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Team AVALON

Algorithms and Software Architectures for Parallel and Distributed Systems

IN COLLABORATION WITH: Laboratoire de l'Informatique du Parallélisme (LIP)

RESEARCH CENTER
Grenoble - Rhône-Alpes

THEME
Distributed and High Performance Computing

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Team AVALON

Keywords: Distributed System, Parallel Programming Model, Scheduling, Middleware, Energy Consumption

The AVALON *team is common to CNRS, ENS Lyon, UCBL, and Inria. This team is part of the Laboratoire de l'Informatique du Parallélisme (LIP), UMR ENS Lyon/CNRS/Inria/UCBL 5668. The team is partly located at the École normale supérieure de Lyon, the IN2P3/CNRS Computing Center (USR 6402), and the Université Claude Bernard – Lyon 1.*

Creation of the Team: February 01, 2012 .

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2. Overall Objectives

2.1. Introduction

The fast evolution of hardware capabilities in terms of wide area communication, computation and machine virtualization leads to the requirement of another step in the abstraction of resources with respect to applications. Those large scale platforms based on the aggregation of large clusters (Grids), huge datacenters (Clouds), collections of volunteer PC (Desktop computing platforms), or high performance machines (Supercomputers) are now available to researchers of different fields of science as well as to private companies. This variety of platforms and the way they are accessed have also an important impact on how applications are designed (*i.e.,* the programming model used) as well as how applications are executed (*i.e.,* the runtime/middleware system used). The access to these platforms is driven through the use of different services providing mandatory features such as security, resource discovery, virtualization, load-balancing, monitoring, etc. Infrastructure/Platform/Software as a Service (IaaS, PaaS, SaaS) have thus to play an important role in the future development of large scale applications.

The overall idea of the Avalon project-team is to consider the whole system, ranging from resources to applications, to be able to design adequate programming and resources abstractions to provide simple to use abstractions to programmers while enabling efficient exploitation of resources. More precisely, the team is going to focus on large-scale, heterogeneous, and elastic resources – ranging from supercomputers to Clouds and Grids, and to services, component and workflow models – including some domain specific models such as GridRPC or MapReduce. In addition to well-known metrics such as makespan, resource utilization, etc., the team considers other metrics, such as energy efficiency or consumption in particular.

The AVALON team in particular focuses on

- **elasticity management** of parallel and distributed platforms,
- **energy efficiency** of parallel and distributed platforms,

3. Scientific Foundations

3.1. Algorithmics

The researches conducted by the Avalon team address both complex applications, coming from service/component composition and more generally organized as workflows, and complex architectures, that are heterogeneous, distributed, shared, and elastic. While some characteristics are classical to parallel and distributed platforms such as Clusters and Grids, new challenges arise because of the increase of complexity of application structures as well as by the elasticity of infrastructures such as Clouds and by the importance of taking into account energy concerns in Supercomputers for example.

Moreover data-intensive applications imply not only to consider computations in a scheduling process but also data movements in a coordinated way.

In such a context, many metrics can be optimized by transformation and/or scheduling algorithms in order to deploy services or applications on resources. Classical ones are the minimization of application completion or turnaround times, the maximization of the resource usage, or taking care of the fairness between applications. But new challenging optimizations are now related to the economical cost of an execution or to its energy efficiency.

Our main challenge is to propose smart transformation and scheduling algorithms that are inherently multi-criteria optimizations. As not all metrics can be simultaneously optimized, the proposed algorithms consider subsets of them: we target at finding efficient trade-offs. Note that our main concern is to design practical algorithms rather than conducting purely theoretical studies as our goal is at implementing the proposed algorithms in actual software environments.

Moreover, in recent years, we have seen the apparition of hardware-based green leverages (on/off, idle modes, dynamic frequency and speed scaling, etc) applied to various kinds of physical resources (CPU, memory, storage and network interconnect). To exploit them, these facilities must be incorporated into middleware software layers (schedulers, resource managers, etc). The Avalon team explores the benefits of such leverages, for example with respect to elasticity, to improve the energy efficiency of distributed applications and services and to limit the energy consumption of platforms. The goal is to provide the needed amount of physical and virtual resources to fulfill the needs of applications. Such provision is greatly influenced by a large set of contextual choices (hardware infrastructures, software, location, etc).

3.2. Application and Resource Models

A second research direction consists in providing accurate, or at least realistic, models of applications and execution infrastructures. Such a goal has been the main concern of the *SimGrid* project for more than 10 years. Hence, this simulation toolkit provides most of the technological background to allow for the exploration of new scientific challenges. Moreover, simulation is a classical and efficient way to explore many “what-if” scenarios in order to better understand how an application behaves under various experimental conditions.

The Avalon team considers using simulation for application performance prediction. The scientific challenges lie in the diversity of applications and available execution environments. Moreover the behavior and performance of a given application may vary greatly if the execution context changes. Simulation allows us to explore many scenarios in a reasonable time, but this require to get a good understanding of both application structure and target environment.

