RESEARCH CENTER

FIELD
Networks, Systems and Services, Distributed Computing

Activity Report 2013

Section Software

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DISTRIBUTED SYSTEMS AND SERVICES

DISTRIBUTED SYSTEMS AND MIDDLEWARE

DISTRIBUTED AND HIGH PERFORMANCE COMPUTING

DISTRIBUTED PROGRAMMING AND SOFTWARE ENGINEERING

NETWORKS AND TELECOMMUNICATIONS

ACES Project-Team

4. Software and Platforms

4.1. Software and Platforms

4.1.1. THE GAME: THeory of Evidence in a lanGuage Adapted for Many Embedded systems

Context-aware applications have to sense the environment in order to adapt themselves and provide with contextual services. This is the case of Smart Homes equipped with sensors and augmented appliances. However, sensors can be numerous, heterogeneous and unreliable. Thus the data fusion is complex and requires a solid theory to handle those problems. The aim of the data fusion, in our case, is to compute small pieces of context we call context attributes. Those context attributes are diverse and could be for example the presence in a room, the number of people in a room or even that someone may be sleeping in a room. For this purpose, we developed an implementation of the belief functions theory (BFT). THE GAME (THeory of Evidence in a lanGuage Adapted for Many Embedded systems) is made of a set of C-Libraries. It provides the basics of belief functions theory, computations are optimized for an embedded environment (binary representation of sets, conditional compilation and diverse algorithmic optimizations).

THE GAME has been developed within the ACES-EDF collaboration (see 6.1.1), and is published under apache licence (https://github.com/bpietropaoli/THEGAME/). It is maintained and experimented by Aurélien Richez within a sensor network platform developed by ACES since June 2013.

ADAM Project-Team

5. Software and Platforms

5.1. APISENSE

Participants: María Gómez Lacruz, Nicolas Haderer, Christophe Ribeiro, Romain Rouvoy [correspondant].

APISENSE® is a distributed platform dedicated to crowdsensing activities [30], [31], [24], [77], [67], [66]. Crowdsensing intends to leverage mobile devices to seamlessly collect valuable dataset for different categories of stakeholders. APISENSE® intends to be used in a wide variety of scientific and industrial domains, including network quality monitoring, social behavior analysis, epidemy predictions, emergency crisis support, open maps initiatives, wild applications debugging. APISENSE® is composed of a HIVE and an HONEYCOMB delivered as a *Platform-as-a-Service* (PaaS) to the stakeholders who can pilot and customize their own crowdsensing environment [77], and *Bee.mob* supporting participants with a mobile application to control the sensors to be shared with the rest of the world [30], [31]. The platform is used by the Metroscope project, an Internet scientific observatory initiative supported by Inria.

Web site: http://www.apisense.fr. Registered with the APP (*Agence pour la Protection des Programmes*) under reference IDDN.FR.001.080006.000.S.P.2013.000.10000 is pending. License: Proprietary.

5.2. FraSCAti

Participants: Gwenaël Cattez, Philippe Merle [correspondant], Fawaz Paraïso, Romain Rouvoy, Lionel Seinturier.

FRASCATI is a service-oriented component-based middleware platform implementing OASIS *Service Component Architecture* (SCA) specifications.The main originality of OW2 FRASCATI is to bring FRACTAL-based reflectivity to SCA, *i.e.*, any FRASCATI software component is equipped with both the SOA capabilities brought by SCA and the reflective capabilities (*i.e.*, introspection and reconfiguration) brought by FRACTAL. Various micro-benchmarks have shown that FRASCATI reflectivity is achieved without hindering its performance relative to the de facto reference SCA implementation, *i.e.*, Apache Tuscany. Non-functional concerns (logging, transaction, security, etc.), so called intents in SCA terms, are also programmed as FRASCATI components and are (un)woven on business components dynamically at runtime, this is based on aspect-oriented concepts defined in FAC [78]. OW2 FRASCATI supports various implementation technologies (SCA Composite, Java, WS-BPEL, Spring Framework, OSGi, Fractal ADL, native C library, Apache Velocity templates, and seven scripting languages as BeanShell, FScript, Groovy, JavaScript, JRuby, Jython, XQuery) for programming services or integrating legacy code, various binding protocols (SOAP, REST, JSON-RPC, UPnP, HTTP servlets, Java RMI, JMS, JGroups) and interface definition languages (WSDL, Java, WADL) for interoperating with existing services. OW2 FRASCATI provides management tools like standalone, Web-based, and JMX-based graphical consoles and a dedicated scripting language for reconfiguring SCA applications. The whole OW2 FRASCATI platform is itself built as a set of reflective SCA components.

Inria Evaluation Committee Criteria for Software Self-Assessment: A-4-up, SO-4, SM-4-up, EM-3-up, SDL-4-up, DA-4, CD-4, MS-4, TPM-4. FRASCATI is a project of the OW2 consortium for open-source middleware. Web site: http://frascati.ow2.org. 292 Kloc (mainly Java). Registered with the APP (Agence pour la Protection des Programmes) under reference FR.001.050017.000.S.P.2010.000.10000. License: LGPL. Embedded into several industrial software systems: EasySOA, Petals Link EasyViper, EasyBPEL, EasyESB, OW2 PEtALS, OW2 Scarbo. Various demonstrators built during funded projects: ANR SCOrWare, FP7 SOA4All, ANR ITEmIS, ANR SALTY, ANR SocEDA, FUI Macchiato, FUI EasySOA, ADT Galaxy and ADT Adapt. Main publications: [82], [81], [70], [71], [62], [61].

5.3. PowerAPI

Participants: Aurélien Bourdon, Maxime Colmant, Lo√øc Huertas, Adel Noureddine, Romain Rouvoy [correspondant].

PowerAPI is a Scala-based library for monitoring energy at the process-level. It is based on a modular and asynchronous event-driven architecture using the Akka library. PowerAPI differs from existing energy process-level monitoring tool in its pure software, fully customizable and modular aspect which let users precisely define what they want to monitor, without plugging any external device. PowerAPI offers an API which can be used to express requests about energy spent by a process, following its hardware resource utilization (in terms of CPU, memory, disk, network, etc.). Its applications cover energy-driven benchmarking [74], [50], [49], [23], energy hotspots and bugs detection [75], [76] and real-time distributed system monitoring.

Web site: http://www.powerapi.org. Registered with the APP (Agence pour la Protection des Programmes) under reference IDDN.FR.001.400015.000.S.P.2012.000.10000. License: AGPL.

ARLES Project-Team

5. Software and Platforms

5.1. Introduction

In order to validate our research results, our research activities encompass the development of related prototypes as surveyed below.

5.2. iCONNECT – Emergent Middleware Enablers

Participant: Valérie Issarny [correspondent].

As part of our research work on Emergent Middleware, we have implemented Enablers (or Enabler functionalities) that make part of the overall CONNECT architecture realizing Emergent Middleware in practice [2]. The focus of ARLES work is on the: *Discovery enabler* that builds on our extensive background in the area of interoperable pervasive service discovery; and *Synthesis enabler* that synthesizes mediators that allow Networked Systems (NSs) that have compatible functionalities to interact despite mismatching interfaces and/or behaviors.

The Discovery Enabler is the component of the overall CONNECT architecture that handles discovery of networked systems (NSs), stores their descriptions (NS models), and performs an initial phase of matchmaking to determine which pairs of systems are likely to be able to interoperate. Such pairs are then passed to the Synthesis Enabler so that mediators can be generated. The Discovery Enabler is written in Java and implements several legacy discovery protocols including DPWS and UPnP.

The Synthesis Enabler assumes semantically-annotated system descriptions *à la* OWL-S, which are made available by the Discovery Enabler, together with a domain ontology, and produces the mediators that enable functionally compatible networked systems to interoperate. The semantically-annotated interfaces of the NSs that need to communicate are processed to compute the semantic mapping between their respective operations using a constraint solver. The resulting mapping serves generating a mediator that coordinates the behaviors of the NSs and guarantees their successful interaction. Only when the mediator includes all the details about the communication of NSs, can interoperability be achieved, which calls for the adequate concretization of synthesized mediators.

The *concretization of mediators* bridges the gap between the application level, which provides the abstraction necessary to reason about interoperability and synthesize mediators, and the middleware-level, which provides the techniques necessary to implement these mediators. Concretization entails the instantiation of the data structures expected by each NS and their delivery according to the interaction pattern defined by the middleware, based on which the NS is implemented. Therefore, we have been developing a mediation engine that, besides executing the data translations specified by the mediator, generates composed parsers and composers, which can process complex messages, by relying on existing libraries associated with standard protocols and state-of-the-art middleware solutions.

The Discovery and Synthesis Enablers have been integrated and experimented with by the CONNECT consortium to effectively enable Emergent Middleware. Part of them are available for download under an open source license at the CONNECT Web site at https://www.connect-forever.eu/software.html.

5.3. Service-oriented Middleware for Pervasive Computing

Participants: Nikolaos Georgantas [correspondent], Valérie Issarny [correspondent].

In the past years, we have built a strong foundation of service-oriented middleware to support the pervasive computing vision. This specifically takes the form of a family of middlewares, all of which have been released under the open source LGPL license:

- **WSAMI - A Middleware Based on Web Services for Ambient Intelligence:** WSAMI (Web Services for AMbient Intelligence) is based on the Web services architecture and allows for the deployment of services on wireless handheld devices like smartphones.
  URL: http://www-rocq.inria.fr/arles/download/ozone/index.htm
- **Ariadne - A Protocol for Scalable Service Discovery in MANETs:** Ariadne enriches WSAMI with the Ariadne service discovery protocol, which has been designed to support decentralized Web service discovery in multi-hop mobile ad hoc networks (MANETs). Ariadne enables small and resource-constrained mobile devices to seek and find complementary, possibly mobile, Web services needed to complete specified tasks in MANETs, while minimizing the traffic generated and tolerating intermittent connectivity.
  URL: http://www-rocq.inria.fr/arles/download/ariadne/index.html
- **MUSDAC - A Middleware for Service Discovery and Access in Pervasive Networks:** The MUlti-protocol Service Discovery and ACcess (MUSDAC) middleware platform enriches WSAMI so as to enable the discovery and access to services in the pervasive environment, which is viewed as a loose and dynamic composition of independent networks. MUSDAC manages the efficient dissemination of discovery requests between the different networks and relies on specific plug-ins to interact with the various middleware used by the networked services.
  URL: http://www-rocq.inria.fr/arles/download/ubisec/index.html
- **INMIDIO - An Interoperable Middleware for Ambient Intelligence:** INMIDIO (INteroperable MIddleware for service Discovery and service InteractiOn) dynamically resolves middleware mismatch. More particularly, INMIDIO identifies the interaction middleware and also the discovery protocols that execute on the network and translates the incoming/outgoing messages of one protocol into messages of another, target protocol.
  URL: http://www-rocq.inria.fr/arles/download/inmidio/index.html
- **COCOA - A Semantic Service Middleware:** COCOA is a comprehensive approach to semantic service description, discovery, composition, adaptation and execution, which enables the integration of heterogeneous services of the pervasive environment into complex user tasks based on their abstract specification. Using COCOA, abstract user tasks are realized by dynamically composing the capabilities of services that are currently available in the environment.
  URL: http://gforge.inria.fr/projects/amigo/
- **ubiSOAP - A Service Oriented Middleware for Seamless Networking:** ubiSOAP brings multi-radio, multi-network connectivity to services through a comprehensive layered architecture: (i) the multi-radio device management and networking layers together abstract multi-radio connectivity, selecting the optimal communication link to/from nodes, according to quality parameters; (ii) the communication layer allows for SOAP-based point-to-point and group-based interactions in the pervasive network; and (iii) the middleware services layer brings advanced distributed resource management functionalities customized for the pervasive networking environment.
  URL: http://www.ist-plastic.org.

5.4. XSB – eXtensible Service Bus for the Future Internet

Participant: Nikolaos Georgantas [correspondent].

The eXtensible Service Bus (XSB) is a development and runtime environment dedicated to complex distributed applications of the Future Internet. Such applications will be based, to a large extent, on the open integration of extremely heterogeneous systems, such as lightweight embedded systems (e.g., sensors, actuators and networks of them), mobile systems (e.g., smartphone applications), and resource-rich IT systems (e.g., systems hosted on enterprise servers and Cloud infrastructures). Such heterogeneous systems are supported by enabling middleware platforms, particularly for their interaction. With regard to middleware-supported interaction, the client-service (CS), publish-subscribe (PS), and tuple space (TS) paradigms are among the most widely employed ones, with numerous related middleware platforms, such as: Web Services, Java RMI for CS; JMS, SIENA for PS; and JavaSpaces, Lime for TS. XSB then provides support for the seamless integration of heterogeneous interaction paradigms (CS, PS and TS).

In a nutshell, our systematic interoperability approach implemented by the proposed XSB is carried out in two stages. First, a middleware platform is abstracted under a corresponding interaction paradigm among the three base ones, i.e., CS, PS and TS. To this aim, we have elicited a connector model for each paradigm, which comprehensively covers its essential semantics. Then, these three models are abstracted further into a single generic application (GA) connector model, which encompasses their common interaction semantics. Based on GA, we build abstract connector converters that enable interconnecting the base interaction paradigms.

Following the above, XSB is an abstract service bus that prescribes only the high-level semantics of the common bus protocol, which is the GA semantics. Furthermore, we provide an implementation of the XSB, building upon existing SOA and ESB realizations. XSB features richer interaction semantics than common ESBs to deal effectively with the increased Future Internet heterogeneity. Moreover, from its very conception, XSB incorporates special consideration for the cross-integration of heterogeneous interaction paradigms. Services relying on different interaction paradigms can be plugged into XSB by employing binding components (BCs) that adapt between their native middleware and the common bus protocol. This adaptation is based on the abstractions, and in particular on the conversion between the native middleware, the corresponding CS/PS/TS abstraction, and the GA abstraction.

Furthermore, we provide a companion implementation, named Light Service Bus (LSB), targeting the Internet of Things(IoT) domain. LSB forms a concrete access solution for IoT systems as it is able to cope with the diversity of the involved interaction protocols and take care of the IoTS specifics, such as resource constraints, dynamic environments, data orientation, etc. It is implemented to be lightweight in nature and uses REST as the common protocol/bus in place of an ESB solution. In LSB, we confirm the wide use of the aforementioned interaction paradigms (CS/PS/TS) but also underline the existence of an additional paradigm focused on continuous interaction known as Streaming (STR).

Both the XSB and LSB solutions are available for download under open source licenses at http://xsb.inria.fr and http://websvn.ow2.org/listing.php?repname=choreos&path=%2Ftrunk%2Fextensible-service-access%2Flsb%2FLsbBindingComponents%2F respectively.

5.5. MobIoT – Service-oriented Middleware for the Mobile IoT

Participant: Valérie Issarny [correspondent].

MobIoT is a service-oriented middleware aimed at the mobile Internet of Things (IoT), which in particular deals with the ultra-large scale, heterogeneity and dynamics of the target networking environment. MobIoT offers novel probabilistic service discovery and composition approaches, and wraps legacy access protocols to be seamlessly executed by the middleware. The middleware exposes two levels of service abstractions: Thing as a service (on the service provider side); and Things measurements/actions as a service (on the service consumer side).

Key features of MobIoT lie in: (i) the exploitation of ontologies to overcome the heterogeneity of the Things network, (ii) the introduction of probabilistic approaches for both registering and retrieving networked things so as to filter out the ones that are redundant with already known alternatives, and finally, (iii) the exploitation of Thing services composition for responding to user queries asking information about the physical world so as to ease interaction with such a complex and dynamic networking environment.

MobIoT is implemented using Java and the Android platform, and consists of two complementary components: The MobIoT Mobile middleware and the MobIoT Web Service. The MobIoT Mobile middleware is deployed on mobile devices (e.g., smartphones, tablets, sensor devices). It wraps: (i) the Query component that enables the querying of the physical world, (ii) the Registration component that deals with the probabilistic registration of local sensors and actuators, (iii) the domain ontology that allows reasoning about the features of Things, and (iv) the Sensor Access component that enables the sensor data retrieval and exposure. The MobIoT Web Service wraps: (i) the Registry component that keeps tracks of the registered services, (ii) the probabilistic Lookup component that allow retrieving relevant services in a scalable way, and (iii) the Composition & Estimation component to answer queries over the physical world using available Thing services, and finally domain and devices ontologies.

The MobIoT middleware is available for download under an open source license at http://choreos.eu/bin/Documentation/IoTS_Middleware.

5.6. Srijan: Data-driven Macroprogramming for Sensor Networks

Participant: Animesh Pathak [correspondent].

Macroprogramming is an application development technique for wireless sensor networks (WSNs) where the developer specifies the behavior of the system, as opposed to that of the constituent nodes. As part of our work in this domain, we are working on *Srijan*, a toolkit that enables application development for WSNs in a graphical manner using data-driven macroprogramming.

It can be used in various stages of application development, *viz.,*

1. Specification of application as a task graph,
2. Customization of the auto-generated source files with domain-specific imperative code,
3. Specification of the target system structure,
4. Compilation of the macroprogram into individual customized runtimes for each constituent node of the target system, and finally
5. Deployment of the auto generated node-level code in an over-the-air manner to the nodes in the target system.

The current implementation of *Srijan* targets both the Sun SPOT sensor nodes and larger nodes with J2SE. Most recently, *Srijan* also includes rudimentary support for incorporating Web services in the application being designed.

The software is released under open source license, and available as an Eclipse plug-in at http://code.google.com/p/srijan-toolkit/.

5.7. Yarta: Middleware for supporting Mobile Social Applications

Participant: Animesh Pathak [correspondent].

With the increased prevalence of advanced mobile devices (the so-called “smart” phones), interest has grown in *Mobile Social Ecosystems* (MSEs), where users not only access traditional Web-based social networks using their mobile devices, but are also able to use the context information provided by these devices to further enrich their interactions. We are developing a middleware framework for managing mobile social ecosystems, having a multi-layer middleware architecture consisting of modules, which will provide the needed functionalities, including:

- Extraction of social ties from context (both physical and virtual),
- Enforcement of access control to protect social data from arbitrary access,
- A rich set of MSE management functionalities, using which mobile social applications can be developed.

Our middleware adopts a graph-based model for representing social data, where nodes and arcs describe socially relevant entities and their connections. In particular, we exploit the Resource Description Framework (RDF), a basic Semantic Web standard language that allows representing and reasoning about social vocabulary, and creating an interconnected graph of socially relevant information from different sources.

The current implementation of the Yarta middleware targets both desktop/laptop nodes running Java 2 SE, as well as Android smart phones.

The software is released under open source license at https://gforge.inria.fr/projects/yarta/.

5.8. iBICOOP: Mobile Data Management in Multi-* Networks

Participant: Valérie Issarny [correspondent].

Building on the lessons learned with the development of pervasive service oriented middleware and of applications using them, we have been developing the custom iBICOOP middleware. iBICOOP specifically aims at assisting the development of advanced mobile, collaborative application services by supporting interactions between mobile users.

Briefly, the iBICOOP middleware addresses the challenges of easily accessing content stored on mobile devices, and consistent data access across multiple mobile devices by targeting both fixed and mobile devices, leveraging their characteristics (e.g., always on and unlimited storage for home/enterprise servers, ad hoc communication link between mobile devices), and by leveraging the capabilities of all available networks (e.g., ad hoc networks, Internet, Telecoms infrastructure networks). It also relies on Web and Telecoms standards to promote interoperability.

The base architecture of the iBICOOP middleware consists of core modules on top of which we can develop applications that may arise in the up-coming multi-device, multi-user world:

- The *Communication Manager* provides mechanisms to communicate over different available network interfaces of a device — Bluetooth, WiFi, Cellular — and also using different technologies e.g., Web services, HTTP/TCP sockets, ad hoc mode.
- The *Security Manager* uses well-established techniques of cryptography and secure communication to provide necessary security.
- The *Partnership Manager* provides device or user information in the form of *profiles*.
- iBICOOP relies on service location protocols for *naming and discovery* of nearby services on currently active network interfaces that support IP multicast.
- Besides normal file managing tasks, the *Local File Manager* gives the user clear cues to the files that have been replicated across multiple devices or shared among different users by using different icons.

The iBICOOP middleware has been licensed by AMBIENTIC (http://www.ambientic.com/), a start-up that specifically develops innovative mobile distributed services on top of the iBICOOP middleware that allows for seamless interaction and content sharing in today’s multi-* networks.

LOGNET Team

5. Software and Platforms

5.1. myMed

Our flagship software is called myMed. myMed is a highly innovative project in which three main orthogonal components are brought together:

- a software development kit, SDKmyMed, with which we can build social networks in "rush time";
- a novel distributed hosting cloud, CLOUDmyMed, with which the social applications (developed by us and by third parties) can be hosted and run;
- a pull of 5-10 social network applications, aka "sociapps" developed in our team to test the SDKmyMed.

The sociapp can be enjoyed in almost all platforms, from web browsers, to mobile web, until IOS and Android devices.

5.2. myMed backbone

Participants: Luigi Liquori [contact], The Mymed Engineer Team.

../../../../projets/lognet/IMG/splash3.pn
../../../../projets/lognet/IMG/myMed-backbone.jpg

Figure 4. The myMed backbone and the myMed LaunchPad

We have implemented a “backbone” for the myMed social network using a nosql database called Cassandra http://cassandra.apache.org, the latter used also by social networks like Facebook and Twitter. The backbone relies on 50 PC quad code HP400, equipped with 2Tb of hard drive each.

5.3. myMed frontend

Participants: Luigi Liquori [contact], The Mymed Engineer Team.

We have implemented a front-end with which all the social application can be used and downloaded via a “store” mechanism similar to the ones of Apple and Google stores. Social applications can be chosen, voted for via a reputation system, and uninstalled (including all personal data) if the user wants. We have also implemented a “template” allowing to build “proofs-of-concept” of social networks in a very short time.

5.4. Synapse simulator in Oversim

Participants: Vincenzo Ciancaglini [contact], Luigi Liquori.

Synapse-Oversim is an implementation of the Synapse overlay interconnection protocol in the Oversim overlay simulator. The software presents two main contributions: first of all, a fork of the original Oversim simulator has been implemented in order to support running multiple protocol modules in a single instance of Oversim, a necessary feature in order to simulate a set of heterogeneous interconnected networks. Secondly, the whole Synapse protocol has been implemented on top of Oversim, in order to allow for the efficient inter-routing of messages between heterogeneous overlays. The Synapse code has been developed in C++, by running in Oversim, its correctness and its performances can be evaluated, while then the code can be easily ported to a real-world application.

5.5. Synapse model Erlang validator

Participant: Vincenzo Ciancaglini [contact].

During the work on the Synapse protocol, we devised a mathematical model which would allow us to estimate performance indexes of an interconnected system without having to deploy a full-scale experiment. In order to be validated, however, the model results needed to be verified against some simulation results, run under simplified conditions, but with the highest possible number of nodes. To achieve this, a dedicated simulator has been developed using Erlang, a programming language dedicated to parallel and distributed applications, which allow for the simulation of extreme systems, with a number of nodes beyond one million, in the fastest way achievable, by fully exploiting the multicore architecture of modern machines. The simulator instantiates a lightweight thread for each node, and the communication are rendered by message passing between the different node threads, thus keeping the simulation conditions as close as possible to a real world behavior.

5.6. CCN-TV Omnet++ simulator

Participants: Vincenzo Ciancaglini [contact], Riccardo Loti, Luigi Liquori.

CCN-TV-SIM is a software, based on the network simulation framework Omnet++, which simulates a real time video broadcast system over content-centric networks. The system is able to manage multiple streams of video at different rates, using real video traces, simulate different caching policies, different channels being transmitted concurrently, background network traffic, and different channel switch rates. Furthermore it can exploits network topologies taken from real networks, like the Deutsche Telecom network, or the Geant.

5.7. Java implementation of the OGP protocol and the experiment controller

Participants: Giang Ngo Hoang [contact], Luigi Liquori.

OGP-Experiment contains Java implementation of the OGP protocol (OGP stands for overlay gateway protocol) which is used for inter-routing between heterogeneous overlay networks, and a Java implementation of the experiment controller, which is responsible for scheduling, managing and monitoring the statistics of the experiments. The software supports experiments in churn and no-churn environments. Performance metrics of the OGP protocol, such as the latency, the successful rate of data lookup and the traffic generated by a peer are reported. The experiments are performed on the Grid 5000 platform. Heterogeneous overlays which are connected by OGP can be easily plugged into the software.

5.8. Java implementation of the Synapse protocol and the experiment controller

Participants: Hoang Giang Ngo [contact], Luigi Liquori.

Synapse-Experiment contains Java implementation of the Synapse overlay interconnection protocol and Java implementation of the experiment controller which is responsible for scheduling, managing and monitoring the statistics of the experiments. The software supports experiments in churn and no-churn environments. Performance metrics of the Synapse protocol, such as the latency, the successful rate of data looking up and the traffic generated by a peer are reported. The experiments are performed on the Grid 5000 platform.

5.9. Reputation Computation Engine for Social Web Platforms

Participant: Thao Nguyen [contact].

Among the three components of a Trust and Reputation System, information gathering is most dependent on the application system, followed by the decision support component and then by the building of a robust Reputation Computation Engine and an experimental GUI, showing how bad users are segregated by the engine. To simulate the working of the reputation engine, we set up a population of Nu users, providing the same service, and undertaking Nt transactions. In each transaction, a random consumer is assigned to request the service. Other users will then be candidate providers for this request. When a user plays the role of a consumer, his behavior is modeled in the raterType attribute. Three types of raters include HONEST, DISHONEST and COLLUSIVE. HONEST raters share their personal experience honestly, i.e. Rr = Ep. DISHONEST raters provide ratings 0:5 different from their true estimation, i.e. Rr = Ep +- 0:5. COLLUSIVE raters give the highest ratings (Rr = 1) to users in their collusion and the lowest ratings (Rr = 0) to the rest. Similarly, when a user acts as a provider, he can be one of the following types of providers: GOOD, NORMAL, BAD, or GOODTURNBAD. This type is denoted in providerType attribute. The QoS of the service provided by a BAD, NORMAL, or GOOD provider has a value in the interval (0; 0:4], (0:4; 0:7], or (0:7; 1] respectively. A GOODTURNBAD provider will change the QoS of his service when 50% of Nt transactions have been done in the simulation. To get a transaction done, a consumer obtains a list of providers, computes reputation scores for them, chooses a provider to perform the transaction, updates his private information, and publishes his rating for the provider. The quality of service that the consumer will experience depends on the providerType of the chosen provider. The difference between the consumer's rating for the provider and his observation depends on the consumer's raterType.

To run a simulation, the user must specify 10 parameters as described above: Simulation(Nu, Nt, %G, %N, %B, %GTB, %H, %D, %C, %dataLost). The simulator has been published in [22].

In 2013, the simulator has been improved and made more robust: it would one of the output of the Ph.D. work of Thao Nguyen whose defense is envisaged in the first half of 2014.

5.10. Ariwheels

Participants: Luigi Liquori [contact for the *Ariwheels* simulator], Claudio Casetti [Politecnico di Torino, Italy], Diego Borsetti [Politecnico di Torino, Italy], Carla-Fabiana Chiasserini [Politecnico di Torino, Italy], Diego Malandrino [Politecnico di Torino, Italy, contact for the *Ariwheels* client].

../../../../projets/lognet/IMG/simtrust.png

Figure 5. A prototype graphical GUI for the Reputation Computation Engine

Ariwheels is an info-mobility solution for urban environments, with access points deployed at both bus stops (forming thus a wired backbone) and inside the buses themselves. Such a network is meant to provide connectivity and services to the users of the public transport system, allowing them to exchange services, resources and information through their mobile devices. *Ariwheels* is both:

- a protocol, based on *Arigatoni* and the publish/subscribe paradigm;
- a set of applications, implementing the protocol on the different types of nodes;
- a simulator, written in OMNET++ and recently ported to the ns2 simulator, see Fig 6 .

