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FIELD

Activity Report 2012

Section Software

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ALGORITHMICS, PROGRAMMING, SOFTWARE AND ARCHITECTURE

ALF Project-Team

5. Software

5.1. Panorama

The ALF team is developing several software prototypes for research purposes: compilers, architectural simulators, programming environments, ...

Among the many prototypes developed in the project, we describe here **ATMI**, a microarchitecture temperature model for processor simulation, **STiMuL**, a temperature model for steady state studies, **ATC**, an address trace compressor, **HAVEGE**, an unpredictable random number generator and **tiptop**, a user-level Linux utility that collects data from hardware performance counters for running tasks, software developed by the team.

5.2. ATMI

Participant: Pierre Michaud.

Microarchitecture temperature model **Contact :** Pierre Michaud

Status : Registered with APP Number IDDN.FR.001.250021.000.S.P.2006.000.10600, Available under GNU General Public License

Research on temperature-aware computer architecture requires a chip temperature model. General purpose models based on classical numerical methods like finite differences or finite elements are not appropriate for such research, because they are generally too slow for modeling the time-varying thermal behavior of a processing chip.

We have developed an ad hoc temperature model, ATMI (Analytical model of Temperature in MIcroprocessors), for studying thermal behaviors over a time scale ranging from microseconds to several minutes. ATMI is based on an explicit solution to the heat equation and on the principle of superposition. ATMI can model any power density map that can be described as a superposition of rectangle sources, which is appropriate for modeling the microarchitectural units of a microprocessor.

Visit http://www.irisa.fr/alf/ATMI or contact Pierre Michaud.

5.3. STiMuL

Participant: Pierre Michaud.

Microarchitecture temperature modeling

Status: Registered with APP Number IDDN.FR.001.220013.000.S.P.2010.000.31235, Available under GNU General Public License

Some recent research has started investigating the microarchitectural implications of 3D circuits, for which the thermal constraint is stronger than for conventional 2D circuits.

STiMuL can be used to model steady-state temperature in 3D circuits consisting of several layers of different materials. STiMuL is based on a rigorous solution to the Laplace equation [6]. The number and characteristics of layers can be defined by the user. The boundary conditions can also be defined by the user. In particular, STiMuL can be used along with thermal imaging to obtain the power density inside an integrated circuit. This power density could be used for instance in a dynamic simulation oriented temperature modeling such as ATMI.

STiMuL is written in C and uses the FFTW library for discrete Fourier transforms computations.

Visit http://www.irisa.fr/alf/stimul or contact Pierre Michaud.

5.4. ATC

Participant: Pierre Michaud.

Address trace compression **Contact :** Pierre Michaud

Status: registered with APP number IDDN.FR.001.160031.000.S.P.2009.000.10800, available under GNU LGPL License.

Trace-driven simulation is an important tool in the computer architect's toolbox. However, one drawback of trace-driven simulation is the large amount of storage that may be necessary to store traces. Trace compression techniques are useful for decreasing the storage space requirement. But general-purpose compression techniques are generally not optimal for compressing traces because they do not take advantage of certain characteristics of traces. By specializing the compression method and taking advantages of known trace characterics, it is possible to obtain a better tradeoff between the compression ratio, the memory consumption and the compression and decompression speed.

ATC is a utility and a C library for compressing/decompressing address traces. It implements a new lossless transformation, Bytesort, that exploits spatial locality in address traces. ATC leverages existing general-purpose compressors such as gzip and bzip2. ATC also provides a lossy compression mode that yields higher compression ratios while preserving certain important characteristics of the original trace.

Visit http://www.irisa.fr/alf/atc or contact Pierre Michaud.

5.5. HAVEGE

Participant: André Seznec.

Unpredictable random number generator

Contact : André Seznec

Status : Registered with APP Number IDDN.FR.001.500017.001.S.P.2001.000.10000. Available under the LGPL license.

An unpredictable random number generator is a practical approximation of a truly random number generator. Such unpredictable random number generators are needed for cryptography. HAVEGE (HArdware Volatile Entropy Gathering and Expansion) is a user-level software unpredictable random number generator for general-purpose computers that exploits the continuous modifications of the internal volatile hardware states in the processor as a source of uncertainty [12]. HAVEGE combines on-the-fly hardware volatile entropy gathering with pseudo-random number generation.

The internal state of HAVEGE includes thousands of internal volatile hardware states and is merely unmonitorable. HAVEGE can reach an unprecedented throughput for a software unpredictable random number generator: several hundreds of megabits per second on current workstations and PCs.

The throughput of HAVEGE favorably competes with usual pseudo-random number generators such as `rand()` or `random()`. While HAVEGE was initially designed for cryptology-like applications, this high throughput makes HAVEGE usable for all application domains demanding high performance and high quality random number generators, e.g., Monte Carlo simulations.

Visit http://www.irisa.fr/alf/HAVEGE or contact André Seznec.

5.6. Tiptop

Participant: Erven Rohou.

Performance, hardware counters, analysis tool.

Status: Registered with APP (Agence de Protection des Programmes). Available under GNU General Public License v2.

Tiptop is a new simple and flexible user-level tool that collects hardware counter data on Linux platforms (version 2.6.31+). The goal is to make the collection of performance and bottleneck data as simple as possible, including simple installation and usage. In particular, we stress the following points.

- Installation is only a matter of compiling the source code. No patching of the Linux kernel is needed, and no special-purpose module needs to be loaded.

- No privilege is required, any user can run *tiptop* — non-privileged users can only watch processes they own, ability to monitor anybody's process opens the door to side-channel attacks.

- The usage is similar to *top*. There is no need for the source code of the applications of interest, making it possible to monitor proprietary applications or libraries. And since there is no probe to insert in the application, understanding of the structure and implementation of complex algorithms and code bases is not required.

- Applications do not need to be restarted, and monitoring can start at any time (obviously, only events that occur after the start of *tiptop* are observed).

- Events can be counted per thread, or per process.

- Any expression can be computed, using the basic arithmetic operators, constants, and counter values.

- A configuration file lets users define their prefered setup, as well as custom expressions.

Tiptop is written in C. It can take advantage of libncurses when available for pseudo-graphic display.

For more information, please contact Erven Rohou.

<p style="text-align:center;">CAIRN Project-Team</p>

5. Software

5.1. Panorama

With the ever raising complexity of embedded applications and platforms, the need for efficient and customizable compilation flows is stronger than ever. This need of flexibility is even stronger when it comes to research compiler infrastructures that are necessary to gather quantitative evidence of the performance/energy or cost benefits obtained through the use of reconfigurable platforms. From a compiler point of view, the challenges exposed by these complex reconfigurable platforms are quite significant, since they require the compiler to extract and to expose an important amount of coarse and/or fine grain parallelism, to take complex resource constraints into consideration while providing efficient memory hierarchy and power management.

Because they are geared toward industrial use, production compiler infrastructures do not offer the level of flexibility and productivity that is required for compiler and CAD tool prototyping. To address this issue, we have designed an extensible source-to-source compiler infrastructure that takes advantage of leading edge model-driven object-oriented software engineering principles and technologies.
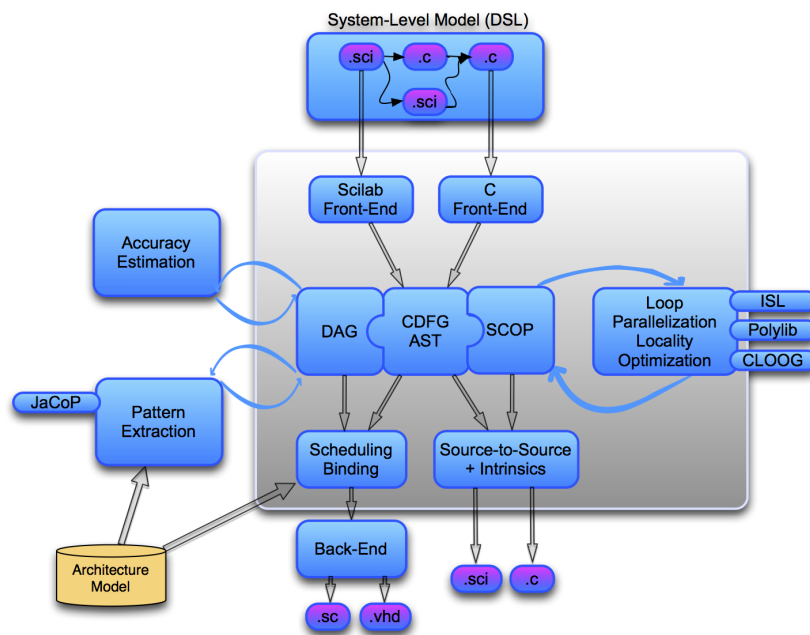
Figure 2. CAIRN*'s general software development framework.*

Figure 2 shows the global framework that is being developed in the group. Our compiler flow mixes several types of intermediate representations. The baseline representation is a simple tree-based model enriched with control flow information. This model is mainly used to support our source-to-source flow, and serves as the backbone for the infrastructure. We use the extensibility of the framework to provide more advanced representations along with their corresponding optimizations and code generation plug-ins. For example,

for our pattern selection and accuracy estimation tools, we use a data dependence graph model in all basic blocks instead of the tree model. Similarly, to enable polyhedral based program transformations and analysis, we introduced a specific representation for affine control loops that we use to derive a Polyhedral Reduced Dependence Graph (PRDG). Our current flow assumes that the application is specified as a system level hierarchy of communicating tasks, where each task is expressed using C (or Scilab in the short future), and where the system level representation and the target platform model are defined using Domain Specific Languages (DSL).

Gecos (Generic Compiler Suite) is the main backbone of CAIRN's flow. It is an open source Eclipse-based flexible compiler infrastructure developed for fast prototyping of complex compiler passes. Gecos is a 100% Java based implementation and is based on modern software engineering practices such as Eclipse plugin or model-driven software engineering with EMF (Eclipse Modeling Framework). As of today, our flow offers the following features:

- An automatic floating-point to fixed-point conversion flow (for HLS and embedded processors). **ID.Fix** is an infrastructure for the automatic transformation of software code aiming at the conversion of floating-point data types into a fixed-point representation. http://idfix.gforge.inria.fr.

- A polyhedral-based loop transformation and parallelization engine (mostly targeted at HLS). http://gecos.gforge.inria.fr. It was used for source-to-source transformations in the context of Nano2012 projects in collaboration with STMicroelectronics.

- A custom instruction extraction flow (for ASIP and dynamically reconfigurable architectures). **Durase** and **UPaK** are developed for the compilation and the synthesis targeting reconfigurable platforms and the automatic synthesis of application specific processor extensions. They use advanced technologies, such as graph matching and graph merging together with constraint programming methods.

- Several back-ends to enable the generation of VHDL for specialized or reconfigurable IPs, and SystemC for simulation purposes (e.g. fixed-point simulations).

5.2. Gecos

Participants: Steven Derrien [corresponding author], Nicolas Simon, Maxime Naullet, Antoine Floc'h, Antoine Morvan, Clément Guy.

Keywords: source-to-source compiler, model-driven software engineering, retargetable compilation.

The Gecos (Generic Compiler Suite) project is a source-to-source compiler infrastructure developed in the CAIRN group since 2004. It was designed to enable fast prototyping of program analysis and transformation and is aims the hardware synthesis and retargetable compilation domains.

Gecos is 100% Java based and takes advantage of modern model driven software engineering practices. It uses the Eclipse Modeling Framework (EMF) as an underlying infrastructure and takes benefits of its features to make it easily extensible. Gecos is open-source and is hosted on the Inria gforge at http://gecos.gforge.inria.fr.

The Gecos infrastructure is still under very active development, and serves as a backbone infrastructure to projects of the group (project S2S4HSL, ID.FIX). Part of the framework is jointly developed with Colorado State University and since 2012 it is used in the context of the ALMA European project.

Development in Gecos in 2012 have mostly focused on the polyhedral loop transformation engine and its use for hardware synthesis. As a part of the ALMA project, significant efforts are also being made to develop a coarse-grain parallelization engine targeting a distributed memory machine model.

5.3. ID.Fix: Infrastructure for the Design of Fixed-point Systems

Participants: Daniel Menard, Olivier Sentieys [corresponding author], Romuald Rocher, Nicolas Simon.

Keywords: fixed-point arithmetic, source-to-source code transformation, accuracy optimization, dynamic range evaluation

The different techniques proposed by the team for fixed-point conversion are implemented on the ID.Fix infrastructure. The application is described with a C code using floating-point data types and different pragmas, used to specify parameters (dynamic, input/output word-length, delay operations) for the fixed-point conversion. This tool determines and optimizes the fixed-point specification and then, generates a C code using fixed-point data types (ac_fixed) from Mentor Graphics. The infrastructure is made-up of two main modules corresponding to the fixed-point conversion (ID.Fix-Conv) and the accuracy evaluation (ID.Fix-Eval)

The different developments carried-out in 2012 allowed us to obtain a fixed-point conversion tool handling functions, conditional structures and repetitive structures having a fixed number of iterations during time. New optimization algorithms have been added. A simulator has been created to verify the results from our analytical approach. For the accuracy evaluation (Acc.Eval), conditional structures and correlation between noise sources have been considered. Some optimizations have been implemented to reduce the computing time and the division operator treatment has been integrated. A tutorial has also been created to install and use this tool.

The development of this tool has been achieved thanks to a University of Rennes graduate engineer from November 2011 in the context of DEFIS ANR project and different students during their training period.

5.4. UPaK: Abstract Unified Pattern-Based Synthesis Kernel for Hardware and Software Systems

Participants: Christophe Wolinski [corresponding author], François Charot, Antoine Floc'h.

Keywords: compilation for reconfigurable systems, pattern extraction, constraint-based programming.

We are developing (with strong collaboration of Lund University, Sweden and Queensland University, Australia) UPaK *Abstract Unified Pattern Based Synthesis Kernel for Hardware and Software Systems* [123]. The preliminary experimental results obtained by the UPak system show that the methods employed in the systems enable a high coverage of application graphs with small quantities of patterns. Moreover, high application execution speed-ups are ensured, both for sequential and parallel application execution with processor extensions implementing the selected patterns. UPaK is one of the basis for our research on compilation and synthesis for reconfigurable platforms. It is based on the HCDG representation of the Polychrony software designed at Inria-Rennes in the project-team Espresso.

5.5. DURASE: Automatic Synthesis of Application-Specific Processor Extensions

Participants: Christophe Wolinski [corresponding author], François Charot, Antoine Floc'h.

Keywords: compilation for reconfigurable systems, instruction-set extension, pattern extraction, graph covering, constraint-based programming.

We are developing a framework enabling the automatic synthesis of application specific processor extensions. It uses advanced technologies, such as algorithms for graph matching and graph merging together with constraints programming methods. The framework is organized around several modules.

- CoSaP: Constraint Satisfaction Problem. The goal of CoSaP is to decouple the statement of a constraint satisfaction problem from the solver used to solve it. The CoSaP model is an Eclipse plugin described using EMF to take advantage of the automatic code generation and of various EMF tools.

- HCDG: Hierarchical Conditional Dependency Graph. HCDG is an intermediate representation mixing control and data flow in a single acyclic representation. The control flow is represented as hierarchical guards specifying the execution or the definition conditions of nodes. It can be used in the Gecos compilation framework via a specific pass which translates a CDFG representation into an HCDG.

- Patterns: Flexible tools for identification of computational pattern in a graph and graph covering. These tools model the concept of pattern in a graph and provide generic algorithms for the identification of pattern and the covering of a graph. The following sub-problems are addressed: (sub)-graphs isomorphism, patterns generation under constraints, covering of a graph using a library of patterns. Most of the implemented algorithms use constraints programming and rely on the CoSaP module to solve the optimization problem.

5.6. PowWow: Power Optimized Hardware and Software FrameWork for Wireless Motes (AP-L-10-01)

Participants: Olivier Sentieys [corresponding author], Olivier Berder, Arnaud Carer, Steven Derrien.

Keywords: Wireless Sensor Networks, Low Power, Preamble Sampling MAC Protocol, Hardware and Software Platform

PowWow is an open-source hardware and software platform designed to handle wireless sensor network (WSN) protocols and related applications. Based on an optimized preamble sampling medium access (MAC) protocol, geographical routing and `protothread` library, PowWow requires a lighter hardware system than Zigbee [86] to be processed (memory usage including application is less than 10kb). Therefore, network lifetime is increased and price per node is significantly decreased.

CAIRN's hardware platform (see Figure 3) is composed of:

- The motherboard, designed to reduce power consumption of sensor nodes, embeds an MSP430 microcontroller and all needed components to process PowWow protocol except radio chip. JTAG, RS232, and I2C interfaces are available on this board.

- The radio chip daughter board is currently based on a TI CC2420.

- The coprocessing daughter board includes a low-power FPGA which allows for hardware acceleration for some PowWow features and also includes dynamic voltage scaling features to increase power efficiency. The current version of PowWow integrates an Actel IGLOO AGL250 FPGA and a programmable DC-DC converter. We have shown that gains in energy of up to 700 can be obtained by using FPGA acceleration on functions like CRC-32 or error detection with regards to a software implementation on the MSP430.

- Finally, a last daughter board is dedicated to energy harvesting techniques. Based on the energy management component LTC3108 from Linear Technologies, the board can be configured with several types of stored energy (batteries, micro-batteries, super-capacitors) and several types of energy sources (a small solar panel to recover photovoltaic energy, a piezoelectric sensor for mechanical energy and a Peltier thermal energy sensor).

PowWow distribution also includes a generic software architecture using event-driven programming and organized into protocol layers (PHY, MAC, LINK, NET and APP). The software is based on Contiki [102], and more precisely on the `Protothread` library which provides a sequential control flow without complex state machines or full multi-threading.

To optimize the network regarding a particular application and to define a global strategy to reduce energy, PowWow offers the following extra tools: over-the-air reprogramming (and soon reconfiguration), analytical power estimation based on software profiling and power measurements, a dedicated network analyzer to probe and fix transmissions errors in the network. More information can be found at http://powwow.gforge.inria.fr.

5.7. SoCLib: Open Platform for Virtual Prototyping of Multi-Processors System on Chip

Participants: François Charot [corresponding author], Laurent Perraudeau.

Keywords: SoC modeling, SystemC simulation model

Figure 3. CAIRN*'s PowWow motherboard with radio and energy-harvesting boards connected*

SoCLib is an open platform for virtual prototyping of multi-processors system on chip (MP-SoC) developed in the framework of the SoCLib ANR project. The core of the platform is a library of SystemC simulation models for virtual components (IP cores), with a guaranteed path to silicon. All simulation models are written in SystemC, and can be simulated with the standard SystemC simulation environment distributed by the OSCI organization. Two types of models are available for each IP-core: CABA (Cycle Accurate / Bit Accurate), and TLM-DT (Transaction Level Modeling with Distributed Time). All simulation models are distributed as free software. We have developed the simulation model of the NIOSII processor, of the Altera Avalon interconnect, and of the TMS320C62 DSP processor from Texas Instruments. Find more information on its dedicated web page: http://www.soclib.fr.

CELTIQUE Project-Team

4. Software

4.1. Javalib

Participants: Frédéric Besson [correspondant], David Pichardie, Vincent Monfort.

Javalib is an efficient library to parse Java .class files into OCaml data structures, thus enabling the OCaml programmer to extract information from class files, to manipulate and to generate valid .class files.
See also the web page http://sawja.inria.fr/.

- Version: 2.2
- Programming language: Ocaml

4.2. SAWJA

Participants: Frédéric Besson [correspondant], David Pichardie, Vincent Monfort.

Sawja is a library written in OCaml, relying on Javalib to provide a high level representation of Java bytecode programs. It name comes from Static Analysis Workshop for JAva. Whereas Javalib is dedicated to isolated classes, Sawja handles bytecode programs with their class hierarchy and with control flow algorithms.

Moreover, Sawja provides some stackless intermediate representations of code, called JBir and A3Bir. The transformation algorithm, common to these representations, has been formalized and proved to be semantics-preserving.
See also the web page http://sawja.inria.fr/.

- Version: 1.2
- Programming language: Ocaml

4.3. Jacal

Participants: Frédéric Besson [correspondant], Thomas Jensen, David Pichardie, Delphine Demange, Vincent Monfort, Pierre Vittet.

Static program analysis, Javacard, Certification, AFSCM

`Jacal` is a JAvaCard AnaLyseur developed on top of the SAWJA4.2 platform. This proprietary software verifies automatically that Javacard programs conform with the security guidelines issued by the AFSCM (Association Française du Sans Contact Mobile). `Jacal` is based on the theory of abstract interpretation and combines several object-oriented and numeric analyses to automatically infer sophisticated invariants about the program behaviour. The result of the analysis is thereafter harvest to check that it is sufficient to ensure the desired security properties.

4.4. Timbuk

Participant: Thomas Genet [correspondant].

Timbuk is a library of OCAML functions for manipulating tree automata. More precisely, Timbuk deals with finite bottom-up tree automata (deterministic or not). This library provides the classical operations over tree automata (intersection, union, complement, emptiness decision) as well as exact or approximated sets of terms reachable by a given term rewriting system. This last operation can be certified using a checker extracted from a Coq specification. The checker is now part of the Timbuk distribution. Timbuk distribution now also provide a CounterExample Guided Abstraction Refinement (CEGAR) tool for tree automata completion. The CEGAR part is based on the Buddy BDD library.

- Version: 3.1
- Programming language: Ocaml

ESPRESSO Project-Team

5. Software

5.1. The Polychrony toolset and its hypertext source documentation

Participants: Loïc Besnard, Thierry Gautier, Paul Le Guernic.

The Polychrony toolset is an Open Source development environment for critical/embedded systems. It is based on Signal, a real-time polychronous data-flow language. It provides a unified model-driven environment to perform design exploration by using top-down and bottom-up design methodologies formally supported by design model transformations from specification to implementation and from synchrony to asynchrony. It can be included in heterogeneous design systems with various input formalisms and output languages.

The Polychrony toolset provides a formal framework:

- to validate a design at different levels, by the way of formal verification and/or simulation,
- to refine descriptions in a top-down approach,
- to abstract properties needed for black-box composition,
- to assemble heterogeneous predefined components (bottom-up with COTS),
- to generate executable code for various architectures.

The Polychrony toolset contains three main components and an experimental interface to GNU Compiler Collection (GCC):

- The Signal toolbox, a batch compiler for the Signal language, and a structured API that provides a set of program transformations. The Signal toolbox can be installed without other components. The Signal toolbox is distributed under GPL V2 license.
- The Signal GUI, a Graphical User Interface to the Signal toolbox (editor + interactive access to compiling functionalities). The Signal GUI is distributed under GPL V2 license.
- The SME/SSME platform, a front-end to the Signal toolbox in the Eclipse environment. The SME/SSME platform is distributed under EPL license.
- GCCst, a back-end to GCC that generates Signal programs (not yet available for download).

The Polychrony toolset also provides:

- libraries of Signal programs,
- a set of Signal program examples,
- user oriented and implementation documentations,
- facilities to generate new versions.

The Polychrony toolset can be freely downloaded on the following web sites:

- The Polychrony toolset public web site: http://www.irisa.fr/espresso/Polychrony. This site, intended for users and for developers, contains downloadable executable and source versions of the software for differents platforms, user documentation, examples, libraries, scientific publications and implementation documentation. In particular, this is the site for the new open-source distribution of Polychrony.
- The Inria GForge: https://gforge.inria.fr. This site, intended for internal developers, contains the whole sources of the environment and their documentation.
- The TOPCASED distribution site: http://www.topcased.org. This site provides the current reference version of the SSME platform, including the executable of the Signal toolbox.

