applied to a variety of compressed sensing and image reconstruction problems in various research domains. In particular, PySAP offers fast wavelet transforms and a range of integrated optimisation algorithms. It also offers a variety of plugins for specific application domains: on top of Pysap-MRI and PySAP-astro plugins, several complementary modules are now in development for electron tomography and electron microscopy for CEA colleagues. In October 2019, PySAP has been released on PyPi (<https://pypi.org/project/python-pySAP/>, currently version 0.0.3) and in conda (<https://anaconda.org/agrigis/python-pysap>).

The Pysap-MRI has been advertised through a specific abstract accepted to the next workshop of ISMRM on Data Sampling & Image Reconstruction in late January 2020. It will be presented during a power pitch session together with an hands-on demo session using JuPyter notebooks.

- Partner: CEA
- Contact: Philippe Ciuciu

## XPOP Project-Team

# 6. New Software and Platforms

## 6.1. mlxR

KEYWORDS: Simulation - Data visualization - Clinical trial simulator

FUNCTIONAL DESCRIPTION: The models are encoded using the model coding language 'Mlxtran', automatically converted into C++ codes, compiled on the fly and linked to R using the 'Rcpp' package. That allows one to implement very easily complex ODE-based models and complex statistical models, including mixed effects models, for continuous, count, categorical, and time-to-event data.

- Contact: Marc Lavielle
- URL: <http://simulx.webpopix.org/>

## 6.2. Rsmlx

*R speaks Monolix*

KEYWORDS: Data modeling - Nonlinear mixed effects models - Statistical modeling

FUNCTIONAL DESCRIPTION: Among other tasks, 'Rsmlx' provides a powerful tool for automatic PK model building, performs statistical tests for model assessment, bootstrap simulation and likelihood profiling for computing confidence intervals. 'Rsmlx' also proposes several automatic covariate search methods for mixed effects models.

- Partner: Lixoft
- Contact: Marc Lavielle
- URL: <http://rsmlx.webpopix.org/>

## 6.3. SPIX

KEYWORDS: Data modeling - Mass spectrometry - Chemistry

FUNCTIONAL DESCRIPTION: SPIX allows you to - automatically identify, on the basis of statistical approaches, small but significant differences in spectra measured under different conditions, - model the kinetics of entities that evolve over time

- Authors: Marc Lavielle and Yao Xu
- Partner: Laboratoire de Chimie Moléculaire - Ecole Polytechnique
- Contact: Marc Lavielle
- URL: <http://spix.webpopix.org/>

## TRIBE Project-Team

# 5. New Software and Platforms

## 5.1. RIOT

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

**SCIENTIFIC DESCRIPTION:** While requiring as low as 1,5kB of RAM and 5kB of ROM, RIOT offers real time and energy efficiency capabilities, as well as a single API (partially POSIX compliant) across heterogeneous 8-bit, 16-bit and 32-bit low-hardware. This API is developer-friendly in that it enables multi-threading, standard C and C++ application programming and the use of standard debugging tools (which was not possible so far for embedded programming). On top of this, RIOT includes several network stacks, such as a standard IPv6/6LoWPAN stack and an information-centric network stack (based on CCN).

**FUNCTIONAL DESCRIPTION:** RIOT is an Open Source operating system that provides standard protocols for embedded systems. RIOT allows, for example, the development of applications that collect sensor data and transmit it to a central node (e.g. a server). This data can then be used for smart energy management for instance.

RIOT is specially designed for embedded systems, which are strongly constrained in memory and energy. Further, RIOT can easily be ported to different hardware devices and follows the latest evolution of IP standards.

RIOT applications can readily be tested in the FIT IoT-Lab, which provides a large-scale infrastructure facility with 3000 nodes for testing remotely small wireless devices.

- Participants: Emmanuel Baccelli and Oliver Hahm
- Partners: Freie Universität Berlin - University of Hamburg
- Contact: Emmanuel Baccelli
- URL: <http://www.riot-os.org>

## 5.2. openschc

**KEYWORDS:** Internet of things - Internet protocols - Low-Power Wireless

**FUNCTIONAL DESCRIPTION:** OpenSCHC is a OpenSource Implementation of SCHC (Static Context Header Compression) currently being standardized by the LPWAN Working Group at the IETF. Oversimplifying, this is essentially IPv6 compression and fragmentation intended for low datarate, long range IoT networks.

The short/medium term goal is to organize SCHC Hackathons that occur at the IETF meetings.

The long term wish is to have a stable, open-source, reference codebase for the SCHC protocol (in Python).

