Activity Report 2011

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7. Contracts and Grants with Industry

7.1. Contracts with Industry

7.1.1. Contracts

7.1.1.1. Anastasy

- **Title:** ANASTASY
- **Type:** Industrial contract
- **Duration:** September 2009 - December 2011
- **Others partners:** Airbus France

*Abstract:* ANASTASY (ANAlyse STAtíque aSYnchone) is an industrial project with Airbus France on the static program analysis of asynchronous programs by abstract interpretation which objective is determined annually. Patrick Cousot is the principal investigator for this action.

7.1.2. License agreement

7.1.2.1. Astrée

In February 2009 was signed an exploitation license agreement between CNRS, École Normale Supérieure, and AbsInt Angewandte Informatik GmbH for the industrialization of the ASTRÉE analyzer. ASTRÉE is commercially available from AbsInt since January 2010. Continuous work goes on to adapt the ASTRÉE static analyzer to industrial needs, in particular for the automotive industry. Radhia Cousot is the scientific contact.

7.2. Grants with Industry

7.2.1. FNRAE projects

7.2.1.1. Ascert

- **Title:** Analyses Statiques CERTifiés
- **Type:** 6th call: Verification methods for software and systems
- **Instrument:** FNRAE grant
- **Duration:** April 2009 - March 2012
- **Coordinator:** INRIA (France)

*Others partners:* INRIA-Bretagne Atlantique, the INRIA Rhône-Alpes, the INRIA Paris-Rocquencourt, and the ENS.

*See also:* [http://ascert.gforge.inria.fr/](http://ascert.gforge.inria.fr/)

*Abstract:* Although static analyzers have demonstrated their ability to prove the absence of large classes of errors in critical software, they are themselves large and complex software, so it is natural to question their implementation correctness and the validity of their output. The focus of the ASCERT project is the use of formal methods to ensure the correctness of an analyzer with respect to the abstraction interpretation theory. Methods to be investigated include the direct proof of the analyzer, the proof of a verifier for the analyzer result, and the validation of the inductive invariants generated by the analyzer, using the Coq proof assistant. These methods will be applied to the certification of several numerical abstract domains, of an abstract interpreter for imperative programs and its possible extensions to one of the formal semantics of the CompCert verified C compiler.
7.2.1.2. Sardanes

Title: Sémantique, Analyse et tRansformation Des Applications Numériques Embarqués Syn-chrones

Type: 6th call: Verification methods for software and systems

Instrument: FNRAE grant

Duration: February 2009 - September 2013

Coordinator: Université de Perpignan

Others partners: Université de Perpignan and the ENS.

See also: [http://perso.univ-perp.fr/mmartel/sardanes.html](http://perso.univ-perp.fr/mmartel/sardanes.html)

Abstract: SCADE is widely used to write critical embedded software, as a specification and verification language. The semantics of SCADE uses real arithmetics whereas it is compiled into a language that uses floating-point arithmetics. The goal of the SARDANES project is to use expression transformation so as to ensure that the numerical properties of the programs is preserved during the compilation. Patrick Cousot and Radhia Cousot are the principal investigators for this action.
6. Contracts and Grants with Industry

6.1. Contracts with Industry

The Algorithms Project and Waterloo Maple Inc. (WMI) have collaborated for many years based on reciprocal interests. Thanks to this collaboration, the company WMI considers Inria as a special partner and grants it a free license for all of its research units.

Our work on automating the derivation of formulæ for special functions is hosted and funded for 6 years (2007–2012) by the Microsoft Research - INRIA Joint Centre as one of its projects, called “Dynamic Dictionary of Mathematical Functions”.

7. Contracts and Grants with Industry

7.1. ID/TL-M project with ST Microelectronics

Participants: Charles André, Robert de Simone, Benoît Ferrero, Jean-François Le Tallec.

ID/TL-M is a project launched as part of the larger NANO 2012 programme conducted by ST Microelectronics in Rhône-Alpes. Its main goal is to study the potential use of model-driven engineering techniques (MDE) for Electronic System-Level Design (ESL) of Systems-on-Chip (SoC).

In particular we focused this year on the relations and connexions between UML MARTE profile and the other standard IP-XACT, itself introduced as dedicated Architecture Description Language (ADL) for easy assembly of IP hardware components. One advantage here of MARTE in our view is that it is meant to be extendable to comprise Non-Functional Property annotations, such as consumption for low-power, in a much more open and larger setting as the extensions under way at Accelera (the IP-XACT standardisation body which recently merged with OSCI, the Open SystemC Initiative).

The direct collaboration in ID/TL-M allows implementations of tools and methods whose general descriptions are somehow shared with the neighboring ANR project HeLP (see below). Nevertheless, due to external reasons of political nature, funding of the general nano2012 programme was halted in 2011, and this project was consequently put on stand-by.

7.2. Thales ARCADIA/Melody

Participants: Frédéric Mallet, Robert de Simone.

During the course of the ARTEMIS CESAR project, we exchanged views with partners at Thales on potential methodologies based on Model-Driven Engineering for Embedded Systems. These considerations were mostly aimed at the support with tools of the various allocation and refinement steps in a V-cycle process, considering joint software and hardware design. Subsequently we were invited to conduct an evaluation survey and expert consulting on their internal MDE development project, the ARCADIA methodology (supported by the Melody tool environment).

The work included identification of potential ambiguous points in the representation models, followed by the definition of a relevant set of questions regarding possible interpretations. This form was then submitted to a panel of development engineers inside the company. Their return answers were analyzed by us, jointly with the promotors of the methodology inside Thales. Recommendations for improvements followed.

This job was conducted under Non-Disclosure Agreement (as the methodology remains proprietary, and is not part of CESAR tool deliverables). It led to a Grant agreement from this company to our team.
6. Contracts and Grants with Industry

6.1. ANR Projects with Industrials

- **SAPHIR-II (Sécurité et Analyse des Primitives de Hachage Innovantes et Récentes)**
  
  **Security and analysis of innovating and recent hashing primitives.**
  
  **Participants:** Charles Bouillaguet, Pierre-Alain Fouque, Jiqiang Lu, Christian Rechberger.
  
  From April 2009 to March 2013.
  