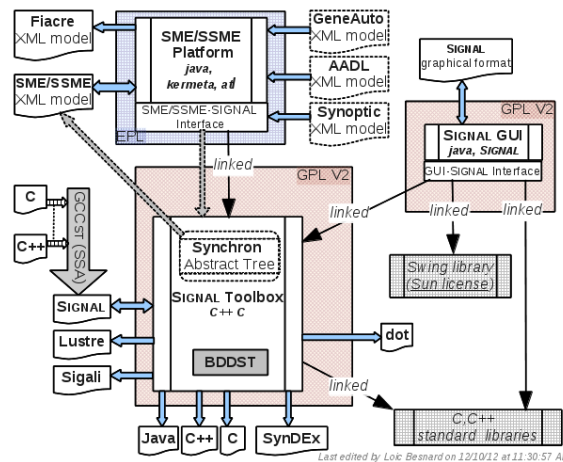The Polychrony toolset currently runs on Linux, MacOS and Windows systems.

Figure 7. The Polychrony toolset high-level architecture

The Geensoft company, now part of Dassault Systèmes, supplies a commercial implementation of Polychrony, called RT-Builder, used for industrial scale projects (see http://www.geensoft.com).

As part of its open-source release, the Polychrony toolset not only comprises source code libraries but also an important corpus of structured documentation, whose aim is not only to document each functionality and service, but also to help a potential developer to package a subset of these functionalities and services, and adapt them to developing a new application-specific tool: a new language front-end, a new back-end compiler. This multi-scale, multi-purpose documentation aims to provide different views of the software, from a high-level structural view to low-level descriptions of basic modules. It supports a distribution of the software "by apartment" (a functionality or a set of functionalities) intended for developers who would only be interested by part of the services of the toolset.

A high-level architectural view of the Polychrony toolset is given in Figure 7 .

5.2. The Eclipse interface

Participants: Loïc Besnard, Yue Ma, Huafeng Yu.

Meta-modeling, Eclipse, Ecore, Signal, Model transformation

We have developed a meta-model and interactive editor of Polychrony in Eclipse. Signal-Meta is the meta-model of the Signal language implemented with Eclipse/Ecore. It describes all syntactic elements specified in [35]: all Signal operators (e.g. arithmetic, clock synchronization), model (e.g. process frame, module), and construction (e.g. iteration, type declaration).

The meta-model primarily aims at making the language and services of the Polychrony environment available to inter-operate and composition with other components (e.g. AADL, Simulink, GeneAuto) within an Eclipse-based development toolchain. Polychrony now comprises the capability to directly import and export Ecore models instead of textual Signal programs, in order to facilitate interaction between components within such a toolchain.

It also provides a graphical modeling framework allowing to design applications using a component-based approach. Application architectures can be easily described by just selecting components via drag and drop, creating some connections between them and specifying their parameters as component attributes. Using the modeling facilities provided with the Topcased framework, we have created a graphical environment for
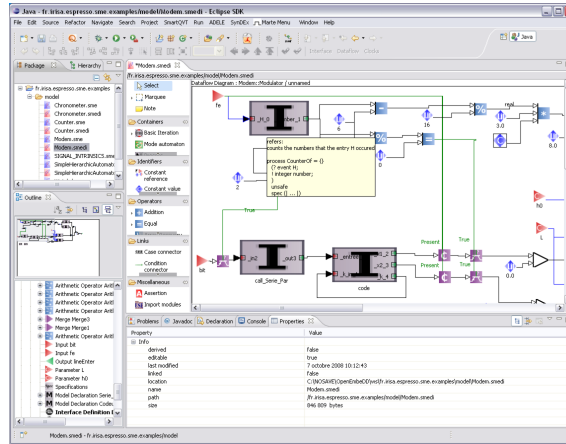
Figure 8. Eclipse SME Environment.

Polychrony (see figure 8) called SME (Signal-Meta under Eclipse). To highlight the different parts of the modeling in Signal, we split the modeling of a Signal process in three diagrams: one to model the interface of the process, one to model the computation (or data-flow) part, and one to model all explicit clock relations and dependences. The SME environment is available through the ESPRESSO update site [23], in the current OpenEmbeDD distribution [22], or in the TopCased distribution [25]. Note that a new meta-model of Signal, called SSME (Syntactic Signal-Meta under Eclipse), closer to the Signal abstract syntax, has been defined and integrated in the Polychrony toolset.

5.3. Integrated Modular Avionics design using Polychrony

Participants: Loïc Besnard, Thierry Gautier, Paul Le Guernic, Jean-Pierre Talpin.

The Apex interface, defined in the ARINC standard [26], provides an avionics application software with the set of basic services to access the operating-system and other system-specific resources. Its definition relies on the Integrated Modular Avionics approach (IMA [27]). A main feature in an IMA architecture is that several avionics applications (possibly with different critical levels) can be hosted on a single, shared computer system. Of course, a critical issue is to ensure safe allocation of shared computer resources in order to prevent fault propagations from one hosted application to another. This is addressed through a functional partitioning of the applications with respect to available time and memory resources. The allocation unit that results from this decomposition is the *partition*.

A partition is composed of *processes* which represent the executive units (an ARINC partition/process is akin to a Unix process/task). When a partition is activated, its owned processes run concurrently to perform the functions associated with the partition. The process scheduling policy is priority preemptive. Each partition is allocated to a processor for a fixed time window within a major time frame maintained by the operating system. Suitable mechanisms and devices are provided for communication and synchronization between processes (e.g. *buffer*, *event*, *semaphore*) and partitions (e.g. *ports* and *channels*). The specification of the ARINC 651-653 services in Signal [5] is now part of the Polychrony distribution and offers a complete implementation of the Apex communication, synchronization, process management and partitioning services. Its Signal implementation consists of a library of generic, parameterizable Signal modules.

5. Software

5.1. Mica: A Modal Interface Compositional Analysis Toolbox

Participant: Benoît Caillaud.

http://www.irisa.fr/s4/tools/mica/

Mica is an Ocaml library developed by Benoît Caillaud implementing the Modal Interface algebra published in [8]. The purpose of Modal Interfaces is to provide a formal support to contract based design methods in the field of system engineering. Modal Interfaces enable compositional reasoning methods on I/O reactive systems.

In Mica, systems and interfaces are represented by extension. However, a careful design of the state and event heap enables the definition, composition and analysis of reasonably large systems and interfaces. The heap stores states and events in a hash table and ensures structural equality (there is no duplication). Therefore complex data-structures for states and events induce a very low overhead, as checking equality is done in constant time.

Thanks to the Inter module and the mica interactive environment, users can define complex systems and interfaces using Ocaml syntax. It is even possible to define parameterized components as Ocaml functions.

Mica is available as an open-source distribution, under the CeCILL-C Free Software License Agreement (http://www.cecill.info/licences/Licence_CeCILL-C_V1-en.html).

5.2. Synet: A General Petri-Net Sythesis Toolbox

Participant: Benoît Caillaud.

http://www.irisa.fr/s4/tools/synet/

Synet is a software tool for the synthesis of bounded and unbounded Petri-nets, based on the theory of regions [33]. It can synthesize Petri-nets from automata or regular expressions and can be configured by command-line options to synthesize nets modulo graph isomorphism or language equality. Petri nets computed by Synet can be displayed using the GraphViz 2D graph layout software, or saved to a file for further transformation and analysis.

The tool actually implements two linear-algebraic synthesis methods: a first method uses the simplex algorithm and the second one is based on the computation of extremal rays of polyhedral cones, using Chernikova's algorithm [35]. Both methods imply that the input graphs are given by extension. Nevertheless, Synet yields good performances on many practical use-cases and is the only tool supporting unbounded net synthesis.

The main application of Synet is the synthesis of communicating distributed protocols and controllers [32]. Synthesis is constrained to produce so-called distributables nets [34], a class of nets that can be turned into networks of communicating automata by automated methods. This allows to divide the synthesis problem in two steps: Given the specification of a protocol as a finite automaton, (i) synthesize (if it exists) a distributable net, and then (ii) derive a network of communicating automata from the distributable net. While the second step is automatic and straightforward, the first step is in essence a computer assisted design task, where the distributed Petri-net synthesis algorithm helps the designer to refine the protocol specification into a graph isomorphic to the marking graph of a distributable net.

TASC Project-Team

5. Software

5.1. CHOCO

Participants: Nicolas Beldiceanu, Alexis De Clerq, Sophie Demassey, Jean-Guillaume Fages, Narendra Jussien [correspondant], Arnaud Letort, Xavier Lorca [correspondant], Thierry Petit, Charles Prud'homme [correspondant], Remi Douence.

CHOCO is a Java discrete constraints library integrating within a same system *explanations*, *soft constraints* and *global constraints* (90000 lines of source code). This year developments were focussing on the following aspects:

1. Since September 2011, we are working on a new version of the CHOCO solver. This implies a total refactoring of the source code in order to make it simpler to use and maintain. We introduce a new propagation engine framework that directly handle state-of-the-art techniques, such as *advisors*, *propagator groups*, *activity-based search* and *explanations*, to ensure a good level of efficiency, and plug a MiniZinc modeling language parser. An alpha release will be available by the beginning of 2013.

2. In the context of the new version of the CHOCO solver we design an *adaptive propagation engine* to enhance performance as well as a *solver independent language to write strategies* for controlling the new adaptive propagation engine. The adaptive propagation engine can both deal with variable-oriented propagation engines and constraint-oriented propagation engines. It is usually accepted that there is no best approach in general and modern constraint solvers therefore implement only one.

3. New scalable global constraints were provides both in the context of *graph constraints* (with also graph variables) and in the context of *scheduling constraints*. These constraints respectively allow to handle sparse graphs with up to 10000 vertices, and resource scheduling problems with up to one million tasks.

4. A new global constraint called *focus* for concentrating high cost values motivated by several concrete examples, such as resource constrained scheduling problems with machine rentals, was introduced.

5. The work on providing probability-based constraints to get light propagation filtering algorithm has been pursued. A particular focus has been put on calculating the probabilistic indicator for the bound-consistency propagator of an *alldifferent* constraint.

N. Beldiceanu, A. De Clerq, S. Demassey, J.-G. Fages, N. Jussien, A. Letort, X. Lorca, T. Petit, C. Prud'Homme and R. Douence have contributed in 2012. The link to the system and documentation is http://choco.emn.fr.

5.2. IBEX

Participants: Ignacio Araya, Anthony Baire, Gilles Chabert [correspondant], Rémi Douence, Bertrand Neveu, Gilles Trombettoni.

IBEX (Interval-Based EXplorer) is a C++ library for solving nonlinear constraints over real numbers (25000 lines of source code). The main feature of Ibex is its ability to build solver/paver strategies declaratively through the contractor programming paradigm.

Continuing last year work on the redesign of the architecture of IBEX, the IBEX library has been entirely re-factored from scratch to provide a more clean and easy-to-use interface as well as a more powerful engine.The development started in late 2011, the kernel has been completed in mid-2012 and almost all the functionalities of IBEX integrated in the new architecture. Global optimization and system solving front-end algorithms have been tested on more than 500 benchmarks. Installation scripts for a deployment on multiple platforms have also been done by an engineer of Inria (Anthony Baire). A first web site has been activated, with an on-line installation documentation, a programming tutorial (still under writing), and an API. An alpha release is now available for download. A first training course on IBEX 2.0 has been organized at ENSTA Bretagne, Brest, the 17-18th December with about 25 participants. Similar training courses will also occur in 2013.

An explorative study aimed at showing that the explicit representation of search trees can play a distinguished role in the field of numerical constraints was done this year. The idea was also to define a new high-level language to handle explicit search trees, in the fashion of quadtrees (that one can intersects, etc.). We have developed a prototype in Haskell to validate the approach and have illustrated it over different examples.

5.3. CHOCO-IBEX

Participants: Gilles Chabert [correspondant], Charles Prud'homme [correspondant].

Work has been done to provide an interface for connecting the CHOCO and the IBEX libraries in order to handle problems where we both have continuous and discrete variables. This interface allows to filter continuous domains from CHOCO with the IBEX engine as well as to check for unsatisfiability or entailment. It also manages reification variables. This interface has been tested on a toy problem and seems to work as expected. Some glue code (on both sides) is still missing to handle reificiation and should be integrated in a short term. The interface should be ready for usage with the next version of CHOCO (3.0).

5.4. Global Constraint Catalog

Participants: Nicolas Beldiceanu [correspondant], Mats Carlsson, Helmut Simonis.

The global constraint catalog presents and classifies global constraints and describes different aspects with meta data. It consist of

1. a pdf version that can be downloaded from http://www.emn.fr/z-info/sdemasse/gccat/ (at item *last working version*) containing 406 constraints, 3397 pages and 758 figures,
2. an on line version accessible from the previous address,
3. meta data describing the constraints (buton *PL* for each constraint, e.g., alldifferent.pl),
4. an online service (i.e, a *constraint seeker*) which provides a web interface to search for global constraints, given positive and negative ground examples.

This year developments were focussing on:

1. maintaining the catalogue,
2. making the *core global constraints* (10 constraints) more accessible to a wider audience:
    - for this purpose examples with their corresponding pictures have been systematically provided for showing all solutions for an example of each core global constraint.
    - in addition a set of about 30 exercises with their corrections have been done for half of the core global constraints.
3. a redesign of all the 758 figures of the catalog has been undertaken in autumn 2012 using TikZ (in December 2012 312 figures were redesigned).
4. adding constraints related to sequences that we found relevant for learning constraints from electricity production curves.

N. Beldiceanu, M. Carlsson (SICS, Sweden) and H. Simonis (4C, Ireland) have contributed in 2012. The link to the global constraint catalog is http://www.emn.fr/z-info/sdemasse/gccat/.

VERTECS Project-Team

5. Software

5.1. STG

Participant: Thierry Jéron.

STG (Symbolic Test Generation) is a prototype tool for the generation and execution of test cases using symbolic techniques. It takes as input a specification and a test purpose described as IOSTS, and generates a test case program also in the form of IOSTS. Test generation in STG is based on a syntactic product of the specification and test purpose IOSTS, an extraction of the subgraph corresponding to the test purpose, elimination of internal actions, determinisation, and simplification. The simplification phase now relies on NBAC, which approximates reachable and coreachable states using abstract interpretation. It is used to eliminate unreachable states, and to strengthen the guards of system inputs in order to eliminate some *Inconclusive* verdicts. After a translation into C++ or Java, test cases can be executed on an implementation in the corresponding language. Constraints on system input parameters are solved on-the-fly (i.e. during execution) using a constraint solver. The first version of STG was developed in C++, using Omega as constraint solver during execution. This version has been deposited at APP under number IDDN.FR.001.510006.000.S.P.2004.000.10600.

A new version in OCaml has been developed in the last years. This version is more generic and will serve as a library for symbolic operations on IOSTS. Most functionalities of the C++ version have been re-implemented. Also a new translation of abstract test cases into Java executable tests has been developed, in which the constraint solver is LUCKYDRAW (VERIMAG). This version has also been deposited at APP and is available for download on the web as well as its documentation and some examples.

Finally, in collaboration with ULB, we implemented a prototype SMACS, derived from STG, devoted to the control of infinite systems modeled by STS.

5.2. SIGALI

Participant: Hervé Marchand.

SIGALI is a model-checking tool that operates on ILTS (Implicit Labeled Transition Systems, an equational representation of an automaton), an intermediate model for discrete event systems. It offers functionalities for verification of reactive systems and discrete controller synthesis. It is developed jointly by the ESPRESSO and VERTECS teams. The techniques used consist in manipulating the system of equations instead of the set of solutions, which avoids the enumeration of the state space. Each set of states is uniquely characterized by a predicate and the operations on sets can be equivalently performed on the associated predicates. Therefore, a wide spectrum of properties, such as liveness, invariance, reachability and attractivity, can be checked. Algorithms for the computation of predicates on states are also available [27] [23]. SIGALI is connected with the Polychrony environment (ESPRESSO project-team) as well as the Matou environment (VERIMAG), thus allowing the modeling of reactive systems by means of Signal Specification or Mode Automata and the visualization of the synthesized controller by an interactive simulation of the controlled system. SIGALI is registered at APP.

Sigali is also integrated as part of the compiler of the language BZR.

ASPI Project-Team (section vide)

5. Software

5.1. COSMAD

With the help of former engineers, I4S team has developed and maintained a Scilab toolbox devoted to modal analysis and vibration monitoring of structures or machines subjected to known or ambient (unknown) excitation. This software (COSMAD 3.64) has been registered at the APP under the number

IDDN.FR.001.210011.002.S.A.2003.000.20700

A list of test-cases (simulators, laboratory test-beds, real structures) for which COSMAD has been used is available on I4S website. The problem is to identify the eigenstructure (eigenvalues and observed components of the associated eigenvectors) of the state transition matrix of a linear dynamical system, using only the observation of some measured outputs summarized into a sequence of covariance matrices corresponding to successive time shifts. Other services are

- *Output-only and Input/Ouptut subspace-based identification*,
- *Automated on-line identification package*,
- *Subspace-based identification through moving sensors data fusion*,
- *Damage detection and monitoring*,
- *Damage localization*,

The modules have been tested by different partners, especially the French industrial partners, EADS, Dassault and Sopemea, within the FLITE2 project, by partners from the past CONSTRUCTIF project, and within the framework of bilateral contracts with SNECMA and SVS.

Based on intensive internal evaluation of the toolbox, on both simulated and real data sets, EADS Space Transportation and CNES have been investigating how to use the toolbox for the exploitation of the Ariane 5 flight data sets.

This Scilabtoolbox continues to play the role of a programming and development environment for all our newly designed algorithms. Moreover, offering a *maintained* Scilab platform turns out to be a crucial factor in convincing industrial partners to undertake joint investigations with us. Just recently, SNECMA funded development for the Cosmad toolbox in 2010.

5.2. Prototypes

Three software have been deposed to the Agency of Program Protection, i.e.

- 1/ VIBRA-PARTICULAIRE : APP IDDN.FR.001.420016.000.S.P.2012.000.20700

They will be transferred to partners and industrial contracts when possible.

+ A new version of the COSMAD toolbox has been deposed at APP and concerns the transfer to SVS action.

IPSO Project-Team (section vide)

DYLISS Team

5. Software

5.1. Data integration: actors involved in the response of a living system

The goal is to offer a toolbox for the reconstruction of networks from genome, literature and large-scale observation data (expression data, metabolomics...) in order to elucidate the main regulators of an observed phenotype.

- **Mobyle@GenOuest network portal** We are developing a web service [2] to use several tools to confront knowledge and data towards the correction of large-scale networks, based either on decision diagrams or on answer set programming. BioQuali [3][4] allows one to confront model and data, localize errors and, when model and data are consistent, to predict the variation of non observed nodes [6]. BioASP [5] was developed in Potsdam and allows one to perform prediction even if model and observations are contradictory, by considering all possible repairs of data and models and computing the common predictions of all repaired models [5]. The portal also include tools for the completion of metabolic networks [32].

- **Combined set of key actors in reaction-based networks: Cadbiom**[6]. This tool is based on state-chart like graphical language. It allows investigating synchronization events in biological networks. It is applied to cancer signaling networks [10].

5.2. Dynamics: actor/parameter combination controlling the response of a system

We wish to develop tools predicting some characteristics of a biological system behavior from incomplete sets of parameters or observations.

- **caspo: Cell ASP Optimizer**. We have implemented a Python package which combines BioASP [7] and CellNOpt[8] to provide an easy to use software for learning Boolean logic models using ASP [19]. The software is available for download[9] and also as a web service through the Mobyle framework.

- **Event network and quantitative time-series data: POGG**[10]. POGG is a tool developed in collaboration with the LINA lab (Nantes) that uses mean dynamics to score the respective relevance of regulatory pathways in a higher-scale phenotype. It was applied to the quantitative prediction of protein quantities under exponential growth [2]. It predicts the main features of a Markov chain model derived from a reaction-based model when confronted to a single time-series quantitative observation.

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[2] http://mobyle.genouest.org/cgi-bin/Mobyle/portal.py
[3] http://www.irisa.fr/symbiose/bioquali/
[4] http://www.irisa.fr/symbiose/projects/bioqualiCytoscapePlugin/
[5] http://www.cs.uni-potsdam.de/bioasp/
[6] http://cadbiom.genouest.org/
[7] http://www.cellnopt.org/
[8]

;sthiele/bioasp/http://www.cs.uni-potsdam.de/˜sthiele/bioasp/
[9] http://pypi.python.org/pypi/caspo
[10] http://pogg.genouest.org/wiki.php/Home

5.3. Sequence annotation

We develop tools for discovery and search of complex pattern signatures within biological sequences, with a focus on protein sequences. An integrated environment, Dr Motif [11] is available on the GenOuest Platform that gathers state-of-the-art tools for pattern discovery and pattern matching including our own developments.

- **Complex pattern discovery: Protomata learner**[12] is a grammatical inference framework suitable for the inference of accurate protein signatures [3], [4]. It was completely redesigned in 2010-2011 thanks to a specific Inria action (ADT support). It is currently applied to the recognition of olfactory receptor genes.

- **Complex pattern matching: Logol [13].** We have completely redesigned Stan (suffix-tree analyser), a former tool to search for nucleotidic and peptidic patterns within whole chromosomes [7]. The result is Logol, a software suite accepting a syntax based on String Variable Grammars, which allows the description of realistic complex patterns including ambiguities, insertions/ deletions, gaps, repeats and palindromes. It has been presented for the first time in [21]. Logol has been applied to the detection of -1 frameshifts, a structure including pseudo knots, on a reference benchmark (Recode2).

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[11]http://www.drmotifs.org/
[12]http://protomata-learner.genouest.org/
[13]http://webapps.genouest.org/LogolDesigner/

FLUMINANCE Project-Team

5. Software

5.1. DenseMotion software - Estimation of 2D dense motion fields

Participants: Thomas Corpetti, Patrick Héas, Etienne Mémin.

This code allows the computation from two consecutive images of a dense motion field. The estimator is expressed as a global energy function minimization. The code enables the choice of different data model and different regularization functional depending on the targeted application. Generic motion estimator for video sequences or dedicated motion estimator for fluid flows can be specified. This estimator allows in addition the users to specify additional correlation based matching measurements. It enables also the inclusion of a temporal smoothing prior relying on a velocity vorticity formulation of the Navier-Stoke equation for Fluid motion analysis applications. The different variants of this code correspond to research studies that have been published in IEEE transaction on Pattern Analysis and machine Intelligence, Experiments in Fluids, IEEE transaction on Image Processing, IEEE transaction on Geo-Science end Remote Sensing. The binary of this code can be freely downloaded on the FLUID web site http://fluid.irisa.fr.

5.2. 2DLayeredMotion software - Estimation of 2D independent mesoscale layered atmospheric motion fields

Participants: Patrick Héas, Etienne Mémin.

This software enables to estimate a stack of 2D horizontal wind fields corresponding to a mesoscale dynamics of atmospheric pressure layers. This estimator is formulated as the minimization of a global energy function. It relies on a vertical decomposition of the atmosphere into pressure layers. This estimator uses pressure data and classification clouds maps and top of clouds pressure maps (or infra-red images). All these images are routinely supplied by the EUMETSAT consortium which handles the Meteosat and MSG satellite data distribution. The energy function relies on a data model built from the integration of the mass conservation on each layer. The estimator also includes a simplified and filtered shallow water dynamical model as temporal smoother and second-order div-curl spatial regularizer. The estimator may also incorporate correlation-based vector fields as additional observations. These correlation vectors are also routinely provided by the Eumetsat consortium. This code corresponds to research studies published in IEEE transaction on Geo-Science and Remote Sensing. It can be freely downloaded on the FLUID web site http://fluid.irisa.fr.