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../../../../projets/lognet/IMG/one.jpg
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Figure 6. The Ariwheels simulator in Omnet

See the web page http://www-sop.inria.fr/members/Luigi.Liquori/ARIGATONI/Ariwheels.htm and http://arigtt.altervista.org.

5.11. Arigatoni simulator

Participants: Luigi Liquori [contact], Raphael Chand [Université de Geneva, Switzerland].

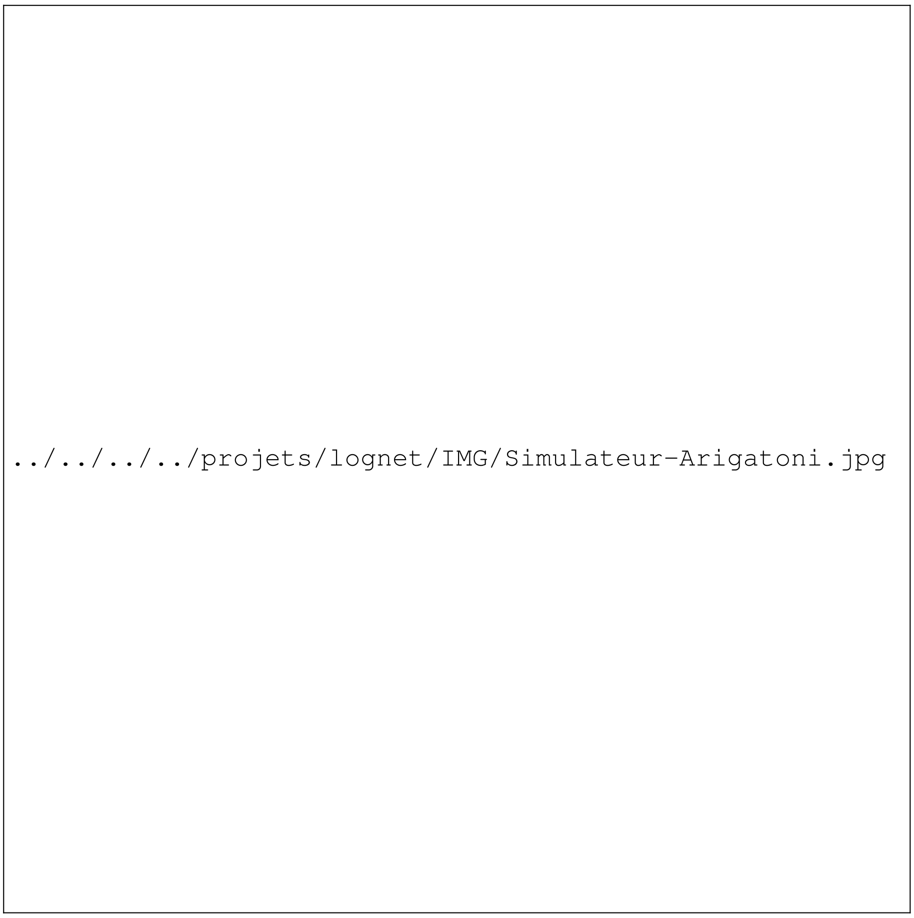

Figure 7. The Arigatoni simulator

We have implemented in C++ (∼2.5K lines of code) the Resource Discovery Algorithm and the Virtual Intermittent Protocol of the Arigatoni Overlay Network. The simulator was used to measure the load when we issued n service requests at Global Computers chosen uniformly at random. Each request contained a certain number of instances of one service, also chosen uniformly at random. Each service request was then handled by the Resource Discovery mechanism of Arigatoni networks.

5.12. Synapse client

Participants: Laurent Vanni [contact], Luigi Liquori, Cédric Tedeschi, Vincenzo Ciancaglini.

In order to test our Synapse protocol [21] on real platforms, we have initially developed JSynapse, a Java software prototype, which uses the Java RMI standard for communication between nodes, and whose purpose is to capture the very essence of our Synapse protocol. It is a flexible and ready-to-be-plugged library which can interconnect any type of overlay networks. In particular, JSynapse fully implements a Chord-based inter-overlay network. It was designed to be a lightweight and easy-to-extend software. We also provided some practical classes which help in automating the generation of the inter-overlay network and the testing of specific scenarios. We have experimented with JSynapse on the Grid'5000 platform connecting more than 20 clusters on 9 different sites. Again, Chord was used as the intra-overlay protocol. See, http://www-sop.inria.fr/teams/lognet/synapse-net2012/.

5.13. Open Synapse client

Participant: Bojan Marinkovic [contact].

Opensynapse is an open source implementation of [21]. It is available for free under the GNU GPL. This implementation is based on Open Chord (v. 1.0.5) - an open source implementation of the Chord distributed hash table implementation by Distributed and Mobile Systems Group Lehrstuhl fuer Praktische Informatik Universitaet Bamberg, see http://www-sop.inria.fr/teams/lognet/synapse-net2012/.

Opensynapse is implemented on top of an arbitrary number of overlay networks. Inter-networking can be built on top of Synapse in a very efficient way. Synapse is based on co-located nodes playing a role that is reminiscent of neural synapses. The current implementation of Opensynapse in this precise case interconnects many Chord overlay networks. The new client currently can interconnect an arbitrary number of Chord networks. This implementation follows the notation presented in [20], and so, each new Chord network is called a *Floor*.

5.14. Husky interpreter

Participants: Marthe Bonamy [contact], Luigi Liquori.

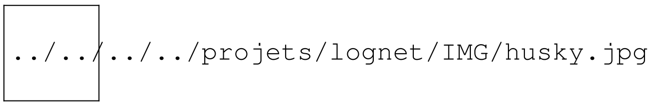

Figure 8. Launching the Husky interpreter

Husky is a variable-less language based on lambda calculus and term rewriting systems. Husky is based on the version 1.1 of *Snake* It was completely rewritten in CAML by Marthe Bonamy, ENSL (new parser, new syntactic constructions, like, *e.g.*, guards, anti-patterns, anti-expressions, exceptions and parametrized pattern matching). In *Husky*, all the keywords of the language are ASCII-symbols. It could be useful for teaching basic algorithms and pattern-matching to children.

5.15. myTransport Gui

Participants: Laurent Vanni [contact], Vincenzo Ciancaglini, Liquori Liquori.

myTransport is a GUI built on top of the Synapse protocol and network. Its purpose is to be a proof of concept of the future service of info-mobility to be available in the myMed social Network, see Figure 9 . The GUI is written in Java and it is fully functional in the Nokia N800 Internet tablet devices. myTransport has been ported to the myMed social network.

5.16. myDistributed Catalog for Digitized Cultural Heritage

Participants: Vincenzo Ciancaglini [contact], Bojan Marinkovic [MISANU, Serbia], Liquori Liquori.

Figure 9. myTransport on the Nokia N800 Internet tablet

Peer-to-peer networks have emerged recently as a flexible decentralized solution to handle large amount of data without the use of high-end servers. We have implemented a distributed catalog built up on an overlay network called “Synapse”. The Synapse protocol allows interconnection of different overlay networks each of them being an abstraction of a “community” of virtual providers. Data storage and data retrieval from different kind of content providers (i.e. libraries, archives, museums, universities, research centers, etc.) can be stored inside one catalog. We illustrate the concept based on the Synapse protocol: a catalog for digitized cultural heritage of Serbia, see Figure 10 .

5.17. myStreaming P2P

Participants: Vincenzo Ciancaglini [contact], Rossella Fortuna [Politech Bari], Salvatore Spoto [Univ. Turin], Liquori Liquori, Luigi Alfredo Grieco [Politech Bari].

We have implemented, in Python, a fork of Goalbit http://goalbit.sourceforge.net, an open source video streaming platform peer-to-peer software streaming platform capable of distributing high-bandwidth live video content to everyone preserving its quality. We have aligned with the classical gossip-based distribution protocol a *DHT* that distribute contents according to a content-based strategy.

../../../../projets/lognet/IMG/mycatalog.png

Figure 10. myDistributed Catalog

ASAP Project-Team

5. Software and Platforms

5.1. MediEgo: A recommendation solution for webmasters

Participants: Antoine Boutet, Jacques Falcou, Arnaud Jégou, Anne-Marie Kermarrec, Jean-François Verdonck.

Contact:	Anne-Marie Kermarrec
Licence:	Proprietary
Presentation:	Recommendation solution for webmasters
Status:	Beta version, IDDN.FR.001.490030.000.S.P.2013.000.30000 on 09/12/2013

MediEgo is a solution for content recommendation based on the users navigation history. The solution 1) collects the usages of the Web users and store them in a profile; 2) uses this profile to associate to each user her most similar users; 3) leverages this implicit network of close users in order to infer their preferences and recommend advertisements and recommendations. MediEgo achieves scalability using a sampling method, which provides very good results at a drastically reduced cost.

5.2. MediEgo Dashboard: A personalized news dashboard

Participants: Yuri Barssi, Antoine Boutet, Anne-Marie Kermarrec, Jean-François Verdonck.

Contact:	Antoine Boutet
Licence:	Proprietary
Status:	Beta version

This work has led to the development of MediEgo Dashboard, a personalized news recommendation system. In MediEgo Dashboard, users benefit from a personalized stream of news matching their interests. Additionally, users can use explicit subscriptions as well as post content and navigate through tags. MediEgo Dashboard is available through a web interface and a mobile-based Android application. To provide personalization, MediEgo Dashboard exploits the users' opinions regarding their received news to identify users with similar interests. MediEgo Dashboard is centralized and it allows us to test and evaluate different recommendation schemes. In collaboration with EIT/ICT Lab, an experiment has been conducted with a set of users at Trento (Italie). This experiment allowed us to collect traces and to perform a user survey to assess and improve our solution. This solution will soon be interconnected to AllYours-P2P.

5.3. AllYours-P2P: A distributed news recommender (former WhatsUp)

Participants: Heverson Borba Ribeiro, Antoine Boutet, Davide Frey, Arnaud Jégou, Anne-Marie Kermarrec, Jean-François Verdonck.

Contact:	Antoine Boutet
Licence:	AGPL 3.0
Presentation:	A distributed news recommender
Status:	Beta version, IDDN.FR.001.500002.000.S.P.2013.000.30000 on 09/12/2013

In the context of the AllYours EIT/ICT Labs project, we refined the implementation of WhatsUp into the AllYours-P2P application. The application provides a distributed recommendation system aimed to distribute instant news in a large scale dynamic system. It consists of two parts, running on each peer: an embedded application server, based on Jetty, and a web interface accessible from any web browser. The application server exchanges information with other peers in the system, while the web interface displays news items and collects the opinions of the user.

5.4. HyRec: A hybrid recommender system

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

Contact:	Antoine Boutet
Licence:	Proprietary
Status:	Beta version, IDDN.FR.001.500007.000.S.P.2013.000.30000 on 09/12/2013

This work leads to the development of HyRec, a hybrid recommender system. The motivation of this work is to explore solutions that could in some sense democratize personalization by making it accessible to any content provider company without generating huge investments. HyRec implements a user-based collaborative filtering scheme and offloads CPU-intensive recommendation tasks to front-end client browsers, while retaining storage and orchestration tasks within back-end servers. HyRec seeks to provide the scalability of P2P approaches without forcing content providers to give up the control of the system.

5.5. GossipLib: A library for gossip-based applications

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

Contact:	Heverson Borba Ribeiro, Davide Frey
Licence:	AGPL 3.0
Presentation:	Library for gossip protocols
Status:	Alpha version, IDDN.FR.001.500001.000.S.P.2013.000.10000 on 09/12/2013

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 application, and provides also 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.

5.6. YALPS: A library for P2P applications

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

Contact:	Heverson Borba Ribeiro, Davide Frey
Licence:	Open Source
Presentation:	Library for p2p applications
Status:	Beta version, IDDN.FR.001.500003.000.S.P.2013.000.10000 on 09/12/2013

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. 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. This work was done in collaboration with Maxime Monod (EPFL).

5.7. HEAP: Heterogeneity-aware gossip protocol

Participants: Davide Frey, Arnaud Jégou, 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.

ATLANMOD Project-Team

5. Software and Platforms

5.1. The ATL Model Transformation Language

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

Performing just the required work on model transformation improves scalability, an open issue the previous described works contribute to solve. An efficient execution, as in the the lazy and reactive scenarios, may help with scalability problems by focusing the tasks in the required part of a very large transformation. However, this is not always the case and we might have to perform operations in the whole model. In this scenario, a solution for the scalability problem would be to take advantage of multi-core architectures that are very popular today, to improve computation times in the transformation of very large models. In this sense, a first step explores the strong parallelization properties rule-based languages like ATL have. A new prototype implementation of a parallel ATL engine have been developed showing how transformations can be developed without taking into account concurrency concerns, and that a transformation engine can automatically parallelize operations improving execution times.

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 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 design it and make it evolve. The tool has been developed as an Eclipse plugin, with currently the following features implemented:

- Version view to navigate through the Proposals of a version of a language. 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.

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

- 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 menu bar.
- Notation engine and Notation view to render SVG snapshots of the DSL concrete syntax.
- Support for example-driven development of DSMLs, thus incoporating a graphical editor which allows end-users to draw examples of the DSML they are developing.

5.4. JSON Discoverer

URL: http://atlanmod.github.io/json-discoverer/

Given a set of JSON documents, the tool (distributed as an open source Eclipse plugin contributed to MoDisco) returns a model describing their implicit schema. We follow an iterative process where new JSON documents (from the same or different services within the API) contribute to enrich the generated model. The model helps to both understand single services and to infer possible relationships between them, thus suggesting possible compositions and providing an overall view of the application domain. The tool has also been released as a web site, thus allowing any web developer to use our approach without the need of installing Eclipse.

5.5. EMF-REST

URL: http://emf-rest.com/

EMF is *the modeling framework* of the Eclipse community. While EMF is able to automatically generate Java APIs from Ecore models, it is still missing support to deal with Web APIs such as RESTful ones that could boost the use of modeling techniques in the Web. However, the creation of RESTful APIs requires from developers not only an investment in implementation but also a good understanding of the REST Principles to apply them correctly. We therefore created EMF-REST, a tool that empowers EMF to get Truly RESTFul APIs from Ecore models, thus allowing web developers to generate JSON-based Web APIs for their applications. It generates both a JavaScript API to work with models as Javascript Objects in the client-side (without any EMF dependency) and REST services in the server-side based on the Java JAX-RS specification.

5.6. EMF Views (Model Views)

URL: http://emfviews.jdvillacalle.com/

The Eclipse Modeling Framework (EMF) is widely used in the Eclipse community: defining domain models and generating corresponding source code, modeling software architectures, specifying DSL concepts or simply representing software/user data in different contexts. This implies that any software project involves a large number of heterogeneous but interrelated EMF models.

To make matters worse, not all participants in the project should have the same kind of access/views on the models. Some users only need to see some parts of one model, others have to get the full model extended with data from another model, or simply access to a combination of information coming from different interconnected models. Up to now, creating such perspectives transparently in EMF was almost impossible.

Based on the unquestionable success/usefulness of database views to solve similar problems in databases, EMF Views aims to bring the same concept to the modeling world. Thanks to the three main constructs (inspired from SQL) offered by the tool, designers can create new model views: SELECTing a subset of elements from a model, PROJECTing only some of the properties of those elements and/or JOINing them with elements from other models. A model view is a special type of model whose instances are directly computed at runtime based on the model view definition and concerned actual model(s).

EMF Views is currently being developed in the context of the TEAP industrial project http://www.teap-project.org/, by showing different possible applications of model views including:

- Software architect/developer views relating UML design models and Java code models (cf. Eclipse MoDisco);
- Enterprise architect views linking (BPMN) business process models, (ReqIF) requirements models and (TOGAF) architecture models;
- View querying using dedicated technologies (e.g. Eclipse IncQuery);
- View transformation using dedicated technologies (e.g. Eclipse ATL).

5.7. 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.

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 [47] 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.

5.8. EMF Facet

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

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

[4] http://eclipseclp.org/

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.

5.9. Neo4EMF

URL: http://www.neo4emf.com

Neo4EMF is an open source software distributed under the terms of the Eclipse Public License, that provides a persistence backend for big, complex and highly interconnected EMF models.

Neo4EMF is a model repository and persistence framework allowing on-demand loading, storage, and unloading of large-scale EMF models. Neo4EMF uses a sophisticated unloading approach apart from simple Soft/Weak references. Moreover, Neo4EMF provides a No-SQL database persistence framework based on Neo4j [5], which is a transactional property-graph database that proved a remarkable running speed for connected data operations compared to relational databases.

In terms of performance, Neo4EMF eases data access and storage not only in a manner to reduce time and memory usage but also to allow big models to fit into small memory. This is established through an on-demand loading mechanism that offers :

- Lightweight first time loading of model elements : we separated EMF objects and their data fields, thus, data objects are only instantiated if an access request to one of their fields is established
- Dynamic partitioning of model elements : a partition represents a group of model elements to be unloaded all together. Hence, after each EMF operation call, first time loading objects are organized in their suitable partition
- Unloading of model partitions : when memory reaches a given threshold, we use a selection strategy to choose one or more partitions to be removed from the memory

A session about Neo4EMF took place at eclipseCon Europe 2013 [6], held in Ludwigsburgh Germany.

However, works are still going over Neo4EMF (within the context of the project ITM Factory -FUI14), to provide more utilities such as concurrent access, model distribution, and other Ecore utilities.

[5] http://www.neo4j.org

[6] https://www.eclipsecon.org/europe2013/neo4emf-big-models-made-possible

CIDRE Project-Team

5. Software and Platforms

5.1. Intrusion Detection

Members of the team have developed several intrusion detectors and security tools.

Blare implements our approach of illegal information flow detection at the OS level for a single node **and** a set of nodes. Two implementations have been realized: a first one for standard Linux distributions and a second one dedicated to Android operating systems (smartphones, tablets, etc). These implementations imply modification of the standard OS kernel; 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. Thanks to the work conducted by Christophe Hauser during its PhD [34], it is now possible to extend this information flow monitoring between a set of cooperating nodes. This is made possible by using dedicated tags carried out by IPv4 packets header (CIPSO tags).

However, 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.

Both **Blare** and **JBlare** development have been supported by an Inria ADT grant since January 2013. Thanks to this grant, Guillaume Brogi has been hired as an engineer to improve the development process of these tools and their quality. He also participates in the dissemination of these tools to the scientific community and potential industrial partners. Blare tools source code and documentation are now available on a dedicated Web site [1].

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.

Netzob is an open-source tool for reverse engineering, traffic generation and fuzzing of communication protocols. It helps security experts to infer both the message format and the state machine of a protocol using passive and active inference approaches. The model can afterward be used to simulate realistic traffic. This tool is developed by AMOSSYS company and Cidre members. Netzob source code and documentation are available on a dedicated Web site [2]

BSPL policy manager is a tool that aims to charge a security policy in a Android device. Policies are fine-grained information flow policies written in BSPL (Blare Security Policies Languages). Such policies precisely describe how a piece of data owned by an application is allowed to disseminate in the operating system. The BSPL policy manager permits to load a policy, checks if the policy is consistent or not. The policy manager permits to compose policies coming with different applications to obtain the policy of the whole device. A policy defined by the manager is enforced by Blare.

[1] https://www.blare-ids.org/

[2] http://www.netzob.org/

5.2. Privacy

GEPETO (GEoPrivacy-Enhancing TOolkit) is an open source software for managing location 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 Moïse) has contributed to the development of a distributed version of GEPETO based on the MapReduce paradigm and the Hadoop framework that is able to analyze datasets composed of millions of mobility traces in a few minutes [30].

GNOME (Geoprivacy eNhancing tOol for MobilE) is an application for Android smartphone whose main objectives are to (1) to help the user to understand which type of personal information can be learnt from his mobility traces through inference attacks as well as (2) to allow him to decide if he want to sanitize his location data before it is released to a third party (for instance this data could be perturbed according to the desired level of privacy of the user). In addition of the inference attacks such as the extraction of the points of interests and the construction of the mobility model, different mechanisms for generating fake yet realistic mobility traces have been implemented. In particular, one of this method leverages on the mobility model learnt while the second one perturbs the location based on a location variant of differential privacy, a well-established privacy model. These fake mobility traces, that are hard to distinguish from real ones, can be fed to applications running on the smartphone instead of his real location upon request of the user. This application is actually available as a beta release and experiments are actually being conducted with real users in order to test the functionalities of the application. This application has been developed by David Lanoë, an engineer hired as part of the "security and privacy for location-based services" EIT ICT labs activity.

MYRIADS Project-Team

5. Software and Platforms

5.1. HOCL-tools

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

Status: Version 1.0 to be released in open source

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 and Myriads teams. 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, 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): 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. It is also used in the framework of the DALHIS [2] associated team.

5.2. Contrail Virtual Execution Platform (VEP)

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

URL: http://project.inria.fr/vep/

Status: Version 2.1

License: BSD

Presentation: Virtual Execution Platform (VEP) [56] is a Contrail service that sits just above IaaS layer at the service provider end of the Contrail cloud federation. The VEP service 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 service 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.

[2] http://project.inria.fr/dalhis

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.

5.3. Snooze

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

URL: http://snooze.inria.fr

Status: Version 2.1.1

License: GPLv2

Presentation: Snooze [26] [53] [5], [4], 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 [59]), 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 of 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. Cassandra (since 2.0.0) can be used as base backend, providing reliability and scalability to the database management system. At a higher level Snooze provides its own REST API as well as an EC2 compatible API (since 2.1.0). It can thus be controlled from the command line (using the legacy client or an EC2 compatible tool), or from different langage libraries (libcloud, jcloud ...). Snooze also provides a web interface to control the system.

Active contributors (from Myriads team): Eugen Feller, Yvon Jégou, David Margery, Christine Morin, Anne-Cécile Orgerie, Matthieu Simonin.

Impact: Snooze has been used by students at LIFL, IRIT in France and LBNL in the US in the framework of internships. It has also been deployed and experimented at EDF R&D. Snooze entry won the 2nd prize of the scalability challenge at CCGrid2013. Finally, we know that it was experimented by external users from academia and industry as we received feed-back from them.

5.4. Resilin

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

URL: http://resilin.inria.fr

Status: Version 1.0

License: GNU Affero GPL

Presentation: Resilin [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, Christine Morin, Nikos Parlavantzas.

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

5.5. Merkat

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

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

Status: Version 1.0

License: TBD

Presentation: Merkat is a market-based private PaaS (Platform-as-a-Service) system, supporting dynamic, fine-grained resource allocation and automatic application management[23], [22], [11]. Merkat implements a proportional-share auction that ensures maximum resource utilization while providing incentives to applications to regulate their resource usage. Merkat 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. Merkat is implemented in Python and uses OpenNebula for virtual machine management. Experimental results on the Grid'5000 testbed show that using Merkat increases resource utilization and improves application performance. Merkat is currently being evaluated by EDF R&D using EDF high-performance applications.

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

Impact: Merkat has been integrated in EDF R&D portal providing access to internal computing resources and is currently used on a testbed at EDF R&D.

5.6. ConPaaS

Contact: Guillaume Pierre, `Guillaume.Pierre@irisa.fr`

URL: http://www.conpaas.eu/

Status: Version 1.3.1

License: BSD

Presentation: ConPaaS [60] is a runtime environment for hosting applications in the cloud. It aims at offering the full power of the cloud to application developers while shielding them from the associated complexity of the cloud. ConPaaS is designed to host both high-performance scientific applications and online Web applications. It automates the entire life-cycle of an application, including collaborative development, deployment, performance monitoring, and automatic scaling. This allows developers to focus their attention on application-specific concerns rather than on cloud-specific details.

Active contributors (from the Myriads team): Eliya Buyukkaya, Ancuta Iordache, Morteza Neishaboori, Guillaume Pierre, Yann Radenac, Dzenan Softic.

Impact: ConPaaS is recognized as one of the major open-source PaaS environments. It is being developed by teams in Rennes, Amsterdan, Berlin and Ljubljana. Technology transfer of ConPaaS technology is ongoing in the context of the MC-DATA EIT ICT Labs project.

5.7. Meryn

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

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

Status: Version 1.0

License: TBD

Presentation: Meryn is an open, SLA-driven PaaS architecture that supports cloud bursting and allows hosting an extensible set of application types. Meryn relies on a decentralized optimization policy that aims at maximizing the overall provider profit, taking into account the penalties incurred when quality guarantees are unsatisfied [24]. The current Meryn prototype is implemented in shell script, builds upon the Snooze VM manager software, and supports batch and MapReduce applications using respectively the Oracle Grid Engine OGE 6.2u7 and Hadoop 0.20.2 frameworks. Meryn is developed in the framework of Djawida Dib's PhD thesis.

Active contributors (from the Myriads team): Djawida Dib, Christine Morin, Nikos Parlavantzas.

Impact: Meryn is not yet distributed as open source.

REGAL Project-Team

4. Software and Platforms

4.1. Coccinelle

Participants: Christian Clausen, Julia Lawall [correspondent], Gilles Muller [correspondent], Suman Saha, Gaël Thomas.

Coccinelle is a program matching and transformation engine which provides the language SmPL (Semantic Patch Language) for specifying desired matches and transformations in C code. Coccinelle was initially targeted towards performing collateral evolutions in Linux. Such evolutions comprise the changes that are needed in client code in response to evolutions in library APIs, and may include modifications such as renaming a function, adding a function argument whose value is somehow context-dependent, and reorganizing a data structure.

Beyond collateral evolutions, Coccinelle has been successfully used for finding and fixing bugs in systems code. One of the main recent results is an extensive study of bugs in Linux 2.6 that has permitted us to demonstrate that the quality of code has been improving over the last six years, even though the code size has more than doubled.

Coccinelle is freely available at http://coccinelle.lip6.fr under a GPL v2 license.

4.2. SwiftCloud

Participants: Mahsa Najafzadeh, Burcu Külahçioglu Özkan, Marc Shapiro [correspondent], Marek Zawirski.

Cloud computing infrastructures improve latency and provide high availability by geo-replicating data at different locations across the world. This improves user experience, which is important for services such as social networks, online shops and games. Nevertheless, the distance to the closest data centre is still far from optimal for many users.

SwiftCloud is the first system to bring geo-replication all the way to the client machine, in order to provide the best possible latency and availability. This raises two main challenges. One, how to provide, efficiently, convenient programming guarantees, including access to consistent data in read-write transactions, and ensuring session guarantees. Two, to continue providing these guarantees, despite failures that require a client to switch to a different data centre.

Our research report [61] presents the design of SwiftCloud and the algorithms it uses to achieve the desired properties, while aiming for efficiency and for scalability to large numbers of clients. Our evaluation confirms that its programming model is practical, and that its performance and fault tolerance objectives are met.

SwiftCloud is supported by the ConcoRDanT ANR project (Section 7.1.6), by a Google European Doctoral Fellowship, and by the new FP7 grant SyncFree (Section 7.2.1.1).

The code is freely available on http://gforge.inria.fr/ under a BSD license.

4.3. JESSY

Participants: Masoud Saeida Ardekani, Marc Shapiro [correspondent].