- **PACE: Pairings and Advances in Cryptology for E-cash.**
  
  **Participants:** Olivier Blazy, Pierre-Alain Fouque, David Pointcheval, Mehdi Tibouchi, Damien Vergnaud.
  
  From December 2007 to February 2012.
  
  Partners: France Telecom R&D, NXP, Gemalto, CNRS/LIX (INRIA/TANC), Univ. Caen, Cryptolog.
  
  *This project aims at studying new properties of groups (similar to pairings, or variants), and then to exploit them in order to achieve more practical e-cash systems.*

- **PAMPA: Password Authentication and Methods for Privacy and Anonymity.**
  
  **Participants:** Michel Ferreira Abdalla, Dario Fiore, David Pointcheval.
  
  From December 2007 to December 2011.
  
  Partners: EADS, Cryptolog.
  
  *One of the goals of this project is to improve existing password-based techniques, not only by using a stronger security model but also by integrating one-time passwords (OTP). This could avoid for example having to trust the client machine, which seems hard to guarantee in practice due the existence of numerous viruses, worms, and Trojan horses. Another extension of existing techniques is related to group applications, where we want to allow the establishment of secure multicast networks via password authentication. Several problems are specific to this scenario, such as dynamicity, robustness, and the random property of the session key, even in the presence of dishonest participants.*
  
  *Finally, the need for authentication is often a concern of service providers and not of users, who are usually more interested in anonymity, in order to protect their privacy. Thus, the second goal of this project is to combine authentication methods with techniques for anonymity in order to address the different concerns of each party. However, anonymity is frequently associated with fraud, without any possible pursuit. Fortunately, cryptography makes it possible to provide conditional anonymity, which can be revoked by a judge whenever necessary. This is the type of anonymity that we will privilege.*

- **BEST: Broadcast Encryption for Secure Telecommunications.**
  
  **Participants:** Duong Hieu Phan, David Pointcheval, Mario Strefler.
  
  From December 2009 to November 2013.
  
  
  *This project aims at studying broadcast encryption and traitor tracing, with applications to the PayTV and geolocalisation services.*
- **PRINCE: Proven Resilience against Information leakage in Cryptographic Engineering.**
  **Participants:** Michel Ferreira Abdalla, Bruno Blanchet, Dario Fiore, David Pointcheval.
  From December 2010 to November 2014.
  Partners: UVSQ, Oberthur Technologies, Ingenico, Gemalto, Tranef.
  We aim to undertake research in the field of leakage-resilient cryptography with a practical point of view. Our goal is to design efficient leakage-resilient cryptographic algorithms and invent new countermeasures for non-leakage-resilient cryptographic standards. These outcomes shall realize a provable level of security against side-channel attacks and come with a formally verified implementation. For this every practical aspect of the secure implementation of cryptographic schemes must be taken into account, ranging from the high-level security protocols to the cryptographic algorithms and from these algorithms to their implementation on specific devices which hardware design may feature different leakage models.

6.2. ANR Projects within Academics

- **ProSe: Security protocols : formal model, computational model, and implementations.**
  **Participants:** Bruno Blanchet, David Cadé, Miriam Paiola, David Pointcheval.
  From December 2010 to November 2014.
  Partners: ENS Cachan-INRIA/Secsi, LORIA-INRIA/Cassis, Verimag.
  The goal of the project is to increase the confidence in security protocols, and in order to reach this goal, provide security proofs at three levels: the symbolic level, in which messages are terms; the computational level, in which messages are bitstrings; the implementation level: the program itself.
CONTRAIENSTES Project-Team

7. Contracts and Grants with Industry

7.1. Biointelligence

- OSEO BiIntelligence project (2009-2014) coordinated by Patrick Johnson, Dassault-Systèmes, with EPI ORPAILLEUR, SOBIOS, Aureus pharma, IPSEN, Pierre Fabre, Sanofi-Aventis, Servier, Bayer CropScience, INSERM, Genopole Evry.

7.2. Rules2Optim

- DTI ITI support for the industrialization of Rules2CP software with SME KLS-Optim.

7.3. General Electric Transportation

- Pre-study on urban railway time tabling optimization (2011), General Electric Transportation.
- Cifre PhD accompanying contract on urban railway time tabling optimization (2011-2014), General Electric Transportation.
7. Contracts and Grants with Industry

7.1. Schneider Electric
The goal of this project contracted with Schneider Electric China is to develop a full system simulator for a System-on-Chip used by Schneider Electric in their automation product line.

7.2. Orange IT Labs
The goal of this project is to complete the PowerPC simulator and compare its performance with another simulator used internally by Orange IT Labs.
7. Contracts and Grants with Industry

7.1. The Caml Consortium

Participants: Xavier Leroy [correspondant], Xavier Clerc, Damien Doligez, Didier Rémy.

The Caml Consortium is a formal structure where industrial and academic users of Caml can support the
development of the language and associated tools, express their specific needs, and contribute to the long-term
stability of Caml. Membership fees are used to fund specific developments targeted towards industrial users.
Members of the Consortium automatically benefit from very liberal licensing conditions on the OCaml system,
allowing for instance the OCaml compiler to be embedded within proprietary applications.

The Consortium currently has 13 member companies:

- CEA
- Citrix
- Dassault Aviation
- Dassault Systèmes
- Esterel Technologies
- Jane Street
- LexiFi
- Microsoft
- MLstate
- Mylife.com
- OCamlCore
- OCamlPro
- SimCorp

For a complete description of this structure, refer to http://caml.inria.fr/consortium/. Xavier Leroy chairs the
scientific committee of the Consortium.
7. Contracts and Grants with Industry

7.1. Grants with Industry

In 2006, we started to work at the Microsoft Research-INRIA Joint Centre in a common project with Cédric Fournet (MSR Cambridge), Gilles Barthe (now at IMDEA), Nataliya Guts (who defended her PhD in January 2011) and Jérémy Planul (who will defend on February 2012). The project is named Secure Distributed Computations and their Proofs and deals with security, programming languages theory and formal proofs. This work is still under active collaboration within all year 2011.