5.3. 3DLayeredMotion software - Estimation of 3D interconnected layered atmospheric motion fields

Participants: Patrick Héas, Etienne Mémin.

This software extends the previous 2D version. It allows (for the first time to our knowledge) the recovery of 3D wind fields from satellite image sequences. As with the previous techniques, the atmosphere is decomposed into a stack of pressure layers. The estimation relies also on pressure data and classification clouds maps and top of clouds pressure maps. In order to recover the 3D missing velocity information, physical knowledge on 3D mass exchanges between layers has been introduced in the data model. The corresponding data model appears to be a generalization of the previous data model constructed from a vertical integration of the continuity equation. This research study has been recently accepted for publication in IEEE trans. on Geo-Science and Remote Sensing. A detailed description of the technique can be found in an Inria research report. The binary of this code can be freely downloaded on the FLUID web site http://fluid.irisa.fr.

5.4. Low-Order-Motion - Estimation of low order representation of fluid motion

Participants: Anne Cuzol, Etienne Mémin.

This code enables the estimation of a low order representation of a fluid motion field from two consecutive images.The fluid motion representation is obtained using a discretization of the vorticity and divergence maps through regularized Dirac measure. The irrotational and solenoidal components of the motion fields are expressed as linear combinations of basis functions obtained through the Biot-Savart law. The coefficient values and the basis function parameters are obtained as the minimizer of a functional relying on an intensity variation model obtained from an integrated version of the mass conservation principle of fluid mechanics. Different versions of this estimation are available. The code which includes a Matlab user interface can be downloaded on the FLUID web site http://fluid.irisa.fr. This program corresponds to a research study that has been published in the International Journal on computer Vision.

GENSCALE Team

5. Software

5.1. Next Generation Sequencing

Participants: Alexan Andrieux, Rayan Chikhi, Dominique Lavenier, Claire Lemaitre, Nicolas Maillet, Pierre Peterlongo, Raluca Uricaru.

- **Genome assembly** [contact: P. Peterlongo]
    - **Minia : ultra low memory assembly** Minia is a short-read assembler based on a de Bruijn graph, capable of assembling a human genome on a desktop computer in a day. The output of Minia is a set of contigs. Minia produces results of similar contiguity and accuracy to other de Bruijn assemblers (e.g. Velvet). http://minia.genouest.org/
    - **Mapsembler: targeted assembly software.** Mapsembler is a targeted assembly software. From sets of NGS raw reads and a set of input sequences (starters), it determines if each starter could be constructed from the reads. Then for each "read-coherent" starter, Mapsembler outputs its sequence neighborhood as a linear sequence or as a graph, depending on the user choice. http://alcovna.genouest.org/mapsembler/
- **Variant detection** [contact: C. Lemaitre]
    - **kisSnp and kisSplice : variant identification without the use of a reference genome**. kisSnp is a tool to find single nucleotide polymorphisms (SNP) by comparing two sets of raw NGS reads. http://alcovna.genouest.org/kissnp/ KisSplice finds alternative splicings but also short insertions, deletions and duplications, SNPs and sequencing errors in one or two RNA-seq sets, without assembly nor mapping on a reference genome. http://alcovna.genouest.org/kissplice/
    - **Kissreads: quantification of variants** Kissreads considers sets of NGS raw reads and a set of input sequences (starters). Mapping reads to each starter, it provides quantitative (coverage depth) and qualitative (mapped read quality) information about each starter.
- **Read mapping** [contact: D. Lavenier]
    - **GASSST: short reads mapper** The GASSST software (Global Alignment Short Sequence Search Tool) is a general purpose mapper. GASSST finds global alignments of short DNA sequences against large DNA banks. One main characteristic of GASSST is its ability to perform fast gapped alignments and to process long reads compared to other current similar tools. http://www.irisa.fr/symbiose/projects/gassst/

5.2. High throughput sequence analysis

Participants: Rayan Chikhi, Erwan Drezen, Dominique Lavenier, Claire Lemaitre, Nicolas Maillet, Pierre Peterlongo.

- **PLAST : efficient bank-to-bank alignments** PLAST (Parallel Local Alignment Search Tool) is a parallel alignment search tool for comparing large protein banks. PLAST runs 3 to 5 times faster than the NCBI-BLAST software. An improved version is commercialized by the Korilog Company, including the DNA bank-to-bank option. [contact: D. Lavenier] http://www.irisa.fr/symbiose/projects/plast/
- **Compareads : efficient comparison of large metagenomics NGS datasets** This software extracts similar DNA sequences (reads) between two metagenomic datasets. It requires a small and fixed amount of memory and can thus be used on huge datasets. [contact: P. Peterlongo] http://alcovna.genouest.org/compareads/

5.3. 3D Protein structures

Participants: Rumen Andonov, Guillaume Chapuis, Mathilde Le Boudic-Jamin, Antonio Mucherino.

- **CSA and DALIX** CSA (Comparative Structural Alignment) is a webserver for computing and comparing protein structure alignments. CSA is able to compute score-optimal alignments with respect to various inter-residue distance-based scoring schemes. [contact: R. Andonov] http://csa.project.cwi.nl/

- **A_purva** A_purva is a Contact Map Overlap maximization (CMO) solver. Given two protein structures represented by two contact maps, A_purva computes the amino-acid alignment which maximize the number of common contacts. [contact: R. Andonov] http://mobyle.genouest.org/cgi-bin/Mobyle/portal.py?forms::A_Purva

- **MD-Jeep** MD-jeep is a software tool for solving distance geometry problems. It is able to solve a subclass of instances of the problem for which a discrete reformulation can be supplied. We refer to this subclass of instances as the Discretizable Molecular Distance Geometry Problem (DMDGP). We employ a Branch & Prune (BP) algorithm for the solution of DMDGPs. [contact: A. Mucherino] http://www.antoniomucherino.it/en/mdjeep.php

5.4. HPC and Parallelism

Participants: Guillaume Chapuis, Dominique Lavenier, François Moreews.

- **QTLmap** QTLMap is a tool dedicated to the detection of Quantitative Trait Loci (QTL) from experimental designs in outbred population. QTLMap was recently ported to GPU and offers reduced run times. [contact: D. Lavenier] http://www.inra.fr/qtlmap/

- **SLICEE** (Service Layer for Intensive Computation Execution Environment) is part of the BioWIC project. This software proposes (1) to abstract the calls to the cluster scheduler by handling command submission; (2) to take care of exploiting the data parallelism with data specific methods; (3) to manage data using a cache references mecanism and route data between tasks. [contact: F. Moreews] http://vapor.gforge.inria.fr/

<div align="center">

SAGE Project-Team

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5. Software

5.1. H2OLab

Participants: Thomas Dufaud, Jocelyne Erhel [correspondant], Grégoire Lecourt, Aurélien Le Gentil, Géraldine Pichot.

The software platform H2OLab is devoted to stochastic simulations of groundwater flow and contaminant transport in highly heterogeneous porous and fractured geological media. It contains a database which is interfaced through the web portal H2OWeb. It contains also software modules which can be used through the interface H2OGuilde. The platform H2OLab is an essential tool for the dissemination of scientific results. Currently, software and database are shared by the partners of the h2mno4 project (see 8.1.1). Software integrated in the platform and registered at APP are GW-UTIL, GW-NUM, PARADIS, MP-FRAC.

See also the web page http://h2olab.inria.fr.

5.2. GW-UTIL

Participants: Jocelyne Erhel, Grégoire Lecourt, Aurélien Le Gentil, Géraldine Pichot [correspondant].

- Version: version 1.0, May 2008
- APP: registered
- Programming language: C++
- See also: http://h2olab.inria.fr.
- Abstract: The software GW-UTIL allows to discretize PDE for flow and transport in aquifers and to deal with stochastic models. It contains a set of utilitary modules for geometry, input, output, random numbers, visualization, parallel computing, numerical algorithms, etc. A package is devoted to launch applications.
- Current work: refactoring.

5.3. GW-NUM

Participants: Thomas Dufaud, Jocelyne Erhel, Grégoire Lecourt, Aurélien Le Gentil, Géraldine Pichot [correspondant].

- Version: version 1.0, May 2008
- APP: registered
- Programming language: C++
- See also: http://h2olab.inria.fr.
- Abstract: The software GW-NUM is a set of generic modules to discretize PDE of flow and transport in 2D computational domains in order to deal with stochastic models. Methods for flow simulations are either Finite Volume on structured meshes or Mixed Finite Element with unstructured meshes. Method for transport simulations is a particle tracker for advection and a random walker for diffusion. Uncertainty Quantification method is Monte-Carlo. For flow computations, the involved linear system is solved by external software devoted to sparse matrices.
- Current work: refactoring.

5.4. MP-FRAC

Participants: Thomas Dufaud, Jocelyne Erhel, Aurélien Le Gentil, Géraldine Pichot [correspondant].

- Version: version 1.0, May 2008
- APP: registered
- Programming language: C++
- See also: http://h2olab.inria.fr.
- Abstract: The software MP-FRAC aims at modelling and simulating numerically flow in a fractured aquifer. The physical domain is a network of fractures, either deterministic or stochastic, with a permeability field either deterministic or stochastic. The software computes the velocity field in the aquifer, by assuming that the medium is saturated and that flow is steady-state. Physical equations are stochastic PDEs, handled by a Monte-Carlo method. This non intrusive approach generates a set of random samples, which are used for simulations. Then, the software analyzes statistically the flow in the stochastic case. The objective is to characterize hydraulic properties in Discrete Fracture Networks. The software MP-FRAC handles a simulation corresponding to one sample, whereas Monte-Carlo method is implemented in a generic way by the software GW-NUM. The software is specific of the physical model (Discrete Fracture Network) and of the application (steady-state flow). Generic numerical methods to discretize PDE are implemented in the software GW-NUM.
- Current work: refactoring and design of libraries.

5.5. PARADIS

Participants: Jocelyne Erhel, Grégoire Lecourt, Aurélien Le Gentil, Géraldine Pichot [correspondant].

- Version: version 1.0, May 2008
- APP: registered
- Programming language: C++
- See also: http://h2olab.inria.fr/.
- Abstract: The software PARADIS aims at modelling and simulating numerically flow in a porous aquifer and transport by convection-diffusion of an inert solute. The porous medium is heterogeneous, with a stochastic or deterministic permeability field. A first step computes the velocity filed in the aquifer, by assuming that the medium is saturated and that flow is steady-state. A second step computes the distribution of solute concentration, by assuming a transport by convection and by molecular diffusion. Physical equations are stochastic PDEs, handled by a Monte-Carlo method and discretized by numerical methods. This non intrusive approach generates a set of random samples, which are used for simulations. Then, the software analyzes statistically the flow in the stochastic case. The objectives are to determine asymptotic laws of transport, to characterize pre-asymptotic behavior and to define global laws.

  The software PARADIS handles a simulation corresponding to one sample, whereas Monte-Carlo method is implemented in a generic way by the software GW-NUM. The software is specific of the physical model (heterogeneous porous medium) and of the application (steady-state flow then transport with macro-dispersion). Generic numerical methods to discretize PDE are implemented in the software GW-NUM.
- Current work: refactoring and design of libraries.

5.6. GRT3D

Participants: Édouard Canot, Jocelyne Erhel [correspondant], Souhila Sabit.

- Version: version 1.0, April 2011
- APP: registered
- Programming language: C
- Abstract: Reactive transport modeling has become an essential tool for understanding complex environmental problems. It is an important issue for MoMaS partners (see section 8.1.7), in particular Andra (see section 7.1). We have developed a method coupling transport and chemistry, based on a method of lines such that spatial discretization leads to a semi-discrete system of algebraic differential equations (DAE system). The main advantage is to use a complex DAE solver, which controls simultaneously the timestep and the convergence of Newton algorithm. Another approach, called SIA, is to use a fixed-point method to solve the nonlinear system at each timestep.

    The software suite GRT3D has four executable modules:
    - SIA1D: Sequential Iterative Approach for 1D domains;
    - GDAE1D: Global DAE approach for 1D domains;
    - SNIA3D: Sequential Non Iterative Approach for 1D, 2D or 3D domains.
    - GDAE3D: Global DAE approach for 1D, 2D or 3D domains.
- Current work: extension of the chemistry module and reduction of CPU time.

5.7. GPREMS

Participants: Édouard Canot, Jocelyne Erhel [correspondant].

- Version: version 1.0, May 2008
- APP: registered
- Programming language: C++
- See also: http://www.irisa.fr/sage/.
- Abstract: GPREMS implements a robust hybrid solver for large sparse linear systems that combines a Krylov subspace method as accelerator with a Schwarz-based preconditioner. This preconditioner uses an explicit formulation associated to one iteration of the multiplicative Schwarz method. The Newton-basis GMRES, which aims at expressing a good data parallelism between subdomains is used as accelerator.

5.8. DGMRES

Participant: Jocelyne Erhel [correspondant].

- Version: version 1.0, June 2011
- APP: distributed with the free software PETSC
- Programming language: C
- See also: http://www.irisa.fr/sage/.
- Abstract: DGMRES implements a preconditioner based on adaptive deflation, which can be used with any preconditioner for the GMRES algorithm.

5.9. AGMRES

Participant: Jocelyne Erhel [correspondant].

- Version: version 1.0, November 2011
- APP: distributed with the free software PETSC
- Programming language: C
- See also: http://www.irisa.fr/sage/.
- Abstract: AGMRES implements an augmented subspace approach, based on adaptive deflation, which can be used with any preconditioner for the GMRES algorithm. It also implements a Newton basis for enhancing parallelism.

5.10. PPAT: pseudo-spectrum

Participants: Édouard Canot [corresponding author], Bernard Philippe.

PPAT (Parallel PATh following software) is a parallel code, developed by D. Mezher, W. Najem (University of Saint-Joseph, Beirut, Lebanon) and B. Philippe. This tool can follow the contours of a functional from $\mathbb{C}$ to $\mathbb{R}^+$. The present version is adapted for determining the level curves of the function $f(z) = \sigma_{\min}(A - zI)$ which gives the pseudospectrum of matrix A.

The algorithm is reliable: it does not assume that the curve has a derivative everywhere. The process is proved to terminate even when taking into account roundoff errors. The structure of the code spawns many independent tasks which provide a good efficiency in the parallel runs.

The software can be downloaded under the GPL licence from: http://sourceforge.net/projects/ppat.

5.11. MUESLI: Scientific computing

Participant: Édouard Canot [corresponding author].

Doing linear algebra with sparse and dense matrices is somehow difficult in scientific computing. Specific libraries do exist to deal with this area (*e.g.* BLAS and LAPACK for dense matrices, SPARSKIT for sparse ones) but their use is often awful and tedious, mainly because of the large number of arguments which must be used. Moreover, classical libraries do not provide dynamic allocation. Lastly, the two types of storage (sparse and dense) are so different that the user must know in advance the storage used in order to declare correctly the corresponding numerical arrays.

MUESLI is designed to help in dealing with such structures and it provides the convenience of coding in Fortran with a matrix-oriented syntax; its aim is therefore to speed-up development process and to enhance portability. It is a Fortran 95 library split in two modules: (i) FML (Fortran Muesli Library) contains all necessary material to numerically work with a dynamic array (dynamic in size, type and structure), called `mfArray`; (ii) FGL (Fortran Graphics Library) contains graphical routines (some are interactive) which use the `mfArray` objects.

MUESLI includes some parts of the following numerical libraries: Arpack, Slatec, SuiteSparse, Triangle, BLAS and LAPACK.

Linux is the platform which has been used for developing and testing MUESLI. Whereas the FML part (numerical computations) should work on any platform (*e.g.* Win32, Mac OS X, Unix), the FGL part is intended to be used only with X11 (*i.e.* under all UNIXes).

Last version of MUESLI is 2.6.6 (2012-08-29). More information can be found at: http://people.irisa.fr/Edouard.Canot/muesli

5.12. CANARD: BEM for surface flows

Participant: Édouard Canot [corresponding author].

When dealing with non-linear free-surface flows, mixed Eulerian-Lagrangian methods have numerous advantages, because we can follow marker particles distributed on the free-surface and then compute with accuracy the surface position without the need of interpolation over a grid. Besides, if the liquid velocity is large enough, Navier-Stokes equations can be reduced to a Laplace equation, which is numerically solved by a Boundary Element Method (BEM); this latter method is very fast and efficient because computing occur only on the fluid boundary. This method has been applied to the spreading of a liquid drop impacting on a solid wall and to the droplet formation at a nozzle; applications take place, among others, in ink-jet printing processes.

The code used (CANARD) has been developped with Jean-Luc Achard (LEGI, Grenoble) for fifteen years and is used today mainly through collaborations with Carmen Georgescu at UPB (University Polytechnica of Bucarest, Romania), and with Alain Glière (CEA-LETI, Grenoble).

SERPICO Team

5. Software

5.1. Software for live cell imaging

Participants: Charles Kervrann, Patrick Bouthemy, Tristan Lecorgne.

Motion2d: parametric motion model estimation

The MOTION2D software written in C++ (APP deposit number: FR.001.520021.001.S.A.1998.000.21000 / release 1.3.11, January 2005) and JAVA (plug-in IMAGEJ (http://rsbweb.nih.gov/ij/) is a multi-platform object-oriented library to estimate 2D parametric motion models in an image sequence. It can handle several types of motion models, namely, constant (translation), affine, and quadratic models. Moreover, it includes the possibility of accounting for a global variation of illumination. The use of such motion models has been proved adequate and efficient for solving problems such as optic flow computation, motion segmentation, detection of independent moving objects, object tracking, or camera motion estimation, and in numerous application domains (video surveillance, visual servoing for robots, video coding, video indexing), including biological imaging (image stack registration, motion compensation in videomicroscopy). Motion2D is an extended and optimized implementation of the robust, multi-resolution and incremental estimation method (exploiting only the spatio-temporal derivatives of the image intensity function). Real-time processing is achievable for motion models involving up to six parameters. Motion2D can be applied to the entire image or to any pre-defined window or region in the image.

Free academic software distribution: Motion2D Free Edition is the version of Motion2D available for development of Free and Open Source software only. More information on Motion2D can be found at http://www.irisa.fr/vista/Motion2D and the software can be downloaded at the same Web address.
On-line demo: Mobyle@GenOuest Bioinformatics http://mobyle.genouest.org/cgi-bin/Mobyle/portal.py#forms:Motion2D (see Fig. 5).

Partner: Fabien Spindler (Inria Lagadic team).

ND-Safir and Fast2D-SAFIR: Image denoising software

The ND-SAFIR software (APP deposit number: IDDN.FR.001.190033.002.S.A.2007.000.21000 / new release 3.0 in 2013) written in C++, JAVA and MATLAB, removes additive Gaussian and non-Gaussian noise in still 2D or 3D images or in 2D or 3D image sequences (with no motion computation) (see Figure 2) [4]. The method is unsupervised and is based on a pointwise selection of small image patches of fixed size (a data-driven adapted way) in spatial or space-time neighbourhood of each pixel (or voxel). The main idea is to modify each pixel (or voxel) using the weighted sum of intensities within an adaptive 2D or 3D (or 2D or 3D + time) neighbourhood and to use image patches to take into account complex spatial interactions. The neighbourhood size is selected at each spatial or space-time position according to a bias-variance criterion. The algorithm requires no tuning of control parameters (already calibrated with statistical arguments) and no library of image patches. The method has been applied to real noisy images (old photographs, JPEG-coded images, videos, ...) and is exploited in different biomedical application domains (time-lapse fluorescence microscopy, video-microscopy, MRI imagery, X-ray imagery, ultrasound imagery, ...).

The FAST-2D-SAFIR software (APP deposit number: IDDN.FR.001.190033.001.S.A.2007.000.21000) written in C++ removes mixed Gaussian-Poisson noise in large 2D images, typically $10^3 \times 10^3$ pixels, in a few seconds. The method is unsupervised and is a simplified version of the method related to the SAFIR-nD software. The software dedicated to microarrays image denoising, was licensed to the INNOPSYS company which develops scanners for disease diagnosis and multiple applications (gene expression, genotyping, aCGH, ChIP-chip, microRNA, ...).

On-line demo: Mobyle@GenOuest Bioinformatics
http://mobyle.genouest.org/cgi-bin/Mobyle/portal.py#forms::NDSafir

Free download binaries: Binaries of the software ND-SAFIR are freely and electronically distributed. Developed in standard C/C++ under Linux using the CImg library, it has been tested over several platforms such as Linux/Unix, Windows XP and Mac OS.

Academic licence agreements: Institut Curie, CNRS, ENS Ulm, Oxford university, Weizmann Institute, UCSF San-Francisco, Harvard university, Berkeley university, Stanford university, Princeton university, Georgia-Tech, Kyoto university, IMCB Singapore ...

Partners: J. Boulanger, J. Salamero (UMR 144 CNRS Institut Curie), P. Elbau (RICAM Linz, Austria), J.B. Sibarita (UMR 5091 University of Bordeaux 2).
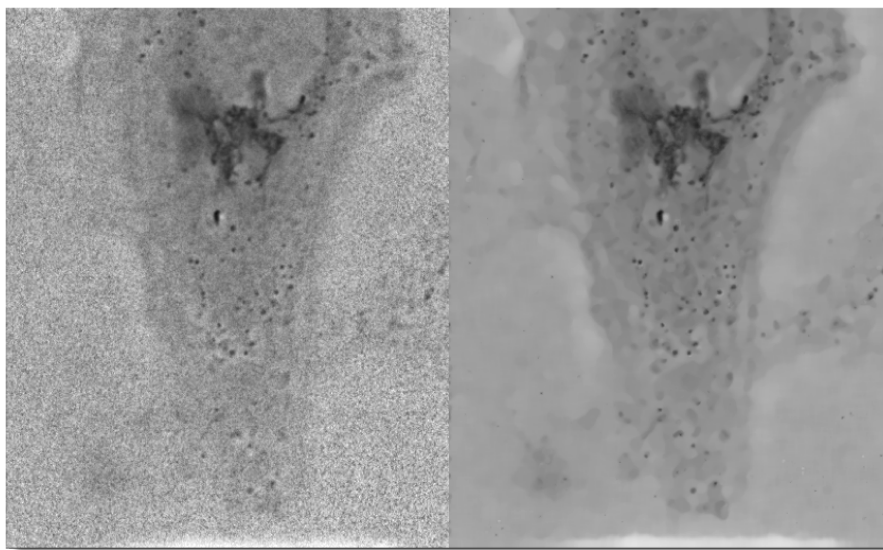

Figure 2. ND-SAFIR *software: denoising of a 3D image sequence in wide-field (WF) microscopy (GFP-Rab6A (Hela cell), UMR 144 CNRS Institut Curie).*

HullkGround: Background subtraction by convex hull estimation

The HULLKGROUND software (APP deposit number: IDDN.FR.001.400005.000.S.P.2009.000.21000) written in JAVA (plug-in IMAGEJ, see Fig. 3) decomposes a fluorescence microscopy image sequence into two dynamic components: i/ an image sequence showing mobile objects; ii/ an image sequence showing the slightly moving background. Each temporal signal of the sequence is processed individually and analyzed with computational geometry tools. The convex hull is estimated automatically for each pixel and subtracted to the

original signal. The method is unsupervised, requires no parameter tuning and is a simplified version of the α shapes-based scale-space method [25].