The authors of OpenSCHC are listed here: <https://github.com/openschc/openschc/blob/master/AUTHORS.txt>

- Partner: OpenSCHC Authors
- Contact: Cédric Adjih
- URL: <https://github.com/openschc/openschc>

## 5.3. Gardinet

**KEYWORD:** Distributed networks

**FUNCTIONAL DESCRIPTION:** Gardinet (previously DragonNet) is a generic framework for network coding in wireless networks. It is an initial 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, DragonNet 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: Antonia Masucci, Cédric Adjih, Hana Baccouch and Ichrak Amdouni
- Contact: Cédric Adjih
- URL: <http://gitlab.inria.fr/gardinet>

## AVIZ Project-Team

# 6. New Software and Platforms

## 6.1. Cartolabe

KEYWORD: Information visualization

FUNCTIONAL DESCRIPTION: The goal of Cartolabe is to build a visual map representing the scientific activity of an institution/university/domain from published articles and reports. Using the HAL Database, Cartolabe provides the user with a map of the thematics, authors and articles . ML techniques are used for dimensionality reduction, cluster and topics identification, visualisation techniques are used for a scalable 2D representation of the results.

NEWS OF THE YEAR: Improvement of the graphical interface

- Participants: Philippe Caillou, Jean-Daniel Fekete, Jonas Renault and Anne-Catherine Letournel
- Partners: LRI - Laboratoire de Recherche en Informatique - CNRS
- Contact: Philippe Caillou
- URL: <http://www.cartolabe.fr/>

## 6.2. BitConduite

*BitConduite Bitcoin explorer*

KEYWORDS: Data visualization - Clustering - Financial analysis - Cryptocurrency

FUNCTIONAL DESCRIPTION: BitConduite is a web-based visual tool that allows for a high level explorative analysis of the Bitcoin blockchain. It offers a data transformation back end that gives us an entity-based access to the blockchain data and a visualization front end that supports a novel high-level view on transactions over time. In particular, it facilitates the exploration of activity through filtering and clustering interactions. This gives analysts a new perspective on the data stored on the blockchain.

- Authors: Jean-Daniel Fekete, Petra Isenberg and Christoph Kinkeldey
- Contact: Petra Isenberg

## 6.3. PAOHvis

*Parallel Aggregated Ordered Hypergraph Visualization*

KEYWORDS: Dynamic networks - Hypergraphs

FUNCTIONAL DESCRIPTION: Parallel Aggregated Ordered Hypergraph (PAOH) is a novel technique to visualize dynamic hypergraphs [26]. Hypergraphs are a generalization of graphs where edges can connect more than two vertices. Hypergraphs can be used to model co-authorship networks with multiple authors per article, or networks of business partners. A dynamic hypergraph evolves over discrete time slots. A PAOH display represents vertices as parallel horizontal bars and hyperedges as vertical lines that connect two or more vertices. We believe that PAOH is the first technique with a highly readable representation of dynamic hypergraphs without overlaps. It is easy to learn and is well suited for medium size dynamic hypergraph networks such as those commonly generated by digital humanities projects - our driving application domain (see Fig. 3 ).

- Contact: Paola Tatiana Llerena Valdivia
- URL: <https://aviz.fr/paohvis>

## 6.4. AR Collaborative Visualization

KEYWORDS: Augmented reality - Collaborative science - Android

FUNCTIONAL DESCRIPTION: Allows to look at VTK datasets using AR-HMD (Microsoft HoloLens) in multi-users environments (i.e., one headset per user). A Multi-touch tablet is provided per user to manipulate the environment.

- Contact: Mickael Sereno

## 6.5. Platforms

### 6.5.1. *Vispubdata.org*

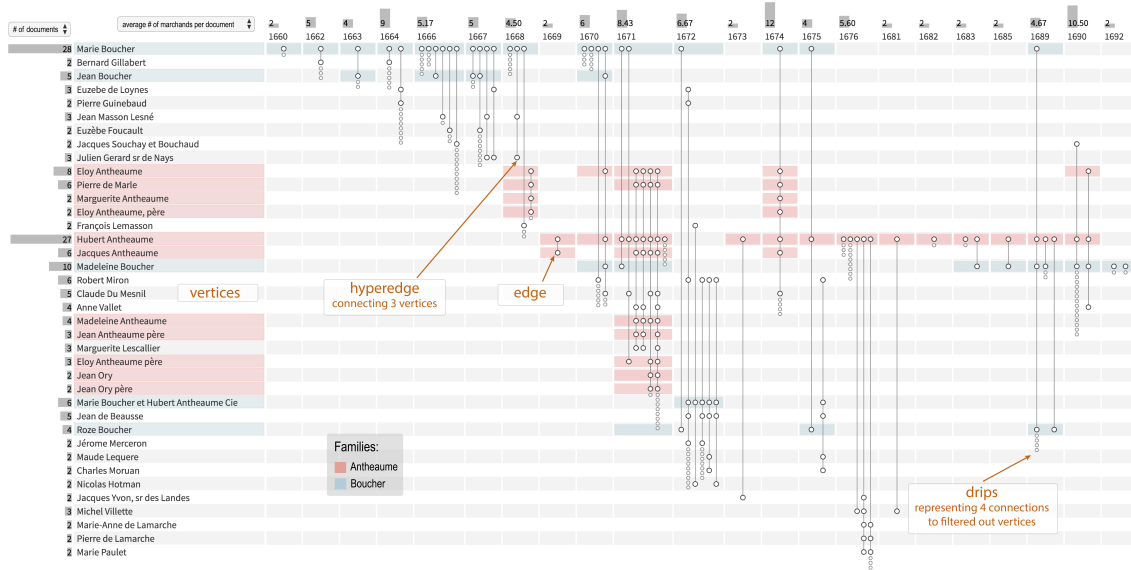


Figure 3. Using Dynamic Hypergraphs to Reveal the Evolution of the Business Network of a 17th Century French Woman Merchant

AVIZ members are making available for research a dataset of IEEE VIS publications at <http://vispubdata.org>. This dataset is actively being used for research and conference organization.