7.2. European Initiatives

7.2.1. FP7 Project

7.2.1.1. CRYSP

Title: CRYSP: A Novel Framework for Collaboratively Building Cryptographically Secure Programs and their Proofs
Type: IDEAS ()
Instrument: ERC Starting Grant (Starting)
Duration: November 2010 - October 2015
Coordinator: Karthikeyan Bhargavan, INRIA (France)
Abstract: The goal of this grant proposal is to develop a collaborative specification framework and to build incremental, modular, scalable verification techniques that enable a group of collaborating programmers to build an application and its security proof side-by-side. We propose to validate this framework by developing the first large-scale web application and full-featured cryptographic protocol libraries with formal proofs of security.

7.3. International Initiatives

We are Équipe Associée with Computer lab at University of Cambridge (P. Sewell et al).
7. Contracts and Grants with Industry

7.1. Grants with Industry

- Google European Doctoral Fellowship for Tobias Grosser, 120k €.
7. Contracts and Grants with Industry

7.1. National Initiatives

Matthieu Sozeau is member of the ANR Typex project (Types and certification for XML) and is coordinator of one of the tasks of the project on formalization and certification of XML tools. The project will kick-off on January 8th, 2012 and is a joint project with LRI, PPS and INRIA Grenoble.

Matthieu Sozeau, Hugo Herbelin and Yann Régis-Gianas are members of the ANR Paral-ITP started November 2011. Paral-ITP is about preparing the Coq and Isabelle interactive theorem provers to a new generation of user interfaces thanks to massive parallelism and incremental type-checking.

Hugo Herbelin is the coordinator of the PPS site for the ANR Récré accepted in 2011 and starting January 2012. Pierre Letouzey is member of the ANR Récré. Récré is about realizability and rewriting, with applications to proving with side-effects and concurrency.

7.2. European Initiatives

Yann Régis-Gianas is a participant of the EU-FP7 Certified Complexity project (CerCo). This European project started in February 2010 as a collaboration between Bologna university (Asperti, Coen), Edinburgh university (Pollack) and Paris Diderot university (Amadio, Régis-Gianas). The CerCo project aims at the construction of a formally verified complexity preserving compiler from a large subset of the C programming language to some typical micro-controller assembly language, of the kind traditionally used in embedded systems. Nicolas Ayache’s postdoc is funded by this project.

Hugo Herbelin, Pierre Letouzey and Matthieu Sozeau submitted a proposal for a PHC Van Gogh with the university of Nijmegen in the Netherlands. This proposal is about the mathematical libraries of Coq, type classes, and the homotopic interpretation of equality in the Calculus of Inductive Constructions.

Hugo Herbelin is the participant of a submitted proposal for a PHC Pavle Savić with the university of Novi Sad in Serbia, the mathematical institute of Belgrade, ENS Lyon and the university of Turin. This proposal is on a general thematic logic and types. Hugo Herbelin is also the participant of a submitted proposal for another PHC Pavle Savić with the university of Belgrade and the university of Strasbourg. This proposal is about automated deduction and formal geometry.
7. Contracts and Grants with Industry

7.1. Contract with Thalès

Participants: J.-C. Faugère [contact], G. Renault, C. Goyet.

The goal of this contract (including a CIFRE PhD grant) is to mix side channel attacks (DPA) and algebraic cryptanalysis.
6. Contracts and Grants with Industry

6.1. Grants with Industry

- Gemalto (01/10 → 12/12)
  CIFRE grant for Christina Boura.
7. Contracts and Grants with Industry

7.1. EADS
We cooperate with EADS on geometric representation and FEM.

7.2. Sony Corporation
We cooperate with Sony Corporation on the research of image-based translucent material transfer.

7.3. Samsung Advanced Institute of Technology
We cooperate with Samsung Advanced Institute of Technology (China) on the research of stereo matching.

7.4. CAS-BEGCL Imaging Technology Corporation
We cooperate with CAS-BEGCL Imaging Technology Corporation on fluid simulation, object deformation and realistic rendering.

7.5. ANR/ NSFC AND SYSTEM@TIC: 2010-2013
The objectives of these Programs address Geometry Modeling and Computing, mainly Robustness and Tolerance as well as Geometric Uncertainties.
6. Contracts and Grants with Industry

6.1. Contracts with Industry

Gérard Biau has been supervising the PhD thesis of Benoît Patra, which takes places within an industrial contract (“thèse CIFRE”) with Lokad.com (http://www.lokad.com/).
4. Contracts and Grants with Industry

4.1. Contracts with Industry

- ANDRA, projet 1, Maillage adaptatif hexaédrique appliqué à une alvéole de stockage, D. Moreau et H. Borouchaki, 24 k-euros, 01/06/2010 - 31/05/2011.
- DASSAULT AVIATION, Maillage surfacique et topologie, P. Laug et H. Borouchaki, 33 k-euros, 01/01/2010 - 31/12/2012.

4.2. Grants with Industry

- Fondation EADS Grant, F. Alauzet, 150 k-euros, 2012-2015
- Fondation EADS Grant, A. Loseille, 140 k-euros, 2012-2015
6. Contracts and Grants with Industry

6.1. Contracts with Industry

Consortium Premia presently composed of CALYON, Société Générale, Natixis, and Pricing Partners.

6.2. Grants with Industry

- Chair “Risques financiers”, Fondation du Risque: 2007-2012
- Fondation Natixis grant
- Fondation Axa grant
6. Contracts and Grants with Industry

6.1. Contracts and Grants with Industry

Many research activities of the project-team are conducted in close collaboration with private or public companies. A recent example is a contract with Michelin for greedy algorithms and uncertainty propagation in mechanics. The project-team is also supported by Office of Naval Research and European Office of Aerospace Research and Development, for multiscale simulations of random materials. All these contracts are operated at and administrated by the Ecole des Ponts.
7. Contracts and Grants with Industry

7.1. Contract POEMS-CEA-LIST-1 : CASSIS PROJECT
   **Participant:** Gary Cohen.
   G. Cohen participates to Project CASSIS headed by the LIST laboratory of CEA and funded by the EADS Foundation which started in June 2008. This project aims to simulate elastic waves in thin layered anisotropic media for non-destructive testing. In collaboration with E. Demaldent, G. Cohen must provide a code based on spectral element methods to model these waves.

7.2. Contract POEMS-CEA-LIST-2
   **Participant:** Anne-Sophie Bonnet-Ben Dhia.
   This contract is about the scattering of elastic waves by a stiffener in an anisotropic plate.