A large family of distributed transactional protocols have a common structure, called Deferred Update Replication (DUR). DUR provides dependability by replicating data, and performance by not re-executing transactions but only applying their updates. Protocols of the DUR family differ only in behaviors of few generic functions. Based on this insight, we offer a generic DUR framework, called Jessy, along with a library of finely-optimized plug-in implementations of the required behaviors. Our empirical study shows that:

1. The framework provides a fair, apples-to-apples comparison between transactional protocols;
2. By replacing plugs-ins, developers can use Jessy to understand bottlenecks in their protocols;
3. This in turn enables the improvement of existing protocols; and
4. Given a protocol, Jessy allows to evaluate the cost of ensuring various degrees of dependability.

Articles related to Jessy were published in an Inria research report [60], in the Symp. on Reliable Distr. Sys. (SRDS) [43] and in the Euro-Par conference [42] Jessy is supported by a UPMC PhD scholarship to Masoud Saeida Ardekani, and by the ConcoRDanT ANR project (Section 7.1.6).

Jessy is freely available on github under http://Github.com/msaeida/jessy under an Apache license.

4.4. Java and .Net runtimes for LLVM

Participants: Koutheir Attouchi, Harris Bakiras, Bertil Folliot, Julia Lawall, Gilles Muller, Thomas Preud'Homme, Gaël Thomas [correspondent].

Many systems research projects now target managed runtime environments (MREs) because they provide better productivity and safety compared to native environments. Still, developing and optimizing an MRE is a tedious task that requires many years of development. Although MREs share some common functionalities, such as a Just In Time Compiler or a Garbage Collector, this opportunity for sharing implementations has not been yet exploited in implementing MREs. We are working on VMKit, a first attempt to build a common substrate that eases the development and experimentation of high-level MREs and systems mechanisms.

VMKit has been used to implement a JVM and a CLI Virtual Machine (Microsoft .NET is an implementation of the CLI) using the LLVM compiler framework and the MMTk garbage collectors. The JVM, called J3, executes real-world applications such as Tomcat, Felix or Eclipse and the DaCapo benchmark. It uses the GNU Classpath project for the base classes. The CLI implementation, called N3, is its in early stages but can execute simple applications and the “pnetmark” benchmark. It uses the pnetlib project or Mono as its core library. The VMKit VMs compare in performance with industrial and top open-source VMs on CPU-intensive applications. VMKit is publicly available under the LLVM license.

http://vmkit2.gforge.inria.fr/

SCORE Team

4. Software and Platforms

4.1. Rivage

Participants: Claudia-Lavinia Ignat, Stéphane Martin [contact].

Rivage (Real-tIme Vector grAphic Group Editor) is a real-time collaborative graphical editor. Several users can edit at the same time and in real-time a graphical document, user changes being immediately seen by the other users. The editor relies on a peer-to-peer architecture where users can join and leave the group at any time. Each user has a copy of the shared document and user changes on the document copies are merged in real-time by using a CRDT (Commutative Replicated Data Type) algorithm. The code is available at https://github.com/stephanemartin/rivage.

4.2. Replication Benchmarker

Participants: Pascal Urso [contact], Mehdi Ahmed-Nacer, Stéphane Martin, Gérald Oster.

The Replication Benchmarker is a performance evaluation framework for optimistic replication mechanisms used in collaborative applications. It contains a library of implementation of several CRDT (Commutative Replicated Data Type) and OT (Operational Transformation) algorithms for different data types: text, set, trees. The framework is able to evaluate the performance of comparable algorithms on different corpus of events traces. These events traces can be produced randomly according to different parameters, can be extracted from real real-time editing session that have been recorded, or can be automatically extracted from distributed version control repositories such as the one produced with Git. Performances of the algorithms are measured in term of execution time, memory footprint and merge result quality (compared to manual merge history stored in git repositories). The source code of this evaluation framework is available at https://github.com/score-team/replication-benchmarker.

4.3. BeGoood

Participant: Gérôme Canals.

BeGoood is a generic system for managing non-regression tests on knowledge-bases. BeGoood allows to define test plans in order to monitor the evolution of knowledge-bases. Any system answering queries by providing results in the form of set of strings can be tested with BeGoood. BeGoood has been developed following a REST architecture and is independent of any application domain. BeGoood is a part of the Kolflow infrastructure and is available at https://github.com/kolflow.

ALGORILLE Project-Team

5. Software and Platforms

5.1. Introduction

Software is a central part of our output. In the following we present the main tools to which we contribute. We use the Inria software self-assessment catalog for a classification.

5.2. Implementing parallel models

Several software platforms have served us to implement and promote our ideas in the domain of coarse grained computation and application structuring.

5.2.1. ORWL and P99

Participants: Jens Gustedt, Rodrigo Campos-Catelin, Stéphane Vialle, Mariem Saied.

ORWL is a reference implementation of the Ordered Read-Write Lock tools as described in [4]. The macro definitions and tools for programming in C99 that have been implemented for ORWL have been separated out into a toolbox called P99. ORWL is intended to become opensource, once it will be in a publishable state. P99 is available under a QPL at http://p99.gforge.inria.fr/.
Software classification: A-3-up, SO-4, SM-3, EM-3, SDL (P99: 4, ORWL: 2-up), DA-4, CD-4, MS-3, TPM-4

5.2.2. parXXL

Participants: Jens Gustedt, Stéphane Vialle.

ParXXL is a library for large scale computation and communication that executes fine grained algorithms on coarse grained architectures (clusters, grids, mainframes). It has been one of the software bases of the InterCell project and has been proven to be a stable support, there. It is available under a GPLv2 at http://parxxl.gforge.inria.fr/. ParXXL is not under active development anymore, but still maintained in the case of bugs or portability problems.
Software classification: A-3, SO-4, SM-3, EM-2, SDL-4, DA-4, CD-4, MS-2, TPM-2

5.3. Distem

Participants: Tomasz Buchert, Emmanuel Jeanvoine, Lucas Nussbaum, Luc Sarzyniec.

Wrekavoc and Distem are distributed system emulators. They enable researchers to evaluate unmodified distributed applications on heterogeneous distributed platforms created from an homogeneous cluster: CPU performance and network characteristics are altered by the emulator.
Wrekavoc was developed until 2010, and we then focused our efforts on **Distem**, that shares the same goals with a different design. Distem is available from http://distem.gforge.inria.fr/ under GPLv3.
Software classification: A-3-up, SO-4, SM-3-up, EM-3, SDL-4, DA-4, CD-4, MS-4, TPM-4.

5.4. SimGrid

SimGrid is a toolkit for the simulation of distributed applications in heterogeneous distributed environments. The specific goal of the project is to facilitate research in the area of parallel and distributed large scale systems, such as Grids, P2P systems and clouds. Its use cases encompass heuristic evaluation, application prototyping or even real application development and tuning.

5.4.1. Core distribution

Participants: Martin Quinson, Marion Guthmuller, Paul Bédaride, Gabriel Corona, Lucas Nussbaum.

SimGrid has an active user community of more than one hundred members, and is available under GPLv3 from http://simgrid.gforge.inria.fr/. One third of the source code is devoted to about 12000 unit tests and 500 full integration tests. These tests are run for each commit for 4 package configurations and on 4 operating systems thanks to the Inria continuous integration platform.
Software classification: A-4-up, SO-4, SM-4, EM-4, SDL-5, DA-4, CD-4, MS-3, TPM-4.

5.4.2. SimGridMC

Participants: Martin Quinson, Marion Guthmuller, Gabriel Corona.

SimGridMC is a module of SimGrid that can be used to formally assess any distributed system that can be simulated within SimGrid. It explores all possible message interleavings searching for states violating the provided properties. We recently added the ability to assess liveness properties over arbitrary C codes, thanks to a system-level introspection tool that provides a finely detailed view of the running application to the model checker. This can for example be leveraged to verify arbitrary MPI code written in C.
Software classification: A-3-up, SO-4, SM-3-up, EM-3-up, SDL-5, DA-4, CD-4, MS-4, TPM-4.

5.4.3. SCHIaaS

Participants: Julien Gossa, Stéphane Genaud, Luke Bertot, Rajni Aron, Étienne Michon.

The *Simulation of Clouds, Hypervisor and IaaS* (SCHIaaS) is an extension of SimGrid that can be used to comprehensively simulate clouds, from the hypervisor/system level, to the IaaS/administrator level. The hypervisor level includes models about virtualization overhead and VMs operations like boot, start, suspend, migrate, and network capping. The IaaS level includes models about instances management like image storage and deployment and VM scheduling. This extension allows to fully simulate any cloud infrastructure, whatever the hypervisor or the IaaS manager. This can be used by both cloud administrators to dimension and tune clouds, and cloud users to simulate cloud applications and assess provisioning strategies in term of performances and cost.
Software classification: A-4-up, SO-4, SM-2-up, EM-2-up, SDL-2, DA-4, CD-4, MS-4, TPM-4.

5.5. Kadeploy

Participants: Luc Sarzyniec, Emmanuel Jeanvoine, Lucas Nussbaum.

Kadeploy is a scalable, efficient and reliable deployment (provisioning) system for clusters and grids. It provides a set of tools for cloning, configuring (post installation) and managing cluster nodes. It can deploy a 300-nodes cluster in a few minutes, without intervention from the system administrator. It plays a key role on the Grid'5000 testbed, where it allows users to reconfigure the software environment on the nodes, and is also used on a dozen of production clusters both inside and outside INRIA. It is available from http://kadeploy3.gforge.inria.fr/ under the Cecill license.
Software classification: A-4-up, SO-3, SM-4, EM-4, SDL-4-up, DA-4, CD-4, MS-4, TPM-4.

5.6. XPFlow

Participants: Tomasz Buchert, Lucas Nussbaum.

XPFlow is an implementation of a new, workflow-inspired approach to control of experiments involving large-scale computer installations. Such systems pose many difficult problems to researchers due to their complexity, their numerous constituents and scalability problems. The main idea of the approach consists in describing the experiment as a workflow and execute it using achievements of Business Workflow Management (BPM), workflow management techniques and scientific workflows. The website of XPFlow is http://xpflow.gforge.inria.fr/. The software itself is not released to the general public yet, a fact that will be addressed during the year 2014.
Software classification: A-2-up, SO-3-up, SM-2-up, EM-3-up, SDL-2-up, DA-4, CD-4, MS-4, TPM-4.

5.7. Grid’5000 testbed

Participants: Luc Sarzyniec, Emmanuel Jeanvoine, Émile Morel, Lucas Nussbaum.

Grid’5000 (http://www.grid5000.fr) is a scientific instrument designed to support experiment-driven research in all areas of computer science related to parallel, large-scale or distributed computing and networking. It gathers 10 sites, 25 clusters, 1200 nodes, for a total of 8000 cores. It provides its users with a fully reconfigurable environment (bare metal OS deployment with Kadeploy, network isolation with KaVLAN) and a strong focus on enabling high-quality, reproducible experiments.

The AlGorille team contributes to the design of Grid’5000, to the administration of the local Grid’5000 site in Nancy, and to the design and development of Kadeploy (in close cooperation with the Grid’5000 technical team). The AlGorille engineers also administer *Inria Nancy – Grand Est*’s local production cluster, named *Talc*, leveraging the experience and tools from Grid’5000.

Software classification: A-5, SO-4, SM-4, EM-4, SDL-N/A, DA-4, CD-4, MS-4, TPM-4.

ALPINES Team

5. Software and Platforms

5.1. Software and Platforms

5.1.1. Platforms

5.1.1.1. FreeFem++, http://www.freefem.org/ff++/

FreeFem++ is a PDE solver based on a flexible language that allows a large number of problems to be expressed (elasticity, fluids, etc) with different finite element approximations on different meshes. There are more than 2000 users, and on the mailing list there are 430 members. Among those, we are aware of at least 10 industrial companies, 8 french companies and 2 non-french companies. It is used for teaching at Ecole Polytechnique, Ecole Centrale, Ecole des Ponts, Ecole des Mines, University Paris 11, University Paris Dauphine, La Rochelle, Nancy, Metz, Lyon, etc. Outside France, it is used for example at universities in Japan (Tokyo, Kyoto, Hiroshima, there is a userguide FreeFem++ in japan), Spain (Sevilla, BCAM, userguide available in spanish), UK (Oxford), Slovenia, Switzerland (EPFL, ETH), China. For every new version, there are 350 regression tests, and we provide a rapid correction of reported bugs. The licence of FreeFem++ is LGPL.

5.1.1.2. Library for preconditioned iterative methods

In the project-team we develop a library that integrates the direction preserving and low rank approximation preconditioners for both approached factorizations and domain decomposition like methods. It will be available through FreeFem++ and also as a stand alone library, and we expect to have one version of this library available in 2014.

AVALON Team

5. Software and Platforms

5.1. BitDew

Participants: Gilles Fedak [correspondant], Haiwu He.

BITDEW is an open source middleware implementing a set of distributed services for large scale data management on Desktop Grids and Clouds. BITDEW relies on five abstractions to manage the data : i) replication indicates how many occurrences of a data should be available at the same time on the network, ii) fault-tolerance controls the policy in presence of hardware failures, iii) lifetime is an attribute absolute or relative to the existence of other data, which decides of the life cycle of a data in the system, iv) affinity drives movement of data according to dependency rules, v) protocol gives the runtime environment hints about the protocol to distribute the data (http, ftp, or bittorrent). Programmers define for every data these simple criteria, and let the BITDEW runtime environment manage operations of data creation, deletion, movement, replication, and fault-tolerance operation.

BITDEW is distributed open source under the GPLv3 or Cecill licence at the user's choice. 10 releases were produced over the last two years, and it has been downloaded approximately 6,000 times on the Inria forge. Known users are Université Paris-XI, Université Paris-XIII, University of Florida (USA), Cardiff University (UK) and University of Sfax (Tunisia). In terms of support, the development of BitDew is partly funded by the Inria ADT BitDew and by the ANR MapReduce projects. Thanks to this support, we have developed and released the first prototype of the MapReduce programming model for Desktop Grids on top of BitDew. In 2012, 8 versions of the software have been released, including the version 1.2.0 considered as a stable release of BitDew with many advanced features. Our most current work focuses on providing reliable storage on top of hybrid distributed computing infrastructures.

5.2. DIET

Participants: Daniel Balouek, Eddy Caron [correspondant], Frédéric Desprez, Maurice-Djibril Faye, Arnaud Lefray, Guillaume Verger, Jonathan Rouzaud-Cornabas, Lamiel Toch, Huaxi Zhang.

Huge problems can now be processed over the Internet thanks to Grid and Cloud middleware systems. The use of on-the-shelf applications is needed by scientists of other disciplines. Moreover, the computational power and memory needs of such applications may of course not be met by every workstation. Thus, the RPC paradigm seems to be a good candidate to build Problem Solving Environments on the Grid or Cloud. The aim of the DIET project (http://graal.ens-lyon.fr/DIET) is to develop a set of tools to build computational servers accessible through a GridRPC API.

Moreover, the aim of a middleware system such as DIET is to provide a transparent access to a pool of computational servers. DIET focuses on offering such a service at a very large scale. A client which has a problem to solve should be able to obtain a reference to the server that is best suited for it. DIET is designed to take into account the data location when scheduling jobs. Data are kept as long as possible on (or near to) the computational servers in order to minimize transfer times. This kind of optimization is mandatory when performing job scheduling on a wide-area network. DIET is built upon *Server Daemons*. The scheduler is scattered across a hierarchy of *Local Agents* and *Master Agents*. Applications targeted for the DIET platform are now able to exert a degree of control over the scheduling subsystem via *plug-in schedulers*. As the applications that are to be deployed on the Grid vary greatly in terms of performance demands, the DIET plug-in scheduler facility permits the application designer to express application needs and features in order that they be taken into account when application tasks are scheduled. These features are invoked at runtime after a user has submitted a service request to the MA, which broadcasts the request to its agent hierarchy.

DIET provide a support for Cloud architecture. and it takes benefits from virtualized resources. As cloud resources are dynamic, we have on-going research in the field of automatic and elastic deployment for middleware systems. DIET will be able to extend and reduce the amount on aggregated resources and adjust itself when resources fail.

In the context of the Seed4C project, we have studied how secured our platform, authenticated and secured interactions between the different parts of our middleware and between our middleware and its users. By the way, we have added the SSL support into the DIET communication layer. We have worked to show how to securely use public cloud storage without taking the risk of losing confidentiality of data stored on them.

We have started a work to design a plug-in schedulers into DIET to deal with energy management. Using this scheduler we have obtain a significatif gain close to 25% with a minor weakening of performance (6%). Moreover we have experimented some dynamic resources management through DIET based on the energy criteria.

5.3. Pilgrim

Participants: Eddy Caron, Matthieu Imbert [correspondant].

Pilgrim (http://pilgrim.gforge.inria.fr) is an open metrology and prediction performance framework whose goal is to provide easy and powerful tools for instrumenting computer platforms and predicting their behavior. Those tools are aimed at being used not only by humans but also by programs, in particular by resource managers and schedulers. Pilgrim is designed to be a loosely coupled integration of various custom-developed or off-the-shelf tools.

5.4. Sam4c

Participants: Eddy Caron, Arnaud Lefray [correspondant], Jonathan Rouzaud-Cornabas.

Sam4C (https://gforge.inria.fr/projects/sam4c/) -Security-Aware Models for Clouds- is a graphical and textual editor to model Cloud applications (as virtual machines, processes, files and communications) and describe its security policy. Sam4C is suitable to represent any static application without deadline or execution time such as n-tiers or parallel applications. This editor is generated in Java from an EMF -Eclipse Modeling Framework- metamodel to simplify any modifications or extensions. The application model and the associated security policy are compiled in a single XML file which serves as input for an external Cloud security-aware scheduler. Alongside with this editor, Cloud architecture models and provisioning algorithms are provided for simulation (in the current version) or real deployments (in future versions). During this step of development this software is private and available only for Seed4C project members. The design of Sam4c is a joint effort with ENSIB (Bourges).

5.5. SimGrid

Participants: Georgios Markomanolis, Jonathan Rouzaud-Cornabas, Frédéric Suter [correspondant].

SIMGRID is a toolkit for the simulation of distributed applications in heterogeneous distributed environments. The specific goal of the project is to facilitate research in the area of parallel and distributed large scale systems, such as Grids, P2P systems and clouds. Its use cases encompass heuristic evaluation, application prototyping or even real application development and tuning. SIMGRID has an active user community of more than one hundred members, and is available under GPLv3 from http://simgrid.gforge.inria.fr/.

5.6. HLCMi, L^2C, & Gluon++

Participants: Zhengxiong Hou, Vincent Lanore, Christian Perez [correspondant].

HLCMI (http://hlcm.gforge.inria.fr) is an implementation of the HLCM component model. HLCM is a generic extensible component model with respect to component implementations and interaction concerns. Moreover, HLCM is abstract; it is its specialization—such as HLCM/L^2C—that defines the primitive elements of the model, such as the primitive components and the primitive interactions.

HLCMI is making use of Model-driven Engineering (MDE) methodology to generate a concrete assembly from an high level description. It is based on the Eclipse Modeling Framework (EMF). HLCMI contains 700 Emfatic lines to describe its models and 7000 JAVA lines for utility and model transformation purposes. HLCMI is a general framework that supports several HLCM specializations: HLCM/CCM, HLCM/JAVA, HLCM/L^2C and HLCM/Charm++ (known as Gluon++).

L^2C (http://hlcm.gforge.inria.fr) is a *Low Level Component* model implementation targeting at use-cases where overhead matters such as High-Performance Computing. L^2C does not offer network transparency neither language transparency. Instead, L^2C lets the user choose between various kinds of interactions between components, some with ultra low overhead and others that support network transport. L^2C is extensible as additional interaction kinds can be added quite easily. L^2C currently supports C++, FORTRAN 2013, MPI and CORBA interactions.

Gluon++(http://hlcm.gforge.inria.fr) is a thin component model layer added on top of Charm++ (http://charm.cs.uiuc.edu/). It defines chare components as a Charm++ chare with minimal metadata, C++ components as a C++ class with minimal metadata, (asynchronous) entry method calls between components, and plain C++ method calls between components.

L^2C and Gluon++ are implemented in the LLCMc++ framework (http://hlcm.gforge.inria.fr). It is distributed under a LGPL licence and represents 6400 lines of C++.

5.7. Execo

Participants: Matthieu Imbert [correspondant], Laurent Pouilloux.

Execo (http://execo.gforge.inria.fr) offers a Python API for local or remote, standalone or parallel, processes execution. It is especially well suited for scripting workflows of parallel/distributed operations on local or remote hosts: automating a scientific workflow, conducting computer science experiments, performing automated tests, etc. The core python package is `Execo`. The `execo_g5k` package provides a set of tools and extensions for GRID'5000. The `execo_engine` package and `execo-run` script provide an extendable experiment engine.

Execo currently has more than 10 users in and outside the AVALON team, who rely on it to automate experimental workflows, mainly on GRID'5000 ([26]).

It is distributed under GPLv3 and it is made of 5200 lines of Python.

5.8. Grid'5000

Participants: Frédéric Desprez, Simon Delamare, Laurent Lefèvre, Christian Perez.

The GRID'5000 experimental platform (http://www.grid5000.fr) is a scientific instrument to support computer science research related to distributed systems, including parallel processing, high performance computing, cloud computing, operating systems, peer-to-peer systems and networks. It is distributed on 10 sites in France and Luxembourg, including Lyon. GRID'5000 is a unique platform as it offers to researchers many and varied hardware resources and a complete software stack to conduct complex experiments, ensure reproducibility and ease understanding of results.

Not only GRID'5000 is heavily used for Avalon research, but several team members are also involved in GRID'5000 direction:

- Frédéric Desprez is leading the “Groupement d'Intérêt Scientifique Groupement Grille 5K” which drives GRID'5000.
- Laurent Lefèvre is responsible of the GRID'5000 Lyon platform and member of the GRID'5000 direction committee.
- Christian Perez is leading the Hemera initiative (https://www.grid5000.fr/Hemera) and he is a member of the GRID'5000 direction committee.
- Simon Delamare is the operational manager of the technical team.

CEPAGE Project-Team

5. Software and Platforms

5.1. SimGrid

Participants: Paul Renaud-Goud, Lionel Eyraud-Dubois [correspondant].

SimGrid (http://simgrid.gforge.inria.fr/) is a toolkit that provides core functionalities for the simulation of distributed applications in heterogeneous distributed environments. The specific goal of the project is to facilitate research in the area of parallel and distributed large scale systems, such as Grids, P2P systems and clouds. Its use cases encompass heuristic evaluation, application prototyping or even real application development and tuning. It is based on experimentally validated models, and features very high scalability, which allows to perform very large scale simulations. It is used by over a hundred academic users all over the world, and has been used in about one hundred scientific articles.

CEPAGE has contributed to this software by participating in the management of the project and in many design decisions. As a part of the SONGS project, we also participated in the development and validation of new models and interfaces for the HPC and Cloud Computing platforms.

Software assessment : A-4, SO-4, SM-4, EM-3, SDL-5
Contribution : DA-2, CD-2, MS-2, TPM-3.

5.2. Hubble

Participants: Ludovic Courtes, Nicolas Bonichon [correspondant].

Hubble is implemented in Scheme, using GNU Guile version 2. Details of the simulation, such as keeping track of processor occupation and network usage, are taken care of by SimGrid, a toolkit for the simulation of distributed applications in heterogeneous distributed environments.

The input to Hubble is an XML description of the DAG of build tasks. For each task, a build duration and the size in bytes of the build output are specified. For our evaluation purposes, we collected this data on a production system, the http://hydra.nixos.org/ build farm hosted at the Technical University of Delft. The DAG itself is the snapshot of the Nix Package Collection (Nixpkgs) corresponding to this data. Hubble has its own in-memory representation of the DAG in the form of a purely functional data structure.

The Nixpkgs DAG contains fixed-output nodes, i.e., nodes whose output is known in advance and does not require any computation. These nodes are typically downloads of source code from external web sites. The raw data collected on http://hydra.nixos.org/ specifies a non-zero duration for these nodes, which represents the time it took to perform the download. This duration info is irrelevant in our context, since they don't require any computation, and Hubble views these nodes as instantaneous.

See also the web page http://hubble.gforge.inria.fr/.

Software assessment: A-3, SO-3, SM-2, EM-1, SDL-2.
Contribution: DA-4, CD-4, MS-4, TPM-4.

5.3. Gengraph

Participant: Cyril Gavoille [correspondant].

This is a command-line tool for generating graphs. There are several output formats, includes the dot format from GraphViz. It generates also .pdf files for visualization. Several graph algorithms have been implemented (diameter, connectivity, treewidth, etc.) which can be tested on the graphs. The software has been originally designed for teaching purpose so that students can test their project algorithms on many non trivial families like random geometric graphs, graphs of given density, given treewidth. It is also used for research purpose, in particular the exhaustive search results in the Emilie Diot's thesis are based on `gengraph`. The program can filter a list of graphs based to many criteria, as for instance it can extract all graphs of a given list that are 2-connected, of diameter at least four, and that exclude some minor (or some induced subgraph).

Currently, more than 100 parametrized graph families are implemented, supporting simple operators like complementation, random edge/vertex removal, and others. The source has more than 10,000 lines including a command-line documentation of 2,000 lines. The single source file is available at http://dept-info.labri.fr/~gavoille/gengraph.c

Software assessment: A-3, SO-3, SM-2, EM-2, SDL-2.
Contribution: DA-4, CD-4, MS-4, TPM-4.

5.4. Bedibe

Participants: Lionel Eyraud-Dubois [correspondant], Przemyslaw Uznanski.

Bedibe (Benchmarking Distributed Bandwidth Estimation) is a software to compare different models for bandwidth estimation on the Internet, and their associated instantiation algorithms. The goal is to ease the development of new models and algorithms, and the comparison with existing solutions. Additionally, we have developed a measuring framework which can be deployed on PlanetLab to obtain available bandwidth datasets.

See also the web page http://bedibe.gforge.inria.fr/.

Software assessment : A-1-up2, SO-3, SM-1-up2, EM-2, SDL-1-up2.

5.5. MineWithRounds

Participants: Sofian Maabout [correspondant], Nicolas Hanusse.

The software implements a parallel algorithm aiming at computing *Borders* that's sets of maximal/minimal subsets of objects satisfying some anti-monotone condition. It is implemented in `C++` together with the `openMP` library to exploit multi-core machines. In its current status, it outperforms state of the art implementations addressing the Maximal Frequent Itemsets problem.

Software assessment: A-2, SO-4, SM-2, EM-2, SDL-2.
Contribution: DA-4, CD-4, MS-4, TPM-4.

5.6. FSM: Full Skycube Materialization

Participant: Sofian Maabout [correspondant].

The software implements a parallel algorithm aiming at fully materializing skycubes: the set of all possible skyline queries. It is implemented in C++ together with the openMP library to exploit multi-core machines. In its current status, it outperforms state of the art implementations such as QSkycube and PSkyCube (VLDB Journal '13)

Software assessment: A-2, SO-4, SM-2, EM-2, SDL-2.
Contribution: DA-4, CD-4, MS-4, TPM-4.

ADT: Pierre Matri has been hired as an engineer for two year starting from September 15th, 2013. He is in charge to implement our algorithm on top of a large scale infrastructure especially by using Map-Reduce paradigm and its Hadoop implementation. His main focus during 2013 concerned the functional dependencies extraction from large distributed data bases by considering exact and approximate solutions.

GRAND-LARGE Project-Team

4. Software and Platforms

4.1. APMC-CA

Participants: Sylvain Peyronnet [correspondant], Joel Falcou, Pierre Esterie, Khaled Hamidouche, Alexandre Borghi.

The APMC model checker implements the state-of-the-art approximate probabilistic model checking methods. Last year we develop a version of the tool dedicated to the CELL architecture. Clearly, it was very pedagogic, but the conclusion is that the CELL is not adapted to sampling based verification methods.