## CEDAR Project-Team

# 6. New Software and Platforms

## 6.1. Tatoonine

KEYWORDS: RDF - JSon - Knowledge database - Databases - Data integration - Polystore

FUNCTIONAL DESCRIPTION: Tatoonine allows to jointly query data sources of heterogeneous formats and data models (relations, RDF graphs, JSON documents etc.) under a single interface. It is capable of evaluating conjunctive queries over several such data sources, distributing computations between the underlying single-data model systems and a Java-based integration layer based on nested tuples.

- Participants: François Goasdoué, Ioana Manolescu, Javier Letelier Ruiz, Michaël Thomazo, Oscar Santiago Mendoza Rivera, Raphael Bonaque, Swen Ribeiro, Tien Duc Cao and Xavier Tannier
- Contact: Ioana Manolescu

## 6.2. AIDES

KEYWORDS: Data Exploration - Active Learning

FUNCTIONAL DESCRIPTION: AIDES is a data exploration software. It allows a user to explore a huge (tabular) dataset and discover tuples matching his or her interest. Our system repeatedly proposes the most informative tuples to the user, who must annotate them as “interesting” / “not-interesting”, and as iterations progress an increasingly accurate model of the user’s interest region is built. Our system also focuses on supporting low selectivity, high-dimensional interest regions.

- Contact: Yanlei Diao

## 6.3. OntoSQL

KEYWORDS: RDF - Semantic Web - Querying - Databases

FUNCTIONAL DESCRIPTION: OntoSQL is a tool providing three main functionalities: - Loading RDF graphs (consisting of data triples and possibly a schema or ontology) into a relational database, - Saturating the data based on the ontology. Currently, RDF Schema ontologies are supported. - Querying the loaded data using conjunctive queries. Data can be loaded either from distinct files or from a single file containing them both. The loading process allows to choose between two storage schemas: - One triples table. - One table per role and concept. Querying provides an SQL translation for each conjunctive query according to the storage schema used in the loading process, then the SQL query is evaluated by the underlying relational database.

- Participants: Ioana Manolescu, Michaël Thomazo and Tayeb Merabti
- Partner: Université de Rennes 1
- Contact: Ioana Manolescu
- URL: <https://ontosql.inria.fr/>

## 6.4. ConnectionLens

KEYWORDS: Data management - Big data - Information extraction - Semantic Web

**FUNCTIONAL DESCRIPTION:** ConnectionLens treats a set of heterogeneous, independently authored data sources as a single virtual graph, whereas nodes represent fine-granularity data items (relational tuples, attributes, key-value pairs, RDF, JSON or XML nodes. . .) and edges correspond either to structural connections (e.g., a tuple is in a database, an attribute is in a tuple, a JSON node has a parent. . .) or to similarity (sameAs) links. To further enrich the content journalists work with, we also apply entity extraction which enables to detect the people, organizations etc. mentioned in text, whether full-text or text snippets found e.g. in RDF or XML. ConnectionLens is thus capable of finding and exploiting connections present across heterogeneous data sources without requiring the user to specify any join predicate.

- Contact: Manolescu Ioana
- Publication: [ConnectionLens: Finding Connections Across Heterogeneous Data Sources](#)
- URL: <https://team.inria.fr/cedar/connectionlens/>

## 6.5. INSEE-Extract

*Spreadsheets extractor*

**KEYWORDS:** RDF - Data extraction

**FUNCTIONAL DESCRIPTION:** Extract content of spreadsheets automatically and store it as RDF triples

- Participants: Ioana Manolescu, Xavier Tannier and Tien Duc Cao
- Contact: Tien Duc Cao
- Publication: [Extracting Linked Data from statistic spreadsheets](#)
- URL: <https://gitlab.inria.fr/cedar/excel-extractor>

## 6.6. INSEE-Search

**KEYWORDS:** Document ranking - RDF

**FUNCTIONAL DESCRIPTION:** Searching for relevant data cells (or data row/column) given a query in natural language (French)

- Participants: Ioana Manolescu, Xavier Tannier and Tien Duc Cao
- Contact: Tien Duc Cao
- Publications: [Extracting Linked Data from statistic spreadsheets - Searching for Truth in a Database of Statistics](#)

## 6.7. RDFQuotient

*Quotient summaries of RDF graphs*

**KEYWORDS:** RDF - Graph algorithmics - Graph visualization - Graph summaries - Semantic Web

**FUNCTIONAL DESCRIPTION:** RDF graphs can be large and heterogeneous, making it hard for users to get acquainted with a new graph and understand whether it may have interesting information. To help users figure it out, we have devised novel equivalence relations among RDF nodes, capable of recognizing them as equivalent (and thus, summarize them together) despite the heterogeneity often exhibited by their incoming and outgoing node properties. From these relations, we derive four novel summaries, called Weak, Strong, Typed Weak and Typed Strong, and show how to obtain from them compact and enticing visualizations.