7.3. Contract POEMS-CEA-LIST-3
   **Participants:** Laurent Bourgeois, Eric Lunéville.
   Start : 10/01/2011, End : 09/30/2012. Administrator : ENSTA.
   This contract is about the linear sampling methods for elastic waveguides.

7.4. Contract POEMS-CEA-LIST-DIGITEO
   **Participants:** Anne-Sophie Bonnet-Ben Dhia, Sonia Fliss, Antoine Tonnoir.
   Start : 10/01/2011, End : 09/30/2014. Administrator : ENSTA.
   This contract is about the scattering of elastic waves by a local defects in an anisotropic plate. It consists on the funding of Antoine Tonnoir’s Phd.

7.5. Contract POEMS-DGA
   **Participants:** Anne-Sophie Bonnet-Ben Dhia, Sonia Fliss, Patrick Joly.
   Start : 09/01/2011, End : 12/31/2012. Administrator : ENSTA.
   This contract is about the waveguide in photonic crystals: we want to develop new mathematical and numerical tools for the characterization, the study and the computation of the guided modes in photonic crystals.

7.6. Contract POEMS-ONERA-CE Gramat : DIGATOP PROJECT
   **Participant:** Gary Cohen.
   In collaboration with ONERA-DEM, G. Cohen participates to the FEMGD project funded by CEG (Centre d’Études de Gramat), which started in 2004. This project is devoted to the construction of a software using spectral discontinuous Galerkin methods for Maxwell’s equations.

7.7. Contract POEMS-CE Gramat : NADEGE PROJECT
   **Participants:** Gary Cohen, Alexandre Sinding.
Start : 03/06/2009, End : 03/06/2012. Administrator : INRIA.
In collaboration with ONERA-DEMR, G. Cohen participates with A. Sinding to the NADEGE project funded by CEG (Centre d’Études de Gramat). This project is devoted to the construction of a software based on FEMGD for solving Vlasov-Maxwell’s equations by a PIC method.

7.8. Contract POEMS-Airbus : ADNUMO PROJECT

Participant: Patrick Joly.

Start : 01/01/2011, End : 12/31/2011. Administrator : INRIA.
This contract is about the hybridation of time domain numerical techniques in aeroacoustics (Linearized Euler equations).
SIERRA Project-Team (section vide)
6. Contracts and Grants with Industry

6.1. Grants with Industry

Grant EDF-LNHE  Grant with EDF-LNHE (2010-2011) “Modélisation hydraulique des milieux naturels.” Simulation of free surface stratified flows (the density stratification being due to temperature and/or salinity), effect of the wind, upwellings.
Comparison of the variable density multilayer code developed at Inria and the rigid lid hydrostatic Navier-Stokes code (Ophélie) of EDF.
7. Contracts and Grants with Industry

7.1. INERIS

Clime is partner with INERIS (National Institute for Environmental and Industrial Risks) in a joint cooperation devoted to air quality forecast. This includes research topics in uncertainty estimation, data assimilation and ensemble modeling.

Clime also provides support to INERIS in order to operate the Polyphemus system for ensemble forecasting, uncertainty estimations and operational data assimilation at continental scale.

7.2. IRSN

Clime is partner with IRSN, the French national institute for radioprotection and nuclear safety, for inverse modeling of emission sources and uncertainty estimation of dispersion simulations. The collaboration aims at better estimating emission sources, at improving operational forecasts for crisis situations and at estimating the reliability of the forecasts. The work is derived at large scale (continental scale) and small scale (a few kilometers around a nuclear power plant).

7.3. NUMTECH

Clime takes part to a joint Ilab with the group SETH (Numtech). The objective is to (1) transfer Clime work in data assimilation, ensemble forecasting and uncertainty estimation, with application to urban air quality, (2) identify the specific problems encountered at urban scale in order to determine new research directions. The first study addresses the application of data assimilation at urban scale.
4. Contracts and Grants with Industry

4.1. Contracts with Industry

(EdF) A. Chiche is preparing a PhD thesis (Cifre EdF-Inria, direction J. Ch. Gilbert) on decomposition-coordination methods for the middle-term optimization of the electricity production. The case where uncertainties are present is also considered, using scenario trees, which leads to even larger deterministic optimization problems. Improvements have been brought

- on the solution to infeasible convex quadratic optimization problems using the augmented Lagrangian approach \[8\] and
- on the solution to the optimization of the electricity production under uncertainties, using the progressive hedging algorithm.

(Andra) Estime takes part in 2 projects in the framework of the Andra–Inria research agreement;

- Ph. Hoang–Thi–THao is preparing a PhD (surpervised by J. E. Roberts, C. Japhet and M. Kern) on space–time domain decomposition methods for modeling transport in porous media. At the end of the first year, a Matlab prototype has been developed, that enables comparing different domain decomposition methods.
- M. Kern is advising Andra in the choice of high performance linear algebra solvers for the heterogeneous problems encountered in flow simulations. The numerical properties and expected parallel performance have been analyzed.
MACS Project-Team (section vide)
NEUROMATHCOMP Project-Team (section vide)
REO Project-Team (section vide)
6. Contracts and Grants with Industry

6.1. LK2 contract: Tight glycemic control for Intensive Care Units

Participants: Alexandre Guerrini, Michel Sorine.

Collaboration with the Intensive Care Unit (ICU) of Chartres Hospital headed by Dr Pierre Kalfon.

This work on tight glycaemic control (TGC) for ICU started in September 2008. It is done in the framework of the CIFRE contract of Alexandre Guerrini with the small medtech company LK2 (Tours, France). For the medical context of this study, see [69]. Blood glucose has become a key biological parameter in critical care since publication of the study conducted by van den Berghe and colleagues [85], who demonstrated decreased mortality in surgical intensive care patients in association with TGC, based on intensive insulin therapy. However, two negative studies were recently reported, which were interrupted early because of high rates of severe hypoglycaemia, namely the VISEP study [65] and the Glucotrial trial.

After having studied a possible origin of the failure of the recent study NICE-SUGAR, we have worked on more robust control algorithms based on a database of representative “virtual patients” [66].