A first focus is on HPC, regular, and parallel applications. For instance, we study those based on the message passing paradigm, as we have already developed some online and offline simulators. However, the different APIs provided by *SimGrid* allow us to also consider other kinds of applications, such as scientific workflows or CSPs.

A second focus is on data-intensive applications. It implies to also consider storage elements as a main modeling target. In the literature, the modeling of disk is either simplistic or done at a very-low level. This leads to unrealistic or intractable models that prevent the acquisition of sound information. Our goal is then to propose comprehensive models at the storage system level, *e.g.,* one big disk bay accessed through the network. The main challenge associated to this objective is to analyze lots of logs of accesses to data to find patterns and derive sound models. The IN2P3 Computing Center gives us an easy access to such logs. Moreover a collaboration with CERN will allow us to validate the proposed model on an actual use case, the distributed data management system of the ATLAS experiment.

Modeling applications and infrastructures is in particular required to deal with energy concerns, as energy price is becoming a major limiting factor for large scale infrastructures. Physically monitoring the energy consumption of few resources is now becoming a reality; injecting such local measurements as a new parameter in multi-objective optimization models is also more and more common. However, dealing with energy consumption and energy efficiency at large scale is still a real challenge. This activity, initiated in the

RESO team since 2008, is continued by the Avalon team by investigating energy consumption and efficiency on large scale (external, internal) monitoring of resources. Also, while physical resources start to be well mastered, another challenge is to deal with virtualized resources and environments.

3.3. Programming Abstractions

Another research direction deals with determining well suited programming abstractions to reconcile a priori contradictory goals: being "simple" to use and portable, while enabling high performance. Existing parallel and distributed programming models either expose infrastructure artifacts to programmers so that performance can be achieved —by experts!— but not portability or they propose very specialized models such as GridRPC and Google's MapReduce. In the latter case, an application is restricted to use one concept at a time. For example, it is very difficult for an application to simultaneously use two middleware systems providing respectively GridRPC and MapReduce.

The Avalon team addresses the challenge of designing a general composition based model supporting as many composition operators as possible while enabling efficient execution on parallel and distributed infrastructures. We mainly consider component based models as they offer the ability to manipulate the software architecture of an application. To achieve our goal, we consider a "compilation" approach that transforms a resource agnostic application description into a resource specific description. The challenge is thus to determine the best suited models.

Many works have already been done with respect to component models. However, existing model such as Fractal, CCA, BIP do not provide an adequate solution as they only support a limited set of interactions. We aims to extend the approach initiated with HLCM that aims at identifying core elements to let a programmer define any (spatial) compositions. We also target to provide mechanisms to support application and resource specialization algorithms.

A first challenge is to conduct an in depth validation of the ability of the proposed HLCM approach to deal with any kind of static compositions. In particular, it includes designing efficient transformation algorithms and understanding their generality.

A second challenge is to extend the proposed approach to support dynamic applications, either because of adaptation issues or because of temporal compositions such as workflows. Starting from motivating use cases, we will study whether just-in-time assembly transformation techniques provide an efficient and scalable solution.

3.4. Resource abstractions

Computing resources and infrastructures have a wide variety of characteristics in terms of reliability, performance, service quality, price, energy consumption, etc. Moreover, resource usage and access differ from batch scheduler, reservation, on-demand, best-effort, virtualized, etc.

The Avalon team addresses issues related to the provision of the necessary resource abstractions to allow efficient resource usage, the accurate description of resource properties, and the efficient management of the complexity of hybrid distributed infrastructures.

The challenge is threefold: $i)$ providing the adequate resource management services to cope with large scale, heterogeneous, volatile, and elastic infrastructures, $ii)$ combining several DCIs together, $iii)$ providing feedback on how applications make use of resources, which implies for instance energy monitoring facility.

The Avalon team aims at designing and evaluating adapted services such as job scheduler, decentralized resource discovery, data management, monitoring systems, or QoS services. Moreover, the team studies at which level in the design stack advanced features, such as QoS, reliability, security, have to/can be provided.

Our methodology consists in designing experiments involving the investigated services. Therefore, the team closely collaborates with large-scale infrastructure operators and designers such as CC-IN2P3, GRID'5000, FutureGrid or the International Desktop Grid Federation. We aim at making use of existing DCIs services as much as possible and develop new services otherwise. In the past years, the team members have gained a recognized experience in designing middleware systems for distributed and parallel computing that rely on different resource abstractions: data management and data-intense computing (BitDew, DIET), workflows (DIET), component model (HLCM). In the next years, we plan to improve these systems or develop new services with respect to challenges related on determining how resources are found, queried, accessed, used, and released. For example, the Avalon team contributes to energy monitoring services as well as to information services, and job submission services for elastic resources.