- Participants: Ioana Manolescu, Pawel Guzewicz and François Goasdoué
- Partner: Université de Rennes 1
- Contact: Manolescu Ioana
- Publications: [hal-01325900v6 - Structural Summarization of Semantic Graphs](#)

## 6.8. AIDeMe

KEYWORDS: Active Learning - Data Exploration

SCIENTIFIC DESCRIPTION: AIDeMe is a large-scale interactive data exploration system that is cast in a principled active learning (AL) framework: in this context, we consider the data content as a large set of records in a data source, and the user is interested in some of them but not all. In the data exploration process, the system allows the user to label a record as “interesting” or “not interesting” in each iteration, so that it can construct an increasingly-more-accurate model of the user interest. Active learning techniques are employed to select a new record from the unlabeled data source in each iteration for the user to label next in order to improve the model accuracy. Upon convergence, the model is run through the entire data source to retrieve all relevant records.

A challenge in building such a system is that existing active learning techniques experience slow convergence in learning the user interest when such exploration is performed on large datasets: for example, hundreds of labeled examples are needed to learn a user interest model over 6 attributes, as we showed using a digital sky survey of 1.9 million records. AIDeMe employs a set of novel techniques to overcome the slow convergence problem:

- **Factorization:** We observe that a user labels a data record, her decision making process often can be broken into a set of smaller questions, and the answers to these questions can be combined to derive the final answer. This insight, formally modeled as a factorization structure, allows us to design new active learning algorithms, e.g., factorized version space algorithms [2], that break the learning problem into subproblems in a set of subspaces and perform active learning in each subspace, thereby significantly expediting convergence.
- **Optimization based on class distribution:** Another interesting observation is that when projecting the data space for exploration onto a subset of dimensions, the user interest pattern projected onto such a subspace often entails a convex object. When such a subspace convex property holds, we introduce a new “dual-space model” (DSM) that builds not only a classification model from labeled examples, but also a polytope model of the data space that offers a more direct description of the areas known to be positive, areas known to be negative, and areas with unknown labels. We use both the classification model and the polytope model to predict unlabeled examples and choose the best example to label next.
- **Formal results on convergence:** We further provide theoretical results on the convergence of our proposed techniques. Some of them can be used to detect convergence and terminate the exploration process.
- **Scaling to large datasets:** In many applications the dataset may be too large to fit in memory. In this case, we introduce subsampling procedures and provide provable results that guarantee the performance of the model learned from the sample over the entire data source.

FUNCTIONAL DESCRIPTION: There is an increasing gap between fast growth of data and limited human ability to comprehend data. Consequently, there has been a growing demand for analytics tools that can bridge this gap and help the user retrieve high-value content from data. We introduce AIDeMe, a scalable interactive data exploration system for efficiently learning a user interest pattern over a large dataset. The system is cast in a principled active learning (AL) framework, which iteratively presents strategically selected records for user labeling, thereby building an increasingly-more-accurate model of the user interest. However, a challenge in building such a system is that existing active learning techniques experience slow convergence when learning the user interest on large datasets. To overcome the problem, AIDeMe explores properties of the user labeling process and the class distribution of observed data to design new active learning algorithms, which come with provable results on model accuracy, convergence, and approximation, and have evaluation results showing much improved convergence over existing AL methods while maintaining interactive speed.

RELEASE FUNCTIONAL DESCRIPTION: Project code can be found over: <https://gitlab.inria.fr/ldipalma/aideme>

- Participants: Luciano Di Palma and Enhui Huang
- Contact: Yanlei Diao
- URL: <http://www.lix.polytechnique.fr/aideme>

## EX-SITU Project-Team

# 6. New Software and Platforms

## 6.1. Digiscope

KEYWORDS: 2D - 3D - Node.js - Unity 3D - Video stream

FUNCTIONAL DESCRIPTION: Through the Digiscope application, the users can connect to a remote workspace and share files, video and audio streams with other users. Application running on complex visualization platforms can be easily launched and synchronized.