In this study, we have developed efficient monitoring and control tools, now marketed by LK2 that will help clinicians and nursing staff to control blood glucose levels in ICU patients, in particular to avoid hyperglycaemia superior to 10 mmol/l and hypoglycaemia episodes. Our first controller has been assessed in the study Cgao-Rea (see 4.3) with more than 3500 included patients. The controller determines the insulin infusion rate on the basis of the standard available glycaemia measurements despite their irregular sampling rate.

6.2. CARMAT SAS contract: Modeling and control of a Total Artificial Heart

Participants: Julien Bernard, Michel Sorine.

This is a cooperation with CARMAT SAS (Suresnes, France) on the development of a Total Artificial Heart. This fully implantable artificial heart is designed to replace the two ventricles, possibly as an alternative to heart transplant from donors. In a first time, it will be used as an end-of-life treatment for patients waiting for a transplant. The first patients may receive this artificial organ in less than three years.

Compared with the mechanical hearts used up today, that are mainly LVAD (left ventricular assist devices) or with its main concurrent, the Abiocor implantable replacement heart system (Abiomed), the present artificial heart is designed to be highly reliable and with a low thromboembolism rate. It will allow longer waiting periods for heart transplants and even, in a next future, may be an alternative to these transplants.

The prosthesis uses two controlled pumps that are not in direct contact with the blood, eliminating hemolysis risk and is equipped with miniature sensors in order to have a full control of the heart rate and arterial blood pressure. Our objective is to improve the control strategies by mimicking the physiological feedback loops (Starling effect, baroreflex loop, ...) to allowing patients to live as normally as possible. In a first step, this year we have modeled the prosthesis with its present controller and its testbed, a “mock circulation system” (MCS). This year we have tried some control algorithms with the MCS.

6.3. ANR project DMASC: Scaling Invariance of Cardiac Signals, Dynamical Systems and Multifractal Analysis

Participants: Julien Barral, Patrick Loiseau, Claire Médigue, Michel Sorine.

Collaboration with Denis Chemla (Kremlin-Bicêtre Hospital), Paulo Gonçalves (INRIA Rhônes-Alpes) and Stéphane Seuret (Paris 12 University).
The ANR project DMASC (Program SYSCOMM 2008) started in January 2009 under the coordination of J. Barral.

Numerical studies using ideas from statistical physics, large deviations theory and functions analysis have exhibited striking scaling invariance properties for human long-term R-R interval signals extracted from ECG (intervals between two consecutive heartbeats). These numerical studies reveal that the scaling invariance may have different forms depending upon the states of the patients in particular for certain cardiac diseases. These observations suggest that a good understanding of multifractal properties of cardiac signals might lead to new pertinent tools for diagnosis and surveillance. However, until now, neither satisfactory physiological interpretations of these properties nor mathematical models have been proposed for these signals. For medical applications we need to go beyond the previously mentioned works and achieve a deepened study of the scaling invariance structure of cardiac signals. This is the aim of DMASC.

New robust algorithms for the multifractal signals processing are required; specifically, it seems relevant to complete the usual statistical approach with a geometric study of the scaling invariance. In addition, it is necessary to apply these tools to a number of data arising from distinct pathologies, in order to start a classification of the different features of the observed scaling invariance, and to relate them to physiology. This should contribute to develop a new flexible multifractal mathematical model whose parameters could be adjusted according to the observed pathology. This multifractal analysis can be applied to another fundamental signal, the arterial blood pressure, as well as to the couple (R-R, Blood Pressure). An article has been submitted [54].

6.4. Modeling for diagnosis and prognosis (Paris Region ASTech project)
Participants: Abdouramane Moussa Ali, Qinghua Zhang.

In order to improve the safety and reliability of airplanes, the MODIPRO project (Modélisation pour le Diagnostic et le Pronostic) funded by the Pôle de Compétitivité Aérospatial ASTech of Paris Region aims at developing a software for deriving airplane functional models for the purpose of fault diagnosis and prognosis, by analyzing the flight data of a fleet of airplanes. The involved partners are Dassault Aviation (project leader), Snecma, IT4Control, Bayesia, KBS, UPMC, Supelec and INRIA.

6.5. ANR project EBONSI: Extended Block-Oriented Nonlinear System Identification
Participants: Pierre-Alexandre Bliman, Michel Sorine, Qinghua Zhang.

The main idea of block-oriented nonlinear system identification is to model a complex system with interconnected simple blocks. Such models can cover a large number of industrial applications, and are yet simple enough for theoretic studies. The objectives of the EBONSI project are to extend block-oriented nonlinear models with hysteresis blocks and bilinear blocks, and to relax some traditional restrictions on nonlinearity structures and on experimental conditions. The two extensions with hysteresis blocks and bilinear blocks have been motivated by their importance in process control. Through these extensions, it is expected to considerably increase the applicability of block-oriented nonlinear system identification to industrial systems. This is an international project jointly funded by the French Agence Nationale de la Recherche (ANR) and the Chinese National Natural Science Foundation (NSFC). Its duration is 3 years starting from March 2011. The project partners are the SISYPHE project-team of INRIA (project leader), the Centre de Recherche en Automatique de Nancy (CRAN), and the Laboratory of Industrial Process Monitoring and Optimization of Peking University.

6.6. ANR project 0-DEFECT: On-board fault diagnosis for wired networks in automotive systems
Participants: Mohamed Oumri, Michel Sorine, Qinghua Zhang.
The number of electric and electronic equipments is increasing rapidly in automotive vehicles. Consequently, the reliability of electric connections is becoming more and more important. The project entitled “Outil de diagnostic embarqué de faisceaux automobiles” (0-DEFECT) aims at developing tools for on-board diagnosis of failures in electric wire connections in automotive systems. This project is funded by Agence Nationale de la Recherche (ANR) for three years from 2009. The involved partners are CEA LIST (project leader), Renault Trucks, Freescale, PSA, Delphi, Supelec LGEP and INRIA. A prototype of a reflectometry-based diagnosis tool is under development in this project.

6.7. ANR project INSCAN: Fault diagnosis for security critical long distance electric transmission lines

Participants: Leila Djaziri, Michel Sorine, Huaibin Tang, Qinghua Zhang.