On-line demo: Mobyle@GenOuest Bioinformatics http://mobyle.genouest.org/cgi-bin/Mobyle/portal.py#forms::Hullkground

Partners: A. Chessel and J. Salamero (UMR 144 CNRS Institut Curie)
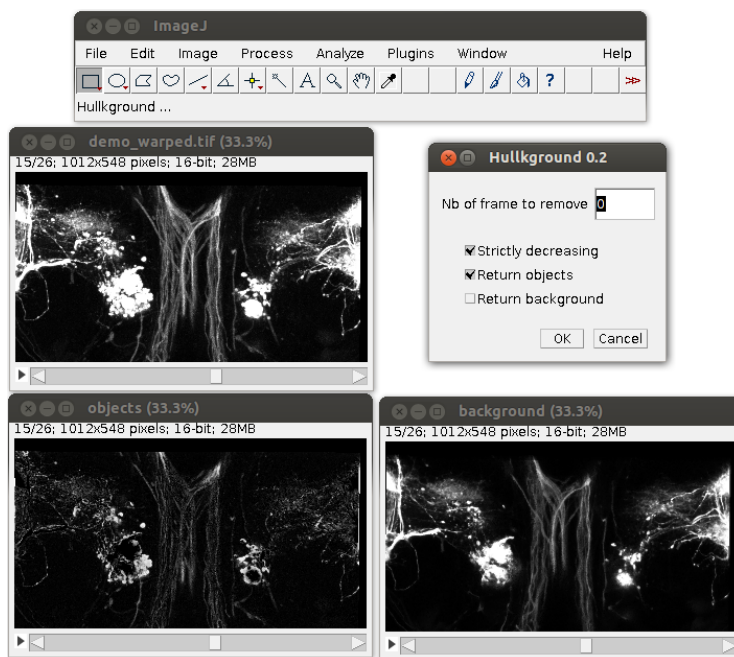

Figure 3. HULLKGROUND *software: plug-in* IMAGEJ.

5.2. Software for Cyo-electron tomography

Participant: Charles Kervrann.

TubuleJ: Straightening of microtubule cryo-EM projection views

The TUBULEJ software (APP deposit number: IDDN.FR.001.240023.000.S.P.2011.000.21000) written in JAVA (plug-in IMAGEJ) is devoted to the analysis of microtubules and helical structures in 2D cryo-electron microscope images. The software straightens curved microtubule images by estimating automatically points locations on the microtubule axis. The estimation of microtubule principal axis relies on microtubule cylindrical shape analyzed in the Fourier domain. A user-friendly interface enables to filter straight fiber images by selecting manually the layer lines of interest in the Fourier domain. This software can be used to generate a set of 2D projection views from a single microtubule projection view and a few parameters of this microtubule structure. These projection views are then back projected, by using the IMOD plug-in (http://rsbweb.nih.gov/ij/), to reconstruct 3D microtubules.

On-line demo: see http://equipes.igdr.univ-rennes1.fr/en/tips/Software/TubuleJ/

Partners: S. Blestel and D. Chrétien (UMR 6290 CNRS University of Rennes 1)

Cryo-Seg: Segmentation of tomograms in cryo-electron microscopy

The CRYO-SEG software written in C++ and JAVA (plug-in MAGEJ) has been developed to detect microtubule structures and helical structures in 2D cryo-electron microscope images (see Figure 4). Cryo-electron tomography allows 3D observation of biological specimens in their hydrated state. Segmentation is formulated as Maximum A Posteriori estimation problem and exploits image patches to take into account spatial contexts (Markov Random Fields). Because of the contrast anisotropy in the specimen thickness direction, the whole tomogram is segmented section by section, with an automatic update of reference patches. This algorithm has been evaluated on synthetic data and on cryo-electron tomograms of in vitro microtubules. On real data, this segmentation method extracts the most contrasted regions of microtubules, and 3D visualization is improved.

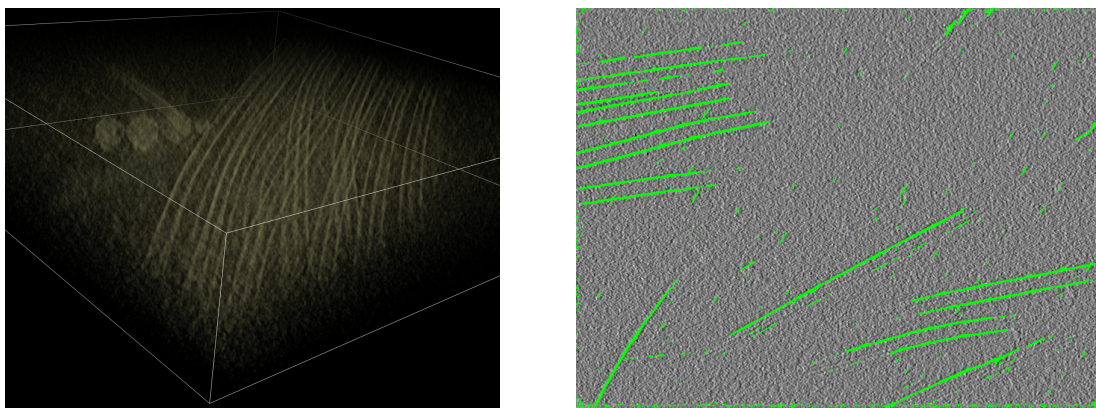**Partners:** S. Blestel and D. Chrétien (UMR 6290 CNRS University of Rennes 1)

Figure 4. CRYO-SEG *software: Segmentation of 3D microtubles in a cryo-EM tomogram (left) and 2D view (right)*
(UMR 6290 CNRS University of Rennes 1).

5.3. Image Processing software distribution

Participants: Tristan Lecorgne, Charles Kervrann.

The objective is to disseminate the distribution of SERPICO image processing software for biologist users:

- *Free binaries:* software packages have been compiled for the main operating systems (Linux, MacOS, Windows) using CMake (see http://www.cmake.org/). They are freely available on the team website under a proprietary license (e.g. ND-SAFIR and HULLKGROUND are distributed this way at http://serpico.rennes.inria.fr/doku.php?id=software:index).

- *Mobyle web portal*: An online version of the software has been released using the Mobyle framework (see http://mobyle.pasteur.fr/) developed at Institut Pasteur. The main role of this web portal is to demonstrate the performance of the programs developed by the team. The web interface makes our image processing methods available for biologist users without any installation or configuration (see ND-SAFIR, HULLKGROUND, MOTION2D (see Fig. 5) at http://mobyle.genouest.org/). The size of submitted images is limited by network bandwidth. We use the computing facility of the GenOuest platform to run calculations.

- IMAGEJ *plug-ins*: IMAGEJ (see http://rsb.info.nih.gov/ij/) is a widely used image visualization and analysis software for biologist users. We have developed IMAGEJ plug-in JAVA versions of the following software: ND-SAFIR, HULLKGROUND (see Fig. 3), MOTION2D, HOTSPOTDETECTION and OPTICALFLOW.

- *Institut Curie database*: Institut Curie is currently acquiring a new database system to store mass of data. The database can be searched via meta-data and includes menu selections that enable to run remote processing. We have integrated ND-SAFIR in the interface environment to allow the database users to denoise images easily.

Partners: C. Deltel (Inria Rennes SED) and Perrine Paul-Gilloteux (UMR 144 PICT IBiSA CNRS Institut Curie)

Figure 5. Motion2D on Mobyle@GenOuest Bioinformatics.

VISAGES Project-Team

5. Software

5.1. Vistal

Participants: Olivier Commowick, Clément Philipot.

VistaL is a software platform of 3D and 3D+t image analysis allowing the development of generic algorithms used in different contexts (rigid and non-rigid registration, segmentation, statistical modelling, calibration of free-hand 3D ultrasound system and so on, diffusion tensor image processing, tractography). This software platform is composed of generic C++ template classes (Image3D, Image4D, Lattice and so on) and a set of 3D/3D+t image processing libraries. VistaL is a multi-operating system environment (Windows, Linux/Unix...). A web site presenting the project has been developped, precompiled packages and the SDK are now available. VistaL APP registration number is:IDDN.FR.001.200014.S.P.2000.000.21000.
See also the web page http://vistal.gforge.inria.fr.

(a)   (b)   (c)
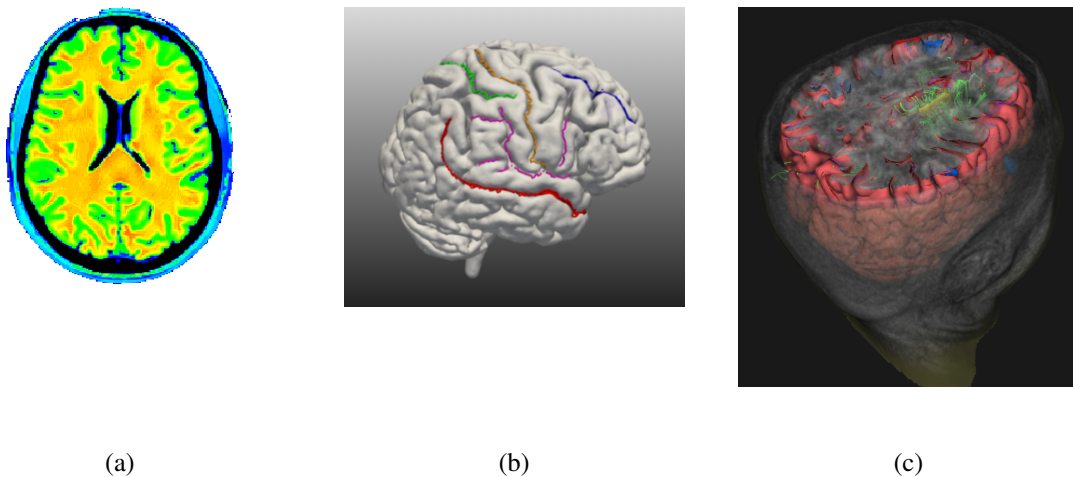
Figure 2. Some ViSTAL results screenshots: a) The ViSTAL Logo, b) ViSTAL Brain surface and sulci modelisation,
c) The ROI3D Extraction view

- Keywords: medical image processing, image analysis, registration, segmentation, denoising
- Software benefit: New methodological image processing, some GPU based algorithms, easy to use C++ library
- APP: IDDN.FR.001.200014.S.P.2000.000.21000
- License: Licence Propriétaire
- Type of human computer interaction: C++ API and less complete Python API
- OS/Middleware: Windows, Mac et Linux.
- Required library or software: CMake (GPL) - ITK (BSD) - VTK (BSD) - Boost (BSD) - Libxml++ (LGPL) - CppUnit (LGPL)
- Programming language: C/C++, Python
- Documentation: Documentation Doxygen, documentation utilisateur.

5.2. CLARCS: C++ Library for Automated Registration and Comparison of Surfaces

Participants: Juan Francisco Garamendi, Sylvain Prima.

In collaboration with Benoit Combès (Géosciences Rennes, UMR 6118) and Alexandre Abadie (Inria Saclay Île-de-France), within the 3D-MORPHINE ARC project (http://3dmorphine.inria.fr), we conceived and implemented a C++ library (named CLARCS) for the automated analysis and comparison of surfaces. One of the primary goal of this library is to allow the assessment and quantification of morphological differences of free-form surfaces from medical or paleoanthropological data.

- APP: IDDN.FR.001.130002.000.S.P.2011.000.21000
- Programming language: CC++

CLARCS was presented at the MeshMed MICCAI workshop (http://www2.imm.dtu.dk/projects/MeshMed/2011/index.html) [49] and is to be distributed through a dedicated website (http://clarcs.inria.fr).

We also developed a surface viewer (named 'Surface').

- APP: IDDN.FR.001.110019.000.S.P.2011.000.21000
- Programming language: C++, Python

5.3. SUBANA: SUrface-BAsed Neuronavigation on Atlas for TMS

Participant: Sylvain Prima.

In collaboration with Charles Garraud (Syneika), Benoit Combès (Géosciences Rennes, UMR 6118) and Pierre Hellier (Technicolor), we developed a software for i) the automated surface reconstruction of the face and skull cap from sparsely acquired points and ii) the automated nonlinear registration of free-form surfaces. The latter step is implemented using the CLARCS library (http://clarcs.inria.fr). The primary goal of this software is the surface-based neuronavigation for transcranial magnetic stimulation. The method was presented at the MeshMed MICCAI workshop (http://www2.imm.dtu.dk/projects/MeshMed/2011/index.html) [50].

- APP: IDDN.FR.001.440010.000.S.P.2010.000.31230
- Patent: was granted, but the reference number is unknown
- Programming language: C++

5.4. Shanoir

Participants: Guillaume Renard, Justine Guillaumont, Christian Barillot.

Shanoir (Sharing NeurOImaging Resources) is an open source neuroinformatics platform designed to share, archive, search and visualize neuroimaging data. It provides a user-friendly secure web access and offers an intuitive workflow to facilitate the collecting and retrieving of neuroimaging data from multiple sources and a wizzard to make the completion of metadata easy. Shanoir comes along many features such as anonymization of data, support for multi-centres clinical studies on subjects or group of subjects.

Shanoir APP registration number is : IDDN.FR.001.520021.000.S.P.2008.000.31230

See also the web page http://www.shanoir.org

- Keywords: neuroimaging, ontology, sharing neuroimage
- Software benefit: full featured neuroimaging management system with additionnal web services
- APP: IDDN.FR.001.200014.S.P.2000.000.21000
- License: Licence QPL
- Type of human computer interaction: Online web application, web service (SOAP messages based)
- OS/Middelware: Windows, Mac et Linux.
- Required library or software : Java 1.6, JBoss server, JBoss Seam, JSF, JPA Hibernate, EJB, Richfaces, Faceless, Ajax4JSF, Dcmtk, Dcm4chee.
- Programming language: Java
- Documentation : see the website

5.5. QtShanoir

Participants: Olivier Commowick, Guillaume Renard.

QtShanoir is a C++ Qt based library for querying data from a Shanoir server. For those who don't know what is shanoir, see the shanoir website at http://shanoir.org. QtShanoir uses the soap based webservices provided by a shanoir server to get and display studies, patients, data with their associated metadata. In QtShanoir, you will find a set of Qt widgets (inherited from a QWidget object) that you can embed in your Qt application.

An APP registration is in progress and the library has been release in october under the LGPL license. See http://qtshanoir.gforge.inria.fr.

- Keywords : medical imaging, dicom
- Software benefit: offers a great solution to query a Shanoir server. Can be easily re used in larger Qt applications
- License: no defined licence for the moment
- Type of human computer interaction: C++ library
- OS/Middelware: Linux, Windows and Mac
- Required library or software : Qt
- Programming language: C++
- Documentation : http://qtshanoir.gforge.inria.fr

5.6. AutoMRI

Participants: Camille Maumet, Isabelle Corouge, Elise Bannier.

AutoMRI is an SPM-based set of tools to study structural and functional MRI data. This software is currently made up of 9 modules : autofMRI, autoVBM, automorpho, autoASL, autoFASL, autoROI, autoasltemplate, autofmriacontrario and autoNCEMRA. AutofMRI produces statistical maps of activations and deactivations at the group or the subject level based on functional MRI data. It can deal with block or event-related designs and is highly configurable in order to fit to a wide range of needs. autoVBM performs between-group voxel-based morphometric analysis in order to outline regions of grey (or white) matter volume reduction and increase. To further study a morphometric or a functional analysis, regions of interest analysis can be performed with autoROI. This module also provides the user with laterality indexes. Automorpho performs one-versus-many group analysis on anatomical data in order to outline pathological dysplasia or heterotopia. AutoFASL (collaboration with Rémi Dubujet) produces statistical maps of activations and deactivations at the group or the subject level based on functional Arterial Spin Labeling data. AutoASL performs between-group voxel-based morphometric analysis in order to outline regions of reduced (or increased) perfusion. Autoasltemplate focus on patient-specific detection of perfusion abnormalities with a standard massively univariate General Linear Model or with an a contrario approach. Autofmriacontrario provides an alternative to autofmri to produce statistical maps of activations and deactivations at the subject level using an a contrario approach. autoNCEMRA enables automatic processing of 4D MRA data to remove unwanted signal from the skull, using a mask based on 3D T1w segmentation of grey matter, white matter and CSF. Thus, denoised maximum intensity projections in axial, coronal and sagittal planes can be calculated to enable accurate assessment of hemodynamic patterns, from arterial input to venous drainage (in particular in patients presenting arteriovenous malformations).

- Keywords : fMRI, MRI, ASL, fASL, SPM, automation
- Software benefit: Automatic MRI data analysis based on SPM. Once the parameters are set, the analysis is performed without human interaction.
- APP: Part in IDDN.FR.001.130017.000.S.A.2012.000.31230
- Type of human computer interaction: Matlab function (script, no GUI)
- OS/Middleware: Linux/Windows
- Required library or software : Matlab, SPM, SPM toolboxes : Marsbar, LI-toolbox, NS
- Programming language: Matlab
- Documentation : Available

5.7. Medinria

Participants: René-Paul Debroize, Clément Philipot, Guillaume Pasquier, Olivier Commowick.

Medinria is a national Inria project shared between 4 Inria teams (Asclepios, Athena, Parietal and Visages). It aims at creating an easily extensible platform for the distribution of research algorithms developed at Inria for medical image processing. This project has been funded by the D2T (ADT MedInria-NT) in 2010 and renewed for two years in 2012. The Visages team leads this Inria national project and participates in the development of the common core architecture and features of the software as well as in the development of specific plugins for the team's algorithm. Medinria 2.0.1 has been released in April 2012 for the main distribution platforms. Development of an SDK and of a new verions is underway and should be released in June 2013.

See also the web page http://med.inria.fr

- Keywords: medical imaging, diffusion imaging, registration, filtering, user-friendly interface
- Software benefit: user-friendly interface to cutting-edge research tools for research clinicians. Straightforward to add functionalities through plugins.
- License: core: BSD, plugins: choice of each team.
- Type of human computer interaction: Qt-based GUI
- OS/Middelware: Windows, Mac et Linux.
- Required library or software : Qt, DTK, ITK, VTK.
- Programming language: C++

5.8. USGraphCut

Participant: Christian Barillot.

This software has been developed in collaboration with Jan Petr and Alexandre Krupa during the ANR USComp project. It concerns the segmentation of echographic data by using the graph cut algorithm. It allows the segmentation and the tracking of evolving objects in 2D/3G echographic data in real time thanks to a specific CUDA framework.

5.9. CtrlQ - MR Quality Assurance

Participants: René-Paul Debroize, Isabelle Corouge, Elise Bannier.

As part of the monitoring of the 3Tesla MR equipment, a quality control consistent with the one recommended by the American College Of Radiology (ACR) is performed weekly. As part of its MRI accreditation program, the ACR standardized a procedure for monitoring quality consisting of a series of measurements performed on a standardized imaging protocol on a test object with known geometry. A robust and intuitive software was developed, with a graphical interface, to ensure the automation of the measurements necessary to the control. The application was developed in C++ using the Qt, ITK, and DCMTK libraries.

5.10. SimuBloch

Participants: Fang Cao, Olivier Commowick, Elise Bannier, Christian Barillot.

We developed a simulator package *SimuBloch*, which is made for a fast simulation of image sequences based on Bloch equations, which can be run directly from VIP Portal: http://vip.creatis.insa-lyon.fr. The current version is v0.3. The simulator allows to construct 6 different MR pulse sequences:

1. *SimuBlochSE*: Simulation of spin echo sequences.
2. *SimuBlochGRE*: Simulation of gradient echo sequences.
3. *SimuBlochIR-SE*: Simulation of inversion recovery spin echo sequences.
4. *SimuBlochIR-GRE*: Simulation of inversion recovery gradient echo sequences.
5. *SimuBlochSP-GRE*: Simulation of spoiled gradient echo sequences.
6. *SimuBlochCoherentGRE*: Simulation of coherent gradient echo sequences.

ACES Project-Team (section vide)

ASAP Project-Team

5. Software

5.1. WhatsUp: A Distributed News Recommender

Participants: Antoine Boutet, Davide Frey, Arnaud Jegou, Anne-Marie Kermarrec.

Contact:	Antoine Boutet
Licence:	Open Source
Presentation:	A Distributed News Recommender
Status:	Beta version

This work has lead to the development of WhatsUp, a distributed recommendation system aimed to distribute instant news in a large scale dynamic system. WhatsUp has two parts, an embedded application server in order to exchange with other peers in the system and a fully dynamic web interface for displaying news and collecting opinions about what the user reads. Underlying this web-based application lies Beep, a biased epidemic dissemination protocol that delivers news to interested users in a fast manner while limiting spam. Beep is parametrized on the fly to manage the orientation and the amplification of news dissemination. Every user forwards the news of interest to a randomly selected set of users with a preference towards those that have similar interests (orientation). The notion of interest does not rely on any explicit social network or subscription scheme, but rather on an implicit and dynamic overlay capturing the commonalities between users with respect to what they are interested in. The size of the set of users to which a news is forwarded depends on the interest of the news (amplification). A centralized version of WhatsUp is already up and running and the decentralized one is still in beta version.

5.2. GossipLib: effective development of gossip-based applications

Participants: Davide Frey, Heverson Borba Ribeiro, Anne-Marie Kermarrec.

Contact:	Davide Frey
Licence:	Open Source
Presentation:	Library for Gossip protocols
Status:	released version 0.7alpha

GossipLib is a library consisting of a set of JAVA classes aimed to facilitate the development of gossip-based application in a large-scale setting. It provides developers with a set of support classes that constitute a solid starting point for building any gossip-based application. GossipLib is designed to facilitate code reuse and testing of distributed applications: it thus provides the implementation of a number of standard gossip protocols that may be used out of the box or extended to build more complex protocols and applications. These include for example the peer-sampling protocols for overlay management.

GossipLib also provides facility for the configuration and deployment of applications as final-product but also as research prototype in environments like PlanetLab, clusters, network emulators, and even as event-based simulation. The code developed with GossipLib can be run both as a real application and in simulation simply by changing one line in a configuration file.

5.3. YALPS

Participants: Davide Frey, Heverson Borba Ribeiro, Anne-Marie Kermarrec.

Contact:	Davide Frey
Licence:	Open Source
Presentation:	Library for Gossip protocols
Status:	released version 0.3alpha

YALPS is an open-source Java library designed to facilitate the development, deployment, and testing of distributed applications. Applications written using YALPS can be run both in simulation and in real-world mode without changing a line of code or even recompiling the sources. A simple change in a configuration file will load the application in the proper environment. A number of features make YALPS useful both for the design and evaluation of research prototypes and for the development of applications to be released to the public. Specifically, YALPS makes it possible to run the same application as a simulation or in a real deployment without a single change in the code. Applications communicate by means of application-defined messages which are then routed either through UDP/TCP or through YALPS's simulation infrastructure. In both cases, YALPS's communication layer offers features for testing and evaluating distributed protocols and applications. Communication channels can be tuned to incorporate message losses or to constrain their outgoing bandwidth. Finally, YALPS includes facilities to support operation in the presence of NATs and firewalls using relaying and NAT-traversal techniques.

The work has been done in collaboration with Maxime Monod (EPFL).

5.4. HEAP: Heterogeneity-aware gossip protocol.

Participants: Davide Frey, Arnaud Jegou, Anne-Marie Kermarrec.

Contact:	Davide Frey
Licence:	Open Source
Presentation:	Java Application
Status:	release & ongoing development

This work has been done in collaboration with Vivien Quéma (CNRS Grenoble), Maxime Monod and Rachid Guerraoui (EPFL), and has lead to the development of a video streaming platform based on HEAP, *HEterogeneity-Aware gossip Protocol*. The platform is particularly suited for environment characterized by heterogeneous bandwidth capabilities such as those comprising ADSL edge nodes. HEAP is, in fact, able to dynamically leverage the most capable nodes and increase their contribution to the protocol, while decreasing by the same proportion that of less capable nodes. During the last few months, we have integrated HEAP with the ability to dynamically measure the available bandwidth of nodes, thereby making it independent of the input of the user.