This year we develop, thanks to the BSP++ framework, a version compatible with SPM/multicores machines, clusters and hybrid architectures. This version outperforms all previous ones, thus showing the interest of both these new architectures and of the BSP++ framework.

4.2. YML

Participants: Serge Petiton [correspondant], Nahid Emad, Maxime Hugues.

Scientific end-users face difficulties to program P2P large scale applications using low level languages and middleware. We provide a high level language and a set of tools designed to develop and execute large coarse grain applications on peer-to-peer systems. Thus, we introduced, developed and experimented the YML for parallel programming on P2P architectures. This work was done in collaboration with the PRiSM laboratory (team of Nahid Emad).

The main contribution of YML is its high level language for scientific end-users to develop parallel programs for P2P platforms. This language integrates two different aspects. The first aspect is a component description language. The second aspect allows to link components together. A coordination language called YvetteML can express graphs of components which represent applications for peer-to-peer systems.

Moreover, we designed a framework to take advantage of the YML language. It is based on two component catalogues and an YML engine. The first one concerns end-user's components and the second one is related to middleware criteria. This separation enhances portability of applications and permits real time optimizations. Currently we provide support for the XtremWeb Peer-to-Peer middleware and the OmniRPC grid system. The support for Condor is currently under development and a beta-release will be delivered soon (in this release, we plan to propagate semantic data from the end-users to the middleware). The next development of YML concerns the implementation of a multi-backend scheduler. Therefore, YML will be able to schedule at runtime computing tasks to any global computing platform using any of the targeted middleware.

We experimented YML with basic linear algebra methods on a XtremWeb P2P platform deployed between France and Japan. Recently, we have implemented complex iterative restarted Krylov methods, such as Lanczos-Bisection, GMRES and MERAM methods, using YML with the OmniRPC back-end. The experiments are performed either on the Grid5000 testbed of on a Network of Workstations deployed between Lille, Versailles and Tsukuba in Japan. Demos was proposed on these testbeds from conferences in USA. We recently finished evaluations of the overhead generated using YML, without smart schedulers and with extrapolations due to the lack of smart scheduling strategies inside targeted middleware.

In the context of the FP3C project funded by ANR-JST, we have recently extended YML to support a directive distributed parallel language, XcalableMP http://www.xcalablemp.org/. This extension is based on the support of the XcalableMP language inside YML components. This allows to develop parallel programs with two programming paradigm and thus two parallelism levels. This work is a part of the project that targets post-Petascale supercomputer that would be composed of heterogeneous and massively parallel hardware.

The software is available at http://yml.prism.uvsq.fr/

4.3. The Scientific Programming InterNet (SPIN)

Participant: Serge Petiton [correspondant].

SPIN (Scientific Programming on the InterNet), is a scalable, integrated and interactive set of tools for scientific computations on distributed and heterogeneous environments. These tools create a collaborative environment allowing the access to remote resources.

The goal of SPIN is to provide the following advantages: Platform independence, Flexible parameterization, Incremental capacity growth, Portability and interoperability, and Web integration. The need to develop a tool such as SPIN was recognized by the GRID community of the researchers in scientific domains, such as linear algebra. Since the P2P arrives as a new programming paradigm, the end-users need to have such tools. It becomes a real need for the scientific community to make possible the development of scientific applications assembling basic components hiding the architecture and the middleware. Another use of SPIN consists in allowing to build an application from predefined components ("building blocks") existing in the system or developed by the developer. The SPIN users community can collaborate in order to make more and more predefined components available to be shared via the Internet in order to develop new more specialized components or new applications combining existing and new components thanks to the SPIN user interface.

SPIN was launched at ASCI CNRS lab in 1998 and is now developed in collaboration with the University of Versailles, PRiSM lab. SPIN is currently under adaptation to incorporate YML, cf. above. Nevertheless, we study another solution based on the Linear Algebra KErnel (LAKE), developed by the Nahid Emad team at the University of Versailles, which would be an alternative to SPIN as a component oriented integration with YML.

4.4. V-DS

Participant: Franck Cappello [correspondant].

This project started officially in September 2004, under the name V-Grid. V-DS stands for Virtualization environment for large-scale Distributed Systems. It is a virtualization software for large scale distributed system emulation. This software allows folding a distributed systems 100 or 1000 times larger than the experimental testbed. V-DS virtualizes distributed systems nodes on PC clusters, providing every virtual node its proper and confined operating system and execution environment. Thus compared to large scale distributed system simulators or emulators (like MicroGrid), V-DS virtualizes and schedules a full software environment for every distributed system node. V-DS research concerns emulation realism and performance.

A first work concerns the definition and implementation of metrics and methodologies to compare the merits of distributed system virtualization tools. Since there is no previous work in this domain, it is important to define what and how to measure in order to qualify a virtualization system relatively to realism and performance. We defined a set of metrics and methodologies in order to evaluate and compared virtualization tools for sequential system. For example a key parameter for the realism is the event timing: in the emulated environment, events should occur with a time consistent with a real environment. An example of key parameter for the performance is the linearity. The performance degradation for every virtual machine should evolve linearly with the increase of the number of virtual machines. We conducted a large set of experiments, comparing several virtualization tools including Vserver, VMware, User Mode Linux, Xen, etc. The result demonstrates that none of them provides both enough isolation and performance. As a consequence, we are currently studying approaches to cope with these limits.

We have made a virtual platform on the GDX cluster with the Vserver virtualization tool. On this platform, we have launched more than 20K virtual machines (VM) with a folding of 100 (100 VM on each physical machine). However, some recent experiments have shown that a too high folding factor may cause a too long execution time because of some problems like swapping. Currently, we are conducting experiments on another platform based on the virtualization tool named Xen which has been strongly improved since 2 years. We expect to get better result with Xen than with Vserver. Recently, we have been using the V-DS version based on Xen to evaluate at large scales three P2P middleware [74].

This software is available at http://v-ds.lri.fr/

4.5. PVC: Private Virtual Cluster

Participant: Franck Cappello [correspondant].

Current complexity of Grid technologies, the lack of security of Peer-to-Peer systems and the rigidity of VPN technologies make sharing resources belonging to different institutions still technically difficult.

We propose a new approach called "Instant Grid" (IG), which combines various Grid, P2P and VPN approaches, allowing simple deployment of applications over different administration domains. Three main requirements should be fulfilled to make Instant Grids realistic: simple networking configuration (Firewall and NAT), no degradation of resource security, no need to re-implement existing distributed applications.

Private Virtual Cluster, is a low-level middle-ware that meets Instant Grid requirements. PVC turns dynamically a set of resources belonging to different administration domains into a virtual cluster where existing cluster runtime environments and applications can be run. The major objective of PVC is to establish direct connections between distributed peers. To connect firewall protected nodes in the current implementation, we have integrated three techniques: UPnP, TCP/UDP Hole Punching and a novel technique Traversing-TCP.

One of the major application of PVC is the third generation desktop Grid middleware. Unlike BOINC and XtremWeb (which belong to the second generation of desktop Grid middleware), PVC allows the users to build their Desktop Grid environment and run their favorite batch scheduler, distributed file system, resource monitoring and parallel programming library and runtime software. PVC ensures the connectivity layer and provide a virtual IP network where the user can install and run existing cluster software.

By offering only the connectivity layer, PVC allows to deploy P2P systems with specific applications, like file sharing, distributed computing, distributed storage and archive, video broadcasting, etc.

4.6. OpenWP

Participant: Franck Cappello [correspondant].

Distributed applications can be programmed on the Grid using workflow languages, object oriented approaches (Proactive, IBIS, etc), RPC programming environments (Grid-RPC, DIET), component based environments (generally based on Corba) and parallel programming libraries like MPI.

For high performance computing applications, most of the existing codes are programmed in C, Fortran and Java. These codes have 100,000 to millions of lines. Programmers are not inclined to rewrite then in a "non standard" programming language, like UPC, CoArray Fortran or Global Array. Thus environments like MPI and OpenMPI remain popular even if they require hybrid approaches for programming hierarchical computing infrastructures like cluster of multi-processors equipped with multi-core processors.

Programming applications on the Grid add a novel level in the hierarchy by clustering the cluster of multi-processors. The programmer will face strong difficulties in adapting or programming a new application for these runtime infrastructures featuring a deep hierarchy. Directive based parallel and distributed computing is appealing to reduce the programming difficulty by allowing incremental parallelization and distribution. The programmer add directives on a sequential or parallel code and may check for every inserted directive its correction and performance improvement.

We believe that directive based parallel and distributed computing may play a significant role in the next years for programming High performance parallel computers and Grids. We have started the development of OpenWP. OpenWP is a directive based programming environment and runtime allowing expressing workflows to be executed on Grids. OpenWP is compliant with OpenMP and can be used in conjunction with OpenMP or hybrid parallel programs using MPI + OpenMP.

The OpenWP environment consists in a source to source compiler and a runtime. The OpenWP parser, interprets the user directives and extracts functional blocks from the code. These blocks are inserted in a library distributed on all computing nodes. In the original program, the functional blocks are replaced by RPC calls and calls to synchronization. During the execution, the main program launches non blocking RPC calls to functions on remote nodes and synchronize the execution of remote functions based on the synchronization directives inserted by the programmer in the main code. Compared to OpenMP, OpenWP does not consider a shared memory programming approach. Instead, the source to source compiler insert data movements calls in the main code. Since the data set can be large in Grid application, the OpenWP runtime organize the storage of data sets in a distributed way. Moreover, the parameters and results of RPC calls are passed by reference, using a DHT. Thus, during the execution, parameter and result references are stored in the DHT along with the current position of the datasets. When a remote function is called, the DHT is consulted to obtain the position of the parameter data sets in the system. When a remote function terminates its execution, it stores the result data sets and store a reference to the data set in the DHT.

We are evaluating OpenWP from an industrial application (Amibe), used by the European aerospace company EADS. Amibe is the mesher module of jCAE [1]. Amibe generates a mesh from a CAD geometry in three steps. It first creates edges between every patch of the CAD (mesh in one dimension), then generates a surface mesh for every unfolded patch (mesh in two dimensions) and finally adds the third dimension to the mesh by projecting the 2D mesh into the original CAD surfaces. The first and third operation cannot be distributed. However the second step can easily be distributed following a master/worker approach, transferring the mesh1d results to every computing node and launching the distributed execution of the patches.

4.7. OpenScop

Participant: Cédric Bastoul.

OpenScop is an open specification which defines a file format and a set of data structures to represent a *static control part* (SCoP for short), i.e., a program part that can be represented in the *polyhedral model*, an algebraic representation of programs used for automatic parallelization and optimization (used, e.g., in GNU GCC, LLVM, IBM XL or Reservoir Labs R-Stream compilers). The goal of OpenScop is to provide a common interface to various polyhedral compilation tools in order to simplify their interaction.

OpenScop provides a single format for tools that may have different purposes (e.g., as different as code generation and data dependence analysis). We could observe that most available polyhedral compilation tools during the last decade were manipulating the same kind of data (polyhedra, affine functions...) and were actually sharing a part of their input (e.g., iteration domains and context concepts are nearly everywhere). We could also observe that those tools may rely on different internal representations, mostly based on one of the major polyhedral libraries (e.g., Polylib, PPL or isl), and this representation may change over time (e.g., when switching to a more convenient polyhedral library). OpenScop aims at providing a stable, unified format that offers a durable guarantee that a tool can use an output or provide an input to another tool without breaking a compilation chain because of some internal changes in one element of this chain. The other promise of OpenScop is the ability to assemble or replace the basic blocks of a polyhedral compilation framework at no, or at least low engineering cost. The OpenScop Library (licensed under the 3-clause BSD license) has been developped as an example, yet powerful, implementation of the OpenScop specification.

4.8. Clay

Participant: Cédric Bastoul.

Clay is a free software and library devoted to semi-automatic optimization using the polyhedral model. It can input a high-level program or its polyhedral representation and transform it according to a transformation script. Classic loop transformations primitives are provided. Clay is able to check for the legality of the complete sequence of transformation and to suggest corrections to the user if the original semantics is not preserved (experimental at this document redaction time). Main authors include Joël Poudroux and Cédric Bastoul.

[1] project page: http://jcae.sourceforge.net

4.9. Fast linear system solvers in public domain libraries

Participant: Marc Baboulin [correspondant].

Hybrid multicore+GPU architectures are becoming commonly used systems in high performance computing simulations. In this research, we develop linear algebra solvers where we split the computation over multicore and graphics processors, and use particular techniques to reduce the amount of pivoting and communication between the hybrid components. This results in efficient algorithms that take advantage of each computational unit [16]. Our research in randomized algorithms yields to several contributions to propose public domain libraries PLASMA and MAGMA in the area of fast linear system solvers for general and symmetric indefinite systems. These solvers minimize communication by removing the overhead due to pivoting in LU and $LDLT$ factorization. Different approaches to reduce communication are compared in [2].

See also the web page http://icl.cs.utk.edu/magma/.

4.10. cTuning: Repository and Tools for Collective Characterization and Optimization of Computing Systems

Participant: Grigori Fursin [correspondant].

Designing, porting and optimizing applications for rapidly evolving computing systems is often complex, ad-hoc, repetitive, costly and error prone process due to an enormous number of available design and optimization choices combined with the complex interactions between all components. We attempt to solve this fundamental problem based on collective participation of users combined with empirical tuning and machine learning.

We developed cTuning framework that allows to continuously collect various knowledge about application characterization and optimization in the public repository at cTuning.org. With continuously increasing and systematized knowledge about behavior of computer systems, users should be able to obtain scientifically motivated advices about anomalies in the behavior of their applications and possible solutions to effectively balance performance and power consumption or other important characteristics.

Currently, we use cTuning repository to analyze and learn profitable optimizations for various programs, datasets and architectures using machine learning enabled compiler (MILEPOST GCC). Using collected knowledge, we can quickly suggest better optimizations for a previously unseen programs based on their semantic or dynamic features [8].

We believe that such approach will be vital for developing efficient Exascale computing systems. We are currently developing the new extensible cTuning2 framework for automatic performance and power tuning of HPC applications.

For more information, see the web page http://cTuning.org.

HIEPACS Project-Team

5. Software and Platforms

5.1. Introduction

We describe in this section the software that we are developing. The first list will be the main milestones of our project. The other software developments will be conducted in collaboration with academic partners or in collaboration with some industrial partners in the context of their private R&D or production activities. For all these software developments, we will use first the various (very) large parallel platforms available through GENCI in France (CCRT, CINES and IDRIS Computational Centers), and next the high-end parallel platforms that will be available via European and US initiatives or projects such that PRACE.

5.2. MaPHyS

Participant: Emmanuel Agullo [corresponding member].

MaPHyS (Massivelly Parallel Hybrid Solver) is a software package whose prototype was initially developed in the framework of a PhD thesis and further consolidated first thanks to the ANR-CIS Solstice funding and the Inria Parscali ADT. This parallel linear solver couples direct and iterative approaches. The underlying idea is to apply to general unstructured linear systems domain decomposition ideas developed for the solution of linear systems arising from PDEs. The interface problem, associated with the so called Schur complement system, is solved using a block preconditioner with overlap between the blocks that is referred to as Algebraic Additive Schwarz.

The MaPHyS package is very much a first outcome of the research activity described in Section 3.3 . Finally, MaPHyS is a preconditioner that can be used to speed-up the convergence of any Krylov subspace method. We forsee to either embed in MaPHyS some Krylov solvers or to release them as standalone packages, in particular for the block variants that will be some outcome of the studies discussed in Section 3.3 .

MaPHyS can be found at http://maphys.gforge.inria.fr.

5.3. PaStiX

Participant: Pierre Ramet [corresponding member].

Complete and incomplete supernodal sparse parallel factorizations.

PaStiX (Parallel Sparse matriX package) is a scientific library that provides a high performance parallel solver for very large sparse linear systems based on block direct and block ILU(k) iterative methods. Numerical algorithms are implemented in single or double precision (real or complex): LLt (Cholesky), LDLt (Crout) and LU with static pivoting (for non symmetric matrices having a symmetric pattern).

The PaStiX library uses the graph partitioning and sparse matrix block ordering package Scotch. PaStiX is based on an efficient static scheduling and memory manager, in order to solve 3D problems with more than 50 million of unknowns. The mapping and scheduling algorithm handles a combination of 1D and 2D block distributions. This algorithm computes an efficient static scheduling of the block computations for our supernodal parallel solver which uses a local aggregation of contribution blocks. This can be done by taking into account very precisely the computational costs of the BLAS 3 primitives, the communication costs and the cost of local aggregations. We also improved this static computation and communication scheduling algorithm to anticipate the sending of partially aggregated blocks, in order to free memory dynamically. By doing this, we are able to reduce the aggregated memory overhead, while keeping good performance.

Another important point is that our study is suitable for any heterogeneous parallel/distributed architecture when its performance is predictable, such as clusters of multicore nodes. In particular, we now offer a high performance version with a low memory overhead for multicore node architectures, which fully exploits the advantage of shared memory by using an hybrid MPI-thread implementation.

Direct methods are numerically robust methods, but the very large three dimensional problems may lead to systems that would require a huge amount of memory despite any memory optimization. A studied approach consists in defining an adaptive blockwise incomplete factorization that is much more accurate (and numerically more robust) than the scalar incomplete factorizations commonly used to precondition iterative solvers. Such incomplete factorization can take advantage of the latest breakthroughs in sparse direct methods and particularly should be very competitive in CPU time (effective power used from processors and good scalability) while avoiding the memory limitation encountered by direct methods.

PaStiX is publicly available at http://pastix.gforge.inria.fr under the Inria CeCILL licence.

5.4. HIPS

Participant: Pierre Ramet [corresponding member].

Multilevel method, domain decomposition, Schur complement, parallel iterative solver.

HIPS (Hierarchical Iterative Parallel Solver) is a scientific library that provides an efficient parallel iterative solver for very large sparse linear systems.

The key point of the methods implemented in HIPS is to define an ordering and a partition of the unknowns that relies on a form of nested dissection ordering in which cross points in the separators play a special role (Hierarchical Interface Decomposition ordering). The subgraphs obtained by nested dissection correspond to the unknowns that are eliminated using a direct method and the Schur complement system on the remaining of the unknowns (that correspond to the interface between the sub-graphs viewed as sub-domains) is solved using an iterative method (GMRES or Conjugate Gradient at the time being). This special ordering and partitioning allows for the use of dense block algorithms both in the direct and iterative part of the solver and provides a high degree of parallelism to these algorithms. The code provides a hybrid method which blends direct and iterative solvers. HIPS exploits the partitioning and multistage ILU techniques to enable a highly parallel scheme where several subdomains can be assigned to the same process. It also provides a scalar preconditioner based on the multistage ILUT factorization.

HIPS can be used as a standalone program that reads a sparse linear system from a file ; it also provides an interface to be called from any C, C++ or Fortran code. It handles symmetric, unsymmetric, real or complex matrices. Thus, HIPS is a software library that provides several methods to build an efficient preconditioner in almost all situations.

HIPS is publicly available at http://hips.gforge.inria.fr under the Inria CeCILL licence.

5.5. LBC2

Participant: Aurélien Esnard [corresponding member].

LBC2 (Load-Balancing for Code Coupling) is a library providing different methods for partitioning or repartitioning graphs and hypergraphs. These methods are designed for effective communications during dynamic load balancing with a variable number of processors or coupled code interactions. Repartitioning is achieved with an enriched graph model partitioned using third-party partitioning tools, as Scotch, PaToH, METIS, Zoltan or Mondrian.

The framework is publicy available at Inria Gforge as a part of the MPICPL framework: http://mpicpl.gforge.inria.fr.

5.6. MPICPL

Participant: Aurélien Esnard [corresponding member].

MPICPL (MPI CouPLing) is a software library dedicated to the coupling of parallel legacy codes, that are based on the well-known MPI standard. It proposes a lightweight and comprehensive programing interface that simplifies the coupling of several MPI codes (2, 3 or more). MPICPL facilitates the deployment of these codes thanks to the *mpicplrun* tool and it interconnects them automatically through standard MPI inter-communicators. Moreover, it generates the universe communicator, that merges the world communicators of all coupled-codes. The coupling infrastructure is described by a simple XML file, that is just loaded by the *mpicplrun* tool.

MPICPL was developed by HIEPACS for the purpose of the ANR NOSSI. It uses advanced features of MPI2 standard. The framework is publicy available at Inria Gforge: http://mpicpl.gforge.inria.fr.

5.7. ScalFMM

Participant: Olivier Coulaud [corresponding member].

ScalFMM (Parallel Fast Multipole Library for Large Scale Simulations) is a software library to simulate N-body interactions using the Fast Multipole Method.

ScalFMM intends to offer all the functionalities needed to perform large parallel simulations while enabling an easy customization of the simulation components: kernels, particles and cells. It works in parallel in a shared/distributed memory model using OpenMP and MPI. The software architecture has been designed with two major objectives: being easy to maintain and easy to understand. There is two main parts: 1) the management of the octree and the parallelization of the method ; 2) the kernels. This new architecture allow us to easily add new FMM algorithm or kernels and new paradigm of parallelization. The code is extremely documented and the naming convention fully respected. Driven by its user-oriented philosophy, ScalFMM is using CMAKE as a compiler/installer tool. Even if ScalFMM is written in C++ it will support a C and fortran API soon.

The library offers two methods to compute interactions between bodies when the potential decays like $1/r$. The first method is the classical FMM based on spherical harmonic expansions and the second is the Black-Box method which is an independent kernel formulation (introduced by E. Darve at Stanford). With this method, we can now easily add new non oscillatory kernels in our library. For the classical method, two approaches are used to decrease the complexity of the operators. We consider either matrix formulation that allows us to use BLAS routines or rotation matrix to speed up the M2L operator.

The ScalFMM package is available at http://scalfmm.gforge.inria.fr

5.8. ViTE

Participant: Mathieu Faverge [corresponding member].

Visualization, Execution trace

ViTE is a trace explorer. It is a tool made to visualize execution traces of large parallel programs. It supports Pajé, a trace format created by Inria Grenoble, and OTF and OTF2 formats, developed by the University of Dresden and allows the programmer a simpler way to anlyse, debug and/or profile large parallel applications. It is an open source software licenced under CeCILL-A.

The ViTE software is available at http://vite.gforge.inria.fr and has been developed in collaboration with the Inria Bordeaux - Sud-Ouest SED team, Telecom SudParis and Inria Grenoble.

In the same context we also contribute to the EZtrace and GTG libraries in collaboration with F. Trahay from Telecom SudParis. EZTrace (http://eztrace.gforge.inria.fr) is a tool that aims at generating automatically execution trace from HPC programs. It generates execution trace files thanks to the GTG library (http://gtg.gforge.inria.fr) that can be later interpreted by visualization tools such as ViTE.

5.9. Other software

For the materials physics applications, a lot of development will be done in the context of ANR projects (NOSSI and OPTIDIS, see Section 4.1) in collaboration with LaBRI, CPMOH, IPREM, EPFL and with CEA Saclay and Bruyère-le-Châtel.

- **FAST**
  Participant: Olivier Coulaud [corresponding member].

  FAST is a linear response time dependent density functional program for computing the electronic absorption spectrum of molecular systems. It uses an O(N3) linear response method based on finite numerical atomic orbitals and deflation of linear dependence in atomic orbital product space. This version is designed to work with data produced by the SIESTA DFT code. The code produces as principal output a numerical absorption spectrum (complex part of the polarisability, loosely called the polarisability below) and a list of transition energies and oscillator strengths deduced from fitting Lorentzians to the numerical spectrum. Considering the absence of hybrid functionals in SIESTA and that concerning calculation of spectra, generalized gradient Hamiltonians are not usually considered to be notably better than the local density approximation, the present release of FAST works only with LDA, which despite its limitations, has provided useful results on the systems to which the present authors have applied it. The FAST library is available at http://people.bordeaux.inria.fr/coulaud/Softwares/FAST/index.html.

- **OptiDis**
  Participant: Olivier Coulaud [corresponding member].

  OptiDis is a new code for large scale dislocation dynamics simulations. its aim is to simulate real life dislocation densities (up until 5.10^{22} dislocations/m^{-2}) in order to understand plastic deformation and study strain hardening. The main application is to observe and understand plastic deformation on irradiated zirconium. Zirconium alloys is the first containment barrier against the dissemination of radioactive elements. More precisely, with neutron irradiated zirconium alloys we are talking of channeling mechanism, which mean to stick with the reality,more than tens of thousands of induced loops so 10^8 degrees of freedom in the simulation.

  The code is based on Numodis code developed at CEA Saclay and the ScalFMM library developed in our Inria project. The code is written in C++ language and using the last features of C++11. One of the main aspects is the hybrid parallelism MPI/OpenMP that gives the software the ability to scale on large cluster while the computation load rise. In order to achieve that, we use different level of parallelism. First of all, the simulation box is spread over MPI process, we then use a thinner level for threads, dividing the domain using an Octree representation. All theses parts are driven by the ScalFMM library. On the last level our data are stored in an adaptive structure absorbing dynamic of this kind of simulation and handling well task parallelism.

The two following packages are mainly designed and developed in the context of a US initiative led by ICL and to which we closely collaborate through the associate team MORSE.

- **PLASMA**
  Participant: Mathieu Faverge [corresponding member].

  The PLASMA (Parallel Linear Algebra for Scalable Multi-core Architectures) project aims to address the critical and highly disruptive situation that is facing the Linear Algebra and High Performance Computing community due to the introduction of multi-core architectures.

  The PLASMA ultimate goal is to create software frameworks that enable programmers to simplify the process of developing applications that can achieve both high performance and portability across a range of new architectures.

  The development of programming models that enforce asynchronous, out of order scheduling of operations is the concept used as the basis for the definition of a scalable yet highly efficient software framework for Computational Linear Algebra applications.

The PLASMA library is available at http://icl.cs.utk.edu/plasma.

- **PaRSEC/DPLASMA**
  Participant: Mathieu Faverge [corresponding member].

  PaRSEC Parallel Runtime Scheduling and Execution Controller, is a generic framework for architecture aware scheduling and management of micro-tasks on distributed many-core heterogeneous architectures. Applications we consider can be expressed as a Direct Acyclic Graph of tasks with labeled edges designating data dependencies. DAGs are represented in a compact problem-size independent format that can be queried on-demand to discover data dependencies in a totally distributed fashion. PaRSEC assigns computation threads to the cores, overlaps communications and computations and uses a dynamic, fully-distributed scheduler based on architectural features such as NUMA nodes and algorithmic features such as data reuse.

  The framework includes libraries, a runtime system, and development tools to help application developers tackle the difficult task of porting their applications to highly heterogeneous and diverse environment.

  DPLASMA (Distributed Parallel Linear Algebra Software for Multicore Architectures) is the leading implementation of a dense linear algebra package for distributed heterogeneous systems. It is designed to deliver sustained performance for distributed systems where each node featuring multiple sockets of multicore processors, and if available, accelerators like GPUs or Intel Xeon Phi. DPLASMA achieves this objective through the state of the art PaRSEC runtime, porting the PLASMA algorithms to the distributed memory realm.

  The PaRSEC runtime and the DPLASMA library are available at http://icl.cs.utk.edu/parsec.

KERDATA Project-Team

5. Software and Platforms

5.1. BlobSeer

Participants: Zhe Li, Rohit Saxena, 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) the OpenNebula IaaS cloud toolkit 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 *Technology Research Action* (ADT, *Action de recherche technologique*) started in November 2012 for two years, aiming at robustifying the BlobSeer software and making it a safely distributable product. This project is funded by Inria *Technological Development Office* (D2T, *Direction du Développement Technologique*). Loïc Cloatre, has been hired as a senior engineer for the second year of this project, as a successor of Zhe Li, starting in February 2014.