- Partners: Maison de la simulation - UVSQ - CEA - ENS Cachan - LIMSI - LRI - Laboratoire de Recherche en Informatique - CentraleSupélec - Telecom Paris
- Contact: Olivier Gladin
- URL: <http://www.digiscope.fr>

## 6.2. Touchstone2

KEYWORD: Experimental design

FUNCTIONAL DESCRIPTION: Touchstone2 is a graphical user interface to create and compare experimental designs. It is based on a visual language: Each experiment consists of nested bricks that represent the overall design, blocking levels, independent variables, and their levels. Parameters such as variable names, counterbalancing strategy and trial duration are specified in the bricks and used to compute the minimum number of participants for a balanced design, account for learning effects, and estimate session length. An experiment summary appears below each brick assembly, documenting the design. Manipulating bricks immediately generates a corresponding trial table that shows the distribution of experiment conditions across participants. Trial tables are faceted by participant. Using brushing and fish-eye views, users can easily compare among participants and among designs on one screen, and examine their trade-offs.

Touchstone2 plots a power chart for each experiment in the workspace. Each power curve is a function of the number of participants, and thus increases monotonically. Dots on the curves denote numbers of participants for a balanced design. The pink area corresponds to a power less than the 0.8 criterion: the first dot above it indicates the minimum number of participants. To refine this estimate, users can choose among Cohen's three conventional effect sizes, directly enter a numerical effect size, or use a calculator to enter mean values for each treatment of the dependent variable (often from a pilot study).

Touchstone2 can export a design in a variety of formats, including JSON and XML for the trial table, and TSL, a language we have created to describe experimental designs. A command-line tool is provided to generate a trial table from a TSL description.

Touchstone2 runs in any modern Web browser and is also available as a standalone tool. It is used at ExSitu for the design of our experiments, and by other Universities and research centers worldwide. It is available under an Open Source licence at <https://touchstone2.org>.

- Partner: University of Zurich
- Contact: Wendy Mackay
- URL: <https://touchstone2.org>

## 6.3. UnityCluster

KEYWORDS: 3D - Virtual reality - 3D interaction

**FUNCTIONAL DESCRIPTION:** UnityCluster 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.

UnityCluster provides an easy solution for running existing Unity 3D applications on any display that requires a rendering cluster with several computers. UnityCluster 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. UnityCluster manages data distribution and synchronization among the computers to obtain a consistent image on the entire wall-sized display surface.

UnityCluster 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.

UnityCluster 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.

- Partner: Inria
- Contact: Cédric Fleury

## 6.4. VideoClipper

**KEYWORD:** Video recording

**FUNCTIONAL DESCRIPTION:** VideoClipper is an IOS app for Apple Ipad, designed to guide the capture of video during a variety of prototyping activities, including video brainstorming, interviews, video prototyping and participatory design workshops. It relies heavily on Apple's AVFoundation, a framework that provides essential services for working with time-based audiovisual media on iOS (<https://developer.apple.com/avfoundation/>). Key uses include: transforming still images (title cards) into video tracks, composing video and audio tracks in memory to create a preview of the resulting video project and saving video files into the default Photo Album outside the application.

VideoClipper consists of four main screens: project list, project, capture and import. The project list screen shows a list with the most recent projects at the top and allows the user to quickly add, remove or clone (copy and paste) projects. The project screen includes a storyboard composed of storylines that can be added, cloned or deleted. Each storyline is composed of a single title card, followed by one or more video clips. Users can reorder storylines within the storyboard, and the elements within each storyline through direct manipulation. Users can preview the complete storyboard, including all titlecards and videos, by pressing the play button, or export it to the Ipad's Photo Album by pressing the action button.

VideoClipper offers multiple tools for editing titlecards and storylines. Tapping on the title card lets the user edit the foreground text, including font, size and color, change background color, add or edit text labels, including size, position, color, and add or edit images, both new pictures and existing ones. Users can also delete text labels and images with the trash button. Video clips are presented via a standard video player, with standard interaction. Users can tap on any clip in a storyline to: trim the clip with a non-destructive trimming tool, delete it with a trash button, open a capture screen by clicking on the camera icon, label the clip by clicking a colored label button, and display or hide the selected clip by toggling the eye icon.

VideoClipper is currently in beta test, and is used by students in two HCI classes at the Université Paris-Saclay, researchers in ExSitu as well as external researchers who use it for both teaching and research work. A beta test version is available on demand under the Apple testflight online service.

- Contact: Wendy Mackay

## 6.5. WildOS

**KEYWORDS:** Human Computer Interaction - Wall displays

**FUNCTIONAL DESCRIPTION:** WildOS is middleware to support applications running in an interactive room featuring various interaction resources, such as our WILD and WILDER rooms: a tiled wall display, a motion tracking system, tablets and smartphones, etc. The conceptual model of WildOS is a platform, such as the WILD or WILDER room, described as a set of devices and 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 an Open Source licence at <https://bitbucket.org/mblinsitu/wildos>.