<p style="text-align:center">**ASCOLA Project-Team**</p>

5. Software

5.1. AWED

Participants: Mario Südholt [correspondent], Ismael Mejia.

Aspect-oriented programming, distributed programming, event-based programming, invasive patterns

The model of Aspects With Explicit Distribution (AWED) supports the modularization of crosscutting functionalities of distributed applications. It addresses the problem that common aspect systems do not provide features for distributed programming. It notably features three main aspect abstractions: remote pointcuts, remotely-executed advice, and distributed aspects.

The AWED system has also been employed in the CESSA project proposal (see Sec. 8.1) as a basis for our work on the secure evolution of service-oriented architectures.

AWED is available at http://awed.gforge.inria.fr.

5.2. btrCloud (and Entropy)

Participants: Jean-Marc Menaud [correspondent], Rémy Pottier, Clotilde Massot, Guillaume Le Louët, Thierry Bernard, Frédéric Dumont.

Orchestration, virtualization, energy, autonomic system, placement, cloud computing, cluster, data center, scheduler, grid

btrCloud is a virtual machine manager for clusters and provides a complete solution for the management and optimization of virtualized data center. btrCloud (acronym of better cloud) is composed of three parts.

The analysis function enables operatives and people in charge to monitor and analyze how a data-center works, be it on a daily basis or on the long run and predict future trends. This feature includes a performances, an analysis and a trends board.

btrCloud, by the integration of btrScript, provides (semi-)automated, VM lifecycle management, including provisioning, resource pool management, VM tracking, cost accounting, and scheduled deprovisioning. Key features include a thin client interface, template-based provisioning, approval workflows, and policy-based VM placement.

Finally, Several kinds of optimizations are currently available, such as energy and load balancing. The former can help save up to around 20% of the data-center energy consumption, of course depending on the context. The latter enhances provides optimal quality of service for the applications that are hosted in the virtualized data-center.

btrCloud is available at http://www.btrcloud.org.

5.3. ECaesarJ, EJava and EScala

Participants: Jacques Noyé [correspondent], Jurgen Van Ham.

Symmetric AOP, features, software product lines, inheritance, virtual classes, propagating mixin composition, event-based programming, events, declarative events, state machines, CaesarJ, Java, Scala

ECaesarJ is a language developed in the context of the European project AMPLE, as joint work with the *Technische Universität Darmstadt* (TUD). The basic objective was to provide support for directly mapping the high-level features defined by a software product line onto implementation-level features, beyond standard feature-oriented programming. But the language has much wider applications. ECaesarJ can actually be seen as a language which smoothly integrates Object-Oriented Programming, Feature-Oriented Programming, Aspect-Oriented Programming, and Event-based Programming.

It is an extension of Java with *virtual classes* and *propagating mixin composition* (as its ancestor CaesarJ, developed at TUD), but also *declarative events* and *state machines*. Unlike AspectJ, ECaesarJ does not include a class-like concept of aspect. Instead, it deals with pointcuts and pieces of advice as (implicit) events and event handlers, which are standard class members. This makes it possible to use standard inheritance to reuse and refine them. Explicit events can also be used when events must be explicitly triggered as in traditional event-based programming. Finally, in the same way as pointcuts can be composed using logical operators, *declarative events* can be defined as a composition of other events.

This provides a symmetric version of AOP where virtual classes can be used to deal with structural aspects whereas events can be used to deal with behavioral aspects.

In ECaesarJ, a class can also include, as class members, state transitions. Combining this with virtual classes makes it possible to define, at the programming language level, refinable hierarchical state machines. The combination of state machines and events provides, in particular, effective language support for the State design pattern as well as a form of Event-based AOP.

EJava and EScala are more recent developments of the same ideas applied to Java and Scala, respectively. EJava benefits from Java tooling with an eclipse plugin developed with the Spoofax Language Workbench. Unlike EJava and ECaesarJ, EScala makes it possible to dynamically register and unregister event handlers. It also benefits from a more efficient, compiler-based, implementation. As ECaesarJ, EScala is joint work with TUD.

Prototype implementations of these languages are available through http://ecaesarj.gforge.inria.fr/.

5.4. FPath and FScript

Participants: Thomas Ledoux [correspondent], Frederico Alvares.

dynamic reliable reconfiguration, self-adaptive components, Fractal, autonomic computing

FPath and FScript are two domain-specific languages (DSLs) dealing respectively with the navigation and the dynamic reconfiguration of Fractal architectures. *FPath* is a DSL for querying Fractal architectures. It is restricted to the introspection of architectures by browsing elements identified by their properties or location in the architecture. This focused domain allows FPath to offer a very concise and readable syntax and ensures correctness properties by construction (e.g. any query terminates in a finite time). *FScript* is a DSL dedicated to the reconfiguration of Fractal component architectures. It enables reconfiguration scripts to modify a Fractal architecture. Like FPath, FScript guarantees several properties by construction, e.g. termination of scripts by excluding the possibility of infinite loops. Moreover the FScript interpreter supports a transactional model of reconfigurations and the preservation of the ACID properties.

An adaptation of FPath/FScript to FraSCAti, a component framework providing runtime support for the Service Component Architecture (SCA), has been developed by the Inria Adam project-team. In that way, software architects are able to navigate using FPath notation through FraSCAti architectures and to reconfigure them with FScript. We have used this adaptation in our recent work [11][31] for reconfiguring cloud applications in order to reduce the energy footprint in cloud infrastructures.

FScript and its extensions are available under the LGPL license at http://fractal.ow2.org/fscript.

5.5. WildCAT

Participants: Thomas Ledoux [correspondent], Frederico Alvares.

monitoring, context-aware applications, complex event processing

WildCAT is a generic Java framework for context-aware applications. It permits the monitoring of large-scale applications by allowing developers to easily organize and access resources through a hierarchical organization backed with a powerful SQL-like language to inspect sensors data and to trigger actions upon particular conditions. WildCAT proposes two modes to inspect the resources: a pull mode relies on synchronous communication and a push one relies on asynchronous communication. In the pull mode, developers programmatically get and set attributes. In the push mode, developers register listeners on queries expressed over the events generated by the backend.

WildCAT has been developed by the team in the last years. We have used WildCAT in our recent work [11] for allowing cloud applications to listen events notification fired by the cloud infrastructure (e.g. whenever the pricing policy of cloud resources changes) or to detect changes on the application activity (e.g. to detect whenever the number of requests sharply increases/decreases) in order to launch the reconfiguration of cloud applications.

WildCAT is available under GPL v2 at http://wildcat.ow2.org.

ATLANMOD Team

5. Software

5.1. The ATL Model Transformation Language

URL: http://www.eclipse.org/m2m/atl/

With an eye on the normative work of the OMG (MOF, OCL, QVT, etc.), a new conceptual framework has been developed based on a second generation model transformation language called ATL. Although ATL influenced the OMG standard, the approach is more general as discussed in [8]. In 2004 IBM gave an Eclipse innovation award to the ATL project. In 2007 Eclipse recognized ATL as one central solution for model transformation and promoted it to the M2M project (see *Eclipse.org/m2m*). There are more than 200 industrial and academic sites using ATL today, and several Ph.D. thesis in the world are based on this work.

In 2011 we started a new evolution phase for ATL. Our mid-term plan is making of ATL the leading solution for building autonomous reactive transformation systems, i.e. transformation networks that can autonomously manage a set of dataflows among the application models.

Following this line, we first implemented a new refinement mode for ATL, to support in-place transformations. This extension allows the dynamic manipulation of models while keeping them connected to runtime applications. Next, we presented a lazy execution algorithm for ATL. With it, the elements of the target model are generated only when and if they are accessed. This extension allows to build reactive transformation systems that react to requests of model elements, by triggering the necessary computation. Our lazy version of ATL enables also transformations that generate infinite target models, extending the application space of the model-transformation paradigm.

The latest (still ongoing) work in this direction is the development of a full reactive ATL engine, able to activate the minimal computation for responding to updates or request on the involved models. This engine is studied to scale up with large ATL networks. In this line we also introduced an algorithm for simplifying ATL transformation chains.

5.2. MoDisco (Model Discovery)

URL: http://www.eclipse.org/modisco/

MoDisco is an open source Eclipse project that provides a generic and extensible framework dedicated to the elaboration of Model Driven Reverse Engineering (MDRE) solutions. Gathering contributions from both academics and industrials, the goal of the project is to federate common efforts in the model-based transformation of legacy software systems implemented using different technologies (e.g.; Java, COBOL, C). The first principle is to discover models out of legacy artifacts, representing appropriately all the relevant information, to be then used as part of reverse engineering processes for software understanding, evolution or modernization. Targeted scenarios include software (technical or architectural) migration of large legacy systems, but also retro-documentation, refactoring, quality assurance, etc. Within this context, MoDisco has collaborations with the OMG Architecture Driven Modernization (ADM) Task Force, for which the project provides several reference implementations of its standards: Knowledge Discovery Metamodel (KDM), Software Measurement Metamodel (SMM) and Abstract Syntax Tree Metamodel (ASTM).

The MoDisco framework [12] is composed of a set of Eclipse plugins, and relies on the de-facto standard Eclipse Modeling Framework (EMF) for model handling. Thanks to its modular architecture, it allows completely covering the three steps of a standard MDRE approach: 1) Discovery (i.e. extracting a complete model of the source code), 2) Understanding (i.e. browsing and providing views on this model for a given purpose) and 3) Transformation (evolving the model towards a new technology, architecture, etc). More specifically, as part of its *Infrastructure* layer, MoDisco offers the set of generic (i.e.; legacy technology-independent) reusable components really useful to build the core of MDRE solutions: Discovery Manager and Workflow for MDRE task orchestration, Model Browser for advanced navigation in complex models, model extension and customization capabilities for understanding (e.g.; views definition), etc. As part of its *Technologies* layer, it provides an advanced support for the Java, JEE and XML technologies, including complete metamodels, corresponding model discoverers, transformations, code generators, customizations, query libraries, etc.

MoDisco (or some of its components) is being used by different partners including other academics, industrials (e.g.; Sodifrance on several of their real modernization projects for their customers) or Eclipse projects (e.g.; Eclipse-MDT Papyrus as developed by CEA). Moreover, the Eclipse-EMFT EMF Facet project has been initiated as a MoDisco spin-off, in order to externalize some features which are not actually specific to reverse engineering problems and thus may be reused in many different contexts (cf. corresponding EMF Facet section).

The initiative continues to be developed within the context of the European FP7-ICT project named ARTIST [2], and also to a lower extent within the context of the French FUI 13 project named TEAP.

5.3. Community-driven language development

URL: http://code.google.com/a/eclipselabs.org/p/collaboro/

Software development processes are collaborative in nature. Neglecting the key role of end-users leads to software that does not satisfy their needs. This collaboration becomes specially important when creating Domain-Specific Languages (DSLs), which are (modeling) languages specifically designed to carry out the tasks of a particular domain. While end-users are actually the experts of the domain for which a DSL is developed, their participation in the DSL specification process is still rather limited nowadays.

Thus, Collaboro is an approach to make language development processes more participative, meaning that both developers and users of the language can collaborate together to create and evolve it. The tool has been developed as an Eclipse plugin, whose features currently implemented are:

- Version view to navigate through the Proposals of a version. For each Proposal, the solutions and comments are shown.
- Collaboration view to show the data related to a Collaboration selected in the version view. This view also shows the changes to apply if the selected element is a Solution.
- The user can login to the Collaboro system and create proposals, solutions and comments by right-clicking in the version view. The user can also vote for/against the collaborations.
- Decision engine based on a total agreement (i.e., all the community users must vote for the collaboration). The decision engine can be launch by using the bar menu.
- Notation engine and Notation view to render SVG snapshots of the DSL concrete syntax.

5.4. Virtual EMF (Model Virtualization)

URL: http://code.google.com/a/eclipselabs.org/p/virtual-emf/

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[2] http://www.artist-project.eu/

Virtual EMF is an Eclipse plugin built on top of EMF that enables the creation and manipulation of *virtual models*, i.e., models whose elements do not contain concrete data, but are rather proxies to elements contained in other models. The idea is related to that of model composition, as it aims capturing the (often overlapping) concepts as one single global model. This is a frequently faced problem as, in complex scenarios, modelers often have to deal with a large number of heterogeneous and interrelated models. Most times, the view a specific kind of user requires does not correspond to any of these models but is a combination of cross-domain information scattered among several ones.

Current composition techniques rely on the materialization of the composed model, an approach that poses some important limitations in terms of (i)*efficiency*, as they do not scale (the data duplication mechanism they use implies in extra memory usage and time-consuming generation of the composed model), (ii)*synchronization*, as updates in the composed model are not propagated to the original ones (or vice-versa) thus losing consistency, or even (iii)*interoperability*, as in some cases the composed model requires a specific API/tool to be handled.

Virtual EMF allows overcoming the limitations above. A virtual model provides to tools/users the *illusion* of working with a regular model whereas, in fact, all model access and manipulation requests are transparently redirected to its set of *virtualized* models. It serves as a centralized and transparent access point to a set of interconnected models, allowing users to easily compose, weave and link them. It provides the following beneficial properties:

- *Interoperability:* it behaves as a normal model. Therefore, compatibility with existing EMF-based solutions/tools (e.g. models transformations, model editors, ...) is guaranteed;
- *Synchronization:* changes are automatically and transparently propagated between virtual and original models;
- *Scalability:* support for very big models;
  - low memory usage: no data duplication, direct access to original model elements;
  - faster generation time: no need for (time-consuming) information cloning operations (e.g. executing a model transformation);
- *Genericity:* support for several types of inter-model relationships (e.g. merge, association, filter) and extension capabilities for their semantics.

Virtual EMF is available as an open source project on Eclipse Labs. It has been contributed by the AtlanMod team to the CESAR project. The initiative continues to be developed within the context of the French FUI 13 project named TEAP [TODO Put ref to TEAP http://www.atlanpole.fr/Atlanpole-Digital-Innovation/liste-des-news/TEAP-Projet-Collaboratif-d-Innovation].

5.5. EMFtoCSP

URL: http://code.google.com/a/eclipselabs.org/p/emftocsp/

EMFtoCSP is a tool for the verification of precisely defined conceptual models and metamodels. For these models, the definition of the general model structure (using UML or EMF) is supplemented by OCL constraints. The Eclipse Modeling Development Tools (MDT [3]) provides mature tool support for such OCL-annotated models with respect to model definition, transformation, and validation.

However, an additional important task that is not supported by Eclipse MDT is the assurance of model quality. A systematical assessment of the correctness of such models is a key issue to ensure the quality of the final application. EMFtoCSP fills this gap by provided support for automated model verification in Eclipse.

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[3] http://www.eclipse.org/modeling/mdt/?project=ocl

Essentially, the EMFtoCSP is a sophisticated bounded model finder that yields instances of the model that conform not only to the structural definition of the model (e.g., the multiplicity constraints), but also to the OCL constraints. Based on this core, several correctness properties can be verified:

1. Satisfiability – is the model able to express our domain? For this check, the minimal number of instances and links can be specified to ensure non-trivial instances.

2. Unsatisfiability – is the model unable to express undesirable states? To verify this, we add further constraints to the model that state undesired conditions. Then we can check if is it impossible to instantiate the amended model.

3. Constraint subsumption – is one constraint already implied by others (and could therefore be removed)?

4. Constraint redundancy – do different constraints express the same fact (and could therefore be removed)?

To solve these search problems, EMFtoCSP translates the EMF/OCL (resp. UML/OCL) model into a constraint satisfaction problem and employs the Eclipse CLP solver [4] to solve it. This way, constraint propagation is exploited to tackle the (generally NP-hard) search.

The tool is a continuation of the UMLtoCSP approach [48] developed previously by Jordi Cabot, Robert Clarisó and Daniel Riera. It provides a generic plugin framework for Eclipse to solve OCL-annotated models using constraint logic programming. Apart from already supported Ecore and UML metamodels, further metamodels can be added easily in the future. Similarly, other constraint solving back-ends can be integrated. It is provided under the Eclipse Public License.

5.6. EMF Facet

URL: http://www.eclipse.org/modeling/emft/facet/

EMF Facet is an open source Eclipse project, under the Eclipse Public License (EPL), that provides a generic and extensible framework dedicated to the dynamic and non-intrusive extension of models. It can be used to extend already existing metamodels with additional concepts and properties, the corresponding models being then transparently augmented, reduced or modified accordingly at runtime. Such a metamodel extension is called a facet, and can be specified on top of any metamodel in EMF Ecore. The underlying mechanism is based on the runtime execution of queries on the models corresponding to the *faceted* metamodels. Facets are notably particularly relevant for obtaining different views on existing models without having to actually alter them with any extra data.

The EMF Facet framework is composed of several Eclipse plugins, and relies on the de-facto standard Eclipse Modeling Framework (EMF) for model handling. The facet definitions are stored as facet models, allowing them to be exchanged and reused in various contexts. The queries can be implemented using any suitable query language (e.g.; ATL, OCL, Java, XPath), as far as the corresponding adapters exist and are correctly registered within the framework. The proposed tooling includes dedicated editors for creating, editing and saving both facet and query definitions, the implemented support for Java, OCL and ATL queries, a Table Editor for visualizing query results. An advanced support for the model display customization (e.g.; icons, colors, fonts) is also provided as part of the framework.

EMF Facet is currently intensively used in MoDisco for extracting and displaying different specific views from large models of legacy systems. Its extension and customization capabilities are actually integrated into several MoDisco components, such as notably the MoDisco Model Browser. However, different other integration possibilities will be also explored in the future.

The initiative continues to be developed within the context of the European FP7-ICT project ARTIST.

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[4]http://eclipseclp.org/

5.7. Industrialization strategy for research prototypes

Research labs, as a source of innovation, are potential key actors of the Software Engineering market. However, an important collaborative effort with the other players in the software industry is still needed in order to actually transfer the corresponding techniques or technologies from the research lab to a company. Based on the AtlanMod concrete experience with the previously mentioned open source tools/projects, we have extracted a pragmatic approach [3] for transforming the results of scientific experimentation into practical industrial solutions.

While dealing with innovation, this approach is also innovation-driven itself, as the action is actually conducted by the research lab via a technology transfer. Three different partners are directly involved in this process, using open source as the medium for maintaining a constant interaction between all of them:

- **Use Case Provider.** Usually a company big enough to have to face real complex industrial scenarios which need to be solved (at least partially) by applying new innovative principles and techniques;

- **Research Lab.** Usually a group from a research institute (public or private) or university evaluating the scientific relevance of the problems, identifying the research challenges and prototyping possible solutions;

- **Technology Provider.** Usually a small or medium company, with a particular technical expertise on the given domain or Software Engineering field, building and delivering the industrial version of the designed solutions;

From our past and current experience, three main characteristics of this industrialization *business model* can be highlighted:

- **Win-win situation.** Each partner can actually focus on its core activity while also directly benefiting from the results obtained by the others (notably the research lab can continue to do research);

- **Application-driven context.** The end-user need is at the origin of the process, which finally makes the developed solution actually relevant;

- **Iterative process.** The fact of having three distinct partners requires different regular and consecutive exchanges between all of them.

CIDRE Project-Team

5. Software

5.1. Intrusion Detection

Members of Supélec have developed several intrusion detectors.

Blare implements our approach of illegal information flow detection at the OS level. This implementation is a modification of a standard Linux kernel and it monitors information flows between typical OS containers as files, sockets or IPC. System active entities are processes viewed as black-boxes as we only observe their inputs and outputs. Detection at the OS level is in some cases too coarse-grained to avoid the generation of false positives and to detect attacks targeting the application logic. Even if it remains convenient to define the security policy at the OS-level, sound illegal information flow detection implies an additional detection at the language level. This has led us to implement a detector for Java applications, **JBlare**, to complement the detection at the OS level. JBlare extends the OS-level one by refining the observation of information flows at the language level.

GNG is an intrusion detection system that correlates different sources (such as different logs) in order to identify attacks against the system. The attack scenarios are defined using the Attack Description Langage (**ADeLe**) proposed by our team, and are internally translated to attack recognition automatons. GNG intends to define time efficient algorithms based on these automatons to recognize complex attack scenarios.

SIDAN (Software Instrumentation for Detecting Attacks on Non-control-data) is a tool that aims to instrument automatically C-language software with assertions whose role is to detect attacks against the software. This tool is implemented as a plugin of the FRAMA-C framework that provides an implementation of static analysis techniques.

5.2. Privacy

GEPETO (GEoPrivacy-Enhancing TOolkit) is an open source software for managing geolocated data (currently in development in cooperation with LAAS). GEPETO can be used to visualize, sanitize, perform inference attacks and measure the utility of a particular geolocated dataset. For each of these actions, a set of different techniques and algorithms can be applied. The global objective of GEPETO is to enable a user to design, tune, experiment and evaluate various sanitization algorithms and inference attacks as well as visualizing the following results and evaluating the resulting trade-off between privacy and utility. An engineer (Izabela Moise) is currently working on the development of a distributed version of GEPETO based on the MapReduce paradigm and the Hadoop framework, in order to make it able to deal with datasets composed of millions of mobility traces.

DIONYSOS Project-Team

4. Software

4.1. T3devKit testing toolkit and IPv6 test suites

Participants: Anthony Baire, César Viho.

We have built a toolkit for easing executing tests written in the standardized TTCN-3 test specification language. This toolkit is made of a `C++` library together with a highly customizable CoDec generator that allows fast development of external components (that are required to execute a test suite) such as CoDec (for message Coding/Decoding), System and Platform Adapters. It also provides a framework for representing and manipulating TTCN-3 events so as to ease the production of test reports. The toolkit addresses issues that are not yet covered by ETSI standards while being fully compatible with the existing standard interfaces: TRI (Test Runtime Interfaces) and TCI (Test Control Interfaces), it has been tested with four TTCN-3 environments (IBM, Elvior, Danet and Go4IT) and on three different platforms (Linux, Windows and Cygwin). It is publicly released under the CeCILL-C License.

All these tools with associated test suites (for RIPng, DHCPv6 and examples for DNS) are freely available at http://www.irisa.fr/tipi.

4.2. Interoperability Assessment

Participants: Anthony Baire, Nanxing Chen, Arulnambi Nandagoban, César Viho.

Our experience in interoperability assessment (since 1996) and in using the TTCN-3 standard allowed us to develop a tool (called `ttproto`) that helps in: (i) experimenting new concepts for long term evolution of the TTCN-3 standard [37] and (ii) facilitating new approaches and methods for interoperability assessment. For instance, new passive approaches (see [45], [46], [47]) that we developed have been implemented and validated using `ttproto`. This tool `ttproto` has been used to develop test suites for 6LoWPAN-ND (IPv6 for Low Power Networks) and CoAP (Constrained Application Protocol). The CoAP test suites have been successfully used for two Plugtest interoperability events organized by ETSI, IPSO Alliance and the FP7 PROBE-IT project, respectively 28-29 March in Paris (see [44]) and 28-30 November in Sophia-Antipolis. The tool `ttproto` and the test suites indicated above are freely available at http://www.irisa.fr/tipi.

4.3. Performance and dependability evaluation

Participants: Gerardo Rubino, Bruno Sericola, Bruno Tuffin.