5.2. BlobSeer-WAN

Participants: Rohit Saxena, Alexandru Costan, Gabriel Antoniu.

Contact: Gabriel Antoniu.

Presentation: BlobSeer-WAN was initially designed as an extension of BlobSeer, targeting geographically distributed environments. With BlobSeer-WAN, the metadata is replicated asynchronously for low latency. There is a version manager on each site and vector clocks are used to allow collision detection and resolution under highly concurrent access. Several experiments have been conducted with this setup on the Grid'5000 testbed which have shown scalable metadata performance under geographically distributed environments. Currently, BlobSeer-WAN is integrated within BlobSeer, as a new release of the latter.

Users: BlobSeer-WAN has been preliminarily evaluated at University of Tsukuba (Japan) in the context of the FP3C project. BlobSeer-WAN is used as a storage backend for HGMDS, a multi master metadata server designed for a global distributed file system.

URL: http://blobseer.gforge.inria.fr./doku.php?id=ci:blobseer-wan

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

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

5.3. Damaris

Participants: Matthieu Dorier, Lokman Rahmani, 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, as well as direct (*in situ*) interactive visualization of the generated data.

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 in production 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 and registered with APP. Registration of the latest version with APP is in progress.

5.4. TomusBlobs

Participants: Radu Tudoran, Alexandru Costan, Gabriel Antoniu.

Contact: Gabriel Antoniu.

Presentation: TomusBlobs is a software library for concurrency-optimized data storage for data-intensive applications running on Azure clouds, including MapReduce applications. It is being developed by the KerData Inria Project-Team in the framework of the A-Brain MSR-Inria project. It uses the BlobSeer library.

Users: TomusBlobs has been preliminarily evaluated within the A-Brain project where it was used to execute a real-life application aiming to search for significant associations between brain images and genetics data. The TomusBlobs data-storage layer developed in the framework of the A-Brain MSR-Inria project was demonstrated to scale up to 1000 cores on 3 Azure data centers; it exhibits improvements in execution time up to 50 % compared to standard solutions based on Azure BLOB storage. Based on this storage infrastructure, the A-Brain project consortium has provided the first statistical evidence of the heritability of functional signals in a failed stop task in basal ganglia, using a ridge regression approach, while relying on the Azure cloud to address the computational burden.

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

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

5.5. Darshan-Ruby

Participant: Matthieu Dorier.

Contact: Matthieu Dorier.

Presentation: Darshan-Ruby is a Ruby extension to the Darshan scalable HPC I/O characterization tool (developed by the Mathematics and Computer Science division at Argonne National Lab). It simplifies the access to the contents of Darshan-generated log files, in an object-oriented manner through the Ruby scripting language.

Users: Darshan-Ruby is available as a Ruby gem package on the official Rubygems website (http://rubygems.org/), and is referenced on the Darshan website (http://www.mcs.anl.gov/research/projects/darshan/).

URL: http://darshan-ruby.gforge.inria.fr/

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

Status: This software is available on Inria's forge.

5.6. Derived software

Derived from BlobSeer, an additional platform is currently being developed within KerData: Pyramid, a software service for array-oriented active storage developed within the framework of Viet-Trung Tran's PhD thesis.

MESCAL Project-Team

5. Software and Platforms

5.1. Tools for cluster management and software development

Participant: Olivier Richard [correspondent].

The KA-Tools is a software suite developed by MESCAL for exploitation of clusters and grids. It uses a parallelization technique based on spanning trees with a recursive starting of programs on nodes. Industrial collaborations were carried out with Mandrake, BULL, HP and Microsoft.

KA-DEPLOY is an environment deployment toolkit that provides automated software installation and reconfiguration mechanisms for large clusters and light grids. The main contribution of KA-DEPLOY 2 toolkit is the introduction of a simple idea, aiming to be a new trend in cluster and grid exploitation: letting users concurrently deploy computing environments tailored exactly to their experimental needs on different sets of nodes. To reach this goal KA-DEPLOY must cooperate with batch schedulers, like OAR, and use a parallel launcher like TAKTUK (see below).

TAKTUK is a tool to launch or deploy efficiently parallel applications on large clusters, and simple grids. Efficiency is obtained thanks to the overlap of all independent steps of the deployment. We have shown that this problem is equivalent to the well known problem of the single message broadcast. The performance gap between the cost of a network communication and of a remote execution call enables us to use a work stealing algorithm to realize a near-optimal schedule of remote execution calls. Currently, a complete rewriting based on a high level language (precisely Perl script language) is under progress. The aim is to provide a light and robust implementation. This development is lead by the MOAIS project-team.

5.2. OAR: Batch scheduler for clusters and grids

Participant: Olivier Richard [correspondent].

The OAR project (see http://oar.imag.fr) focuses on robust and highly scalable batch scheduling for clusters and grids. Its main objectives are the validation of grid administration tools such as TAKTUK, the development of new paradigms for grid scheduling and the experimentation of various scheduling algorithms and policies.

The grid development of OAR has already started with the integration of best effort jobs whose purpose is to take advantage of idle times of the resources. Managing such jobs requires a support of the whole system from the highest level (the scheduler has to know which tasks can be canceled) down to the lowest level (the execution layer has to be able to cancel awkward jobs). OAR is perfectly suited to such developments thanks to its highly modular architecture. Moreover, this development is used for the CiGri grid middleware project.

The OAR system can also be viewed as a platform for the experimentation of new scheduling algorithms. Current developments focus on the integration of theoretical batch scheduling results into the system so that they can be validated experimentally.

5.3. CiGri: Computing resource Reaper

Participant: Olivier Richard [correspondent].

CiGri (see http://cigri.imag.fr/) is a middleware which gathers the unused computing resource from intranet infrastructure and makes it available for the processing of large set of tasks. It manages the execution of large sets of parametric tasks on lightweight grid by submitting individual jobs to each batch scheduler. It is s associated to the OAR resource management system (batch scheduler). Users can easily monitor and control their set of jobs through a web portal. CiGri provides mechanisms to identify job error causes, to isolate faulty components and to resubmit jobs in a safer context.

5.4. FTA: Failure Trace Archive

The Failure Trace Archive [11] is available at http://fta.inria.fr. Since Derrick Kondo left on sabbatical, the Failure Trace Archive has been migrated to University of Western Sidney, Australia (http://fta.scem.uws.edu.au/), which allows an easier management by his colleagues Bahman Javadi who was working as a post-doc in the MESCAL team while initializing the FTA.

With the increasing functionality, scale, and complexity of distributed systems, resource failures are inevitable. While numerous models and algorithms for dealing with failures exist, the lack of public trace data sets and tools has prevented meaningful comparisons. To facilitate the design, validation, and comparison of fault-tolerant models and algorithms, we led the creation of the Failure Trace Archive (FTA), an on-line public repository of availability traces taken from diverse parallel and distributed systems.

While several archives exist, the FTA differs in several respects. First, it defines a standard format that facilitates the use and comparison of traces. Second, the archive contains traces in that format for over 20 diverse systems over a time span of 10 years. Third, it provides a public toolbox for failure trace interpretation, analysis, and modeling. The FTA was released in November 2009. It has received over 11,000 hits since then. The FTA has had national and international impact. Several published works have already cited and benefited from the traces and tools of the FTA. Simulation toolkits for distributed systems, such as SimGrid (CNRS/Inria, France) and GridSim (University of Melbourne, Australia), have incorporated the traces to allow for simulations with failures.

5.5. SimGrid: simulation of distributed applications

Participants: Arnaud Legrand [correspondent], Lucas Mello Schnorr, Luka Stanisic, Augustin Degomme.

SimGrid (see http://simgrid.gforge.inria.fr/) is a toolkit that provides core functionalities for the simulation of distributed applications in heterogeneous distributed environments. The specific goal of the project is to facilitate research in the area of distributed and parallel application scheduling on distributed computing platforms ranging from simple network of workstations to Computational Grids.

5.6. TRIVA: interactive trace visualization

Participants: Lucas Mello Schnorr [correspondent], Arnaud Legrand.

TRIVA (see http://triva.gforge.inria.fr/) is an open-source tool used to analyze traces (in the Pajé format) registered during the execution of parallel applications. The tool serves also as a sandbox for the development of new visualization techniques. Some features include: Temporal integration using dynamic time-intervals; Spatial aggregation through hierarchical traces; Scalable visual analysis with squarified treemaps; A Custom Graph Visualization.

5.7. ψ and ψ^2: perfect simulation of Markov Chain stationary distributions

Participant: Jean-Marc Vincent [correspondent].

ψ and ψ^2 (see http://psi.gforge.inria.fr) are two software tools implementing perfect simulation of Markov Chain stationary distributions using *coupling from the past*. ψ starts from the transition kernel to derive the simulation program while ψ^2 uses a monotone constructive definition of a Markov chain.

5.8. GameSeer: simulation of game dynamics

Participant: Panayotis Mertikopoulos [correspondent].

Mathematica toolbox (graphical user interface and functions library) for efficient, robust and modular simulations of game dynamics.

5.9. Kameleon: environment for experiment reproduction

Participants: Olivier Richard [correspondent], Joseph Emeras.

Kameleon is a tool developed to facilitate the building and rebuilding of software environment. It helps the experimenter to manage his experiment's software environment which can include the operating system, libraries, runtimes, his applications and data. This tool is an element in the experimental process to obtain repeatable experiments and therefore reproducible results.

5.10. Platforms

5.10.1. Grid'5000

The MESCAL project-team is involved in development and management of Grid'5000 platform. The Digitalis and IDPot clusters are integrated in Grid'5000 as well as of CIMENT.

5.10.2. The ICluster-2, the IDPot and the new Digitalis Platforms

The MESCAL project-team manages a cluster computing center on the Grenoble campus. The center manages different architectures: a 48 bi-processors PC (ID-POT), and the center is involved with a cluster based on 110 bi-processors Itanium2 (ICluster-2) and another based on 34 bi-processor quad-core XEON (Digitalis) located at Inria. The three of them are integrated in the Grid'5000 grid platform.

More than 60 research projects in France have used the architectures, especially the 204 processors Icluster-2. Half of them have run typical numerical applications on this machine, the remainder has worked on middleware and new technology for cluster and grid computing. The Digitalis cluster is also meant to replace the Grimage platform in which the MOAIS project-team is very involved.

5.10.3. The Bull Machine

In the context of our collaboration with Bull the MESCAL project-team exploits a Novascale NUMA machine. The configuration is based on 8 Itanium II processors at 1.5 Ghz and 16 GB of RAM. This platform is mainly used by the Bull PhD students. This machine is also connected to the CIMENT Grid.

MOAIS Project-Team

5. Software and Platforms

5.1. KAAPI

Participants: Thierry Gautier [correspondant], Vincent Danjean, François Broquedis, Joao Ferreira Lima.

- ACM: D.1.3
- License: CeCILL
- OS/Middelware: Unix (Linux, MacOSX, ...)
- Programming language: C/C++, Fortran
- Characterization of Software : A-3 / SO-4 / SM-3 / EM-3 / SDL-4
- Own Contribution: DA-4 / CD-4 / MS-4 / TPM-4
- Additional information:

  Kaapi (http://kaapi.gforge.inria.fr, coordinator T. Gautier) is a middleware for high performance applications running on multi-cores/multi- processors as well as cluster or computational grid. Kaapi provides 1/ a very high level API based on macro data flow language; 2/ several scheduling algorithms for multi-threaded computations as well as for iterative applications for numerical simulation on multi-CPUs / multi-GPUs; 3/ fault-tolerant protocols. Publicly available at http://kaapi.gforge.inria.fr under CeCILL licence. Kaapi has won the 2008 Plugtest organized by Grid@Works. Kaapi provides ABI compliant implementations of Quark (PLASMA, Linear Algebra, Univ. of Tennesse) and libGOMP (GCC runtime for OpenMP). Direct competitors with 1/: Quark (UTK), OMPSs (UPC, BSC), OpenMP. Direct competitors with 2/: StarSs, StarPU (Inria RUNTIME). Direct competitors providing 3/: Charm++, MPI.

5.2. FlowVR

Participants: Bruno Raffin [correspondant MOAIS], Matthieu Dreher, Jérémy Jaussaud.

- ACM: D.1.3
- License: GPL and LGPL
- OS/Middelware: Unix (Linux, MacOSX, ...)
- Programming language: C/C++
- Characterization of Software : A-3 / SO-4 / SM-3 / EM-3 / SDL-4
- Own Contribution: DA-4 / CD-3 / MS-3 / TPM-4
- Additional information: FlowVR (http://flowvr.sf.net, coordinator B. Raffin) provides users with the necessary tools to develop and run high performance interactive applications on PC clusters and Grids. The main target applications include virtual reality, scientific visualization and in situ analytics. FlowVR enforces a modular programming that leverages software engineering issues while enabling high performance executions on distribued and parallel architectures. FlowVR is the reference backbone for Grimage. See also the web page http://flowvr.sf.net.

5.3. TakTuk - Adaptive large scale remote execution deployment

Participants: Guillaume Huard [correspondant], Pierre Neyron.

- Characterization of Software : A-2 / SO-3 / SM-5 / EM-3 / SDL-4
- Own Contribution: DA-4 / CD-4 / MS-4 / TPM-4
- Additional information:
  - web site: http://taktuk.gforge.inria.fr, Coordinator G. Huard
  - Objective of the software: TakTuk is a tool for deploying parallel remote executions of commands to a potentially large set of remote nodes. It spreads itself using an adaptive algorithm and sets up an interconnection network to transport commands and perform I/Os multiplexing/demultiplexing. The TakTuk mechanics dynamically adapt to environment (machine performance and current load, network contention) by using a reactive work-stealing algorithm that mixes local parallelization and work distribution.
  - Users community: TakTuk is a research open source project available in the Debian GNU/Linux distribution (package taktuk) used in lower levels of Grid5000 software architectures (nodes monitoring in OAR, environment diffusion in Kadeploy). The community is small : developers and administrators for large scale distributed platforms, but active.
  - Positioning: main competing tools are pdsh (but uses linear deployment) and gexec (not fault tolerant, requires installation), for more details : B. Claudel, G. Huard and O. Richard. TakTuk, Adaptive Deployment of Remote Executions. In Proceedings of the International Symposium on High Performance Distributed Computing (HPDC), 2009. TakTuk is the only tool to provide to deployed processes a communication layer (just like an MPIrun, but not tied to a specific environment) and synchronization capabilities.

5.4. Triva

Participant: Guillaume Huard [correspondant].

- Characterization of Software : A-2 / SO-4 / SM-5 / EM-3 / SDL-3
- Own Contribution: DA-4 / CD-3 / MS-3 / TPM-3
- Additional information:
  - web site: http://triva.gforge.inria.fr/, Coordinator, Lucas Schnorr
  - Objective of the software: Triva is an open-source tool used to analyze traces (in the pajé format) registered during the execution of parallel applications. The tool serves also as a sandbox to the development of new visualization techniques.
  - Users community: Research open source project, applications developers, especially parallel applications.
  - Positioning: Main competing tools are Vampir (classical 2D Gantt charts) and Tau (less advanced agregation techniques), more details in : A Hierarchical Aggregation Model to achieve Visualization Scalability in the analysis of Parallel Applications. Lucas Mello Schnorr, Guillaume Huard, Philippe Olivier Alexandre Navaux. Parallel Computing. Volume 38, Issue 3, March 2012.

5.5. OAR

Participants: Pierre Neyron [correspondant MOAIS], Grégory Mounié.

- Characterization of Software : A-5 / SO-3 / SM-4 / EM-4 / SDL-5
- Own Contribution: DA-3 / CD-2 / MS-1 / TPM-1
- Additional information: OAR (http://oar.imag.fr, Coordinator O. Richard, Inria MESCAL) is a batch scheduler. The MOAIS team develops the central automata and the scheduling module that includes successive evolutions and improvements of the policy.OAR is used to schedule jobs both on the CiGri (Grenoble region) and Grid50000 (France) grids. CiGri is a production grid that federates about 500 heterogeneous resources of various Grenoble laboratories to perform computations in physics. MOAIS has also developed the distributed authentication for access to Grid5000.

5.6. SOFA

Participant: Bruno Raffin [correspondant].

- ACM: D.1.3
- Programming language: C/C++
- Characterization of Software : A-5 / SO-4 / SM-4 / EM-4 / SDL-5
- Own Contribution: DA-2 / CD-2 / MS-1 / TPM-1
- Additional information: SOFA (http://www.sofa-framework.org/, Coordinator F. Faure, Inria IMAGINE) is an Open Source framework primarily targeted at real-time simulation, with an emphasis on medical simulation. It is mostly intended for the research community to help develop newer algorithms, but can also be used as an efficient prototyping tool. Moais contributes to parallelization of kernel algorithms used in the simulation.

5.7. LinBox

Participants: Clément Pernet [correspondant], Thierry Gautier.

- Characterization of Software : A-3 / SO-4 / SM-2 / EM-3 / SDL-5
- Own Contribution: DA-4 / CD-3 / MS-3 / TPM-4
- Additional information:
  - web site: http://linalg.org
  - Objective of the software: LinBox is an open-source C++ template library for exact, high-performance linear algebra computations. It is considered as the reference library for numerous computations (such as linear system solving, rank, characteristic polynomial, Smith normal forms,...) over finite fields and integers with dense, sparse, and structured matrices.
  - The LinBox group is an international collaboration (USA: NCSU, UDel; Canada: U Waterloo, U Calgary; France: LIP, LIRMM, LJK and LIG). Articles related to the library have been published in the main Conferences of the area: ISSAC, ICMS. MOAIS contributes to its development and more specifically to its parallelization in the context of ANR HPAC project. It is currently experiencing a major change of design, to better integrate parallelism.
  - Users community: mostly researchers doing computational mathematics (number theory, cryptology, group theory, persistent homology. They use the library by either linking against it directly (the library is packaged in Debian, Fedora, etc) or withing the general purpose math software Sage (sagemath.org very broad diffusion) which includes LinBox as a kernel for exact linear algebra.

ROMA Team

5. Software and Platforms

5.1. MUMPS

Participants: Patrick Amestoy, Alfredo Buttari, Jean-Yves L'Excellent [correspondent], Wissam M. Sid-Lakhdar, Bora Uçar.

MUMPS (for *MUltifrontal Massively Parallel Solver*) see http://mumps-solver.org is a software package for the solution of large sparse systems of linear equations. It implements a direct method, the so called multifrontal method; it is a parallel code capable of exploiting distributed-memory computers as well as multithreaded libraries; its main originalities are its numerical robustness and the wide range of functionalities available.

The latest public release is MUMPS 4.10.0 (May 2011).

The development of MUMPS was initiated by the European project PARASOL (Esprit 4, LTR project 20160, 1996-1999), whose results and developments were public domain. Since then, MUMPS has been supported by CERFACS, CNRS, ENS Lyon, INPT(ENSEEIHT)-IRIT, Inria, and University of Bordeaux. Following a contractual agreement signed by those institutes, the next release of MUMPS will be distributed under the Cecill-C license; a technical committee was also defined, currently composed of Patrick Amestoy, Abdou Guermouche, and Jean-Yves L'Excellent.

In the context of an ADT project (Action of Technological Development), Maurice Brémond (from Inria "SED" service in Grenoble) also worked part-time on the project, in particular on visualization tools helping researchers to analyze the behaviour of a parallel MUMPS execution.

More information on MUMPS is available on http://mumps-solver.org. See also Section 6.20 of this report.

RUNTIME Project-Team

5. Software and Platforms

5.1. Common Communication Interface

Participant: Brice Goglin.

- The *Common Communication Interface* aims at offering a generic and portable programming interface for a wide range of networking technologies (Ethernet, InfiniBand, ...) and application needs (MPI, storage, low latency UDP, ...).
- CCI is developed in collaboration with the *Oak Ridge National Laboratory* and several other academics and industrial partners.
- CCI is in early development and currently composed of 19 000 lines of C.
- http://www.cci-forum.org

5.2. Hardware Locality

Participants: Brice Goglin, Samuel Thibault.

- *Hardware Locality* (HWLOC) is a library and set of tools aiming at discovering and exposing the topology of machines, including processors, cores, threads, shared caches, NUMA memory nodes and I/O devices.
- It builds a widely-portable abstraction of these resources and exposes it to the application so as to help them adapt their behavior to the hardware characteristics.
- HWLOC targets many types of high-performance computing applications [2], from thread scheduling to placement of MPI processes. Most existing MPI implementations, several resource managers and task schedulers already use HWLOC.
- HWLOC is developed in collaboration with the OPEN MPI project. The core development is still mostly performed by Brice GOGLIN and Samuel THIBAULT from the RUNTIME team-project, but many outside contributors are joining the effort, especially from the OPEN MPI and MPICH2 communities.
- HWLOC is composed of 30 000 lines of C.
- http://runtime.bordeaux.inria.fr/hwloc/

5.3. Network Locality

Participant: Brice Goglin.

- *Netloc Locality* (HWLOC) is a library that extends hwloc to network topology information by assembling hwloc knowledge of server internals within graphs of inter-node fabrics such as Ethernet or Infiniband.
- HWLOC targets the same challenges as hwloc but focuses on a wider spectrum by enabling cluster-wide solutions such process placement.
- HWLOC is developed in collaboration with University of Wisconsin in LaCrosse and Cisco, within the OPEN MPI project.
- NETLOC is composed of 15 000 lines of C.
- http://netloc.org

5.4. KNem

Participant: Brice Goglin.

- KNEM (*Kernel Nemesis*) is a Linux kernel module that offers high-performance data transfer between user-space processes.
- KNEM offers a very simple message passing interface that may be used when transferring very large messages within point-to-point or collective MPI operations between processes on the same node.
- Thanks to its kernel-based design, KNEM is able to transfer messages through a single memory copy, much faster than the usual user-space two-copy model.
- KNEM also offers the optional ability to offload memory copies on INTEL I/O AT hardware which improves throughput and reduces CPU consumption and cache pollution.
- KNEM is developed in collaboration with the MPICH2 team at the Argonne National Laboratory and the OPEN MPI project. These partners already released KNEM support as part of their MPI implementations.
- KNEM is composed of 8 000 lines of C. Its main contributor is Brice GOGLIN.
- http://runtime.bordeaux.inria.fr/knem/

5.5. Open-MX

Participant: Brice Goglin.

- The OPEN-MX software stack is a high-performance message passing implementation for any generic ETHERNET interface.
- It was developed within our collaboration with Myricom, Inc. as a part of the move towards the convergence between high-speed interconnects and generic networks.
- OPEN-MX exposes the raw ETHERNET performance at the application level through a pure message passing protocol.
- While the goal is similar to the old GAMMA stack [42] or the recent iWarp [41] implementations, OPEN-MX relies on generic hardware and drivers and has been designed for message passing.
- OPEN-MX is also wire-compatible with Myricom MX protocol and interface so that any application built for MX may run on any machine without Myricom hardware and talk other nodes running with or without the native MX stack.
- OPEN-MX is also an interesting framework for studying next-generation hardware features that could help ETHERNET hardware become legacy in the context of high-performance computing. Some innovative message-passing-aware stateless abilities, such as multiqueue binding and interrupt coalescing, were designed and evaluated thanks to OPEN-MX [5].
- Brice GOGLIN is the main contributor to OPEN-MX. The software is already composed of more than 45 000 lines of code in the Linux kernel and in user-space.
- http://open-mx.org/

5.6. StarPU

Participants: Olivier Aumage, Andra Hugo, Nathalie Furmento, Raymond Namyst, Marc Sergent, Samuel Thibault, Pierre-André Wacrenier.

- STARPU permits high performance libraries or compiler environments to exploit heterogeneous multicore machines possibly equipped with GPGPUs or Xeon Phi processors.
- STARPU offers a unified offloadable task abstraction named codelet.In case a codelet may run on heterogeneous architectures, it is possible to specify one function for each architectures (e.g. one function for CUDA and one function for CPUs).

- StarPU takes care to schedule and execute those codelets as efficiently as possible over the entire machine. A high-level data management library enforces memory coherency over the machine: before a codelet starts (e.g. on an accelerator), all its data are transparently made available on the compute resource.
- StarPU obtains portable performances by efficiently (and easily) using all computing resources at the same time.
- StarPU also takes advantage of the heterogeneous nature of a machine, for instance by using scheduling strategies based on auto-tuned performance models.
- StarPU can also leverage existing parallel implementations, by supporting *parallel tasks*, which can be run concurrently over the machine.
- StarPU provides *scheduling contexts* which can be used to partition computing resources. Scheduling contexts can be dynamically resized to optimize the allocation of computing resources among concurrently running libraries.
- StarPU provides integration in MPI clusters through a lightweight DSM over MPI.
- StarPU provides a scheduling platform, which makes it easy to implement and experiment with scheduling heuristics
- StarPU comes with a plug-in for the GNU Compiler Collection (GCC), which extends languages of the C family with syntactic devices to describe StarPU's main programming concepts in a concise, high-level way.
- StarPU provides a scheduling platform, which makes it easy to implement and experiment with scheduling heuristics
- http://runtime.bordeaux.inria.fr/StarPU/

5.7. NewMadeleine

Participant: Alexandre Denis.

- NewMadeleine is communication library for high performance networks, based on a modular architecture using software components.
- The NewMadeleine optimizing scheduler aims at enabling the use of a much wider range of communication flow optimization techniques such as packet reordering or cross-flow packet aggregation.
- NewMadeleine targets applications with irregular, multiflow communication schemes such as found in the increasingly common application conglomerates made of multiple programming environments and coupled pieces of code, for instance.
- It is designed to be programmable through the concepts of optimization *strategies*, allowing experimentations with multiple approaches or on multiple issues with regard to processing communication flows, based on basic communication flows operations such as packet merging or reordering.
- The reference software development branch of the NewMadeleine software consists in 90 000 lines of code. NewMadeleine is available on various networking technologies: Myrinet, Infiniband, Quadrics and Ethernet. It is developed and maintained by Alexandre Denis.
- http://runtime.bordeaux.inria.fr/newmadeleine/

5.8. PadicoTM

Participant: Alexandre Denis.

- PadicoTM is a high-performance communication framework for grids. It is designed to enable various middleware systems (such as CORBA, MPI, SOAP, JVM, DSM, etc.) to utilize the networking technologies found on grids.
- PadicoTM aims at decoupling middleware systems from the various networking resources to reach transparent portability and flexibility.
- PadicoTM architecture is based on software components. Puk (the PadicoTM micro-kernel) implements a light-weight high-performance component model that is used to build communication stacks.
- PadicoTM component model is now used in NEWMADELEINE. It is the cornerstone for networking integration in the projects “LEGO” and “COOP” from the ANR.
- PadicoTM is composed of roughly 60 000 lines of C.
- PadicoTM is registered at the APP under number IDDN.FR.001.260013.000.S.P.2002.000.10000.
- http://runtime.bordeaux.inria.fr/PadicoTM/

5.9. MAQAO

Participants: Denis Barthou, Olivier Aumage, Tamara Meunier.

- MAQAO is a performance tuning tool for OpenMP parallel applications. It relies on the static analysis of binary codes and the collection of dynamic information (such as memory traces). It provides hints to the user about performance bottlenecks and possible workarounds.
- MAQAO relies on binary codes for Intel x86 and ARM architectures. For x86 architecture, it can insert probes for instrumention directly inside the binary. There is no need to recompile. The static/dynamic approach of MAQAO analysis is the main originality of the tool, combining performance model with values collected through instrumentation.
- MAQAO has a static performance model for x86 and ARM architectures. This model analyzes performance of the codes on the architectures and provides some feed-back hints on how to improve these codes, in particular for vector instructions.
- The dynamic collection of data in MAQAO enables the analysis of thread interactions, such as false sharing, amount of data reuse, runtime scheduling policy, ...
- MAQAO is in the European FP7 project ”MontBlanc” and in the Samsung GRO project ”Gepetto”.
- http://www.maqao.org/

5.10. QIRAL

Participants: Denis Barthou, Olivier Aumage.