The wired electric networks of the French railway system cover more than 50,000 km. The electric insulation of the signaling lines along the railways is monitored by regular inspections. Today these inspections are based on an expensive procedure realized by human operators located at both ends of each transmission line. The service of signaling devices has to be interrupted during this procedure, and so does the railway traffic. The in situ monitoring of the transmission lines, without interruption of service, is thus an important economic issue. For this purpose, the project entitled “Diagnostic de câbles électriques sécuritaires pour grandes infrastructures” is funded by ANR for three years in order to study the feasibility of in situ monitoring tools for these transmission lines. The involved partners are SNCF (project leader), CEA LIST and INRIA.

6.8. ANR project EPOQ2: Estimation PrOblems for Quantum & Quantumlike systems

Participants: Hadis Amini, Zaki Leghtas, Ram Somaraju, Mazyar Mirrahimi, Pierre Rouchon, Michel Sorine, Filippo Visco Comandini.

The project EPOQ2 is an ANR “Young researcher” project led by Mazyar Mirrahimi (Sisyphè). It has for goal to address a class of inverse problems rising from either the emerging application domain of “quantum engineering” or from some classical applications where a natural quantization lead to quantum-like systems, as it is the case in particular for inverse scattering for transmission lines. The partners of INRIA are Emmanuelle Crépeau-Jaisson (University of Versailles - Saint Quentin), Hideo Mabuchi (Stanford University), Herschel Rabitz and Ramon Van Handel (Princeton University), Pierre Rouchon (Mines de Paris). See EPOQ2.

6.9. Renault contract: Modeling, Control, Monitoring and Diagnosis of Depollution Systems

Participants: Pierre-Alexandre Bliman, David Marie-Luce, Michel Sorine.

This work is done in cooperation with Renault in the framework of a CIFRE contract. The issue of depollution has become a central preoccupation for the automotive industry, and the increased severity of the emission norms necessitates tight modeling and control solutions. We have worked on simple models for two devices, namely the NOx-trap and the SCR (Selective catalytic reduction). Observers have been obtained and tested against real-world data. See [25].
ARLES Project-Team (section vide)
5. Contracts and Grants with Industry

5.1. Contracts with Industry

Collaboration with Alcatel-Lucent Bell Labs France (ALBLF)

Within the Laboratory of Information, Networking and Communication Sciences (LINCS), collaborations have been made with ALBLF. In 2011, it resulted in two internships paid by ALBLF and co-supervised by Fabien Mathieu (INRIA) and Ludovic Noirie (ALBLF). In 2012, both interns should start a thesis in collaboration with ALBLF and INRIA (one CIFRE, one in the context of the joint lab).
7. Contracts and Grants with Industry

7.1. DGA/MI

Participants: Cédric Adjih, Pascale Minet, Paul Mühlethaler.

Period: 2007 - 2011

Partners: DGA/MI.

The DGA/MI, French MoD/DGA, contract has been notified in December 2007. It has a duration of 36 months. It focuses on mobile ad hoc networks. DGA/MI is interested in the standardization done at the IETF and more particularly within the MANET and AUTOCONF groups, where the HIPERCOM team-project is active. Furthermore, this contract addresses topics that belong to DARPA’s recent initiatives about new military wireless networks able to adapt to changing conditions. These networks will be self-forming, self-healing, self-configuring and self-optimizing. They will provide an intelligent relaying and an intelligent power management. All these topics are present in the DGA/MI contract:

- OLSRv2: identification of the differences with the previous version and expected benefits;
- Multicast protocols: analysis and performance evaluation of three multicast protocols: SMOLSR, MOLSR and MOST;
- Autoconfiguration in IPv6: choice of a solution adapted to military applications;
- Dynamic routing over a hierarchical topology: when does a hierarchical routing outperforms a flat one?
- Adaptive routing on high frequency (HF) links;
- Merge of networks.

Three of them are leading an implementation on a real platform comprising 18 nodes. Nodes are equipped with 802.11b cards and measurements tools on Linux. They implement the OLSR routing protocol. This testbed allows CELAR to make demonstrations with a real mobile ad-hoc network, and evaluate the potential benefits of such a network in military tactical applications, with a special focus on performances and reliability.

- OLSRv2,
- Autoconfiguration,
- Multicast.

This year, we were sollicited by DGA/MI for the expertise of European industrial proposals about the design of wireless mobile ad hoc networks supporting tactical military applications. Our comments contributed to improve the solutions presented.

7.2. OCARI2

Participants: Ichrak Amdouni, Pascale Minet, Cédric Adjih, Ridha Soua.

Period: 2010 - 2011

Partners: EDF, LIMOS, TELIT.

At the end of the OCARI (Optimization of Ad hoc Communications in Industrial networks) project, funded by ANR, started in February 2007 and ended in 2010, EDF the coordinator decided to continue the project with a restricted number of partners: TELIT, LIMOS (Clermont Ferrand university) and INRIA. The goal was to prove the feasibility on commercially available cards of the OCARI stack designed during the ANR project and to make a public demonstration of this product. During the year 2011, the OCARI stack has been improved and implemented on the ZE51 module of TELIT based on the Texas Instrument CC2530 Chipset.
The OCARI project deals with wireless sensor networks in an industrial environment. It aims at responding to the following requirements which are particularly important in power generation industry and in warship construction and maintenance:

- Support of deterministic MAC layer for time-constrained communication,
- Support of optimized energy consumption routing strategy in order to maximize the network lifetime,
- Support of human walking speed mobility for some particular network nodes, (e.g. sinks),
- Support of IEC61804/EDDL and HART application layer.

The development of OCARI targets the following industrial applications:

- Real time centralized supervision of personal dose in electrical power plants,
- Condition Based Maintenance of mechanical and electrical components in power plants as well as in warships,
- Environmental monitoring in and around power plants,
- Structure monitoring of hydroelectric dams.

To meet the requirements of supported applications (remote command of actuators, tele-diagnostic...), new solutions will be brought to manage several communication modes, ranging from deterministic data transfers to delay tolerant transfers. A key issue is how to adapt routing algorithms to the industrial environment, taking into account more particularly limited network resources (e.g.; bandwidth), node mobility and hostile environment reducing radio range.

The OCARI project aims at developing a wireless sensor communication module, based on IEEE 802.15.4 PHY layer and supporting EDDL and HART application layer. The INRIA contribution concerns more particularly energy efficient routing and node activity scheduling.