We develop software tools for the evaluation of two classes of models: Markov models and reliability networks. The main objective is to quantify dependability aspects of the behaviors of the modeled systems, but other aspects of the systems can be handled (performance, performability, vulnerability). The tools are specialized libraries implementing numerical, Monte Carlo and Quasi-Monte Carlo algorithms.

One of these libraries has been developed for the Celar (DGA), and its goal is the evaluation of dependability and vulnerability metrics of wide area communication networks (WANs). The algorithms in this library can also evaluate the sensitivities of the implemented dependability measures with respect to the parameters characterizing the behavior of the components of the networks (nodes, lines).

We are also developing tools with the objective of building Markovian models and to compute bounds of asymptotic metrics such as the asymptotic availability of standard metrics of models in equilibrium, loss probabilities, blocking probabilities, mean backlogs,...). A set of functions designed for dependability analysis is being built under the name `DependLib`.

DISTRIBCOM Project-Team

5. Software

5.1. SOFAT

Participants: Loïc Hélouët [correspondant], Rouwaida Abdallah.

SOFAT is the acronym for Scenario Oracle and Formal Analysis Toolbox. As this name suggests it is a formal analysis toolbox for scenarios. Scenarios are informal descriptions of behaviors of distributed systems. SOFAT allows the edition and analysis of distributed systems specifications described using Message Sequence Charts, a scenario language standardized by the ITU [Z.120]. The main functionalities proposed by SOFAT are the textual edition of Message Sequence Charts, their graphical visualization, the analysis of their formal properties, and their simulation. The analysis of the formal properties of a Message Sequence Chart specification determines if a description is regular, local choice, or globally cooperative. Satisfaction of these properties allow respectively for model-checking of logical formulae in temporal logic, implementation, or comparison of specifications. All these applications are either undecidable problems or unfeasible if the Message Sequence Chart description does not satisfy the corresponding property. The SOFAT toolbox implements most of the theoretical results obtained on Message Sequence Charts this last decade. It is regularly updated and re-distributed. The purpose of this is twofold:

- Provide a scenario based specification tool for developers of distributed applications
- Serve as a platform for theoretical results on scenarios and partial orders

SOFAT provides several functionalities, that are: syntactical analysis of scenario descriptions, Formal analysis of scenario properties, Interactive Simulation of scenarios when possible, and diagnosis. This year, SOFAT was extended with code synthesis functionalities, allowing to generate communicating automata, promela code, or rest based web services from HMSCs. A new release of the software is expected before the end of the year.

See also the web page http://www.irisa.fr/distribcom/Prototypes/SOFAT/index.html.

- AMS: Order; lattices; ordered algebraic structures
- APP: IDDN.FR.001.080027.000.S.P.2003.00.10600
- Programming language: Java

5.2. PLASMA

Participants: Sean Sedwards, Benoit Boyer, Kevin Corre, Axel Legay [correspondant].

PLASMA is our implementation of Statistical Model Checking. PLASMA adopts a modular architecture to facilitate the extension of its features. Models can currently be specified using the PRISM reactive modules syntax or a biochemical syntax, while properties are specified in a discrete bounded temporal logic. Our goal is to allow the implementation of other modeling languages and logics by means of self-contained *drop-in* modules. PLASMA facilitates this by providing an intermediate language to generate transition systems based on the notion of the construct (guard, rate, actions), where guard, rate and actions are functions over the current state of the system and control whether and how fast the system may perform certain actions in each state. New modeling languages may be thus added to PLASMA's repertoire by constructing parsers that translate such languages into the intermediate language.

Web site: https://project.inria.fr/plasma-lab/

5.3. LotrecScheme

Participant: François Schwarzentruber [correspondant].

LotrecScheme is the implementation of a generic tableau method prover based on LoTREC (http://www.irit.fr/Lotrec/). LotrecScheme is more expressive than LoTREC. Both LoTREC and LotrecScheme provides tableau methods for standard modal logic K, KT, S4, etc. Contrary to LoTREC, LotrecScheme is expressive enough to capture some satisfiability problem for Dynamic Epistemic Logic.

The prover inside LotrecScheme is written in Scheme and embedded in a JAVA application.

See also the web page http://www.irisa.fr/distribcom/Prototypes/LotrecScheme/index.html.

KERDATA Project-Team

5. Software

5.1. BlobSeer

Participants: Viet-Trung Tran, Zhe Li, Alexandru Costan, Gabriel Antoniu, Luc Bougé.

Contact: Gabriel Antoniu.

Presentation: BlobSeer is the core software platform for most current projects of the KerData team. It is a data storage service specifically designed to deal with the requirements of large-scale data-intensive distributed applications that abstract data as huge sequences of bytes, called BLOBs (Binary Large OBjects). It provides a versatile versioning interface for manipulating BLOBs that enables reading, writing and appending to them.

BlobSeer offers both scalability and performance with respect to a series of issues typically associated with the data-intensive context: *scalable aggregation of storage space* from the participating nodes with minimal overhead, ability to store *huge data objects*, *efficient fine-grain access* to data subsets, *high throughput in spite of heavy access concurrency*, as well as *fault-tolerance*.

Users: Work is currently in progress in several formalized projects (see previous section) to integrate and leverage BlobSeer as a data storage back-end in the reference cloud environments: a) Microsoft Azure; b) the Nimbus cloud toolkit developed at Argonne National Lab (USA); and c) in the OpenNebula IaaS cloud environment developed at UCM (Madrid).

URL: http://blobseer.gforge.inria.fr/

License: GNU Lesser General Public License (LGPL) version 3.

Status: This software is available on Inria's forge. Version 1.0 (released late 2010) registered with APP: IDDN.FR.001.310009.000.S.P.000.10700.

A new *Technology Research Action* (ADT, *Action de recherche technologique*) has been launched in Septembre 2012 for one year, with a possible 1-year renewal, to robustify the BlobSeer software and and make it a safeky distributable product. This project is funded by Inria *Technological Development Office* (D2T, *Direction du Développement Technologique*). Zhe Li has been hired as a senior (PhD) engineer for this task.

5.2. Damaris

Participants: Matthieu Dorier, Gabriel Antoniu.

Contact: Gabriel Antoniu.

Presentation: Damaris is a middleware for multicore SMP nodes enabling them to efficiently handle data transfers for storage and visualization. The key idea is to dedicate one or a few cores of each SMP node to the application I/O. It is developed within the framework of a collaboration between KerData and the Joint Laboratory for Petascale Computing (JLPC). The current version enables efficient asynchronous I/O, hiding all I/O related overheads such as data compression and post-processing. On-going work is targeting fast direct access to the data from running simulations, and efficient I/O scheduling.

Users: Damaris has been preliminarily evaluated at NCSA (Urbana-Champaign) with the CM1 tornado simulation code. CM1 is one of the target applications of the Blue Waters supercomputer developed by at NCSA/UIUC (USA), in the framework of the Inria-UIUC-ANL Joint Lab (JLPC). Damaris now has external users, including (to our knowledge) visualization specialists from NCSA and researchers from the France/Brazil Associated research team on Parallel Computing (joint team between Inria/LIG Grenoble and the UFRGS in Brazil). Damaris has been successfully integrated into three large-scale simulations (CM1, OLAM, Nek5000). Works are in progress to evaluate it in the context of several other simulations including HACC (cosmology code) and GTC (fusion).

URL: http://damaris.gforge.inria.fr/

License: GNU Lesser General Public License (LGPL) version 3.

Status: This software is available on Inria's forge. Registration with APP is in progress.

5.3. Derived software

Derived from BlobSeer, two additional platforms are currently being developed within KerData: 1) Pyramid, a software service for array-oriented active storage developed within the framework of the PhD thesis of Viet-Trung Tran; and 2) BlobSeer-WAN, a data management service specifically optimized for geographically distributed environments. It is also developed within the framework of the PhD thesis of Viet-Trung Tran in relation to the FP3C project. These platforms have not been publicly released yet.

<p align="center" style="color:red;">MYRIADS Project-Team</p>

5. Software

5.1. SAFDIS

Contact: Jean-Louis Pazat, `Jean-Louis.Pazat@irisa.fr`

URL: http://www.irisa.fr/myriads/software/folder.2011-12-13.8949308917/

Status: Version 1.0

License: TBD

Presentation: SAFDIS (Self Adaptation for Distributed Services) is a generic framework allowing the self-adaptation of distributed service based applications within a highly volatile context. Compared to other adaptation frameworks, the main advantages of SAFDIS are its genericity, its distributed nature and the focus on SOAs. SAFDIS is in its final implementation and testing phase within the Myriads team and is being used with a real life use case for emergency services.

The current implementation of SAFDIS is based on a Java OSGi implementation. SAFDIS is written in Java and organized into OSGi bundles. SAFDIS is not tight to any specific operating system and work within any JAVA 1.6 platform. An OSGi implementation is needed (such as the Apache Felix http://felix.apache.org or Equinox eclipse.org/equinox implementations). In order to benefit from the reactive adaptation tools, the Jess engine is also needed as an OSGi bundle (http://www.jessrules.com).

Active contributors (from Myriads project-team):   Erwan Daubert, Guillaume Gauvrit, Jean-Louis Pazat.

5.2. HOCL-tools

Contact: Cédric Tedeschi, `Cedric.Tedeschi@irisa.fr`

Status: Version 1.0 to be released

License: TBD

Presentation: HOCL (Higher Order Chemical Language) is a chemical programming language based on the chemical metaphor presented before (see Section 3.5). It was developed for several years within the PARIS team. Within HOCL, following the chemical metaphor, computations can be regarded as chemical reactions, and data can be seen as molecules which participate in these reactions. If a certain condition is held, the reaction will be triggered, thus continuing until it gets inert: no more data can satisfy any computing conditions. To realize this program paradigm, a multiset is implemented to act as a chemical tank, containing necessary data and rules. An HOCL program is then composed of two parts: *chemical rule definitions* (reaction rules) and *multiset definition* (data). More specifically, HOCL provides the high order: reaction rules are molecules that can be manipulated like any other molecules. In other words, HOCL programs can manipulate other HOCL programs.

An HOCL compiler was developed using java to execute some chemical programs expressed with HOCL. This compiler is based on the translation of HOCL programs to java code. As a support for service coordination and service adaptation (refer to Section 6.3), we recently extended the HOCL compiler with the support of decentralized workflow execution. Works around the implementation of a distributed multiset gave birth to an underlying layer for this compiler, making it able to deploy HOCL programs transparently over large scale platforms. This last part is currently considered to be interfaced with the current HOCL compiler. All these features are planned to be released under the common name of *HOCL-tools*.

Active contributors (from Myriads project-team):   Héctor Fernández, Marko Obrovac, Cédric Tedeschi.

Impact: The compiler is used as a tool within the team to develop HOCL programs. The decentralized workflow execution support has been used extensively to produce results published and presented at several conferences.

5.3. XtreemOS

Contact: Yvon Jégou, `Yvon.Jegou@inria.fr`

URL: http://www.xtreemos.eu, http://gforge.inria.fr/projects/xtreemos

Status: Version 3.0

License: GPL-2/BSD depending on software packages composing the system

Presentation: XTREEMOS is a Grid Operating system based on Linux with native support for virtual organizations. Three flavours of XTREEMOS were developed for individual PCs, clusters and mobile devices (PDA, notebooks and smartphones). XTREEMOS has been developed by the XTREEMOS consortium.

XTREEMOS software is a set of services developed in Java, C++ and C. XTREEMOS cluster version leverages KERRIGHED single system image operating system. A permanent testbed composed of computers provided by several XTREEMOS partners has been public since fall 2010. The third public version of XTREEMOS has been released in February 2012 for the OpenSuse Linux distribution. Ready-to-use XtreemOS virtual machine images have been made available for the community.

Active contributors (from Myriads project-team):   Amine Belhaj, Rémy Garrigue, Yvon Jégou, Christine Morin, Yann Radenac.

Impact: XtreemOS software has been used as part of the COOP ANR project. It was also used in the ANR CLOUD project.Some services such as XtreemFS are used in various R&D projects including Contrail European project.

5.4. Contrail Virtual Execution Platform (VEP)

Contact: Yvon Jégou, `Yvon.Jegou@inria.fr`

URL: http://vep.gforge.inria.fr/index.php?title=Main_Page

Status: Version 1.0

License: BSD

Presentation: Virtual Execution Platform (VEP)[32] is a Contrail service that sits just above IaaS layer at the service provider end of the Contrail cloud federation. The VEP provides a uniform interface for managing the whole lifecycle of elastic applications on the cloud and hides the details of the IaaS layer to the user. VEP applications are described in OVF (Open Virtualization Format) standard format. Resource usage is controlled by CEE (Constrained Execution Environment) rules which can be derived from SLAs (Service Level Agreement). The VEP integrates a monitoring system where the major events about the application, mainly resource usage, are made available to the user.

The VEP service provides a RESTful interface and can be exploited directly by users on top of the provider IaaS. OpenNebula and OCCI-based IaaS interfaces are currently supported.

Active contributors (from Myriads project-team):   Roberto Cascella, Florian Dudouet, Filippo Gaudenzi, Piyush Harsh, Yvon Jégou, Christine Morin.

Impact: VEP is part of Contrail software stack. Several Contrail partners experiment use cases on top of VEP. External users can experiment with it using the open testbed operated by Myriads team.

5.5. Snooze

Contact: Christine Morin, `Christine.Morin@inria.fr`

URL: http://snooze.inria.fr

Status: Version 1.0

License: GPLv2

Presentation: Snooze [25], [26], a novel Infrastructure-as-a-Service (IaaS) cloud management system, which is designed to scale across many thousands of servers and virtual machines (VMs) while being easy to configure, highly available, and energy efficient. For scalability, Snooze performs distributed VM management based on a hierarchical architecture. To support ease of configuration and high availability Snooze implements self-configuring and self-healing features. Finally, for energy efficiency, Snooze integrates a holistic energy management approach via VM resource (i.e. CPU, memory, network) utilization monitoring, underload/overload detection and mitigation, VM consolidation (by implementing a modified version of the Sercon algorithm [69]), and power management to transition idle servers into a power saving mode. Snooze is a highly modular Software. It has been extensively evaluated on the Grid'5000 testbed using realistic applications.

Snooze is fully implemented from scratch in Java and currently comprises approximately 15.000 lines of maintainable abstractions-based code. In order to provide a uniform interface to the underlying hypervisors and support transparent VM monitoring and management, Snooze integrates the *libvirt* virtualization library. Snooze provides a RESTful command line interface (CLI) to support virtual cluster (VC) definitions and management (i.e., start, shutdown, destroy, suspend, etc.) as well hierarchy visualization and exporting in GraphML format.

Active contributors (from Myriads team):   Eugen Feller, Christine Morin.

Impact: Snooze has been used by students at LIFL, IRIT in France and LBNL in the US in the framework of internships during the summer 2012. It has also been deployed and experimented at EDF R&D. Finally, we know that it was experimented by external users from academia and industry as we received feed-back from them.

5.6. Resilin

Contact: Christine Morin, `Christine.Morin@inria.fr`

URL: http://resilin.inria.fr

Status: Version 1.0

License: GNU Affero GPL

Presentation: Resilin [51], [31] is an open-source system for creating and managing MapReduce execution platforms over clouds. Resilin is compatible with the Amazon Elastic MapReduce (EMR) API, but it goes beyond Amazon's proprietary EMR solution in allowing users (e.g. companies, scientists) to leverage resources from one or more public and/or private clouds. This enables performing MapReduce computations over a large number of geographically-distributed and diverse resources. Resilin can be deployed across most of the open-source and commercial IaaS cloud management systems (e.g., OpenStack, OpenNebula, Amazon EC2). Once deployed, Resilin takes care of provisioning Hadoop clusters and submitting MapReduce jobs, allowing users to focus on writing their MapReduce applications rather than managing cloud resources. Resilin is implemented in the Python language and uses the Apache Libcloud library to interact with IaaS clouds. Resilin has been evaluated on multiple clusters of the Grid'5000 experimentation testbed. The results show that Resilin enables the use of geographically distributed resources with a limited impact on MapReduce job execution time.

Active contributors (from the Myriads project-team):   Ancuta Iordache, Nikos Parlavantzas, Christine Morin.

Impact: Resilin is being used in the MOAIS project-team at Inria Grenoble - Rhône Alpes.

5.7. QU4DS

Contact: Jean-Louis Pazat, `Jean-Louis.Pazat@inria.fr`

URL: http://www.irisa.fr/myriads/software/quads/

Status: Version 0.1

License: TBD

Presentation: The QU4DS framework provides PaaS (Platform-as-a-Service) support that fills the gap between the higher-level SaaS (Software-as-a-Service) and the underlying IaaS (Infrastructure-as-a-Service). Qu4DS aids service administrators to define high-level objectives that guide execution management in an automatic and transparent fashion. Moreover, Qu4DS supports the full SLA life-cycle while increasing the service provider profit. SLA support includes service negotiation, instantiation and management on the infrastructure. Orthogonally to these features, complementary actions are in charge of increasing the provider profit guided by SLA constraints.

Currently, Qu4DS targets the development of service providers that use the Master/Worker pattern. Qu4DS assists the development of such services by freeing developers from managing workers and by ensuring their proper execution in accordance with time constraints and by reacting to job failures and delays at runtime. At development time, service developers use the Qu4DS library to develop applications and create a Java jar file. The Qu4DS framework uses this jar file to deploy and manage the service instance on the infrastructure according to SLA constraints.

Active contributors (from Myriads team):   André Lage Freitas, Nikos Parlavantzas, Jean-Louis Pazat

5.8. Themis

Contact: Nikos Parlavantzas, `Nikos.Parlavantzas@irisa.fr`

URL: http://www.irisa.fr/myriads/software/themis/

Status: Version 1.0

License: TBD

Presentation: Themis is a market-based private PaaS (Platform-as-a-Service) system, supporting dynamic, fine-grained resource allocation and automatic application management[19], [20]. Themis implements a proportional-share auction that ensures maximum resource utilization while providing incentives to applications to regulate their resource usage. Themis includes generic mechanisms for application deployment and automatic scaling. These mechanisms can be adapted to support diverse performance goals and application types, such as master-worker, MPI, or MapReduce applications. Themis is implemented in Python and uses OpenNebula for virtual machine management. Experimental results on the Grid'5000 testbed show that using Themis increases resource utilization and improves application performance. Themis is currently installed and being evaluated by EDF R&D using EDF high-performance applications.

Active contributors (from the Myriads team):   Stefania Costache, Nikos Parlavantzas, Christine Morin.

Impact: Themis is not yet distributed in open source. However, it has been integrated in EDF R&D portal providing access to internal computing resources and is currently experimented on a testbed at EDF R&D.

<p align="center" style="color:red">TRISKELL Project-Team</p>

5. Software

5.1. Kermeta

Participants: Didier Vojtisek [correspondant], Olivier Barais, Arnaud Blouin, Benoit Combemale, Jacques Falcou, François Fouquet, Marie Gouyette, Clément Guy, Jean-Marc Jézéquel, Jonathan Marchand.

Nowadays, object-oriented meta-languages such as MOF (meta-object Facility) are increasingly used to specify domain-specific languages in the model-driven engineering community. However, these meta-languages focus on structural specifications and have no built-in support for specifications of operational semantics. Integrated with the industrial standard Ecore and aligned with the OMG standard EMOF 2.0, the Kermeta language consists in a extension to these meta languages to support behavior definition. The language adds precise action specifications with static type checking and genericity at the meta level. Based on object-orientation and aspect orientation concepts, the Kermeta language adds model specific concepts. It is used in several use cases:

- to give a precise semantic of the behavior of a metamodel which then can be simulated.
- to act as a model transformation language.
- to act as a constraint language.

The development environment built for the Kermeta language provides an integrated workbench based on Eclipse. It offers services such as : model execution, text editor (with syntax higlighting, code autocompletion), additional views and various import/export transformations.

Thanks to Kermeta it is possible to build various frameworks dedicated to domain specific metamodels. Those frameworks are organised into MDKs (Model Development Kits). For example, Triskell proposes MDKs to work with metamodels such as Java5, UML2, RDL (requirements), Ecore, Traceability,...

In 2011, Kermeta tooling has been refactored into a version 2.0.x in order to ease the integration of various MOF related languages in the tool chain. This new version also focuses on a fully compiled mode that allows to deploy Kermeta programs in production environments.

See also the web page http://www.kermeta.org.

- APP: IDDN.FR.001.420009.000.S.P.2005.000.10400
- Version: 2.0.1
- Programming language: Java, Scala, Kermeta

Main competitors:

- XMF-Mosaic is developed by Ceteva and is now open-source since 2008.
- GME is a large scale Meta-Modeling Environment developed at Vanderbilt University (ISIS project) since 2002.
- MOFLON is a Metamodeling Framework with Graph Transformations, developed by A. Schuerr's group (TU-Darmstadt) since 2008.
- XCore is a recent (2011) Eclipse project supported by Itemis/Macro Modelling that provides a single operational surface syntax for Ecore.
- Many QVT inspired model transformation tools focused on model transformations.

Main innovative features:

Kermeta was one of the first solutions to offer an operational semantics on top of EMOF. It still proposes several unique features that cannot be found in the tools presented above, such as:

- aspect weaving at the metamodel level allows fast prototyping of a wide variety of tools;
- model typing allows a safe reuse of algorithms and transformations accross diffrent metamodels.

5.2. Kevoree

Participants: Olivier Barais [correspondant], François Fouquet, Erwan Daubert, Jean-Émile Dartois, Johann Bourcier, Antonio Mattos, Noël Plouzeau.

Kevoree is an open-source models@runtime platform [1] to properly support the dynamic adaptation of distributed systems. Models@runtime basically pushes the idea of reflection [82] one step further by considering the reflection layer as a real model that can be uncoupled from the running architecture (e.g. for reasoning, validation, and simulation purposes) and later automatically resynchronized with its running instance.

Kevoree has been influenced by previous work that we carried out in the DiVA project [82] and the Entimid project [83]. With Kevoree we push our vision of models@runtime [81] farther. In particular, Kevoree provides a proper support for distributed models@runtime. To this aim we introduced the *Node* concept to model the infrastructure topology and the *Group* concept to model semantics of inter node communication during synchronization of the reflection model among nodes. Kevoree includes a *Channel* concept to allow for multiple communication semantics between remote*Components* deployed on heterogeneous nodes. All Kevoree concepts (Component, Channel, Node, Group) obey the object type design pattern to separate deployment artifacts from running artifacts. Kevoree supports multiple kinds of very different execution node technology (e.g. Java, Android, MiniCloud, FreeBSD, Arduino, ...).

Kevoree is distributed under the terms of the LGPL open source license.

Main competitors:

- the Fractal/Frascati eco-system [2].
- SpringSource Dynamic Module [3]
- GCM-Proactive [4]
- OSGi [5]
- Chef [6]
- Vagran [7]

Main innovative features:

- distributed models@runtime platform (with a distributed reflection model and an extensible models@runtime dissemination set of strategies).
- Support for heterogeneous node type (from Cyber Physical System with few resources until cloud computing infrastructure).
- Fully automated provisioning model to correctly deploy software modules and their dependencies.
- Communication and concurrency access between software modules expressed at the model level (not in the module implementation).