- Contact: Michel Beaudouin-Lafon
- URL: <https://bitbucket.org/mblinsitu/wildos>

## 6.6. Platforms

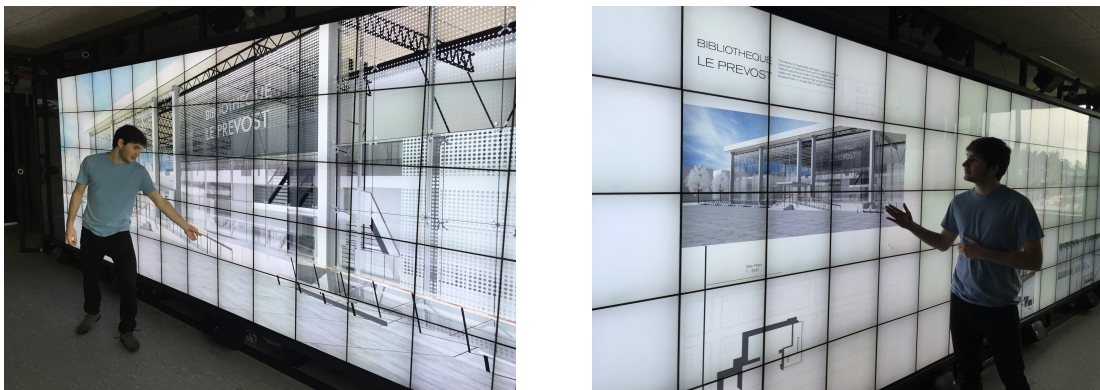
### 6.6.1. WILDER

**Participants:** Michel Beaudouin-Lafon [correspondant], Cédric Fleury, Olivier Gladin.

WILDER (Figure 1) is our second experimental ultra-high-resolution interactive environment, which follows the WILD platform developed in 2009. 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.*

## ILDA Project-Team

# 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 developer 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:** Big data - Visualization - Data visualization - Information visualization - 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 and Emmanuel Pietriga
- Contact: Emmanuel Pietriga
- Publications: [Rapid Development of User Interfaces on Cluster-Driven Wall Displays with jBricks - A Toolkit for Addressing HCI Issues in Visual Language Environments](#)
- URL: <http://zvtm.sf.net>

## 6.3. MapMosaic

**KEYWORDS:** Geo-visualization - Data visualization

**SCIENTIFIC DESCRIPTION:** GIS software applications and other mapping tools enable users to correlate data from multiple layers and gain insight from the resulting visualizations. However, most of these applications only feature basic, monolithic layer compositing techniques. These techniques do not always support users effectively in their tasks, as we observed during interviews with GIS experts. MapMosaic is a novel approach based on dynamic visual compositing that enables users to interactively create and manipulate local composites of multiple vector and raster map layers, taking into account the semantics and attribute values of objects and fields in the compositing process. We evaluated MapMosaic's interaction model against that of QGIS (a widely-used desktop GIS) and MAPublisher (a professional cartography tool) using the "Cognitive Dimensions" framework and through an analytical comparison, showing that MapMosaic's model is more flexible and can support users more effectively in their tasks.



**FUNCTIONAL DESCRIPTION:** MapMosaic is a novel approach to combine geographical layers based on dynamic visual compositing that enables users to interactively create and manipulate local composites of multiple vector and raster map layers. It takes into account the semantics and attribute values of objects and fields in the compositing process. MapMosaic aims at better supporting GIS users in their tasks such as correlating data from multiple layers and gaining insight from the resulting visualizations.

**RELEASE FUNCTIONAL DESCRIPTION:** First public release.

- Participants: Maria Jesus Lobo, Caroline Appert and Emmanuel Pietriga
- Contact: Emmanuel Pietriga
- Publications: [MapMosaic: Dynamic Layer Compositing for Interactive Geovisualization - An Evaluation of Interactive Map Comparison Techniques](#)
- URL: <http://ilda.saclay.inria.fr/mapmuxing/mapmosaic/index.html>

## 6.4. Baia

*Before-and-after satellite image animation*

**KEYWORDS:** Geo-visualization - 2D animation

**SCIENTIFIC DESCRIPTION:** Before-and-after image pairs show how entities in a given region have evolved over a specific period of time. Satellite images are a major source of such data, that capture how natural phenomena or human activity impact a geographical area. These images are used both for data analysis and to illustrate the resulting findings to diverse audiences. The simple techniques used to display them, including juxtaposing, swapping and monolithic blending, often fail to convey the underlying phenomenon in a meaningful manner. Baia is a framework to create advanced animated transitions, called animation plans, between before-and-after images. Baia relies on a pixel-based transition model that gives authors much expressive power, while keeping animations for common types of changes easy to create thanks to predefined animation primitives.

**FUNCTIONAL DESCRIPTION:** Baia is a framework to create advanced animated transitions, called animation plans, between before-and-after satellite images.

Before-and-after image pairs show how entities in a given region have evolved over a specific period of time. Satellite images are a major source of such data, that capture how natural phenomena or human activity impact a geographical area. These images are used both for data analysis and to illustrate the resulting findings to diverse audiences. The simple techniques used to display them, including juxtaposing, swapping and monolithic blending, often fail to convey the underlying phenomenon in a meaningful manner.

Baia relies on a pixel-based transition model that gives authors much expressive power. The animation editor enables authors to easily represent common types of changes thanks to predefined animation primitives and to sequence different changes across time.