- QIRAL is a high level language (expressed through LaTeX) that is used to described Lattice QCD problems. It describes matrix formulations, domain specific properties on preconditionings, and algorithms.
- The compiler chain for QIRAL can combine algorithms and preconditionings, checking validity of the composition automatically. It generates OpenMP parallel code, using libraries, such as BLAS.
- This code is developped in collaboration with other teams participating to the ANR PetaQCD project.

5.11. TreeMatch

Participants: Emmanuel Jeannot, Guillaume Mercier, François Tessier.

- TREEMATCH is a library for performing process placement based on the topology of the machine and the communication pattern of the application.
- TREEMATCH provides a permutation of the processes to the processors/cores in order to minimize the communication cost of the application.
- Important features are : the number of processors can be greater than the number of applications processes ; it assumes that the topology is a tree and does not require valuation of the topology (e.g. communication speeds) ; it implements different placement algorithms that are switched according to the input size.
- Some core algorithms are parallel to speed-up the execution.
- TREEMATCH is integrated into various software such as the Charm++ programming environment as well as in both major open-source MPI implementations: Open MPI and MPICH2.
- TREEMATCH is available at: http://treematch.gforge.inria.fr.

ASCOLA Project-Team

5. Software and Platforms

5.1. btrCloud (and Entropy)

Participants: Jean-Marc Menaud [correspondent], 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 performance, 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. The latter provides optimized quality of service properties for applications that are hosted in the virtualized datacenters.

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

5.2. EScala and JEScala

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

AOP, inheritance, event-based programming, events, declarative events, asynchronous events, join operator, Scala

EScala is an extension of the programming language Scala with support for events as object members. EScala combines ideas of event-driven, aspect-oriented and functional reactive programming.

Events are natural abstractions for describing interactive behavior as part of an object interface. In conventional object-oriented languages, events are implemented indirectly, typically using the Observer pattern. C# eliminates the corresponding glue code and directly supports events as object members. However, events are still *explicitly* triggered at specific locations within the program.

EScala goes much further. First, it also supports *implicit* events. Akin to join points in aspect-oriented languages, these events are implicitly produced at specific execution points, such as the beginning or the end of the execution of a method. Second, *declarative events* make it possible to compose events using logical operators as well as to filter them and alter their content.

EScala events are fully integrated with object-oriented features. An event is defined in the context of its owner object. Event definitions are inherited in subclasses and event uses are late-bound. Unlike typical aspect-oriented languages, EScala preserves object-oriented encapsulation and modular reasoning.

JEScala extends EScala with support for concurrent programming (see Sec. 6.2). Events can be declared as *asynchronous* so that their handling takes place concurrently. A new composition operator, the *join* operator, inspired by the join calculus, can also be used to synchronize the concurrent activities created by asynchronous events and communicate between them.

This is joint work with the Software Technology Group at TU Darmstadt.

Prototype implementations of these languages are available through http://www.stg.tu-darmstadt.de/research.

5.3. CSLA

Participants: Thomas Ledoux [correspondent], Yousri Kouki.

Service-level agreement, Cloud computing, elasticity

Verifying non-functional properties like performance, dependability, energy consumption and economical costs of Clouds is challenging today due to ad-hoc management in terms of Quality-of-Service (QoS). We believe that a differentiating element between Cloud computing environments will be the QoS and the service-level agreement (SLA) provided by the Cloud.

CSLA, the Cloud Service Level Agreement language, allows the definition of SLA properties for arbitrary Cloud services (XaaS). CSLA addresses QoS uncertainty in unpredictable and dynamic environment and provides a cost model of Cloud computing. Besides the standard formal definition of contracts – comprising validity, parties, services definition and guarantees/violations – CSLA is enriched with features, such as QoS degradation and an advanced penalty model, thus introducing fine-grained language support for Cloud elasticity management [13].

CSLA is available at http://www.emn.fr/z-info/csla.

5.4. SAdapt

Participants: Ronan-Alexandre Cherrueau [correspondent], Mario Südholt.

Service-oriented systems, distributed programming, event-based programming, workflow patterns

The SAdapt tool provides an implementation of workflow adaptation patterns and allows the transformation of service-oriented systems implemented using Apache's CXF service infrastructure in terms of high-level declarative service transformations. The transformations are defined using an expressive language that supports matching of the execution of service-based systems in terms of flexible patterns over service compositions.

The SAdapt tool has partially been developed and is employed in the A4Cloud EU project (see Sec. 8.2) as a basis for our work on the enforcement of accountability properties in complex cloud-based systems.

The SAdapt tool and its application, notably to the security hardening of service systems that use OAuth 2 for the authorization of resource accesses is available at http://a4cloud.gforge.inria.fr/doku.php?id=start:advservcomp.

FOCUS Project-Team

5. Software and Platforms

5.1. Jolie

Members of Focus have developed Jolie [8] (Java Orchestration Language Interpreter Engine, see http://www.jolie-lang.org/). Jolie is a service-oriented programming language. Jolie can be used to program services that interact over the Internet using different communication protocols. Differently from other Web Services programming languages such as WS-BPEL, Jolie is based on a user-friendly C/Java-like syntax (more readable than the verbose XML syntax of WS-BPEL) and, moreover, the language is equipped with a formal operational semantics. This language is used for the *proof of concepts* developed around Focus activities. For instance, contract theories can be exploited for checking the conformance of a Jolie program with respect to a given contract. A spin-off, called “Italiana Software”, has been launched around Jolie, its general aim is to transfer the expertise in formal methods for Web Services matured in the last few years onto Service Oriented Business Applications. The spin-off is a software producer and consulting company that offers service-oriented solutions (for instance, a “‘single sign-on” application) based on the Jolie language.

In 2013 the development of the Jolie language has mainly focused on tools for the programming environment and on the integration of the language with cloud infrastructure. More in detail, we have produced the following software.

- PaaSSOA. This is a prototype for the deployment of Jolie services in a cloud infrastructure. We have also worked on the integration of Jolie with the Drools engine. Drools is used in PaaSSOA for storing and managing monitor events from services.
- JEye. This is web GUI prototype for designing Jolie graphical workflows which can be deployed into PaaSSOA.
- WSOA. We have developed a SaaS (Software as a Service) layer for the publication of Jolie APIs using different formats (http, JSON, SOAP, XML, and so on). We have also enhanced some libraries for the integration between Jolie and GWT technology.

All the server side code of PaaSSOA, JEye and WSOA has been developed by using Jolie.

5.2. Others

Below we list some software that has been developed, or is under development, in Focus.

- *Deadlock analysis* We have prototyped a framework for statically detecting deadlocks in a concurrent object-oriented language with asynchronous method calls and cooperative scheduling of method activations (the language is inspired by the ABS language developed in the EU project HATS).

  Since this language features recursion and dynamic resource creation, deadlock detection is extremely complex and state-of-the-art solutions either give imprecise answers or do not scale.

  In order to augment precision and scalability we propose a modular framework that allows several techniques to be combined. The basic component of the framework is a front-end inference algorithm that extracts abstract behavioral descriptions of methods, called contracts, which retain resource dependency information. Then this algorithm is integrated with a number of possible different back-ends that analyze contracts and derive deadlock information. We have prototyped two such back-ends:

  1. an evaluator that computes a fixpoint semantics, and
  2. an evaluator using abstract model checking.

  The evaluator (1) is available at http://www.cs.unibo.it/~laneve/deadlock/index.html

The evaluator (2) is available at http://www.cs.unibo.it/~giachino/siteDat/index.php

- *CaReDeb* (http://proton.inrialpes.fr/~mezzina/deb/).

  Reversible debugging provides developers with a way to execute their applications both forward and backward, seeking the cause of an unexpected or undesired event. We have developed CaReDeb, the first prototype of a causal-consistent reversible debugger. Causal consistent here means that independent actions are undone independently, while dependent actions are undone in reverse order. This allows the programmer to concentrate on the threads responsible of the bug, independently of the actual interleaving. CaReDeb provides primitives that given a misbehavior, e.g., a variable has not the expected value, allow one to go back to the action responsible for it, e.g., the one that assigned the wrong value to the variable. Notably, the programmer has no need to know which thread the action belongs to, since this is found automatically by the debugger. The procedure can be iterated till the bug is found. CaReDeb targets a fragment of the language Oz, which is at the basis of Mozart. The considered fragment provides functional variables, procedures, threads, and asynchronous communication via ports.

- *AIOCJ* (http://www.cs.unibo.it/projects/jolie/aiocj.html).

  AIOCJ is a framework for programming adaptive distributed systems based on message passing. AIOCJ comes as a plugin for Eclipse, AIOCJ-ecl, allowing to edit descriptions of distributed systems as adaptive interaction-oriented choreographies (AIOC). From interaction-oriented choreographies the description of single participants can be automatically derived. Adaptation is specified by rules allowing to replace predetermined parts of the AIOC with a new behaviour. A suitable protocol ensures that all the participants are updated in a coordinated way. As a result, the distributed system follows the specification given by the AIOC under all changing sets of adaptation rules and environment conditions. In particular, the system is always deadlock-free.

- *METIS* (https://github.com/aeolus-project/metis)

  As partners of the Aeolus project we have developed a tool for the automatic synthesis of deployment plans. A deployment plan is a sequence of actions that, when performed, allows the deployment of a given configuration of components. METIS (Modern Engineered Tool for Installing Software systems) is a tool that enables one to automatically generate a deployment plan, starting from a description of the configuration following the Aeolus model. The software is open source. It is written entirely in OCaml and is about 3.5K lines of source code. The tool is based on theoretical results that guarantee its soundness and completeness, while maintaining polynomial computational complexity. Experimental results are encouraging as METIS looks quite effective in practice by handling problem instances with hundreds of components in less than a minute. This is a key ingredient in the solution to the automation problem addressed by the Aeolus project. The paper [48] is dedicated to the description of the tool, while [41] addresses the formal aspects of the technique.

The sofware below have not undergone substantial modifications during 2013

- *Croll-pi Interpreter* (http://proton.inrialpes.fr/~mlienhar/croll-pi/implem/).

  Croll-pi is a concurrent reversible language featuring a rollback operator to undo a past action (together with all the actions depending on it), and a compensation mechanism to avoid cycling by redoing the same action again and again. We have developed an interpreter for croll-pi using Maude.

  We used the interpreter to test the expressive power of croll-pi on various problems, including the 8-queen problem, error handling in an automotive scenario from the EU project Sensoria, and constructs for distributed error handling such as stabilizers.

- *IntML* is a functional programming language guaranteeing sublinear space bounds for all programs [50]. See the Activity Reports of previous years (in particular 2010) for more details.

- *Lideal* (http://lideal.cs.unibo.it/) is an experimental tool implementing type inference for dependently linear type systems. The tool reduces the problem of evaluating the complexity of PCF (i.e.

functional programs with primitive integers and recursive definitions) to checking a set of first-order inequalities for validity. The latter can then be handled through SMT solvers or put in a form suitable for managing them with tools such as CoQ.

OASIS Project-Team

5. Software and Platforms

5.1. ProActive

Participants: Françoise Baude, Denis Caromel, Ludovic Henrio, Fabrice Huet [correspondant], Bastien Sauvan.

ProActive (Proactive Parallel Suite) is a Java library (Source code under AGPL license) for parallel, distributed, and concurrent computing, also featuring mobility and security in a uniform framework. With a reduced set of simple primitives, ProActive provides a comprehensive API to simplify the programming of applications that are distributed on a Local Area Network (LAN), on cluster of workstations, Clouds, or on Internet Grids.

The library is based on an Active Object pattern that is a uniform way to encapsulate:

- a remotely accessible object,
- a thread,
- an actor with its own script,
- a server of incoming requests,
- a mobile and potentially secure agent.

and has an architecture to inter-operate with (de facto) standards such as Web Service, HTTP transport, ssh, Globus, etc.

ProActive is only made of standard Java classes, and requires **no changes to the Java Virtual Machine**, no preprocessing or compiler modification; programmers write standard Java code. Based on a simple Meta-Object Protocol, the library is itself extensible, making the system open for adaptations and optimisations. ProActive currently uses the RMI Java standard library as default portable transport layer, but others such as Ibis or HTTP can be used instead, in an adaptive way.

ProActive is particularly well-adapted for the development of applications distributed over the Internet, thanks to reuse of sequential code, through polymorphism, automatic future-based synchronisations, migration of activities from one virtual machine to another. The underlying programming model is thus innovative compared to, for instance, the well established MPI programming model.

In order to cope with the requirements of large-scale distributed and heterogeneous systems like the Grid, many features have been incorporated into ProActive, including support for many transport and job submission protocols, GCM component support, graphical visualization interface, object migration, distributed and non-functional exception handling, fault-tolerance and checkpointing mechanisms; file transfer capabilities, a job scheduler, a resource manager able to manage various hosting machines, support for JMX and OSGi capabilities, web service object exposition, an SCA personality, etc.

ProActive is a project of the former ObjectWeb, now OW2 Consortium. OW2 is an international consortium fostering the development of open-source middleware for cutting-edge applications: EAI, e-business, clustering, grid computing, managed services and more. For more information, refer to [39], [37] and to the web pages http://www.objectweb.org and http://proactive.inria.fr/.

ProActive management, distribution, support, and commercialisation is now ensured by the start-up company ActiveEon (http://www.activeeon.com), in the context of a collaboration with Inria and UNS.

This year, the OASIS team made the following extensions to the ProActive library:

- Implementations related to the multi-active object programming model: multi-active components, declarative request service priority.
- Extension of the support of non-functional aspects for component systems: scripting language for reconfiguration, interceptor components.

5.2. Vercors platform

Participants: Eric Madelaine, Ludovic Henrio, Bartlomiej Szejna, Alexandra Savu, Oleksandra Kulankhina, Dongqian Liu.

The Vercors tools (http://www-sop.inria.fr/oasis/Vercors) include front-ends for specifying the architecture and behaviour of components in the form of UML diagrams. We translate these high-level specifications, into behavioural models in various formats, and we also transform these models using abstractions. In a final step, abstract models are translated into the input format for various verification toolsets. Currently we mainly use the various analysis modules of the CADP toolset.

- We have finished conducting experiments within the Papyrus environment, aiming at the definition of a graphical specification environment combining some of the standard UML formalisms with a dedicated graphical formalism for the architecture of GCM components. We have concluded that Papyrus is not an appropriate environment for our purpose due to the fact that the software is very unstable and badly-documented.
- We have achieved this year a major port of the frontend of the Vercors, namely VCE, the Vercors Component Editor, that is now based on the Obeo Designer (Eclipse) platform (http://www.obeodesigner.com). The main motivation, and achievement of this port was to integrate editors for some existing UML formalisms (Class and State-machines) with our GCM architecture editor. The new version of Vercors Component Editor (VCE v.3) has an editor for the GCM Components diagrams integrated with the UML class and state-machines diagrams editors. It also includes a generator of the ADL v.2 specification of the GCM-based architecture and a diagrams validation module.

5.3. Open Simulation Architecture (OSA)

Participant: Olivier Dalle.

OSA stands for Open Simulation Architecture. OSA is primarily intended to be a federating platform for the simulation community: it is designed to favor the integration of new or existing contributions at every level of its architecture. The platform core supports discrete-event simulation engine(s) built on top of the ObjectWeb Consortium's Fractal component model. In OSA, the systems to be simulated are modeled and instrumented using Fractal components. In OSA, the event handling is mostly hidden in the controller part of the components, which alleviates noticeably the modeling process, but also eases the replacement of any part of the simulation engine. Apart the simulation engine, OSA aims at integrating useful tools for modeling, developing, experimenting, and analysing simulations. OSA is also a platform for experimenting new techniques and approaches in simulation, such as aspect oriented programming, separation of concerns, innovative component architectures, and so on.

5.4. BtrPlace

Participants: Fabien Hermenier, Vincent Kherbache, Huynh Tu Dang.

Btrplace (http://btrp.inria.fr) is an open source virtual machine (VM) placement algorithm for datacenters. BtrPlace has been designed to be extensible. It can be customized by plugins from third party developers to address new SLAs or optimization constraints. Its extensibility is possible thanks to a composable core reconfiguration algorithm implemented using Constraint Programming. BtrPlace is currently bundled with a catalog of more than 20 constraints to address performance, fault tolerance, isolation, infrastructure management or energy efficiency concerns. It is currently used inside the FSN project OpenCloudWare (http://opencloudware.org/) and the European project DC4Cities (http://dc4cities.eu/).

This year, the catalog of constraints has been augmented according to the needs expressed inside OpenCloudWare. It as also been upgraded to a support for *continuous constraints* [11], a safer restriction mode to ensure the constraints can be satisfied at any moment, even during a reconfiguration process. A significant effort has also been made to make BtrPlace more usable and visible thanks to frequent releases, software documentation, tutorials, and live demo.

5.5. EventCloud

Participants: Françoise Baude, Fabrice Huet, Laurent Pellegrino, Bastien Sauvan, Iyad Alshabani, Maeva Antoine, Amjad Alshabani, Justine Rochas, Michel Jackson de Souza.

EventCloud (http://eventcloud.inria.fr) is an open source middleware that aims to act as a distributed datastore for data fulfiling the W3C RDF specification (www.w3.org/RDF/). It allows storing and retrieving quadruples (RDF triples with context) through SPARQL but also managing events represented as quadruples. The EventCloud architecture is based on a structured P2P overlay network targetting high-performance elastic data processing. Consequently it aims to be deployed on infrastructures like grids, clouds, i.e. whose nodes acquisition and relinquishment can be dynamic and subject to a pay-per-use mode. Each node participating in the overlay networks constituting EventCloud instances is responsible for managing the storage of subsets of the events, and helps in matching potential looked up events and disseminating them in a collaborative manner. As such, each node is also potentially an event broker responsible for managing subscriptions and routing notifications.

The EventCloud middleware has been developed using the GCM/ProActive library embedding the most recent advances from the Multi-active Object model (see Section 6.1.1) and its implementation. Interactions from end user applications with an EventCloud instance can happen directly using Java APIs along the GCM/ProActive model, or they can be achieved through GCM interfaces exposed following the Web Services Notification specification. Web Services Notification (WSN) is a set of specifications from the OASIS consortium (www.oasis-open.org) that standardises the way Web Services interact using "Notifications" or "Events". They form the foundation for Event Driven Architectures built using Web Services.

The EventCloud middleware is currently used as a component within the platforms developed within ANR SocEDA (Section 7.1.1) and FP7 PLAY (Section 7.2.1.1) projects. A significant effort has also started to apply it in application domains from the BigData area, as in Intelligent Transportation Systems 7.2.2 .

PHOENIX Project-Team

5. Software and Platforms

5.1. DiaSuite: a Development Environment for Sense/Compute/Control Applications

Participants: Charles Consel [correspondent], Damien Martin-Guillerez, Milan Kabac, Paul Van Der Walt, Camille Manano, Adrien Carteron, Alexandre Spriet, Emilie Balland.

Despite much progress, developing a pervasive computing application remains a challenge because of a lack of conceptual frameworks and supporting tools. This challenge involves coping with heterogeneous devices, overcoming the intricacies of distributed systems technologies, working out an architecture for the application, encoding it in a program, writing specific code to test the application, and finally deploying it.

DIASUITE is a suite of tools covering the development life-cycle of a pervasive computing application:

- *Defining an application area.* First, an expert defines a catalog of entities, whether hardware or software, that are specific to a target area. These entities serve as building blocks to develop applications in this area. They are gathered in a taxonomy definition, written in the taxonomy layer of the DIASPEC language.
- *Designing an application.* Given a taxonomy, the architect can design and structure applications. To do so, the DIASPEC language provides an application design layer [31]. This layer is dedicated to an architectural pattern commonly used in the pervasive computing domain [27]. Describing the architecture application allows to further model a pervasive computing system, making explicit its functional decomposition.
- *Implementing an application.* We leverage the taxonomy definition and the architecture description to provide dedicated support to both the entity and the application developers. This support takes the form of a Java programming framework, generated by the DIAGEN compiler. The generated programming framework precisely guides the developer with respect to the taxonomy definition and the architecture description. It consists of high-level operations to discover entities and interact with both entities and application components. In doing so, it abstracts away from the underlying distributed technologies, providing further separation of concerns.
- *Testing an application.*DIAGEN generates a simulation support to test pervasive computing applications before their actual deployment. An application is simulated in the DIASIM tool, without requiring any code modification. DIASIM provides an editor to define simulation scenarios and a 2D-renderer to monitor the simulated application. Furthermore, simulated and actual entities can be mixed. This hybrid simulation enables an application to migrate incrementally to an actual environment.
- *Deploying a system.* Finally, the system administrator deploys the pervasive computing system. To this end, a distributed systems technology is selected. We have developed a back-end that currently targets the following technologies: Web Services, RMI, SIP and OSGI. This targeting is transparent for the application code. The variety of these target technologies demonstrates that our development approach separates concerns into well-defined layers.

This development cycle is summarized in the Figure 2 .

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

../../../../projets/phoenix/IMG/DevCycle.jpg

Figure 2. DIASUITE *Development Cycle*

5.1.1. DiaSpec: a Domain-Specific Language for Networked Entities

The core of the DIASUITE development environment is the domain specific language called DIASPEC and its compiler DIAGEN:

- DIASPEC is composed of two layers:
  - The *Taxonomy Layer* allows the declaration of entities that are relevant to the target application area. An entity consists of sensing capabilities, producing data, and actuating capabilities, providing actions. Accordingly, an entity description declares a data source for each one of its sensing capabilities. As well, an actuating capability corresponds to a set of method declarations. An entity declaration also includes attributes, characterizing properties of entity instances. Entity declarations are organized hierarchically allowing entity classes to inherit attributes, sources and actions. A taxonomy allows separation of concerns in that the expert can focus on the concerns of cataloging area-specific entities. The entity developer is concerned about mapping a taxonomical description into an actual entity, and the application developer concentrates on the application logic.
  - The *Architecture Layer* is based on an architectural pattern commonly used in the pervasive computing domain [27]. It consists of context components fueled by sensing entities. These components process gathered data to make them amenable to the application needs. Context data are then passed to controller components that trigger actions on entities. Using an architecture description enables the key components of an application to be identified, allowing their implementation to evolve with the requirements (*e.g.,* varying light management implementations in a controller component to optimize energy consumption).
- DIAGEN is the DIASPEC compiler that performs both static and runtime verifications over DIASPEC declarations and produces a dedicated programming framework that guides and eases the implementation of components. The generated framework is independent of the underlying distributed technology. As of today, DIAGEN supports multiple targets: Local, RMI, SIP, Web Services and OSGI.

5.1.2. DiaSim: a Parametrized Simulator for Pervasive Computing Applications

Pervasive computing applications involve both software and integration concerns. This situation is problematic for testing pervasive computing applications because it requires acquiring, testing and interfacing a variety of software and hardware entities. This process can rapidly become costly and time-consuming when the target environment involves many entities.

To ease the testing of pervasive applications, we are developing a simulator for pervasive computing applications: DIASIM. To cope with widely heterogeneous entities, DIASIM is parameterized with respect to a DIASPEC specification describing a target pervasive computing environment. This description is used to generate with DIAGEN both a programming framework to develop the simulation logic and an emulation layer to execute applications. Furthermore, a simulation renderer is coupled to DIASIM to allow a simulated pervasive system to be visually monitored and debugged. The simulation renderer is illustrated in Figure 3 .

../../../../projets/phoenix/IMG/Diasim.jpg

Figure 3. A screenshot of the DIASIM *simulator*

5.2. DiaSuiteBox: an Open Orchestration Platform

Participants: Julien Bruneau [correspondent], Damien Martin-Guillerez, Quentin Enard, Charles Consel.

The DiaSuiteBox platform runs an open-ended set of applications leveraging a range of appliances and web services. Our solution consists of a dedicated development environment, a certifying application store, and a lightweight runtime platform. This solution is based on the DIASUITE project.

DiaSuiteBox platform architecture The DiaSuiteBox platform can be embedded in a small plug-computer or deployed in the cloud. Thanks to the application store and the developer community, the platform is fed by a full offer of new innovative applications. During the submission process, an application is automatically analyzed and checked in order to be certified. The user is ensured the behavior of its applications are innocuous and correct with respect to the provided information. Finally, DiaSuiteBox provides an extensible software architecture. This allows the easily connect new device technologies to the platform. For example, the support for new wireless communication technologies such as Zigbee, Z-Wave or Sigfox can be easily added to the DiaSuiteBox platform.

More details can be found on the web page http://diasuitebox.inria.fr.

The iQSpot startup uses DiaSuiteBox as a software platform to ease the management of Smart Buildings. In this project, the DiaSuiteBox platform is first used to host building management functionalities such as lighting management, heating/ventilating/air conditioning management, energy efficiency monitoring. It is also used to host software drivers that allow the building management functionalities to interact with the connected devices deployed in buildings. These devices can use wired communication technologies such LonWorks, BACNet or KNX, as well as wireless communication technologies such as Z-Wave or Zigbee.

5.3. School+ Apps: Assistive tablet applications for school Inclusion

Participants: Charles Consel [correspondent], Charles Fage, Damien Martin-Guillerez, Camille Manano, Hélène Sauzéon.

College+ is a package of 7 applications. Three applications are assistive applications, guiding the child doing specific tasks. Three others are training applications made as serious games, addressing specific skills. The last application is a meta-application, comprising a link to the three training applications, with an access to statistics of their usage. For each application, data are separated from the design, meaning that every element of each application (pictures, texts, settings, etc.) can be changed at any time. Each application records a log file every interactions performed by the child.

Assistive applications :

- *Routines application.* This application shows a list of tasks, with a short description. After clicking the starting button, a specific slideshow is shown ; it decomposes a task into steps. For each step, a text and a picture can be displayed. Thumbnail of previous and next steps are also displayed. This application guides the child through classroom situations: entering classroom, taking school materials out of a backpack, writing notes, handling agenda, leaving the classroom.
- *Communication application.* With the same design, the assistance provided by this application targets to communicating situations inside the classroom. The application covers four scenarios addressing two interaction situations (initiating and answering the interaction) and two types of interlocutors (professor and classmate). For each scenario, different slideshows guide the child, depending on the goal of the interaction.
- *Emotion Regulation application.* This application aims to assist the child to self-regulate his/her emotions. Four simplified emoticons are proposed to the child to choose from: anger, sadness, joy and fear. Then, (s)he selects a level of intensity via a thermometer with a scale from 1 to 4. In response, the application delivers different multimedia contents according to the level selected to help the child regulate his/her emotions. Typically, a text (breathing instructions) are shown at level 1, pictures at level 2, a video at level 3 and another text at level 4.