Impact: Several European projects leveraging the Kevoree platform have recently been accepted. Besides we are currently developing a testbed named DAUM. This testbed is developed since mid 2011 to experiment with Kevoree in real life situations. More precisely, DAUM is a highly dynamic pervasive system that mixes wireless smart sensors, user interaction devices such as digital pads, and distributed data servers in a cloud. The current specialization of DAUM is a distributed tactical information and decision system for firefighters. This application includes individual sensors in the personal protective equipment of firefighters, embedded computation nodes that are fully reconfigurable in real time and over the air, distributed monitoring servers

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[1] http://www.kevoree.org
[2] http://frascati.ow2.org
[3] http://www.springsource.org/osgi/
[4] http://proactive.inria.fr/
[5] http://www.osgi.org
[6] http://wiki.opscode.com/display/chef/Deploy+Resource
[7] http://vagrantup.com/

in trucks, and personal computers for information access and decision making. The DAUM platform is used internally to try research results on distributed *models@runtime*. DAUM is used externally to prepare and support cooperation activities with other research teams (the Myriads Inria team is a partner of DAUM) and with potential industrial partners.

See also the web page http://www.kevoree.org.

- Version: 1.0
- Programming language: Java, Scala, Kermeta

<p style="text-align: center;">**DREAM Project-Team**</p>

5. Software

5.1. Introduction

The pieces of software described in this section are prototypes implemented by members of the project. Any interested person should contact relevant members of the project.

5.2. QTempIntMiner: quantitative temporal sequence mining

QTEMPINTMINER (Quantitative Temporal Interval Miner) is a data mining (cf. 3.2.2) software that implements several algorithms presented in [48] and [3].

The software is mainly implemented in Matlab. A standalone application is now avalaible. It uses the Mixmod toolbox [35] to compute multi-dimensional Gaussian distributions. The main features of QTEMPINTMINER are:

- a tool for generating synthetic noisy sequences of temporal events,

- an implementation of the QTEMPINTMINER, QTIAPRIORI and QTIPREFIXSPAN algorithms,

- a graphical interface that enables the user to generate or import data set and to define the parameters of the algorithm and that displays the extracted temporal patterns.

- a sequence transformer to process long sequences of temporal events. Long sequences are transformed into a database of short temporal sequences that are used as input instances for the available algorithms.

The following website gives many details about the algorithms and provides the latest stable implementation of QTEMPINTMINER: http://www.irisa.fr/dream/QTempIntMiner/.

5.3. Sacadeau: qualitative modeling and decision-aid to preserve the water quality from pollutants as herbicides

SACADEAU is an environmental decision software (cf. 4.3) that implements the SACADEAU transfer model presented in section 7.2.1 . The SACADEAU simulation model couples two qualitative models, a transfer model describing the pesticide transfer through the catchment and a management model describing the farmer decisions. Giving as inputs a climate file, a topological description of a catchment, and a cadastral repartition of the plots, the SACADEAU model simulates the application of herbicides by the farmers on the maize plots, and the transfer of these pollutants through the catchment until the river. The two main simulated processes are the runoff and the leaching. The output of the model simulation is the quantity of herbicides arriving daily to the stream and its concentration at the outlets. The originality of the model is the representation of water and pesticide runoffs with tree structures where leaves and roots are respectively up-streams and down-streams of the catchment.

The software allows the user to see the relationships between these tree structures and the rules learnt from simulations (cf. 3.2.1). A more elaborated version allows to launch simulations and to learn rules on-line. This year, we have developed this new version by enabling access to two recommendation action algorithms (see section 6.3.1). The user can choose different parameters (set of classification rules from which actions will be built, parameters concerning action feasibility, etc) before asking for action recommending process, and then easily visualize the characteristics of situations to improve (polluted ones) compared with the different recommended actions. The software is mainly in Java.

The following website is devoted to the presentation of the SACADEAU: http://www.irisa.fr/dream/SACADEAU/.

5.4. Ecomata

EcoMata is a tool-box for qualitative modeling and exploring ecosystems and for aiding to design environmental guidelines.We have proposed a new qualitative approach for ecosystem modeling (cf. 4.3) based on timed automata (TA) formalism combined to a high-level query language for exploring scenarios.

To date, EcoMata is dedicated to ecosystems that can be modeled as a collection of species (prey-predator systems) under various human pressures and submitted to environmental disturbances. It has two main parts: the Network Editor and the Query Launcher. The Network Editor let a stakeholder describe the trophic food web in a graphical way (the species icons and interactions between them). Only few ecological parameters are required and the user can save species in a library. The number of qualitative biomass levels is set as desired. An efficient algorithm generates automatically the network of timed automata. EcoMata provides also a dedicated window to help the user to define different fishing pressures, a nice way being by using chronograms. In the Query Launcher, the user selects the kind of query and the needed parameters (for example the species biomass levels to define a situation). Results are provided in a control panel or in files that can be exploited later. Several additional features are proposed in EcoMata: building a species library, import/export of ecosystem model, batch processing for long queries, etc. EcoMata is developed in Java (Swing for the GUI) and the model-checker called for the timed properties verification is UPPAAL.

The following website is devoted to the presentation of ECOMATA: http://oban.agrocampus-ouest.fr:8080/ecomata.

5.5. ManageYourself

ManageYourself is a collaborative project between Dream and the Telelogos company aiming at monitoring smartphones from a stream of observations made on the smartphone state (cf. 3.2.3).

Today's smartphones are able to perform calls, as well as to realize much more complex activities. They are small computers. But as in computers, the set of applications embedded on the smartphone can lead to problems. The aim of the project ManagerYourself is to monitor smartphones in order to avoid problems or to detect problems and to repair them.

The ManageYourself application includes three parts :

- A monitoring part which triggers preventive rules at regular time to insure that the system is working correctly, e.g. *if the memory is full then delete the tmp directory*. This part is always running on the smartphone.

- A reporting part which records regularly the state of the smartphone (the memory state - free vs allocated -, the connection state, which applications are running, etc.). This part also is always running on the smartphone. The current state is stored in a report at regular period and is labeled *normal*. When an application or the system bugs, the current buggy state is stored in a report and is labeled *abnormal*. At regular timestamps, all the reports are sent to a server where the learning process is executed.

- A learning part which learns new bug rules from the report dataset. This part is executed offline on the server. Once the bug rules are learnt, human experts translates them into preventive rules which are downloaded and integrated in the monitoring part of the smartphones.

The following website is devoted to the presentation of MANAGEYOURSELF: http://www.irisa.fr/dream/ManageYourself/Site/ManageYourself.html.

LAGADIC Project-Team

5. Software

5.1. ViSP: a visual servoing platform

Participants: Fabien Spindler [correspondant], Filip Novotny, Aurélien Yol, Eric Marchand, François Chaumette.

Since 2005, we develop and release under the terms of the GPLv2 licence, ViSP, an open source library that allows fast prototyping of visual tracking and visual servoing tasks. ViSP was designed to be independent with the hardware, to be simple to use, expandable and cross-platform.

ViSP allows to design vision-based tasks for eye-in-hand and eye-to-hand visual servoing that contains the most classical visual features that are used in practice. It involves a large set of elementary positioning tasks with respect to various visual features (points, segments, straight lines, circles, spheres, cylinders, image moments, pose,...) that can be combined together, and image processing algorithms that allows tracking of visual cues (dots, segments, ellipses,...) or 3D model-based tracking of known objects. Simulation capabilities are also available. ViSP and its full functionalities are presented in Fig. 1 and described in [6].
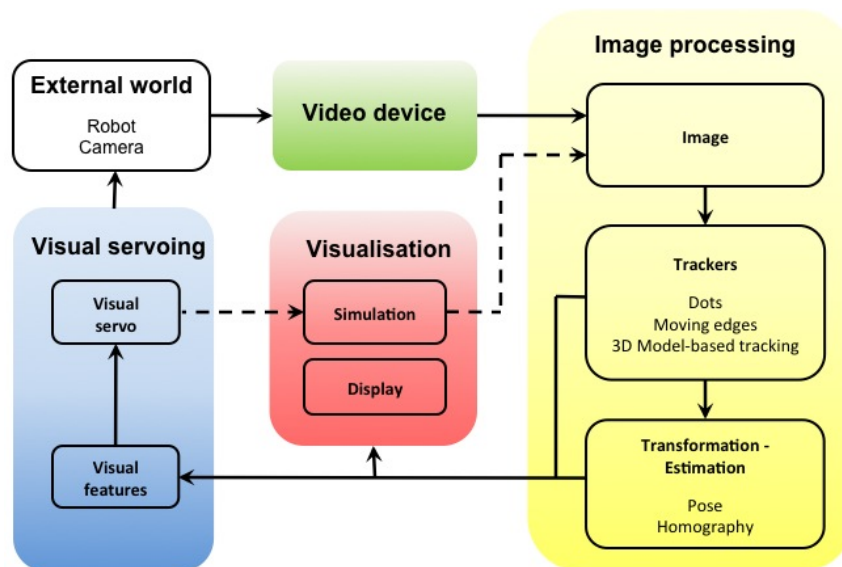

Figure 1. ViSP software architecture.

This year, we continued our efforts to improve the software and documentation quality. A new version available at http://www.irisa.fr/lagadic/visp/visp.html was released in July 2012. To ease ViSP installation, we provide also precompiled ViSP SDK including pre-built ViSP library and headers.

This last release under deposit to the APP ("Agence de Protection des Programmes") has been downloaded 887 times since its availability. It is used in research labs in France, USA, Japan, Korea, India, China, Lebanon, Italy, Spain, Portugal, Hungary, Canada. For instance, it is used as a support in a graduate course delivered at MIT, at IFMA Clermont-Ferrand and ESIR Rennes engineer schools. ViSP is now also part of "`vision_visp`" ROS stack (see http://www.ros.org/wiki/vision_visp) and ViSP 3D model-based tracker has been proposed by colleagues from Laas in Toulouse as a ROS package. This encouraged us to enhance "`vision_visp`" stack by proposing new ROS packages to calibrate intrinsic and extrinsic camera parameters, and a new 3D model-based tracker with automatic initialisation and reinitialisation after tracking loss (with help of specific textured patterns on the object).

5.2. DESlam

Participants: Patrick Rives [correspondant], Maxime Meilland.

The DESlam (Dense Egocentric Slam) software developed in collaboration with Andrew Comport from I3S in Sophia Antipolis was deposited to the APP ("Agence de Protection des Programmes") (IDDN.FR.001.320001.000.S.P.2012.000.21000). This software proposes a full and self content solution to the dense Slam problem. Based on a generic RGB-D representation valid for various type of sensors (stereovision, multi-cameras, RGB-D sensors...), it provides a 3D textured representation of complex large indoors or outdoors environments and it allows to localize in real time (45Hz) a robot or a person carrying out a mobile camera.

5.3. Development work: Robot vision platforms

Participant: Fabien Spindler [correspondant].

We exploit two industrial robotic systems built by Afma Robots in the nineties to validate our researches in visual servoing and active vision. The first one is a Gantry robot with six degrees of freedom, the other one is a cylindrical robot with four degrees of freedom (see Fig. 2). These robots are equipped with cameras. The Gantry robot allows also to embed grippers on its end-effector.

Two papers published by Lagadic in 2012 enclose results validated on this platform. Note that it is also opened to researcher from other labs. For example, this year an associate professor from LSIIT in Strasbourg did experiments on the Gantry robot.

5.4. Development work: Medical robotics platforms

Participants: Fabien Spindler [correspondant], Alexandre Krupa.

This tesbed is of primary interest for researches and experiments concerning ultrasound visual servoing applied to positioning or tracking tasks described in Section 6.4 .

This platform is composed by a six degrees of freedom Adept Viper S850 arm (see Fig. 3). This year we bought a new Adept Viper S650 arm to replace our eight year old Hippocrate medical arm designed by the Sinters company. Ultrasound probes connected either to a SonoSite 180 Plus or an Ultrasonix SonixTouch imaging system can be mounted on a force torque sensor attached to each robot end-effector.

We plan to exploit the two Viper robots for demonstrating needle insertion under ultrasound imaging to precisely guide the needle toward a target while optimizing its visibility (see Section 6.4.4).

Note that four papers published by Lagadic in 2012 enclose experimental results obtained with this platform.

5.5. Development work: Mobile robotics platforms

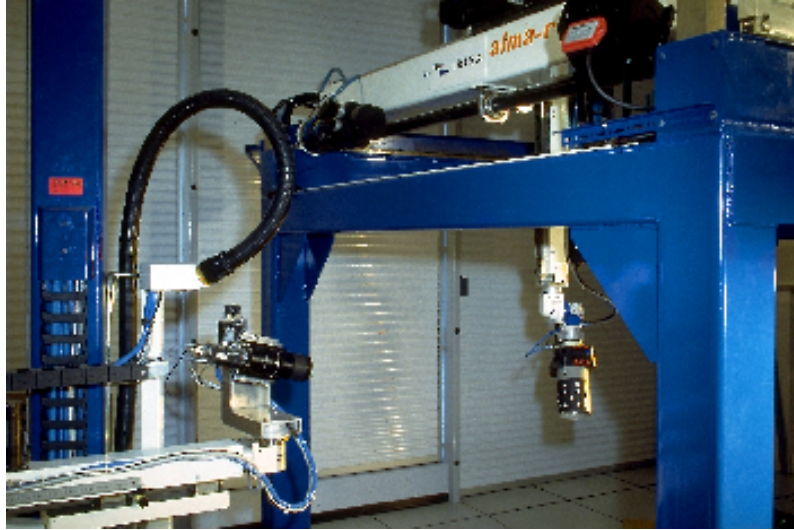**Participants:** Fabien Spindler [correspondant], Marie Babel, Patrick Rives.

Figure 2. Lagadic robotics platforms for vision-based manipulation

Figure 3. Lagadic medical robotics platforms. On the right Viper S850 robot arm equiped with a SonixTouch 3D ultrasound probe. On the left Viper S650 equipped with a tool changer that allows to attach a classical camera.

5.5.1. Indoors mobile robots

For fast prototyping of algorithms in perception, control and autonomous navigation, the team uses Hannibal in Sophia Antipolis, a cart-like platform built by Neobotix (see Fig. 4 .a), and a Pioneer 3DX from Adept in Rennes (see Fig. 4 .b) as well as a Robotino from Festo. These platforms are equipped with various sensors needed for Slam purposes, autonomous navigation and sensor-based control.

Moreover, to validate the researches in personally assisted living topic (see 6.3.6), we bought in Rennes a six wheel electric wheelchair from Penny and Giles Drives Technology (see Fig. 4 .c). The control of the wheelchair is performed using a plug and play system between the joystick and the low level control of the wheelchair. Such a system let us acquire the user intention through the joystick position and control the wheelchair by applying corrections to its motion. The wheelchair has been fitted with three cameras to perform the required servoing for assisting handicaped people. Moreover, to ensure the direct security of the user, seven infrared proximity sensors have been installed all around the wheelchair.

5.5.2. Outdoors mobile robots

The team exploit also Cycab urban electrical cars (see Figs. 4 .d and 4 .e). Two vehicles in Sophia Antipolis and one in Rennes are instrumented with cameras and range finders to validate researches in the domain of intelligent urban vehicle. Cycabs were used as experimental testbeds in several national projects.

Note that 5 papers published by Lagadic in 2012 enclose experimental results obtained with these mobile robotics platforms.
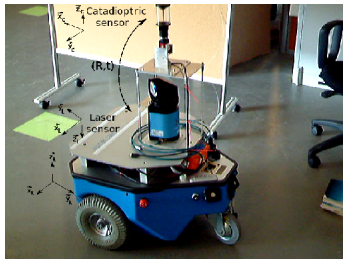
(a)

(b)

(c)

(d)

(e)

Figure 4. a) Hannibal platform, b) Pioneer P3-DX robot, c) six wheel electric wheelchair, d) Cycab available in Rennes, e) one of the Cycabs available in Sophia Antipolis.

METISS Project-Team

5. Software

5.1. Audio signal processing, segmentation and classification toolkits

Participant: Guillaume Gravier.

Guillaume Gravier is now with the TEXMEX group but this software is being used by several members of the METISS group.

speech, audio, signal, analysis, processing, audio stream, detection, tracking, segmentation, audio indexing, speaker verification

The SPro toolkit provides standard front-end analysis algorithms for speech signal processing. It is systematically used in the METISS group for activities in speech and speaker recognition as well as in audio indexing. The toolkit is developed for Unix environments and is distributed as a free software with a GPL license. It is used by several other French laboratories working in the field of speech processing.

In the framework of our activities on audio indexing and speaker recognition, AudioSeg, a toolkit for the segmentation of audio streams has been developed and is distributed for Unix platforms under the GPL agreement. This toolkit provides generic tools for the segmentation and indexing of audio streams, such as audio activity detection, abrupt change detection, segment clustering, Gaussian mixture modeling and joint segmentation and detection using hidden Markov models. The toolkit relies on the SPro software for feature extraction.

Contact : guillaume.gravier@irisa.fr
http://gforge.inria.fr/projects/spro, http://gforge.inria.fr/projects/audioseg

5.2. Irene: a speech recognition and transcription platform

Participant: Guillaume Gravier.

Guillaume Gravier is now with the TEXMEX group but this software is being used by several members of the METISS group.

speech modeling, speech recognition, broadcast news indexing, beam-search, Viterbi, HMM

In collaboration with the computer science dept. at ENST, METISS has actively participated in the past years in the development of the freely available Sirocco large vocabulary speech recognition software [91]. The Sirocco project started as an Inria Concerted Research Action now works on the basis of voluntary contributions.

The Sirocco speech recognition software was then used as the heart of the transcription modules whitin a spoken document analysis platform called IRENE. In particular, it has been extensively used for research on ASR and NLP as well as for work on phonetic landmarks in statistical speech recognition.

In 2009, the integration of IRENE in the multimedia indexing platform of IRISA was completed, incorporating improvements benchmarked during the ESTER 2 evaluation campaign in december 2008. Additionnal improvements were alos carried out such as bandwidth segmentation and improved segment clustering for unsupervised acoustic model adaptation. The integration of IRENE in the multimedia indexing platform was mainly validated on large datasets extracted from TV streams.

Contact : guillaume.gravier@irisa.fr
http://gforge.inria.fr/projects/sirocco

5.3. MPTK: the Matching Pursuit Toolkit

Participants: Rémi Gribonval, Jules Espiau.

The Matching Pursuit ToolKit (MPTK) is a fast and flexible implementation of the Matching Pursuit algorithm for sparse decomposition of monophonic as well as multichannel (audio) signals. MPTK is written in C++ and runs on Windows, MacOS and Unix platforms. It is distributed under a free software license model (GNU General Public License) and comprises a library, some standalone command line utilities and scripts to plot the results under Matlab.

MPTK has been entirely developed within the METISS group mainly to overcome limitations of existing Matching Pursuit implementations in terms of ease of maintainability, memory footage or computation speed. One of the aims is to be able to process in reasonable time large audio files to explore the new possibilities which Matching Pursuit can offer in speech signal processing. With the new implementation, it is now possible indeed to process a one hour audio signal in as little as twenty minutes.

Thanks to an Inria software development operation (Opération de Développement Logiciel, ODL) started in September 2006, METISS efforts have been targeted at easing the distribution of MPTK by improving its portability to different platforms and simplifying its developpers' API. Besides pure software engineering improvements, this implied setting up a new website with an FAQ, developing new interfaces between MPTK and Matlab and Python, writing a portable Graphical User Interface to complement command line utilities, strengthening the robustness of the input/output using XML where possible, and most importantly setting up a whole new plugin API to decouple the core of the library from possible third party contributions.

Collaboration : Laboratoire d'Acoustique Musicale (University of Paris VII, Jussieu).

Contact : remi.gribonval@irisa.fr

http://mptk.gforge.inria.fr, http://mptk.irisa.fr

5.4. FASST

Participants: Emmanuel Vincent [correspondant], Nancy Bertin, Frédéric Bimbot.

FASST is a Flexible Audio Source Separation Toolbox in Matlab, designed to speed up the conception and automate the implementation of new model-based audio source separation algorithms.

5.5. NACHOS

Participants: Nancy Bertin [correspondant], Rémi Gribonval.

The software and associated database were developed within the ANR ECHANGE project, with the participation of Gilles Chardon, Laurent Daudet, François Ollivier and Antoine Peillot.

NACHOS (Nearfield Acoustic HOlography with Sparse regularization) is a downloadable companion software for the journal paper [38], distributed to comply with the "reproducible research" principle. It performs the reconstruction of operational deflection shapes of a vibrating structure, from acoustic measurements of the generated sound field. The software consists in Matlab source code, and automatically downloads the needed database. It allows to reproduce all results and figures of the paper, and to experiment some additional settings. It is distributed under GPL 3.0 license.

MIMETIC Team

5. Software

5.1. HPTS++: Hierarchical Parallel Transition System ++

Participants: Stéphane Donikian [contact], Fabrice Lamarche [contact].

HPTS++ is a platform independent toolkit to describe and handle the execution of multi-agent systems. It provides a specific object oriented language encapsulating C++ code for interfacing facilities and a runtime kernel providing automatic synchronization and adaptation facilities.

The language provides functionalities to describe state machines (states and transitions) and to inform them with user specific C++ code to call at a given point during execution. This language is object oriented and supports concepts such as polymorphism and inheritance (state machines and user defined C++ classes). The compilation phase translates a state machine in a C++ class that can be compiled separately and linked through static or dynamic libraries. The runtime kernel includes a scheduler that handles parallel state machines execution and that provides synchronization facilities such as mutual exclusion on resources, dead lock avoidance, notions of priorities and execution adaptation in accordance with resources availability.

HPTS++ also provides a task model. Thanks to this model, the user can describe primitive behaviors through atomic tasks and combine them with operators (sequence, parallelism, loops, alternatives...). Theses operators are fully dynamic. Hence they can be used at runtime to rapidly create complex behaviors.

5.2. MKM: Manageable Kinematic Motions

Participants: Richard Kulpa [contact], Franck Multon.

We have developed a framework for animating human-like figures in real-time, based on captured motions. This work was carried-out in collaboration with the M2S Laboratory (Mouvement, Sport, Santé) of the University Rennes 2.

In this software, we propose a morphology-independent representation of the motion that is based on a simplified skeleton which normalizes the global postural informations. This formalism is not linked to morphology and allows very fast motion retargetting and adaptation to geometric constraints that can change in real-time This approach dramatically reduces the post production time and allows the animators to handle a general motion library instead of one library per avatar.

The framework provides an animation library which uses the motions either obtenained from our off-line tool (that tranforms standard formats into our morphology-independent representation) or parameterized models in order to create complete animation in real-time. Several models are proposed such as grasping, orientation of the head toward a target. We have also included a new locomotion model that allows to control the character directly using a motion database.

In order to create realistic and smooth animations, MKM uses motion synchronization, blending and adaptation to skeletons and to external constraints. All those processes are performed in real-time in an environment that can change at any time, unpredictably.

All these features have been used to anticipate and control the placement of footprints depending on high level parameters. This link between control and behavior levels will be used for reactive navigation in order to have realistic motion adaptations as well as to deal with constrained environments.

5.3. TopoPlan: Topological Planner and Behaviour Library

Participant: Fabrice Lamarche [contact].

TopoPlan (Topological Planner) is a toolkit dedicated to the analysis of a 3D environment geometry in order to generate suitable data structures for path finding and navigation. This toolkit provides a two step process: an off-line computation of spatial representation and a library providing on-line processes dedicated to path planning, environmental requests...

TopoPlan is based on an exact 3D spatial subdivision that accurately identifies floor and ceiling constraints for each point of the environment. Thanks to this spatial subdivision and some humanoid characteristics, an environment topology is computed. This topology accurately identifies navigable zones by connecting 3D cells of the spatial subdivision. Based on this topology several maps representing the environment are extracted. Those maps identify obstacle and step borders as well as bottlenecks. TopoPlan also provides a runtime library enabling the on-line exploitation of the spatial representation. This library provides several algorithms including roadmap-based path-planning, trajectory optimization, footprint generation, reactive navigation and spatial requests through customizable spatial selectors.