**RELEASE FUNCTIONAL DESCRIPTION:** First public release

- Participants: Maria Jesus Lobo, Caroline Appert and Emmanuel Pietriga
- Contact: Emmanuel Pietriga
- Publication: [Animation Plans for Before-and-After Satellite Images](#)
- URL: <http://ilda.saclay.inria.fr/mapmuxing/baia/index.html>

## 6.5. LODAtlas

**KEYWORDS:** LOD - Linked open data - Semantic Web

**SCIENTIFIC DESCRIPTION:** The Web of Data is growing fast, as exemplified by the evolution of the Linked Open Data (LOD) cloud over the last ten years. One of the consequences of this growth is that it is becoming increasingly difficult for application developers and end-users to find the datasets that would be relevant to them. Semantic Web search engines, open data catalogs, datasets and frameworks such as LODStats and LOD Laundromat, are all useful but only give partial, even if complementary, views on what datasets are available on the Web. LODAtlas is a portal that enables users to find datasets of interest. Users can make different types of queries about both the datasets' metadata and contents, aggregated from multiple sources. They can then quickly evaluate the matching datasets' relevance, thanks to LODAtlas' summary visualizations of their general metadata, connections and contents.

**FUNCTIONAL DESCRIPTION:** The Web of Data is growing fast, as exemplified by the evolution of the Linked Open Data (LOD) cloud over the last ten years. One of the consequences of this growth is that it is becoming increasingly difficult for application developers and end-users to find the datasets that would be relevant to them. Semantic Web search engines, open data catalogs, datasets and frameworks such as LODStats and LOD Laundromat, are all useful but only give partial, even if complementary, views on what datasets are available on the Web. LODAtlas is a portal that enables users to find datasets of interest. Users can make different types of queries about both the datasets' metadata and contents, aggregated from multiple sources. They can then quickly evaluate the matching datasets' relevance, thanks to LODAtlas' summary visualizations of their general metadata, connections and contents.

- Participants: Caroline Appert, Marie Destandau, Ioana Manolescu, François Goasdoué, Sejla Cebiric, Hande Ozaygen and Emmanuel Pietriga
- Contact: Emmanuel Pietriga
- Publication: [Browsing Linked Data Catalogs with LODAtlas](#)
- URL: <http://lodatlas.lri.fr>

## 6.6. TouchTokens

**KEYWORDS:** Tangible interface - HCI

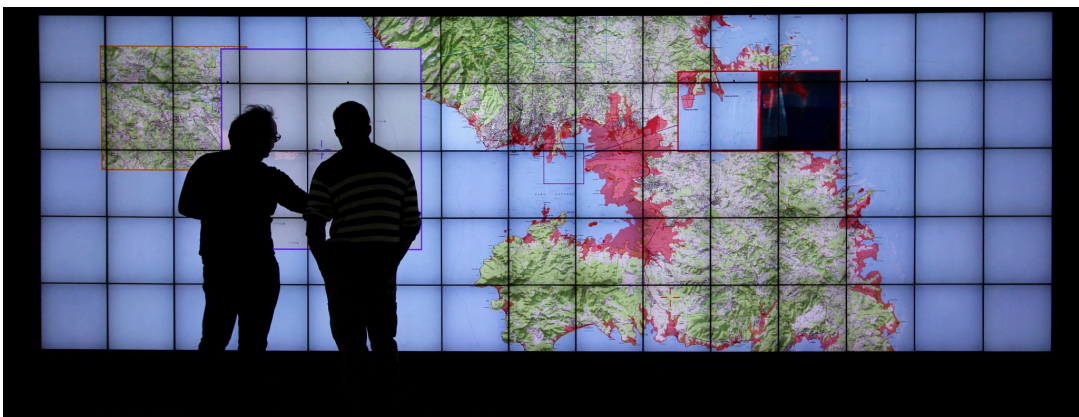
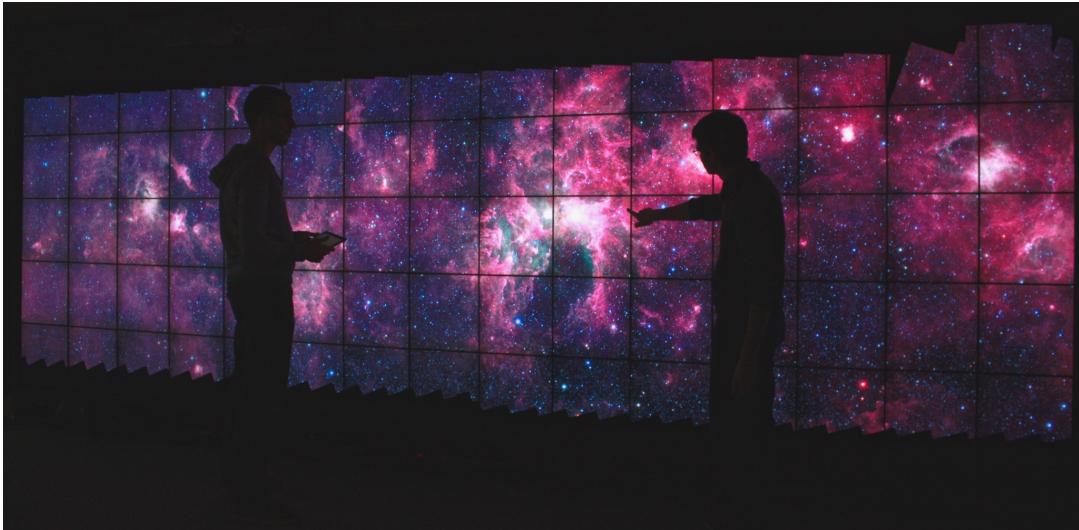
**SCIENTIFIC DESCRIPTION:** TouchTokens make it possible to easily build interfaces that combine tangible and gestural input using passive tokens and a regular multi-touch surface. The tokens constrain users' grasp, and thus, the relative spatial configuration of fingers on the surface, theoretically making it possible to design algorithms that can recognize the resulting touch patterns. See associated scientific articles below.