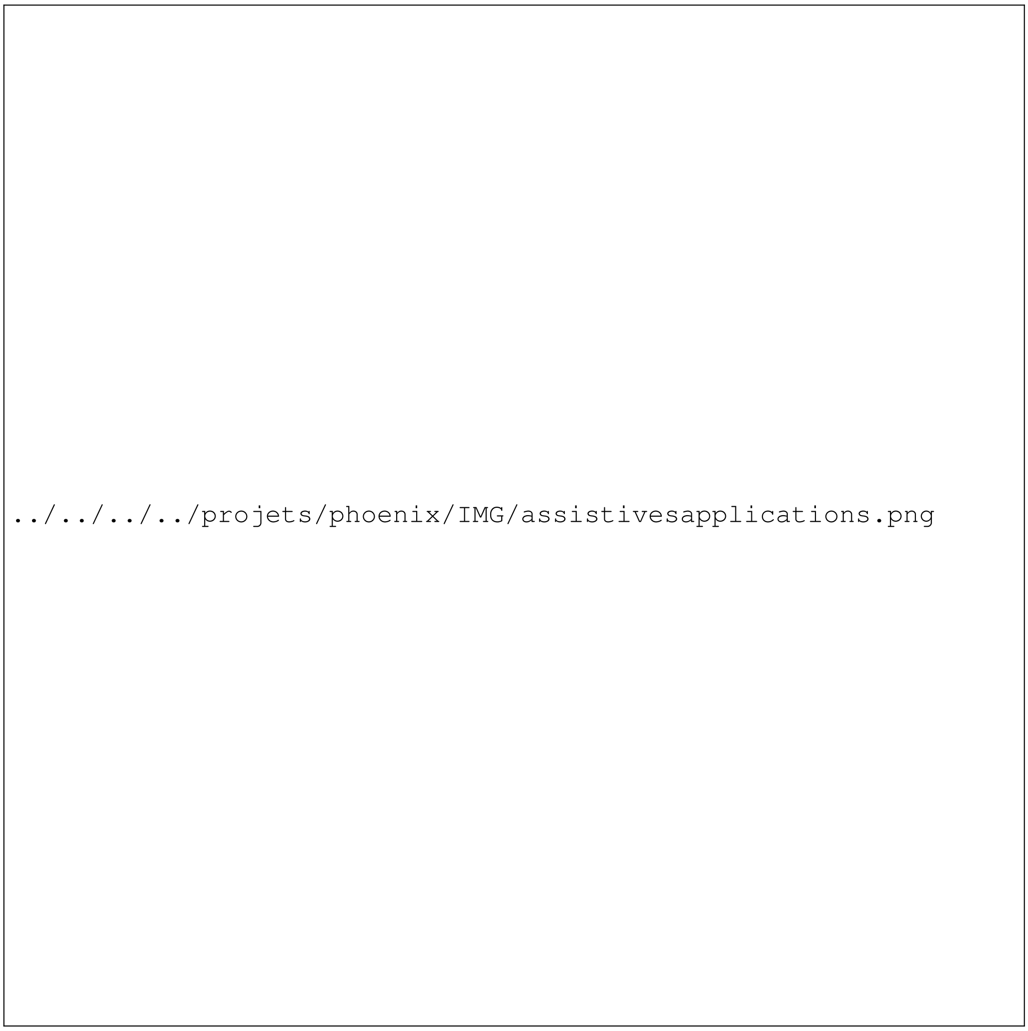

Figure 4. Assistive applications

Figure 5. Assistive applications

Training applications: These three applications are serious games with increasing levels of difficulties, reachable after a ratio of good answers has been attained.

- *Emotion Recognition application: pictures*. In this application, the child is instructed to identify a specific emotion among 4 pictures showing different people exhibiting an emotion. Seven emotions are involved in this application: joy, sadness, fear, anger, surprise, disgust and neutral. The emotion to be recognized is displayed together with its simplified emoticon. The type of pictures changes with the difficulty level: level 1 contains pictures of unfamiliar people and level 2 contains pictures of friends and relatives of the child.
- *Emotion Recognition application: videos*. In this application, the child is presented with a fragment of an animated cartoon. At some point, the video stops and the child is asked to identify the emotion of the character. Four emotions are involved in this application: joy, sadness, fear and anger. Videos are slowed down, with a speed percentage that can be changed at each level. Videos change with difficulty level: level 1 contains videos of a very basic cartoon (only one cartoon character drawn by basic form un-textured), level 2 contains a video of more sophisticated cartoons and level 3 contains movies with actors.
- *Attention Training*. In this application, the child is presented a picture of a face and asked to make eye contact with it. Second, a symbol appears briefly in the eyes of the character. Third, the child is asked to identify the symbol shown in the previously displayed picture, to make sure he kept eye contact. The speed at which the symbol appears and disappears is changed according to the difficulty level. Types of pictures also change with the level : level 1 contains pictures of faces and level 2 contains pictures of classroom situations.

RMOD Project-Team

5. Software and Platforms

5.1. Moose

Participants: Stéphane Ducasse [correspondant], Muhammad Bhatti, Andre Calvante Hora, Nicolas Anquetil, Anne Etien, Guillaume Larcheveque, Tudor Gîrba [University of Bern].

Web: http://www.moosetechnology.org/

The platform. Moose is a language-independent environment for reverse- and re-engineering complex software systems. Moose provides a set of services including a common meta-model, metrics evaluation and visualization, a model repository, and generic GUI support for querying, browsing and grouping. The development of Moose began at the Software Composition Group in 1997, and is currently contributed to and used by researchers in at least seven European universities. Moose offers an extensible meta-described metamodel, a query engine, a metric engine and several visualizations. Moose is currently in its fourth major release and comprises 55,000 lines of code in 700 classes.

The RMoD team is currently the main maintainer of the Moose platform. There are 200 publications (journal, international conferences, PhD theses) based on execution or use of the Moose environment.

The first version running on top of Pharo (Moose 4.0) was released in June 2010. In 2013, three releases of Moose where done: 4.7 to 4.9. The current focus is Moose 5.0, which is running on Pharo3 and will be released together with Pharo3 in spring 2014.
Here is the self-assessment of the team effort following the grid given at http://www.inria.fr/institut/organisation/instances/commission-d-evaluation.

- **(A5)** Audience : 5 – Moose is used by several research groups, a consulting company, and some companies using it in ad-hoc ways.
- **(SO4)** Software originality : 4 – Moose aggregates the last results of several research groups.
- **(SM4)** Software Maturity : 4 – Moose is developed since 1996 and got two main redesign phases.
- **(EM4)** Evolution and Maintenance : 4 – Moose will be used as a foundation of our Synectique start up so its maintenance is planned.
- **(SDL4)** Software Distribution and Licensing : 4 – Moose is licensed under BSD
- **(OC)** Own Contribution : (Design/Architecture)DA-4, (Coding/Debugging)-4, (Maintenance/Support)-4, (Team/Project Management)-4

5.2. Pharo

Participants: Marcus Denker [correspondant], Damien Cassou, Stéphane Ducasse, Esteban Lorenzano, Damien Pollet, Igor Stasenko, Camillo Bruni, Camille Teruel, Clément Bera.

Web: http://www.pharo.org/

The platform. Pharo is a new open-source Smalltalk-inspired language and environment. It provides a platform for innovative development both in industry and research. By providing a stable and small core system, excellent developer tools, and maintained releases, Pharo's goal is to be a platform to build and deploy mission critical applications.

The first stable version, Pharo 1.0, was released in 2010. The development of Pharo accelerated in 2011 and 2012: Versions 1.2 to 1.4 have been released (with more than 2400 closed issues). In 2013, Pharo 2.0 was released. The development cycle will now be one major release per year, with Pharo3 to be released in March 2014.

In 2012, RMoD organized the first *Pharo Conference* during two days in May with 60 participants, the second Pharo conference was held in Bern, Switzerland in 2013.

Additionally, in November 2012 RMoD launched the Pharo Consortium (http://consortium.pharo.org/) and the Pharo Association (http://association.pharo.org). Over 10 companies are now paying members of the Consortium.

RMoD is the main maintainer and coordinator of Pharo.
Here is the self-assessment of the team effort following the grid given at http://www.inria.fr/institut/organisation/instances/commission-d-evaluation.

- **(A5)** Audience: 5 – Used in many universities for teaching, more than 25 companies.
- **(SO3)** Software originality : 3 – Pharo offers a classical basis for some aspects (UI). It includes new frameworks and concepts compared to other Smalltalk implementations.
- **(SM4)** Software Maturity: 4 – Bug tracker, continuous integration, large test suites are on place.
- **(EM4)** Evolution and Maintenance: 4 – Active user group, consortium and association had just been set up.
- **(SDL4)** Software Distribution and Licensing: 4 – Pharo is licensed under MIT.
- **(OC5)** Own Contribution: (Design/Architecture) DA-5, (Coding/Debugging) CD-5, (Maintenance/Support) MS-5, (Team/Project Management) TPM-5

5.3. Fuel

Participants: Martin Dias [Correspondant], Mariano Martinez-Peck.

Web: http://rmod.lille.inria.fr/web/pier/software/fuel

Objects in a running environment are constantly being born, mutating their status and dying in the volatile memory of the system. The goal of serializers is to store and load objects either in the original environment or in another one. Fuel is a general-purpose serializer based on four principles: (1) speed, through a compact binary format and a pickling algorithm which obtains the best performance on materialization; (2) good object-oriented design, without any special help from the virtual machine; (3) specialized for Pharo, so that core objects (such as contexts, block closures and classes) can be serialized too; (4) flexible about how to serialize each object, so that objects are serialized differently depending on the context.

Since Pharo 2.0, Fuel is part of the standard distribution.
Here is the self-assessment of the team effort following the grid given at http://www.inria.fr/institut/organisation/instances/commission-d-evaluation.

- **(A4)** Audience: 4 – Large audience software, usable by people inside and outside the field with a clear and strong dissemination, validation, and support action plan.
- **(SO3)** Software originality : 3.
- **(SM4)** Software Maturity: 4 – Bug tracker, continuous integration, large test suites are on place.
- **(EM4)** Evolution and Maintenance: 4.
- **(SDL4)** Software Distribution and Licensing: 4 – Fuel is licensed under MIT.
- **(OC5)** Own Contribution: (Design/Architecture) DA-5, (Coding/Debugging) CD-5, (Maintenance/Support) MS-5, (Team/Project Management) TPM-5

5.4. Athens

Participant: Igor Stasenko [Correspondant].

Athens is a vector graphics framework for Pharo. Athens is now part of Pharo since version 3 as a technology Preview. We plan to make Athens the default graphics framework with Pharo4 in 2015.

5.5. Citezen

Participants: Damien Pollet [Correspondant], Stéphane Ducasse.

Web: http://people.untyped.org/damien.pollet/software/citezen/

Citezen is a suite of tools for parsing, validating, sorting and displaying BibTeX databases. This tool suite is integrated within the Pier Content Management System (CMS) and both are implemented on top of Pharo. Citezen aims at replacing and extending BibTeX, in Smalltalk; ideally, features would be similar to BibTeX, CrossTeX, and CSL.

5.6. Handles

Participant: Jean-Baptiste Arnaud [Correspondant].

Web: http://jeanbaptiste-arnaud.eu/handles/

An Handle is a first-class reference to a target object. Handles can alter the behavior and isolate the state of the target object. Handles provide infrastructure to automatically create and wrap new handles when required. A real-time control of handles is possible using a special object called metaHandle.

5.7. Hazelnut

Participants: Guillermo Polito [Correspondant], Benjamin Van Ryseghem, Nicolas Paez, Igor Stasenko.

Web: http://rmod.lille.inria.fr/web/pier/software/Seed

Traditionally, Smalltalk-based systems are not bootstrapped because of their ability to evolve by self-modification. Nevertheless, the absence of a bootstrap process exposes many problems in these systems, such as the lack of reproducibility and the impossibility to reach certain evolution paths. Hazelnut is a tool that aims to introduce a bootstrap process into these systems, in particular Pharo.

5.8. LegacyParsers

Participants: Muhammad Bhatti [Correspondant], Nicolas Anquetil, Guillaume Larcheveque, Esteban Lorenzano, Gogui Ndong.

As part of our research on legacy software and also for the Synectique company), we started to define several parsers for old languages like Cobol for example. This work is important to help us validate our meta-model and tools against a larger range of existing technologies and to discover the limits of our approach. From our initial results, and the in-depth understanding that it gave us, we are formulating new research objectives in meta-model driven reverse engineering. This work is also important for the spin-off company, as being able to work with such technologies is fundamental.

5.9. Mate

Participants: Marcus Denker [Correspondant], Clement Bera, Camillo Bruni.

Mate is the future research-oriented virtual machine for Pharo. Its goal is to serve as a prototype for researchers to experiment with. As a result, the design of Mate is very simple to understand. As of today, Mate consists of an AST interpreter, a new object memory layout, and a simple garbage collector.

5.10. NativeBoost

Participant: Igor Stasenko [Correspondant].

Web: http://code.google.com/p/nativeboost/

NativeBoost is a Smalltalk framework for generating and running machine code from the language side of Pharo. As part of it comes a foreign function interface that enables calling external C functions from Smalltalk code with minimal effort.

5.11. Nabujito

Participants: Camillo Bruni [Correspondant], Marcus Denker.

Nabujito is an experimental Just In Time compiler implemented as a Smalltalk application, based on NativeBoost, that does not require changes in the virtual machine.

5.12. Nautilus

Participants: Benjamin Van Ryseghem [Correspondant], Stéphane Ducasse, Igor Stasenko, Camillo Bruni, Esteban Lorenzano.

Nautilus is a new source code browser based on the latest infrastructure representations. Its goal is mainly to replace the current system browser that was implemented in the 80s and that doesn't provide optimal tools for the system as it has evolved.

5.13. Spec

Participants: Benjamin Van Ryseghem [Correspondant], Stéphane Ducasse, Johan Fabry.

Spec is a programming framework for generating graphical user interfaces inspired by VisualWorks' Subcanvas. The goal of Spec is to tackle the lack of reuse experienced in existing tools. Spec serves as a pluggable layer on top of multiple lower-level graphical frameworks. Many improvements have been noticed in Pharo after the introduction of Spec in terms of speed or number of lines of code while we re-implemented existing tools using Spec.

TRISKELL Project-Team

5. Software and Platforms

5.1. Kermeta

Participants: Didier Vojtisek [correspondant], Olivier Barais, Arnaud Blouin, Benoit Combemale, Fabien Coulon, Thomas Degueule, François Fouquet, David Mendez Acuna, Clément Guy, Jean-Marc Jézéquel.

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 highlighting, 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,...

After a first refactoring of Kermeta in 2011 to ease the integration of EMF and to focus on a fully compiled mode, we did a new refactoring of Kermeta in 2013 to leverage on xTend. The Kermeta action language is now defined as an extension of xTend proposing model-specific features (e.g., model type, containment, opposite) and an open class mechanism for aspect weaving. The main objective of this new refactoring was to benefit from the model-non-specific features of xTend (including the basics of the action language and its respective tooling such as editor, type checker and compiler), and to focus in our development on the innovative solutions for MDE.

Especially, in addition to an xTend extension dedicated to model manipulation, we started to integrate in Kermeta various facilities to support a software language engineering (slicing, pruning, reuse, variability management...).

Moreover, while this version of Kermeta is a DSML development workbench that provide good support for developing independent DSMLs, little or no support is provided for integrated use of multiple DSMLs. The lack of support for explicitly relating concepts expressed in different DSMLs makes it very difficult for developers to reason about information spread across models describing different system aspects.

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 model polymorphism (e.g., reuse of algorithms and transformations accross diffrent metamodels), as well as language inheritance, evolution and interoperability.

Impact:

Kermeta is already quite well used by the community as a research platform for trying MDE ideas both in the academic community and in corporate R&D. Many softwares tools are built on top of Kermeta either within the Triskell team, within other Inria teams or in other companies and research institutes:

- The following tools have been built within the Triskell team : K-CVL (implementation of the OMG CVL standard), Kompren (model slicing tool), Malai, Pramana. Kermeta is also used in all the collaborative projects Triskell is involved with, and is the catalyst of many collaborations in industrial contracts.
- The following tools have been built using Kermeta (or use some transformations written in Kermeta) in other Inria teams:
  - Gecos (CAIRN): C compiler infrastructure following the Model Driven Engineering. It leverages the Eclipse Modeling Framework and uses Eclipse as an underlying infrastructure. Consequently, the grammar of the source languages and the intermediate representations become metamodels, and the compilation passes become model transformations.
  - Timesquare (AOSTE) is a language based on the formal Clock Constraint Specification Language (CCSL), which allows the manipulation of logical time.
  - Polychrony (ESPRESSO) is a toolset for a polychronous data-flow language (Signal)
- The following tools have been built using Kermeta outside of Inria:
  - Modhel'x (Supelec) is a framework for simulating multi-formalism models.
  - RAM (Mc Gill University) Reusable Aspect Models is an aspect-oriented multi-view modeling approach that integrates class diagram, sequence diagram and state diagram AOM techniques.

Since 2008, we invested a large effort to transfer these concepts in industry and the standardization bodies. Especially, we have initiated some collaborations with the Eclipse Foundation and OMG to include some Kermeta concepts (model typing, static introduction, ECORE/OCL/Kermeta composition, etc.) in the MXF project proposal [1] of the Eclipse Modeling Project.

According to google scholar [2], the Kermeta platform was used or cited in more than 800 papers. It has been downloaded about 1000 times per year since 2006[3].

[1] cf. http://www.eclipse.org/proposals/mxf

[2] http://scholar.google.fr/scholar?q=kermeta+model

[3] according to the unique visitors count on the Kermeta update site. Cf. http://kermeta.org/awstats.pl?month=all&year=2010&output=main&config=kermeta.org

5.2. Kevoree

Participants: Olivier Barais [correspondant], François Fouquet, Erwan Daubert, Jean-Émile Dartois, Johann Bourcier, Noël Plouzeau, Maxime Tricoire, Francisco-Javier Acosta Padilla, Jacky Bourgeois, Mohamed Boussaa, Antonio de Mattos, Thomas Degueule, Inti Gonzalez Herrera, Tam Le Nhan, Ivan Paez Anaya.

Kevoree is an open-source models@runtime platform [4] to properly support the dynamic adaptation of distributed systems. Models@runtime basically pushes the idea of reflection [85] 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 [85] and the Entimid project [86]. With Kevoree we push our vision of models@runtime [84] 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 [5].
- SpringSource Dynamic Module [6]
- GCM-Proactive [7]
- OSGi [8]
- Chef [9]
- Vagran [10]

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:

A tutorial have been performed at the Middleware conference in december 2013.

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.

[4] http://www.kevoree.org
[5] http://frascati.ow2.org
[6] http://docs.spring.io/osgi/docs/1.2.1/reference/html/
[7] http://proactive.inria.fr/
[8] http://www.osgi.org
[9] http://wiki.opscode.com/display/chef/Deploy+Resource
[10] http://vagrantup.com/

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 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, Kotlin, Javascript

5.3. FAMILIAR

Participants: Mathieu Acher [correspondant], Olivier Barais, Guillaume Bécan, Aymeric Hervieu, Julien Richard-Foy, Sana Ben Nasr, Edward Mauricio Alferez Salinas, João Ferreira Filho, Didier Vojtisek, Benoit Baudry.

Modeling and reasoning about configuration options is crucial for the effective management of configurable software systems and product lines. The FAMILIAR project provides dedicated languages, APIs, and comprehensive environments for that purpose. Specifically, FAMILIAR provides support for feature models (by far the most popular notation). There are more than 20 years of research [75] and the formalism of feature models is widely used in the industry [76]. FAMILIAR (for FeAture Model scrIpt Language for manIpulation and Automatic Reasoning) provides a scripting language for importing, exporting, composing, decomposing, editing, configuring, computing "diffs", refactoring, reverse engineering, testing, and reasoning about (multiple) feature models. For interoperability, many bridges with existing feature modeling languages are implemented. All these operations can be combined to realize complex variability management tasks: extraction of feature models from software artifacts [23], product line evolution [35], management of multiple models [34], model-based validation of SPLs [49], large scale configuration of feature models [68], etc. The level of maturity of the Familiar platform is TRL 3 (New technology tested Prototype built and functionality demonstrated through testing over a limited range of operating conditions. These tests can be done on a scaled version if scalable)

Main competitors:

- FAMA
- TVL
- Clafer
- pure::variants

Main innovative features:

- reverse engineering of variability models from multiple kinds of artefacts
- composition of multiple variability models (e.g., for combining different sources of variability)
- slicing of variability model (e.g., for scheduling a configuration process in different steps)
- connection with the Common Variability Language (CVL)

Impact:

The results are connected to the CVL standardization initiative. From a research perspective, FAMILIAR helps to support all the research activity on variability modeling (e.g., design of new operators, benchmarking). Several tutorials have been performed at SPLC (the major conference in software product lines), at ECOOP, at CIEL and MODELS in 2012 and 2013. FAMILIAR is also used in the context of teaching activities. From an industrial perspective, the languages and tools have already been applied in practical contexts in different application domains (medical imaging, video surveillance, system engineering, web configurators, etc.) and for various purposes. This platform is also used for supporting the transfer activity with company such as Thales or Kereval. FAMILIAR is currently involved in different research projects (in the Merge Itea project, in the MOTIV project, in the VaryMDE project).

FAMILIAR is distributed under the terms of the LGPL and EPL open source license.

See also the web page http://familiar-project.github.com.

- Version: 1.2
- Programming language: Java, Scala

COATI Project-Team

5. Software and Platforms

5.1. Grph

Participants: David Coudert, Luc Hogie [correspondant], Aurélien Lancin, Issam Tahiri, Michel Syska.

Around 20,000 lines of code, developed in Java, and licensed under LGPL. See http://grph.inria.fr.

The objective of GRPH is to provide researchers and engineers a suitable graph library for graph algorithms experimentation and network simulation. GRPH is primarily a software library, but it also comes with a set of executable files for user interaction and graph format conversion; as such, it can be used autonomously. Performance and accessibility are the primary targets of the GRPH library. It allows manipulating large graphs (millions of nodes). Its model considers mixed graphs composed of directed and undirected simple- and hyper-edges. GRPH comes with a collection of graph algorithms which is regularly augmented.

GRPH includes bridges to other graph libraries such as JUNG, JGraphT, CORESE (a software developed by the WIMMICS team Inria-I3S), LAD (Christine Solnon, LIRIS), Nauty (Brendan D. McKay), SageMath, as well as specific algorithms developed by Matthieu Latapy and Jean-Loup Guillaume (LIP6), etc.

In 2013, we have added several graph algorithms to GRPH (e.g., subgraph isomorphism, subgraph search as sets or regular expressions, transitive closure, etc.). In particular, a significant effort has been put on the support for paths with multiple data-structures for more efficient in-memory representation of paths, and the implementation of algorithms for the enumeration of paths, the characterization of paths, the computation of the k-shortest paths, etc. Furthermore, we have improved the support of weigths in graphs and developed software bridges to SageMath and OGDF. We have also added several models (link-failures, node mobility) for graph dynamics using the discrete-event simulator included in GRPH, as well as models for the development of decentralized algorithms (useful for instance for the simulation of routing schemes). Finally, we have redesigned the website which now includes a forum gathering the community of users.

5.2. SageMath

Participant: David Coudert.

Sagemath is a free open-source mathematics software aiming at becoming an alternative to Maple and Matlab. Initially created by William Stein (Professor of mathematics at Washington University), Sagemath is currently developed by more than 180 contributors around the world (mostly researchers) and its source code, developed in Python, Cython, and C++, has reached 350 MB.

It is of interest for COATI members because it combines a large collection of graph algorithms with various libraries in algebra, calculus, combinatorics, linear programming, statistics, etc. We use SageMath for quickly testing algorithms, analyzing graphs, and disseminating algorithms. We also use it for teaching purposes in the Master 2 IFI, stream UBINET.

In 2013, David Coudert has contributed to the development of the SageMath releases 5.0 to 6.0 with 10 patches (from bug fix to advanced graph algorithms) and participated to the reviewing process of more than 20 patches that are now part of the standard distribution.

5.3. DRMSim

Participants: David Coudert, Luc Hogie [correspondant], Aurélien Lancin, Nicolas Nisse, Issam Tahiri.

Around 45,000 lines, developed in Java, collaboration between COATI, LaBRI, and Alcatel-Lucent Bell labs.

DRMSim relies on a discrete-event simulation engine aiming at enabling the large-scale simulations of routing models. DRMSim is developped in the framework of the FP7 EULER project. It proposes a general routing model which accommodates any network configuration. Aside to this, it includes specific models for Generalized Linear Preference (GLP), and k-chordal network topologies, as well as implementations of routing protocols, including a previously defined routing protocol and lightweight versions of BGP (Border Gateway Protocol).

The metric model takes measures along a discrete-event simulation which can be performed in many ways.

Commonly, a simulation campaign consists in iterating over the set of combinations of parameter values, calling the simulation function for every combination. These combinations are most often complex, impeding their description by a set of mathematical functions. Thus DRMSim provides a simulation methodology that describes (programmatically) the way a simulation campaign should be conducted.

DRMSim stores on disk every step of the execution of a simulation campaign. In a simulation campaign, simulation runs are independent (no simulation depends on the result computed by another simulation). Consequently they can be executed in parallel. Because one simulation is most likely to use large amount of memory and to be multi-threaded, parallelizing the simulation campaign on one single computer is a poor parallelization scheme. Instead, we currently work at enabling the remote parallel execution of several simulation runs, with the same distribution framework that is used in the GRPH library.

DRMSim relies on the Mascsim abstract discrete-event simulation framework, the GRPH library and the Java4Unix integration framework.

In 2013, the work on DRMSim consisted (1) in the implementation of a full support for dynamic networks, including topological modifications and evolving transfer loads in the simulated network. The implementation of the BGP protocol was updated so as to support these dynamic properties. (2) This implementation of BGP was also augmented with a framework enabling its dynamic profiling. (3) Finally DRMSim does no longer relies on the Dipergrafs library. Instead it now uses GRPH, which brings better performance, stability and a broader set of graph algorithms.

See also the web page http://drmsim.gforge.inria.fr/.

5.4. Utilities

5.4.1. P2PVSim

Participant: Remigiusz Modrzejewski [correspondant].

Around 12,000 lines, developed in Python.

P2PVSim is a discrete-event simulator created for analyzing theoretical properties of peer-to-peer live video streaming algorithms. Implemented in Python it was designed with clarity and extensibility in mind from the beginning. It is capable of simulating overlays of a few thousands of peers. Multiple control protocols have been implemented. At the same time, a lot of work was put into the performance and scalability aspects of the software. Currently it is meant for simulating overlays of a few thousand peers running multiple control protocols that have been implemented. And in 2012, a distributed version of P2PVSim was developed running on an arbitrary number of computers. It has been so far used with success on a dozen computers with multiple cores all located in the same LAN.

5.4.2. Papareto

Participant: Luc Hogie [correspondant].

About 500 lines, developed in Java.

PAPARETO is a Java framework for the development of evolutionary solutions to computational problems. The primary motivation for developing an evolutionary framework was to give the GRPH library the ability to generate particular graph instances. Papareto differs from other evolutionary frameworks (ECJ, WatchMaker, JGAP, etc) in the following ways:

- it is *multi-objective*;
- it is *not a genetic algorithms (GAs)* framework because it manipulates objects *as is*. It does not consider their chromosomes representation. Performance consequently is no longer impacted by the computational cost of encoding/decoding;
- it *parallelizes* the creation and the evaluation of a new generation, adaptively to the evolving load of the computer;
- it is *self-adaptive* in the sense that it dynamically evaluates the performance of the crossover and mutation operators, then gives greater priority to most efficient ones;
- it is *easy to use*, by exposing the cleanest and more natural API possible and the minimal set of functionality enabling researchers and engineers to perform evolutionary computing;

See also the webpage http://www.i3s.unice.fr/~hogie/papareto/.

5.4.3. Toools

Participants: Luc Hogie [correspondant], Aurélien Lancin.

Around 3,000 lines, developed in Java.

TOOOLS is a general purpose Java toolbox which, much like Google Guava and Apache Commons, aims at providing classes useful in daily programming tasks. It focuses on the following topics:

- runtime (threads, control of parallel executions of SIMD code, execution of external processes, management of I/O operations, piping);
- input/output files (a complete, easier to use and more complete new model for files on disk is provided) and streams;
- reflection, including dynamic loading of classes, classpath management, Java beans, and access to the source code at runtime;
- application configuration files (parsing, querying, saving);
- plain text, XML;
- collections, including Java collection utilities and efficient sets of primitive integers;
- mathematical and statistical operations.