TopoPlan behavior is a library built on top of TopoPlan and MKM providing several behaviors described thanks to the HPTS++ task model. Its goal is to provide a high level interface handling navigation and posture adaptation within TopoPlan environments. Provided behaviors include:

- A behavior handling fully planned navigation toward an arbitrary destination. This behavior precisely handles footprint generation within constrained environments such as stairs for instance.

- A behavior controlling an MKM humanoid to follow a trajectory specified by the user.

- A behavior controlling MKM to follow a list of footprints given by the user.

- A behavior adapting the humanoid posture to avoid collision with ceiling. This behavior runs in parallel of all other behaviors and adapts humanoid motion when needed without any user intervention.

- A behavior handling reactive navigation of virtual humans. This behavior plan a path to a given target and follows the path while avoiding collisions with other navigating entities.

Those behaviors have been built using the HPTS++ task model. Thus, they can be easily combined together or with other described behaviors through task operators.

SIROCCO Project-Team

5. Software

5.1. Oriented wavelet based image codec

Participant: Christine Guillemot [contact person].

This still image codec is based on oriented wavelet transforms developed in the team. The transform is based on wavelet lifting locally oriented according to multiresolution image geometry information. The lifting steps of a 1D wavelet are applied along a discrete set of local orientations defined on a quincunx sampling grid. To maximize energy compaction, the orientation minimizing the prediction error is chosen adaptively. This image codec outperforms JPEG-2000 for lossy compression. This software has been registered at the APP (Agence de Protection des Programmes) under the number IDDN.FR.001.260024.000.S.P.2008.000.21000.

5.2. M3DPlayer: 3D video player

Participant: Laurent Guillo [contact person].

A 3D player - named M3DPlayer - supporting rendering of a 3D scene and navigation within the scene has been developed. It integrates as a plug-in the 3D model-based video codec of the team. From a video sequence of a static scene viewed by a monocular moving camera, the 3D model-based video codec allows the automatic construction of a representation of a video sequence as a stream of textured 3D models. 3D models are extracted using stereovision and dense matching maps estimation techniques. A virtual sequence is reconstructed by projecting the textured 3D models on image planes. This representation enables 3D functionalities such as synthetic objects insertion, lightning modification, stereoscopic visualization or interactive navigation. The codec allows compression at very low bit-rates (16 to 256 kb/s in 25Hz CIF format) with a satisfactory visual quality. It also supports scalable coding of both geometry and texture information. The first version of the software was registered at the Agency for the Protection of Programmes (APP) under the number IDDN.FR.001.130017.000S.P.2003.000.41200.

A second version of the player has been registered at the APP (Agence de Protection des Programmes) under the number IDDN.FR.001.090023.000.S.P.2008.000.21000. In 2009-2010, we focused on improving the rendering engine, based on recent OpenGL extensions, to be able to render the viewed scenes on an auto-stereoscopic display with low-end graphic cards. In our case, auto-stereoscopic display requires the rendering of eight $1920x1200$ frames instead of just one for a standard display. This player is also used to render LDI (Layered Depth Images) and LDV (Layered Depth Videos) and to visualize 3D scenes on autostereoscopic displays taking multiple input views rendered from the LDI representation.

5.3. Depth maps extractor in mono-view (M3dAnalyzer2)

Participant: Laurent Guillo [contact person].

This software estimates depth maps from a video captured by a unique camera moving in a static 3D environment with Lambertian surfaces. These sequences are of interest to specialized applications such as augmented reality, remote-controlled robots operating in hazardous environments or remote exploration by drones. This software has been filed at the APP (Agence de Protection des Programmes) under the number IDDN.FR.001.110031.000.S.P.2010.000.31235.

5.4. Depth maps extractor in multi-view (MV2MVD)

Participant: Laurent Guillo [contact person].

This software estimates depth maps from multi-view videos, to provide Multi-View plus Depth (MVD) videos. MVD videos can be used to synthesize virtual views of the scene, or to render a different number of views than captured in the original video, for instance on an auto-stereoscopic display. This software produces depth maps of higher quality than those generated by the Depth Estimation Reference Software from the MPEG-3DV group, in terms of virtual views synthesis quality. This software has been filed at the APP (Agence de Protection des Programmes) under the number IDDN.FR.001.110034.000.S.P.2010.000.31235.

5.5. JPF-Joint Projection Filling

Participant: Fabien Racapé [contact person].

In the context of multi-view videos, this software generates virtual views of the scene from any viewpoint using a proposed method named Joint Projection Filling (JPF). The latter belongs to Depth-Image-Based Rendering (DIBR) methods, relying on warping equations, which project a reference view onto a virtual viewpoint. Each input view is defined by a "color" (or "texture") map and a "depth" map, which associates a depth value to each image pixel. The JPF method performs forward projection on depth map, using connectivity information to fill in disocclusions in a single step. Depth- based inpainting can then be used to fill in color disocclusions.

5.6. LDI builder

Participant: Fabien Racapé [contact person].

This software constructs a Layered Depth Image (LDI) representation of un-rectified Multi-View + Depth (MVD) sequences. The Incremental construction scheme reduces inter-layer correlation. The generated I-LDI is compatible with the M3DPlayer, permitting 3D visualisation and free viewpoint rendering of the 3D scene. The software also implements a virtual-view rendering technique which significantly reduces ghosting artefacts by eliminating untrusted texture boundaries detected in depth maps, as well as cracking artefacts thanks to an epipolar geometry aided inpainting method.

5.7. Visual Fixation Analysis

Participant: Olivier Le Meur [contact person].

From a set of fixation data and a picture, the software called Visual Fixation Analysis extracts from the input data a number of features (fixation duration, saccade length, orientation of saccade...) and computes an human saliency map. The software can also be used to assess the degree of similarity between a ground truth (eye fixation data) and a predicted saliency map. This software is dedicated to people working in cognitive science and computer vision. This software has been registered at the APP (Agence de Protection des Programmes).

5.8. ADT PICOVIN-P

Participants: Laurent Guillo [contact person], Thomas Guionnet.

The ADT Picovin-P is a technological development action, which works closely with the project-team SIROCCO. This development structure is the follow-up of the ADT Picovin. It gives its support to the project-team to integrate new and relevant algorithms into the state-of-the-art video codec and to take part in standardization.

During this year, the ADT first pursued its developments on Intra prediction in the context of the standardization initiative referred to as High Efficiency Video Coding (HEVC) and led by the Joint ITU/MPEG Collaborative Team on Video Coding (JCT-VC). HEVC is implemented as a test model, the HEVC test Model (HM) in which the ADT tools have been integrated. We then followed the standardization activities within the Joint Collaborative Team on 3D Video Coding Extension (JCT-3V). JCT-VC and JCT-3V have been both created by the ITU-T Study Group 16 (VCEG) and the ISO/IEC JTC 1/SC 29/WG 11 (MPEG). While JCT-VC aims at developing a new generation 2D video coding standard, JCT-3V aims at developing 3D extensions for video codecs, which are AVC (ATM) or HEVC (HTM) based.

As part of JCT-3V, we submitted several proposals related to the handling of the merge list of predictor candidates. They were about the re-ordering of the candidates in the list and about the addition of new candidates. Two of them have been accepted in the dedicated core experiment (CE) during the 1st JCT-3V meeting which was held in Stockholm in July 2012. An improved version related to the addition of candidates has been accepted in a CE during the 2nd JCT-3V meeting in Shanghai in October 2012. It will be integrated in the coming test model (HTM) and evaluated during the next meeting in Geneva in January 2013. During 2012, the ADT also took part in cross checks which aims at evaluating and testing tools studied in core experiments. As part of cross checks related to JCT-VC or JCT-3V the ADT ran 9 tests jointly with companies such as Canon, Huawei, HiSilicon and Nokia. The ADT Picovin-P started in October 2011 and lasted one year. During this year, one permanent engineer from the SED Rennes (development and experimentation department of Inria Rennes) and one senior engineer specialized in video compression are involved in the ADT. It is supported by the technological development department of Inria.

TEXMEX Project-Team

5. Software

5.1. Software

When applicable, we provide the IDDN is the official number, which is obtained when registering the software at the APP (Agence de Protection des Programmes).

5.1.1. New Software

5.1.1.1. Aabot

Participant: Jonathan Delhumeau.

AABOT is a tool to facilitate annotation of large video databases. It's primary design focus has been for the annotation on commercials in two 6-month long TV databases. The software keeps a database of already annotated commercials and suggests when it finds a new probable instance. It also validates user annotations by suggesting similar existing commercials if it finds any which are similar by name or content. The user can then confirm the creation of new commercials or accept the correction if he was mistaken.

AABOT is accessed via a web-browser. It is mostly used by uploading and downloading an annotation file. An interactive HTML5 interface is also available when some user feedback is needed (during validation). It uses Peyote as an description / indexation engine.

First APP deposit: IDDN.FR.001.4200010.000.S.P.2012.000.20900.

5.1.1.2. Peyote

Participants: Sébastien Campion, Jonathan Delhumeau [correspondent], Hervé Jégou.

Peyote is a framework for Video and Image description, indexation and nearest neighbor search. It can be used as-is by a video-search or image-search front-end with the implemented descriptors and search modules. It can also be used via scripting for large-scale experimentation. Finally, thanks to its modularity, it can be used for scientific experimentation on new descriptors or indexation methods. Peyote is used in the AABOT software and was used for the Mediaeval Placing task [68] and the Trecvid Instance Search task.

First APP deposit: IDDN.FR.001.4200008.000.S.P.2012.000.20900.

5.1.1.3. Watermarking Effective Key Length Evaluation

Participant: Teddy Furon [correspondent].

This software was developed in collaboration with Patrick BAS (CNRS, Ecole Centrale de Lille)

Weckle is a software suite in Matlab and R for the numerical evaluation of the effective key length of watermarking schemes based on Spread Spectrum, a concept which was proposed in [22], [23].

5.1.2. Most active software started before 2012

5.1.2.1. Babaz

Participants: Jonathan Delhumeau, Guillaume Gravier, Hervé Jégou [correspondent].

Babaz (http://babaz.gforge.inria.fr/) is a audio database management system with an audio-based search function, which is intended for audio-based search in video archives. First APP deposit: IDDN.FR.001.010006.000.S.P.2012.000.10000. It is licensed under the terms of the GNU General Public License v3.0.

5.1.2.2. Bigimbaz

Participant: Hervé Jégou [correspondent].

Bigimbaz is a platform originally developed in the LEAR project-team, and now co-maintained by TEXMEX. It integrates several contributions on image description and large-scale indexing: detectors, descriptors, retrieval using bag-of-words and inverted files, and geometric verification.

5.1.2.3. BonzaiBoost
Participant: Christian Raymond [correspondent].

The software homepage is available at http://bonzaiboost.gforge.inria.fr/.

BonzaiBoost stands for boosting over small decisions trees. BonzaiBoost is a general purpose machine-learning program based on decision tree and boosting for building a classifier from text and/or attribute-value data. Currently one configuration of BonzaiBoost is ranked first on http://mlcomp.org a website which propose to compare several classification algorithms on many different datasets

5.1.2.4. Irisa_Ne
Participant: Christian Raymond [correspondent].

IRISA_NE is a couple of Named Entity tagger, one of them is based on CRF and the other HMM. It is dedicated to automatic transcriptions of speech. It does not take into account uppercase or punctuation and has no concept of sentences. However, they also manage texts with punctuation and capitalization.

5.1.2.5. Nero
Participant: Sébastien Campion [correspondent].

The service is available at https://nero.irisa.fr.

NERO is an online Named Entities Recognition system. It is implemented within a web service that allows other member of the community to evaluate our results online without any client side setup. An HTTP Rest API, Shell and Python client are provided. The protocol used is HTTPS to secure the transactions between the user and the server. A user account is needed, which allow a fine monitoring. Usage are also limited to 100 thousand characters per account.

5.1.2.6. SURVA
Participants: Sébastien Campion [correspondent], Jonathan Delhumeau.

Speed Up Robust Video Alignement enables to quickly and efficiently synchronize the same video with two coding and quality formats (i.e. without the same number of frame). First APP deposit: IDDN.FR.001.420009.000.S.P.2012.000.20900.

5.1.2.7. PimPy
Participant: Sébastien Campion [correspondent].

PIMPY provides a convenient and high level API to manage common multimedia indexing tasks. It includes severals features. It is used, in particular

- to retrieve video features, such as histogram, binarized DCT descriptor, SIFT, SURF, etc ;
- to detect video cuts and dissolve (GoodShotDetector) ;
- for fast video frame access (pyffas) ;
- for raw frame extraction, or video segment extraction and re-encoding ;
- to search a video segment in another video (content based retrieval) ;
- to perform scene clustering.

First APP deposit: IDDN.FR.001.260038.000.S.P.2011.000.40000

5.1.2.8. Pqcodes
Participant: Hervé Jégou [correspondent].

This software is jointly maintained by Matthijs Douze, from Inria Grenoble.

Pqcodes is a library which implements the approximate k nearest neighbor search method of [83] based on product quantization. This software has been transferred to two companies (in August 2011 and May 2012, respectively).

The current version registered at the APP is IDDN.FR.001.220012.001.S.P.2010.000.10000.

5.1.2.9. Yael

Participant: Hervé Jégou [correspondent].

This software is jointly maintained by Matthijs Douze, from Inria Grenoble.

Yael is a C/python/Matlab library providing (multi-threaded, Blas/Lapack, low level optimization) implementations of computationally demanding functions. In particular, it provides very optimized functions for k-means clustering and exact nearest neighbor search. The library has been downloaded about 1000 times in 2012.

The current version registered at APP is IDDN.FR.001.220014.001.S.P.2010.000.10000.

5.1.2.10. IRISA News Topic Segmenter (irints)

Participants: Guillaume Gravier [correspondent], Camille Guinaudeau, Pascale Sébillot, Anca-Roxana Simon.

This software is dedicated to unsupervised topic segmentation of texts and transcripts. The software implements several of our research methods and is particularly adapted for automatic transcripts. It provides topic segmentation capabilities virtually for any word-based language, with presets for French, English and German. The software has been licensed to several of our industrial partners.

5.1.3. Other softwares

- BAG-OF-COLORS, implements a technique to describe the images based on color.
- I-DESCRIPTION. IDDN.FR.001.270047.000.S.P.2003.000.21000.
- ASARES is a symbolic machine learning system that automatically infers, from descriptions of pairs of linguistic elements found in a corpus in which the components are linked by a given semantic relation, corpus-specific morpho-syntactic and semantic patterns that convey the target relation. IDDN.FR.001.0032.000.S.C.2005.000.20900.
- ANAMORPHO detects morphological relations between words in many languages IDDN.FR.001.050022.000.S.P.2008.000.20900.
- DIVATEX is a audio/video frame server. IDDN.FR.001.320006.000.S.P.2006.000.40000,
- NAVITEX is a video annotation tool. IDDN.FR.001.190034.000.S.P.2007.000.40000,
- TELEMEX is a web service that enables TV and radio stream recording.
- VIDSIG computes a small and robust video signature (64 bits per image).
- VIDSEG computes segmentation features such as cuts, dissolves, silences in audio track, changes of ratio aspect, monochrome images. IDDN.FR.001.250009.000.S.P.2009.000.40000 ,
- ISEC, web application used as graphical interface for image searching engines based on retrieval by content.
- GPU-KMEANS, implementation of k-means algorithm on graphical process unit (graphic cards)
- CORRESPONDENCE ANALYSIS computes a factorial correspondence analysis (FCA) for image retrieval.
- GPU CORRESPONDENCE ANALYSIS is an implementation of the previous software Correspondence Analysis on graphical processing unit (graphical card).
- CAVIZ is an interactive graphical tool that allows to display and to extract knowledge from the results of a Correspondence Analysis on images.
- KIWI (standing for Keywords Extractor) is mostly dedicated to indexing and keyword extraction purposes.

- TOPIC SEGMENTER, is a software dedicated to topic segmentation of texts and (automatic) transcripts.

- S2E (Structuring Events Extractor) is a module which allows the automatic discovery of audiovisual structuring events in videos.

- 2PAC builds classes of words of similar meanings ("semantic classes") specific to the use that is made of them in that given topic. IDDN.FR.001.470028.000.S.P.2006.000.40000

- FAESTOS (Fully Automatic Extraction of Sets of keywords for TOpic characterization and Spotting) is a tool composed of a sequence of statistical treatments that extracts from a morpho-syntactically tagged corpus sets of keywords that characterize the main topics that corpus deals with. IDDN.FR.001.470029.000.S.P.2006.000.40000

- FISHNET is an automatic web pages grabber associated with a specific theme.

- MATCH MAKER, semantic relation extraction by statistical methods.

- IRISAPHON produces phonetic words.

- PYTHON-GEOHASH is an implementation of the Geometric Hashing algorithm of [90] to check if geometrical consistency between pairs of images.

- AVSST is an Automatic Video Stream Structuring Tool. First, it allows the detection of repetitions in a TV stream. Second, a machine learning method allows the classification of programs and inter-programs such as advertisements, trailers, etc. Finally, the electronic program guide is synchronized with the right timestamps based on dynamic time warping. A graphical user interface is provided to manage the complete workflow.

- TVSEARCH is a content based retrieval search engine used to search and propagate manual annotation such as advertisement in a TV corpora.

- SAMUSA detects speech and/or musical segment in multimedia content.

- KERTRACK is a visual graphical interface for tracking visual targets based on particle filter tracking or based on mean-shift.

- MOZAIC2D creates of spatio-temporal mosaic based on dominant motion compensation.

5.2. Demonstration: Texmix

Participants: Morgan Bréhinier, Sébastien Campion [correspondent], Guillaume Gravier.

The gradual migration of television from broadcast diffusion to Internet diffusion offers tremendous possibilities for the generation of rich navigable contents. However, it also raises numerous scientific issues regarding de-linearization of TV streams and content enrichment. In this Texmix demonstration, we illustrate how speech in TV news shows can be exploited for de-linearization of the TV stream. In this context, de-linearization consists in automatically converting a collection of video files extracted from the TV stream into a navigable portal on the Internet where users can directly access specific stories or follow their evolution in an intuitive manner.

Structuring a collection of news shows requires some level of semantic understanding of the content in order to segment shows into their successive stories and to create links between stories in the collection, or between stories and related resources on the Web. Spoken material embedded in videos, accessible by means of automatic speech recognition, is a key feature to semantic description of video contents. We have developed multimedia content analysis technology combining automatic speech recognition, natural language processing and information retrieval to automatically create a fully navigable news portal from a collection of video files.

The demonstration was presented in several workshops (Futur en Seine - Paris, Futur TV - Berlin, ICMR - Hong Kong, French Minister for higher education and research - Rennes, RFIA - Lyon) and a video has been made available online on the portal of the EIT ICT Labs OpenSEM project. An article about this demonstrator was also published in 'Emergences' http://emergences.inria.fr/2012/newsletter-n22/L22-TEXMIX.

See the demo at http://texmix.irisa.fr.

5.3. Experimental platform

Participants: Laurent Amsaleg, Sébastien Campion [correspondent], Patrick Gros, Pascale Sébillot.

Until 2005, we used various computers to store our data and to carry out our experiments. In 2005, we began some work to specify and set-up dedicated equipment to experiment on very large collections of data. During 2006 and 2007, we specified, bought and installed our first complete platform. It is organized around a very large storage capacity (155TB), and contains 4 acquisition devices (for Digital Terrestrial TV), 3 video servers, and 15 computing servers partially included in the local cluster architecture (IGRIDA).

In 2008, we build up a corpus of multimedia data. It consists in a continuous recording (6 months) of two TV channels and three radios. It also includes web pages related to these contents captured on broadcaster's website. This corpus is to be used for different studies like the treatment of news along the time and to provide sub-corpus like TV news within the Quaero project (see below). The manual annotation of all the TV programs is under progress. A dedicated website has been developed in 2009 to provide a user support. It contains useful information such as references of available and ready to use software on the cluster, list of corpus stored on the platform, pages for monitoring disk space consumption and cluster loading, tutorials for best practices and cookbooks for treatments of large datasets. In 2010, we have acquired a new large memory server with 144GB of RAM which is used for memory demanding tasks, in particular to improve the speed of building index or language model. The previous server dedicated to this kind of jobs (acquired in 2008) has been upgraded to 96GB of RAM.

This year, we extended our storage capacity to 215TB and expanded our computing resources with two new large memory servers with 256GB of RAM for each of them.

This platform is funded by a joint effort of Inria, INSA Rennes and University of Rennes 1.

VR4I Team

5. Software

5.1. OpenMASK: Open-Source platform for Virtual Reality

Participants: Alain Chauffaut [contact], Ronan Gaugne [contact], Georges Dumont, Thierry Duval, Marwan Badawi.

OPENMASK (Open Modular Animation and Simulation Kit) is a federative platform for research developments in the VR4i team. Technology transfer is a significant goal of our team so this platform is available as OpenSource software (http://www.openmask.org). OpenMASK is a C++ software platform for the development and execution of modular applications in the fields of animation, simulation and virtual reality. The main unit of modularity is the simulated object (OSO) which can be viewed as frequential or reactive motors. It can be used to describe the behavior or motion control of a virtual object as well as input devices control like haptic interfaces. Two OSO communicate with synchronous data flows or with asynchronous events. OpenMASK is well suited to develop applications in our new immersive room as ergonomics studies, including immersion, interaction, physic and haptic.

5.2. GVT : Generic Virtual Training

Participants: Bruno Arnaldi, Valérie Gouranton [contact], Florian Nouviale, Thomas Lopez, Andrés Saraos Luna.

The aim of GVT software is to offer personalized VR training sessions for industrial equipments. The most important features are the human and equipment security in the VR training (in opposition to the real training), the optimization of the learning process, the creation of dedicated scenarios, multiple hardware configurations: laptop computer, immersion room, distribution on network, etc.

The actual kernel of GVT platform is divided into two main elements that rely on innovative models we have proposed: LORA and STORM models.

- A Behavior Engine. The virtual world is composed of behavioral objects modelled with STORM (Simulation and Training Object-Relation Model).
- A Scenario Engine. This engine is used to determine the next steps of the procedure for a trainee, and its state evolves as the trainee achieves actions. The scenario is written in the LORA language (Language for Object-Relation Application).

A commercialized version of GVT, which includes a pedagogical engine developed in CERV laboratory, proposes training on individual procedures. A prototype is also available that enables users to train on collaborative procedures with one another or with virtual humans.

In the ANR Corvette 7.1.3 and in the FUI SIFORAS 7.1.1 , new features of GVT Software are proposed.

5.3. OpenViBE Software

Participants: Anatole Lécuyer [contact], Laurent Bonnet, Jozef Legény, Yann Renard.

OpenViBE is a free and open-source software devoted to the design, test and use of **Brain-Computer Interfaces**.

The OpenViBE platform consists of a set of software modules that can be integrated easily and efficiently to design BCI applications. Key features of the platform are its modularity, its high-performance, its portability, its multiple-users facilities and its connection with high-end/VR displays. The "designer" of the platform enables to build complete scenarios based on existing software modules using a dedicated graphical language and a simple Graphical User Interface (GUI).

This software is available on the Inria Forge under the terms of the LGPL-V2 licence, and it was officially released in June 2009. Since then, the OpenViBE software has already been downloaded more than 300 time, and it is used by numerous entities worldwide.

Our first international tutorial about OpenViBE was held at the International BCI Meeting in June 2010 (Monterey, US), with around 30 participants.

More information, downloads, tutorials, documentation, videos are available on OpenViBE website : http://openvibe.inria.fr