- The energy efficient extension of OLSR, called EOLSR, is implemented on top of the MAC protocol defined by LATTIS and LIMOS. The MAC protocol is a variant of ZigBee ensuring some determinism and quality of service and allowing leave nodes (e.g. sensor, actuator) as well as router nodes to sleep. The EOLSR protocol avoids nodes with low residual energy and selects the routes minimizing the energy consumed by an end-to-end transmission.
- SERENA, the protocol used to schedule router node activity, is based on three-hop coloring. It allows any node to sleep during the slots that are attributed neither to its color nor to its one-hop neighbors. SERENA contributes to a more efficient use of energy: less energy is spent in the idle and interference states. Hence, network lifetime is considerably increased. SERENA has been optimized for the specific context of OCARI (i.e.; very limited bandwidth 250kbps, small size messages 127 bytes, limited memory and limited processing power) have been delivered.

These protocols have been implemented in the OCARI stack, operating on a ZE51 module of TELIT.

7.3. SensLab and FIT

**Participants:** Cédric Adjih, Emmanuel Baccelli, Ala Eddin Weslati.

**Period:** 2011 - 2021

**Partners:** INRIA (Lille, Sophia-Antipolis, Grenoble), INSA, UPMC, Institut Télécom Paris, Institut Télécom Evry, LSII, Strasbourg.

The HIPERCOM team started the development of a testbed for SensLab in 2010. This testbed located in building 21 at Rocquencourt INRIA center consists now of 40 wireless SensLab nodes. This number will reach 128 nodes by the end of the year 2012.

A location has been found for the new testbed of the EQUIPEX FIT: the basement of building 1 at Rocquencourt. An engineer has been recruited for this project.
7.4. ACRON

**Participant:** Cédric Adjih.

**Period:** 2011 - 2014

**Partners:** Supélec (Télécommunications), INRIA, ENS TREC, INRIA HIPERCOM, Université Paris-Sud, IEF.

ACRON is a DIMLSC DIGITEO project. It deals with analysis and design of self-organized wireless networks. The HIPERCOM team project will study the theoretical limits of wireless networking.

7.5. SWAN

**Participants:** Cédric Adjih, Salman Malik.

**Period:** 2011 - 2014

**Partners:** CNRS, Supélec, Université Paris-Sud (L2S), LTCI, LRI, INRIA Hipercom and IEF.

SWAN, Source-aWAre Network coding, is a DIMLSC DIGITEO project. It deals with network coding for multimedia.

7.6. MOBSIM

**Participants:** Cédric Adjih, Paul Mühlethaler, Hana Baccouch.

**Period:** 2011 - 2013

**Partners:** INRIA Sophia, INRIA Genoble.

MOBSIM is an ADT, Action of Technology Development. It aims at developing the NS3 simulation tool. The HIPERCOM team focuses on routing protocols and MAC protocol (namely the EY-NPMA protocol Elimination Yield Non-Preemptive Multiple Access). An engineer has been recruited for this project.

7.7. SAHARA

**Participants:** Philippe Jacquet, Pascale Minet, Cédric Adjih, Ridha Soua, Erwan Livolant.

**Period:** 2011 - 2014

**Partners:** EADS, Astrium, BeanAir, Eurocopter, Oktal SE, Reflex CES, Safran Engineering Systems, CNES, ECE, EPMI, LIMOS.

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

7.8. e-comp@gnon

**Participants:** Emmanuel Baccelli, Philippe Jacquet, Cédric Adjih, Anis Laouiti, Salman Malik.

**Period:** 2008 - 2011

**Partners:** Archos, SCNF, Telecom SudParis, DGE, Deveryware.

E-comp@gnon is a System@tic project. The goal is the realization of a new type of multimedia terminal, enhanced with wireless ad hoc IP connectivity based on the OLSR protocol.

7.9. SMARTMESH

**Participants:** Philippe Jacquet, Emmanuel Baccelli, Cédric Adjih, Pascale Minet.

**Period:** 2009 - 2012

**Partners:** SAGEM, CEA, Telecom SudParis, Tunecharger, Ineo, Orelia, Prodomo.

SMARTMESH is a System@tic project, focused on the design of intelligent wireless sensor mesh networking for video surveillance and intrusion alarm systems.
5. Contracts and Grants with Industry

5.1. Contracts

- CRE with Orange Labs “Dynamical Optical Networking in the Internet”. Contract on bandwidth allocation algorithm in optical networks. Duration 2 years starting from 01/01/12.

- CELTIC-Plus Saser “Safe and Secure European Routing” submitted. RAP participates in the section on optical networks. Participants include Orange labs, Alcatel-Lucent, Telecom Institute, ENSSAT as well as a number of German laboratories. Duration three years.

- ANR Project “CONNECT: Content-Oriented Networking: a New Experience for Content Transfer”. The proposal submitted to the VERSO programme has been accepted. The planned starting date is January 2011 and the project is scheduled to last 2 years. The lead partner is Alcatel-Lucent Bell Labs France and the other partners are RAP, INRIA/PLANETE, Orange Labs, TelecomParisTech, UPMC.
REGAL Project-Team (section vide)
7. Contracts and Grants with Industry

7.1. ANR CMON

Participants: François Baccelli, Florence Bénédit, Bruno Kauffmann, Darryl Veitch.

TREC is a partner of the 3-year ANR project called CMON, jointly with Technicolor, LIP6, the INRIA project-team Planète and the community http://www.grenouille.com. This project is focused on the development of end-to-end measurement for Internet that can be deployed by end-users, without any support from ISP. A postdoc (F. Bénédit) was hired through this grant from January 2010 till July 2011. The main contribution of this year was the definition of the “Grenouille Cohérente”, a scheme allowing one to globally synchronize Grenouille client, jointly with A. Schmidt [Grenouille].

7.2. ANR PEGASE

Participants: Abir Benabid, Anne Bouillard, Nadir Farhi.

TREC is a partner of the 3-year ANR project called PEGASE, jointly with ENS Lyon, the INRIA project-team MESCAL, ONERA, Real-Time-at-Work (start-up) and Thalès. This project is focused on the analysis of critical embedded networks using algebraic tools. The aim is to apply these techniques to AFDX and Spacewire architectures. Nadir Farhi was a post-doc hired through this grant until January 2011, and Abir Benabid was hired in March 2011.