**FUNCTIONAL DESCRIPTION:** TouchTokens allow interface designers to build low-cost tangible interfaces. The technique consists in recognizing multi-touch patterns that are associated with specific passive tokens. Those physical tokens can be made out of any material to get tracked on any touch-sensitive surface. Implementations of the recognizer (in both TUIO and Android) and vector descriptions of the tokens ready for 3D-printing or laser-cutting are available

- Participants: Caroline Appert, Rafael Morales Gonzalez, Emmanuel Pietriga and Gilles Bailly
- Contact: Caroline Appert
- Publications: [TouchTokens: Guiding Touch Patterns with Passive Tokens - Passive yet Expressive TouchTokens - Custom-made Tangible Interfaces with TouchTokens](#)
- URL: <https://www.lri.fr/~appert/touchtokens/>

## 6.7. Platforms

### 6.7.1. Platform: WILDER



*Figure 2. Example application area for ultra-high-resolution wall-sized displays: geographical information systems, and astronomical data analysis.*

Ultra-high-resolution wall-sized displays [31] 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.

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 information systems and astronomy (Figure 2).

## PETRUS Project-Team

# 5. New Software and Platforms

## 5.1. PLUG-DB ENGINE

KEYWORDS: Databases - Personal information - Privacy - Hardware and Software Platform

FUNCTIONAL DESCRIPTION: en PlugDB is a complete platform dedicated to a secure and ubiquitous management of personal data. It aims at providing an alternative to a systematic centralization of personal data. The PlugDB engine is a personal database server capable of storing data (tuples and documents) in tables and BLOBs, indexing them, querying them in SQL, sharing them through assertional access control policies and enforcing transactional properties (atomicity, integrity, durability).

The PlugDB engine is embedded in a tamper-resistant hardware device combining the security of smartcard with the storage capacity of NAND Flash. The personal database is hosted encrypted in NAND Flash and the PlugDB engine code runs in the microcontroller. Complementary modules allow to pre-compile SQL queries for the applications, communicate with the DBMS from a remote Java program, synchronize local data with remote servers (typically used for recovering the database in the case of a broken or lost devices) and participate in distributed computation (e.g., global queries). PlugDB runs both on secure devices provided by Gemalto and on specific secure devices designed by PETRUS and assembled by electronic SMEs. Mastering the hardware platform opens up new research and experiment opportunities (e.g., support for wireless communication, secure authentication, sensing capabilities, battery powered ...). PlugDB engine has been registered first at APP (Agence de Protection des Programmes) in 2009 - a new version being registered every two years - and the hardware datasheets in 2015.

PlugDB has been experimented in the field, notably in the healthcare domain. We also recently set up an educational platform on top of PlugDB, named SIPD (Système d'Information Privacy-by-Design) and used at ENSIIE, INSA CVL and UVSQ through the Versailles Sciences Lab fablab, to raise students awareness of privacy protection problems and embedded programming. As a conclusion, PlugDB combines several research contributions from the team, at the crossroads of flash data management, embedded data processing and secure distributed computations. It then strongly federates all members of our team (permanent members, PhD students and engineers). It is also a vector of visibility, technological transfer and dissemination and gives us the opportunity to collaborate with researchers from other disciplines around a concrete privacy-enhancing platform.

PlugDB is now being industrialized in the context of the OwnCare Inria Innovation Lab (II-Lab). In OwnCare, PlugDB acts as a secure personal cloud to manage medical/social data for people receiving care at home. It should be deployed over 10.000 patient in the Yvelines district. The industrialization process covers the development of a complete testing environment, the writing of a detailed documentation and the development of additional features (e.g., embedded ODBC driver, TPM support, flexible access control model and embedded code upgrade notably). It has also required the design of a new hardware platform equipped with a battery power supply, introducing new energy consumption issues for the embedded software.

- Participants: Aydogan Ersoz, Laurent Schneider, Luc Bouganim, Nicolas Anciaux and Philippe Pucheral
- Contact: Nicolas Anciaux
- URL: <https://project.inria.fr/plugdb/>