See also the webpage http://www-sop.inria.fr/members/Luc.Hogie/toools/.

5.4.4. Other software

We ensure the maintenance of various tools developped in the past:

Java4unix a software glue for the integration of Java applications intro the UNIX environment; http://www-sop.inria.fr/members/Luc.Hogie/java4unix/;

Jalinopt a Java toolkit for linear optimization; http://www-sop.inria.fr/members/Luc.Hogie/jalinopt/;

JavaFarm a minimal middleware infrastructure for practical distributed computing; see http://www-sop.inria.fr/members/Luc.Hogie/javafarm/;

Macsim a discrete event simulation engine use in the DRMSIM routing model simulator; http://www-sop.inria.fr/mascotte/software/mascsim/;

Jaseto a Java toolkit for the XML (de)serialization of Java objects; http://www-sop.inria.fr/members/Luc.Hogie/jaseto/;

DANTE Team

5. Software and Platforms

5.1. Sensor Network Tools: drivers, OS and more

Participants: Éric Fleury [correspondant], Sandrine Avakian.

As a outcomes of the ANR SensLAB project and the Inria ADT SensTOOLS and SensAS, several softwares (from low level drivers to OSes) were delivered and made available to the research community. The main goal is to lower the cost of developing/deploying a large scale wireless sensor network application. All software are gathered under the SensLAB web site: http://www.senslab.info/ web page where one can find:

- low C-level drivers to all hardware components;
- ports of the main OS, mainly TinyOS, FreeRTOS and Contiki;
- ports and development of higher level library like routing, localization.

5.2. Queueing Systems

Participant: Thomas Begin [correspondant].

Queueing models, steady-state solution, online tool, web interface Online tool: http://queueing-systems.ens-lyon.fr

This tool aims at providing an ergonomic web-based interface to promote the use of our proposed solutions to numerically solve classical queueing systems. This tool was launched in 2011 and presented at the conference [30]. It attracts each month hundreds of visitors scattered accross the world. Its initial implementation only includes the solution for a queue with multiple servers, general arrivals, exponential services and a possibly finite buffer (*i.e.*, $Ph/M/c/N$-like queue). The steady-state solution to this queue is based on a simple and stable recurrence [31] and was performed in collaboration with Pr. Brandwajn (UCSC). Since then, we added new models such that a mono server queue with Poisson arrivals, general services and a possibly finite buffer (*i.e.*, $M/Ph/1/N$-like queue). In 2013, we extended our tool so as to include the solution for a queue with multiple servers, general service times and Poisson arrivals (*i.e.*, $M/Ph/c/N$-like queue). The solution is based on a new approximation that we developed this year in collaboration with Pr. Brandwajn (UCSC) [32]. Associated URL is: http://queueing-systems.ens-lyon.fr

DIANA Team

5. Software and Platforms

5.1. FIT platform

We have started, since 2011, the procedure of building a new experimental platform at Sophia-Antipolis, in the context of the FIT Equipment of Excellence project. This platform has two main goals : the first one is to enable highly controllable experiments due to its anechoic environment. These experiments can be either hybrid-experiments (as NEPI will be deployed, see section 5.4) or federated experiments through several testbeds. The second goal is to make resource consuming experiments (like CCNx) possible due to some powerful servers that will be installed and connected to the PlanetLab testbed. During 2013, a first call for bids has been made during March/April and has been unfortunately declared unsuccessful due to an overestimation of the building's price. As some premises became vacant at the same time, a second call for bids has been launched during September/October. This latter was a success because three interesting offers have been received and negotiated during the end of the year. The notification is planned for the 14th of January 2014.

5.2. ns-3

Participants: Thierry Turletti [correspondant], Daniel Camara, Walid Dabbous.

ns-3 is a discrete-event network simulator for Internet systems, targeted primarily for research and educational use. ns-3 is free software, licensed under the GNU GPLv2 license, and is publicly available for research, development, and use. ns-3 includes a solid event-driven simulation core as well as an object framework focused on simulation configuration and event tracing, a set of solid 802.11 MAC and PHY models, an IPv4, UDP, and TCP stack and support for nsc (integration of Linux and BSD TCP/IP network stacks).
See also the web page http://www.nsnam.org.

- Version: ns-3.19
- Keywords: networking event-driven simulation
- License: GPL (GPLv2)
- Type of human computer interaction: programmation C++/python, No GUI
- OS/Middleware: Linux, cygwin, osX
- Required library or software: standard C++ library: GPLv2
- Programming language: C++, python
- Documentation: doxygen

5.3. DCE

Participants: Emilio Mancini [correspondant], Daniel Camara, Walid Dabbous, Thierry Turletti.

Direct Code Execution (DCE) enables developers and researchers to develop their protocols and applications in a fully controllable and deterministic environment, where tests can be repeated with reproducible results. It allows unmodified protocol implementations and application code to be tested over large and possibly complex network topologies through the ns-3 discrete-event network simulator. The single-process model used in the DCE virtualization core brings key features, such as the possibility to easily debug a distributed system over multiple simulated nodes without the need of a distributed and complex debugger. Examples of tested applications over DCE include Quagga, iperf, torrent, thttpd, CCNx and various Linux kernel versions (from 2.6.36 to 3.12 versions).

DCE is free software, licensed under the GNU GPLv2 license, and is publicly available for research, development, and use.

See also the web page https://www.nsnam.org/overview/projects/direct-code-execution/

- Version: DCE-1.2
- Keywords: emulation, virtualization, networking event-driven simulation
- License: GPL (GPLv2)
- Type of human computer interaction: programmation C/C++, No GUI
- OS/Middleware: Linux
- Required library or software: standard C++ library: GPLv2
- Programming language: C++, python
- Documentation: doxygen

5.4. NEPI

Participants: Thierry Turletti [correspondant], Alina Quereilhac, Julien Tribino, Lucia Guevgeozian Odizzio.

NEPI stands for Network Experimentation Programming Interface. NEPI is a generic framework to manage network experiments, which allows to describe experiments in a simple way and automates experiment execution and result collection in a variety of experimentation environments, including simulators and live testbeds. NEPI was designed to be extensible for potentially any experimentation environment, which can be done by extending its well defined description and execution API's.

During the year 2013 we fully re-implemented NEPI in order to support new important requirements that arose from our participation in the FED4fire and OpenLab European projects. Among those requirements we can enumerate the ability to dynamically provision experiment resources during the experiment run time (e.i. Add new resources to the experiment at any moment), the interactive experiment execution (i.e. NEPI can be used as an interactive experiment management tool), and the description of experiment work-flows (e.i. Allow to include execution/deployment dependencies across resources).

This re-implementation of NEPI gave place to an improved, more extensible and user friendly framework which was officially released as NEPI 3.0 in December 2013. This new version of NEPI was shipped with support for new testbeds, including any testbeds supporting SSH key authentication and OMF (cOntrol and Management Framework) testbeds. Support for OMF technology is a very important features since it is a key part of the federation control management framework proposed in the FED4Fire project. The version of OMF currently supported by NEPI is 5.4. OMF version 6.0, which is the new mainstream release, will be supported during 2014. In order to comply with the requirements of FED4Fire for a federation framework, work is undergo in NEPI to fully support SFA (Slice Federation Architecture), in its latest version, for resource discovery and provisioning across federated testbeds.

Additional improvements to the NEPI framework during 2013 include out-of-the box support for Future Internet technologies such as CCN and OpenFlow for certain testbeds.

Finally, during 2013 a new NEPI web site was released, including an improved look&feel (http://nepi.inria.fr), user manual and code reference pages, detailed experiment examples and a issue tracking page.

- Version: 3.0
- ACM: C.2.2, C.2.4
- Keywords: networking experimentation
- License: GPL (3)
- Type of human computer interaction: python library, QT GUI
- OS/Middelware: Linux
- Required library or software: python – http://www.python.org – http://rpyc.sourceforge.net
- Programming language: python

5.5. Bake

Participants: Daniel Camara [correspondant], Walid Dabbous, Thierry Turletti.

Bake is an integration tool, which can be used by software developers to automate the reproducible build of a number of projects which depend on each other and which might be developed, and hosted by unrelated parties. Bake was developed to automate the reproducible build of ns-3 taking into account the particular needs of it. However, Bake is not specific for ns-3, it can be used by any open source project composed of a number of interdependent sub projects and that needs to simplify and automatize the assembly of these pieces of software in a coherent and useful way.

Bake is free software, licensed under the GNU GPLv2 license, and is publicly available for research, development, and use.

See also the web page http://planete.inria.fr/software/bake/index.html

- Version: Bake-0.1
- Keywords: Integration tool, distributed project, build and installation version control
- License: GPL (GPLv2)
- Type of human computer interaction: command line tool, No GUI
- OS/Middleware: Linux, Mac Os
- Required library or software: Python, GNU C++, Mercurial, CVS, GIT, Bazaar, Tar, Unzip, Unrar, 7z, XZ, Make, cMake, patch, autoreconf
- Programming language: python
- Documentation: doxygen

5.6. Com4Innov Network Testing Platform

Participants: Emilio Mancini [correspondant], Walid Dabbous.

Developed for the Com4Innov project, the platform integrates a set of tools in a virtual appliance, in order to conduct network experiments, store and share their results, and collect network diagnostic information. The platform's core is developed as a Web Application in the Apache Tomcat application server. It has a web user interface, and a public API accessible to external tools. Its architecture is designed to be integrated with SQL or NoSQL databases, and with HTTP or REST client. The core platform is completed by measurement tools and mobile phone clients.

The implementation is available at the url: http://gforge.inria.fr/projects/com4innov. It is currently in advanced development stage.

- Version: 0.5
- Keywords: network, diagnostic
- License: not yet public
- Type of human computer interaction: Web Interface
- OS/Middelware: Linux
- Required library or software: Apache Tomcat Java, Linux Distribution and standard development environment, GPL.
- Programming languages: Java, C++, C#
- Documentation: latex, javadoc

5.7. Mobile Devicess Network Analyzer Tool

Participants: Emilio Mancini [correspondant], Arnaud Legout.

This tool has been developed as a client for the Com4Innov Network Testing Platform, but it evolved in an autonomous one. It samples the signal's strength of wireless networks, correlating it with the GPS position, and then produces coverage maps. Once the sampling is done, it allows the user to upload such data, completed with diagnostic information to the platform.

The implementation is available at the url: http://gforge.inria.fr/projects/com4innov.

- Version: 1.0
- Keywords: network, diagnostic
- License: not yet public
- Type of human computer interaction: Android Application
- OS/Middelware: Android
- Required library or software: Android, GPL.
- Programming languages: Java
- Documentation: latex, javadoc

5.8. SfaWrap

Participants: Thierry Parmentelat [correspondant], Mohamed Larabi.

The SfaWrap is a reference implementation of the Slice-based Federation Architecture (SFA), the emerging standard for networking experimental testbed federation. We are codeveloping the SfaWrap with Princeton University, and during 2013, we have focused on:

- Implementing the Aggregate Manager (AM) API v3.
- Implementing a compatibility layer between AM API v2 and AM API v3.
- Supporting testbed providers in exposing their testbeds through SFA in order to enlarge the federation of testbeds.
- Maintaning the codebase of SFAWrap.
- Releasing SFAWrap software packages for the latest versions of different Linux Distributions (Namely: Fedora, Debian and Ubuntu).
- Version: sfa-3.1-1, myplc-5.3.1
- Keywords: networking testbed federation
- License: Various Open Source Licenses
- Type of human computer interaction: Web-UI, XMLRPC-based API, Qt-based graphical client
- OS/Middelware: Linux
- Required library or software: python2.7 or superior
- Programming languages: python
- Documentation: http://svn.planet-lab.org/#SFAUser-leveldocumentation
- Codebase: http://git.onelab.eu/?p=sfa.git;a=summary

5.9. Experimentation Software

MonLab Monitoring Lab is a platform for the emulation and monitoring of traffic in virtual ISP networks. It was supported by the FP7 ECODE project and is available for download at the web page of the tool http://planete.inria.fr/MonLab/ under the terms of the GPL licence. MonLab presents a new approach for the emulation of Internet traffic and for its monitoring across the different routers of the emulated ISP network. In its current version, the traffic is sampled at the packet level in each router of the platform, then monitored at the flow level. We put at the disposal of users real traffic emulation facilities coupled to a set of libraries and tools capable of Cisco NetFlow data export, collection and analysis. Our aim is to enable running and evaluating advanced applications for network wide traffic monitoring and optimization. The development of such applications is out of the scope of this research. We believe that the framework we are proposing can play a significant role in the systematic evaluation and experimentation of these applications' algorithms. Among the direct candidates figure algorithms for traffic engineering and distributed anomaly detection. Furthermore, methods for placing monitors, sampling traffic, coordinating monitors, and inverting sampling traffic will find in our platform a valuable tool for experimentation.

ACQUA ACQUA is an Application for Collaborative Estimation of QUality of Internet Access. It was supported by the French ANR CMON project on collaborative monitoring. ACQUA is based on the principle of active measurements to a predefined set of landmarks and on the estimation of the Internet access quality by correlating these measurements together. This correlation will point to the importance of observed problems and to estimates to the quality the end user should expect from its access when running his applications over the Internet (one can see the measurements to the landmarks as samples of the global set of possible paths). In its first version (the version available online), ACQUA was concentring on delay measurements at the access and on the detection and estimation of the impact of delay anomalies (local problems, far away problems, etc). The current work is concentring on using the ACQUA principle in the estimation and prediction of the quality of experience of main applications. More details and code can be found at http://planete.inria.fr/acqua/.

ElectroSmart We are developing the application ElectroSmart as part of the Inria ADT ElectroSmart. The ElectroSmart application will enable crowd sourcing of electromagnetic exposures based on the electromagnetic radiations measured by smartphones.

DIONYSOS Project-Team

5. Software and Platforms

5.1. T3devKit testing toolkit and IPv6 test suites

Participants: César Viho, Anthony Baire.

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.

5.2. Interoperability Assessment

Participants: César Viho, Anthony Baire.

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 and (ii) facilitating new approaches and methods for interoperability assessment. For instance, new passive approaches 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. The tool `ttproto` and the test suites indicated above are freely available at http://www.irisa.fr/tipi.

5.3. 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, etc. A set of functions designed for dependability analysis is being built under the name `DependLib`.

DYOGENE Project-Team

5. Software and Platforms

5.1. SINR-based k-coverage probability in cellular networks

H. P. Keeler, "SINR-based k-coverage probability in cellular networks" MATLAB Central File Exchange, 2013.

Available at: http://www.mathworks.fr/matlabcentral/fileexchange/40087-sinr-based-k-coverage-probability-in-cellular-networks

The scripts calculate the SINR k-coverage probability in a single-tier cellular network using a method based on a homogeneous Poisson process model. Details can be found in [20] which presents the model that these scripts are based on.

FUN Project-Team

4. Software and Platforms

4.1. Distributed ONS

Participants: Nathalie Mitton, Roberto Quilez [correspondant].

This module implements a DHT-based Distributed EPC Global ONS issued from the ANR WINGS project and published in [61]. APP number: IDDN.FR.001.180033.000.S.P.2012.000.10000.

- Version: version 1

4.2. GOLIATH 1.0

Participants: Fadila Khadar [correspondant], Nathalie Mitton.

GOLIATH (Generic Optimized LIghtweight communication stack for Ambient TecHnologies) is a full protocol stack for wireless sensor networks.

See also the web page https://gforge.inria.fr/projects/goliath/.

4.3. Linear variable energy module for WSNET.

Participants: Tony Ducrocq [correspondant], Nathalie Mitton.

This module is to be integrated in the WSNET event-based simulator for wireless networks. It implements a Linear transmission variable energy module for WSNET.

- Version: 1.0

4.4. New ALE module for ASPIRERFID middleware.

Participants: Rim Driss [correspondant], Nathalie Mitton, Ibrahim Amadou, Julien Vandaele.

AspireRFID middleware is a modular OW2 open source RFID middleware. It is compliant with EPC Global standards. This new module integrates the modifications of the new standard release, including new RP and LLRP definitions and fixing bugs.

- Version: 1.0

GANG Project-Team (section vide)

HIPERCOM2 Team

5. Software and Platforms

5.1. Software and Platforms

5.1.1. Platforms

5.1.1.1. SensLab and FIT

Participants: Cédric Adjih, Alaeddine Weslati, Vincent Ladeveze.

This is a joint work with Emmanuel Baccelli from Inria Saclay.

Period: 2011 - 2021

Partners: Inria (Lille, Sophia-Antipolis, Grenoble), INSA, UPMC, Institut Télécom Paris, Institut Télécom Evry, LSIIT Strasbourg.

- Deployment: during the year 2013, most of the practical deployment has been planned, designed and realized. A location has been found for the new testbed of the EQUIPEX FIT: the basement of building 1 at Rocquencourt. The preparation of the deployment space, power, GPS and network infrastructures for the deployment of IoT-Lab testbed has been finished: including designing and installing support structures, amenaging space (ventilation, ...), acquiring and installing network equipment, servers, GPS, ...
  The Senslab testbed has been moved to the building 1 and has been integrated into the new platform. Deployment is in a finalization phase and should go in beta testing starting from Q1 2014. The testbed will offer 344 open nodes, including 120 WSN430 nodes, 200 Cortex A8 based nodes, 24 Cortex M3.
- Support of external projects: Support for RIOT-OS and OpenWSN projects has been developed for IoT-Lab hardware and is being tested.
  - RIOT-OS, a joint work between Inria and FU-Berlin to create an Operating System for the Internet of Things.
  - OpenWSN, an open-source protocol stack for Internet of Things developed by UC Berkley.
  - IoT-Lab hardware based on STM stm32f1 series ARM Cortex-M3 MCU and Atmel AT86RF231 radio transceiver.

5.1.2. Software

5.1.2.1. NS3

Participants: Cédric Adjih, Hana Baccouch.

Ey-Wifi, Elimination-Yield for WiFi networks, is a module developed for the ns-3 simulation tool to integrate the features of the EY-NPMA channel access scheme. EY-NPMA (Elimination-Yield Non-Pre-emptive Priority Multiple Access) is a contention based protocol using active signaling (black burst): a node requests access to the medium by transmitting a burst signal. More precisely, the channel access cycle comprises three phases: priority phase, elimination phase and yield phase.

This software was developped thanks to the ADT MOBSIM.

The Ey-Wifi module has been publically released and is available, along with a detailed tutorial explaining how to use it, at: http://hipercom.inria.fr/Ey-Wifi

5.1.2.2. OPERA

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

The OPERA software was developed by the Hipercom2 team in the OCARI project. They include EOLSR, an energy efficient routing protocol and OSERENA, a coloring algorithm optimized for dense wireless networks. OPERA was registered by the APP. In 2013, OPERA has been made available for download as an open software from the InriaGForge site: https://gforge.inria.fr/scm/?group_id=4665

More details and documentation about this software are available in the website made by the Hipercom2 team: http://opera.gforge.inria.fr/index.html

5.1.2.3. SAHARA

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

The software modules developed by the Hipercom2 team in the SAHARA project have been registered by the APP in July 2013:

- Mundi-Safeti V1.0, Reference: IDDN.FR.001.270022.000.S.P.2013.000.10000
- SAHARA-Network V1.0, Reference: IDDN.FR.001.270021.000.S.P.2013.000.10000

MADYNES Project-Team

5. Software and Platforms

5.1. SecSIP

Participants: Abdelkader Lahmadi [contact], Olivier Festor.

SecSip [1] is developed by the team to defend SIP-based (The Session Initiation Protocol) services from known vulnerabilities. It presents a proactive point of defense between a SIP-based network of devices (servers, proxies, user agents) and the open Internet. Therefore, all SIP traffic is inspected and analyzed against authored Veto specification before it is forwarded to these devices. When initializing, the SecSIP runtime starts loading and parsing authored VeTo blocks to identify different variables, event patterns, operations and actions from each rule. Veto is a generic declarative language for attack patterns specification. SecSIP implements an input and output layer, to capture, inject, send and receive SIP packets from and to the network. Intercepted packets are moved to the SIP Packet parser module. The main function of this module is to extract different fields within a SIP message and trigger events specified within the definition blocks. During each execution cycle when a SIP message arrives, the SecSIP runtime uses a data flow acyclic graph network to find definition matching rules and triggers defined events. The paired events in each operator node are propagated over the graph until a pattern is satisfied. When the pattern is satisfied, the respective rule is fired and the set of actions is executed.

5.2. NDPMon

Participants: Isabelle Chrisment, Olivier Festor [contact].

The Neighbor Discovery Protocol Monitor (NDPMon) is an IPv6 implemention of the well-known ArpWatch tool. NDPMon monitors the pairing between IPv6 and Ethernet addresses (NDP activities: new station, changed Ethernet address, flip flop...). NDPMon also detects attacks on the NDP protocol, as defined in RFC 3756 (bogon, fake Router Advertisements...). New attacks based on the Neighbor Discovery Protocol and Address Auto-configuration (RFC 2461 and RFC 2462) have been identified and integrated in the tool. An XML file describes the default behavior of the network, with the authorized routers and prefixes, and a second XML document containing the neighbors database is used. This second file can be filled during a learning phase. All NDP activities are logged in the syslog utility, and so the attacks, but these ones are also reported by mail to the administrator. Finally, NDPMon can detect stack vulnerabilities, like the assignment of an Ethernet broadcast address on an interface.

NDPMon comes along with a WEB interface acting as a GUI to display the informations gathered by the tool, and give an overview of all alerts and reports. Thanks to color codes, the WEB interface makes possible for the administrator to have an history of what happened on his network and identify quickly problems. All the XML files used or produced by the daemon (neighbor cache, configuration file and alerts list) are translated in HTML via XSL for better readability. A statistic module is also integrated and gives informations about the discovery of the nodes and their type (MAC manufacturer distribution ...).

The software package and its source code is freely distributed under an opensource license (LGPL). It is implemented in C, and is available through a SourceForge project at http://ndpmon.sf.net. An open source community is now established for the tool which has distributions for several Operating Systems (Linux, FreeBSD, OpenBSD, NetBSD and Mac OS X). It is also integrated in FreeBSD ports [2]. Binary distributions are also available for .deb and .rpm based Linux flavors.

[1] http://secsip.gforge.inria.fr/doku.php

[2] http://www.freebsd.org/cgi/cvsweb.cgi/ports/net-mgmt/ndpmon/

5.3. AA4MM

Participants: Laurent Ciarletta [contact], Yannick Presse.

Vincent Chevrier (MAIA team, contact), and Benjamin Camus and Julien Vaubourg (MAIA team, LORIA) are contributors for this software.

AA4MM (Agents and Artefacts for Multi-modeling and Multi-simulation) is a framework for coupling existing and heterogeneous models and simulators in order to model and simulate complex systems. The first implementation of the AA4MM meta-model was proposed in Julien Siebert's PhD [49] and written in Java. This version is currently being put into APP (Agence pour la protection des programmes).

This year, we have used this software in a strategic action with EDF R&D in the context of the simulation of smart-grids. Julien Vaubourg started a PhD on this project that is co-directed by Laurent Ciarletta and Vincent Chevrier.

5.4. MASDYNE

Participant: Laurent Ciarletta [contact].

This work was undertaken in a joint PhD Thesis between MAIA and Madynes Team. Vincent Chervrier (MAIA team, LORIA) has been director and co-advisor of this PhD and is correspondant for this software, which has been used by Tomas Navarrete (MAIA team, LORIA). Other contributors to this software were: Julien Siebert, Tom Leclerc, François Klein, Christophe Torin, Marcel Lamenu, Guillaume Favre and Amir Toly.

MASDYNE (Multi-Agent Simulator of DYnamic Networks usErs) is a multi-agent simulator for modeling and simulating users behaviors in mobile ad hoc network. This software is part of joint work with the MAIA team, as part as a modeling and simulation of ubiquitous networks effort.

MAESTRO Project-Team (section vide)

RAP Project-Team (section vide)

SOCRATE Project-Team

5. Software and Platforms

5.1. WSnet

Socrate is an active contributor to WSnet (http://wsnet.gforge.inria.fr/) a multi-hop wireless network discrete event simulator. WSnet was created in the ARES team and it is now supported by the D-NET team of Inria Rhône-Alpes.

5.2. Wiplan

Wiplan is a software including an Indoor propagation engine and a wireless LAN optimization suite, which has been registered by INSA-Lyon. The heart of this software is the propagation simulation core relying on an original method, MR-FDPF (multi-resolution frequency domain ParFlow). The discrete ParFlow equations are translated in the Fourier domain providing a large linear system, solved in two steps taking advantage of a multi- resolution approach. The first step computes a cell-based tree structure referred to as the pyramid. In the second phase, a radiating source is simulated, taking advantage of the pre-processed pyramidal structure. Using of a full-space discrete simulator instead of classical ray-tracing techniques is a challenge due to the inherent high computation requests. However, we have shown that the use of a multi-resolution approach allows the main computation load to be restricted to a pre-processing phase. Extensive works have been done to make predictions more realistic. The network planning and optimization suite is based on a multi-criteria model relying on a Tabu solver. The development of the wiplan software is a part of the european project iPlan (IAPP-FP7 project).

5.3. FloPoCo

The purpose of the open-source FloPoCo project is to explore the many ways in which the flexibility of the FPGA target can be exploited in the arithmetic realm. FloPoCo is a generator of operators written in C++ and outputting synthesizable VHDL automatically pipelined to an arbitrary frequency. In 2013, a CORDIC-based arctangent was written in Socrate.

Among the known users of FloPoCo are U. Bristol,U. Cape Town, U.T. Cluj-Napoca, Imperial College, U. Essex, U. Madrid, U. P. Milano, T.U. Muenchen, T. U. Kaiserslautern, U. Paderborn, CalTech, U. Pernambuco, U. Perpignan, U. Tohoku, U. Tokyo, Virginia Tech U. and several companies.

Web page: http://flopoco.gforge.inria.fr/

URBANET Team

5. Software and Platforms

5.1. WSNet

UrbaNet is an active contributor to WSnet (http://wsnet.gforge.inria.fr/), a discrete event simulator dedicated to large scale wireless networks developed and maintained by members of Inria and CITI lab. A major part of this contribution is represented by the implementation of state of the art protocols for medium access control and routing.

The WSNet simulation results obtained following this process are sometimes used as an input for another part of our development effort, which consists in prototype software based on the combination of CPLEX and AMPL for solving mixed integer linear programming problems with column generation.

5.2. TAPASCologne vehicular mobility dataset

Based on the data made available by the Institute of Transportation Systems at the German Aerospace Center (ITS-DLR), the dataset aims at reproducing, with a high level of realism, car traffic in the greater urban area of the city of Cologne, Germany. To that end, different state-of-art data sources and simulation tools are brought together, so to cover all of the specific aspects required for a proper characterization of vehicular traffic:

- The street layout of the Cologne urban area is obtained from the OpenStreetMap (OSM) database;
- The microscopic mobility of vehicles is simulated with the Simulation of Urban Mobility (SUMO) software;
- The traffic demand information on the macroscopic traffic flows across the Cologne urban area (i.e., the O/D matrix) is derived through the Travel and Activity PAtterns Simulation (TAPAS) methodology;
- The traffic assignment of the vehicular flows described by the TAPASCologne O/D matrix over the road topology is performed by means of Gawron’s dynamic user assignment algorithm.

The resulting synthetic trace of the car traffic in a the city of Cologne covers a region of 400 square kilometers for a period of 24 hours, comprising more than 700.000 individual car trips. More information is available on the project website at http://kolntrace.project.citi-lab.fr/ .