7.3. ANR MAGNUM

Participant: Ana Bušić.

Ana Bušić is participating (20%) in the 4-year ANR project MAGNUM (Méthodes Algorithmiques pour la Génération aléatoire Non Uniforme: Modèles et applications), 2010 – 2014; http://www.lix.polytechnique.fr/~rossin/ANR/Magnum/www/?page_id=4. The central theme of the MAGNUM project is the elaboration of complex discrete models that are of broad applicability in several areas of computer science. A major motivation for the development of such model is the design and analysis of efficient algorithms dedicated to simulation of large discrete systems and random generation of large combinatorial structures.

7.4. CIFRE Grant of Technicolor

Participants: Mathieu Leconte, Marc Lelarge, Laurent Massoulié.

The CIFRE grant of Mathieu started in January 2011. The topic bears on information dissemination and recommendation in social networks. The distribution of multimedia content and the use of social networks like Facebook, Orkut, etc., are booming in today’s networks. These social networks are also increasingly used for dissemination and recommendation of content. The objective of the thesis will be to develop an understanding of how information disseminates in social networks based on the type of information, user tastes, and the topological structure of these networks. This study will result in developing methods for more effective dissemination of content.
7. Contracts and Grants with Industry

7.1. Contracts with Industry

Alpage has developed several collaborations with industrial partners. Apart from grants described in the next section, specific collaboration agreements have been set up with Verbatim Analysis (license agreement and “CIFRE” PhD, see section 4.3), Kwaga (ARITT contract, see section 4.4), TNS-Sofres (see section 4.6), Lingua et Machina (DTI-funded engineer, see section 4.5) and soon Viavoo (a joint “CIFRE” PhD is about to start) and Diadeis (the “Investissements d’Avenir” project PACTE will start in early 2012, see section 4.7).
AXIS Project-Team (section vide)
7. Contracts and Grants with Industry

7.1. Contracts with Industry

This year began a true cooperation between IMARA team and the Valeo Group. A first direct contract has been signed in order to tighten our collaboration on vision and image processing technique within the AMARE project. Later on, Valeo has expressed its wish to collaborate more closely with IMARA in the domain of autonomous navigation and low speed driving in urban areas. A “Chaire” is expected to be signed between Valeo Group, INRIA and Mines ParisTech in order to formalize these collaborations.
IMEDIA Project-Team (section vide)
7. Contracts and Grants with Industry

7.1. Industrial collaborations

The SMIS project has a long lasting cooperation with Axalto, recently merged with Gemplus to form Gemalto, the world’s leading providers of microprocessor cards. Gemalto provides SMIS with advanced hardware and software smart card platforms which are essential to validate numbers of our research results. In return, SMIS provides Gemalto with application requirements and technical feedbacks that help them adapting their future platforms towards data intensive applications. SMIS has also a growing cooperation with Santeos, an Atos Origin company developing software platforms of on-line medical services. Santeos is member of the consortium selected by the French Ministry of Health to host the French DMP (the national Personal Medical Folder initiative). This cooperation helps us tackling one of our targeted applications, namely the protection of medical folders.

7.2. DMSP Yvelines District grant (Nov 2010 - Apr. 2012)

Partners: INRIA-SMIS (coordinator), Gemalto, UVSQ, Santeos
SMIS funding : 75k€
http://www-smis.inria.fr/~DMSP/accueil.php

Electronic Health Record (EHR) projects have been launched in most developed countries to increase the quality of care while decreasing its cost. Despite their unquestionable benefits, patients are reluctant to abandon their control of highly sensitive data to a distant server. The objective of the DMSP project is to complement a traditional EHR server with a secure and mobile personal medical folder (1) to protect and share highly sensitive data among trusted parties and (2) to provide a seamless access to the data even in disconnected mode. The DMSP architecture builds upon the technology designed in the PlugDB project (see above). It is currently experimented in the context of a medical-social network providing care and services at home for elderly people. The experiment in the field started in September 2011 with a population of 120 volunteer patients and practitioners in the Yvelines district.
7. Contracts and Grants with Industry

7.1. EADS (ENS)

**Participants:** Jean Ponce, Josef Sivic, Andrew Zisserman.

The WILLOW team has had collaboration efforts with EADS via tutorial presentations and discussions with A. Zisserman, J. Sivic and J. Ponce at EADS and ENS, and submitting joint grant proposals. In addition, Marc Sturzel (EADS) is doing a PhD at ENS with Jean Ponce and Andrew Zisserman.

7.2. MSR-INRIA joint lab: Image and video mining for science and humanities (INRIA)

**Participants:** Jean Ponce, Andrew Zisserman, Josef Sivic, Ivan Laptev.

This collaborative project, already mentioned several times in this report, brings together the WILLOW and LEAR project-teams with MSR researchers in Cambridge and elsewhere. The concept builds on several ideas articulated in the “2020 Science” report, including the importance of data mining and machine learning in computational science. Rather than focusing only on natural sciences, however, we propose here to expand the breadth of e-science to include humanities and social sciences. The project we propose will focus on fundamental computer science research in computer vision and machine learning, and its application to archaeology, cultural heritage preservation, environmental science, and sociology, and it will be validated by collaborations with researchers and practitioners in these fields.

7.3. DGA: CrowdChecker (ENS and E-vitech)

**Participants:** Jean Ponce, Josef Sivic, Ivan Laptev.

CrowdChecker (DGA) is a joint DGA project with industrial partner E-vitech. This contract belongs to our video understanding research program. It aims at real-time characterization of a crowd seen from a camera mounted 3 to 10 meters over the ground. It includes segmentation of the crowd, clustering by movement, detection of abnormal behaviors (persons, for instance, crossing the crowd flow, or having unusual speed), tracking people. Several parts of computer vision and machine learning are involved: crowd optical flow estimation, image processing, crowd feature extraction, statistical learning from video database, etc.

7.4. PersonSpace (INRIA and Technicolor-R&D)

**Participant:** Ivan Laptev.

PersonSpace is a CIFRE PhD contract with Technicolor-R&D. The project addresses the problem of human pose estimation and human action recognition in still images. We investigate a subspace spanned by images and videos of people and explore the structure of this subspace to formulate useful constraints for automatic interpretation of person images.