4. Application Domains

4.1. Overview

The Avalon team targets applications with large computing and/or data storage needs, which are yet difficult to program and maintain while achieving performance. Those applications can be parallel and/or distributed applications. It is typically the case of large simulations and/or code coupling applications from "classical" computational problems such as climate forecasting or cosmology. The team also deals with bioinformatics as they raise some interesting research issues linked to data management. For example, some of such applications rely on MapReduce algorithmic skeletons.

4.2. Bioinformatics

Large-scale data management is certainly one of the most important applications of distributed systems of the future. Bioinformatics if a field producing such kinds of applications. For example, DNA sequencing applications make use of MapReduce skeletons.

The MapReduce programming model publicized by Google is a widely used model for deploying application services on platforms for data processing on a large scale (Grids and Clouds). MapReduce implementations extremely are scalable and efficient when located on the datacenters of big companies. However, technological (use of a parallel file system) and algorithmic (hard-coded replication) choices of an implementation such as Hadoop compromise performance on platforms like grids of heterogeneous clusters. Applying it to large scale and volatile environments such as desktop grids still remain a challenge.

4.3. Climate Forecasting Simulations

World's climate is currently changing due to the increase of the greenhouse gases in the atmosphere. Climate fluctuations are forecasted for the years to come. For a proper study of the incoming changes, numerical simulations are needed, using general circulation models of a climate system.

As for most applications the team is targeting, our goal is to thoroughly analyze climate forecasting applications to model its needs in terms of programing model, execution model, data access pattern, and computing needs. Once a proper model of the application has been derived, appropriate scheduling heuristics could be designed, tested, and compared.

4.4. Cosmological Simulations

Ramses [1] is a typical computational intensive application used by astrophysicists to study the formation of galaxies. *Ramses* is used, among other things, to simulate the evolution of a collisionless, self-gravitating fluid called "dark matter" through cosmic time. Individual trajectories of macro-particles are integrated using a state-of-the-art "N body solver", coupled to a finite volume Euler solver, based on the Adaptive Mesh Refinement technique. The computational space is decomposed among the available processors using a *mesh partitioning* strategy based on the Peano-Hilbert cell ordering.

[1] http://www.itp.uzh.ch/~teyssier/Site/RAMSES.html

Cosmological simulations are usually divided into two main categories. Large scale periodic boxes requiring massively parallel computers are performed on a very long elapsed time (usually several months). The second category stands for much faster small scale "zoom simulations".

4.5. Code Coupling Applications

Different kinds of code coupling applications are considered. The simplest form is within a parallel code. For example, OpenAtom, a molecular dynamics simulation application exhibits several coupling of different pieces of codes, whose arrangement and configuration depend on many parameters, and some depend on input simulation parameters. The challenge is to let application designers express the functionality of the application while the actual execution code can be automatically configured.

Another class of code coupling applications is the coupling at temporal level. Our collaboration with EDF R&D provides us with several use cases including scenarios with *Code_Aster* (thermo-mechanics simulations), *Syrthes* (transient thermal simulations in complex solid geometries), etc. These couplings face other issues such as combining several large scale resources, managing data transfers, etc.

5. Software

5.1. BitDew

Participants: Gilles Fedak [correspondant], Haiwu He, Bing Tang, José Francisco Saray Villamizar, Mircea Moca, Lu Lu.

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. SBAM

Participants: Eddy Caron [correspondant], Florent Chuffart.

SBAM (http://graal.ens-lyon.fr/SBAM) is the middleware directly coming from results of the ANR project SPADES. SBAM initiates a non-intrusive, but highly dynamic environment able to take advantages of available resources without disturbing their native mechanism. SBAM federates multisite resources in order to schedule, submit and compute users' tasks in a transparent way.

SBAM is, firstly, a decentralized grid middleware. It relies on a P2P approach, i.e., a set of agents able to discover resources and schedule computing tasks over a federation of heterogeneous computing platforms (petascale computers, data centers, clouds, ...). SBAM dynamically acquires and releases resources of computing sites according to users' needs and conditions, to federate them into a global constantly growing or shrinking logical platform, referred to as the overlay.

5.3. DIET

Participants: Daniel Balouek, Eddy Caron [correspondant], Frédéric Desprez, Maurice Djibril Faye, Cristian Klein, Arnaud Lefray, Guillaume Mercier, Adrian Muresan, 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.

In 2012, our objective was to extend DIET to benefit from virtualized resources such as ones coming from cloud platforms. Wa have designed how it can be extended to access virtualized resources. We can easily support new cloud service providers and cloud middleware systems. We have prototyped the new version of DIET which 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. We have started works to extend our data management software, DAGDA, to take advantage of cloud storage and the new data computing paradigms. Moreover we have upgraded the workflow engine of DIET to take advantage of cloud resources. DIET Cloud will be able to provide a large scale distributed and secured platform that spans on a pool of federated resources that range from dedicated HPC clusters and grid to public and private clouds.

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. We have worked to show how to securely use public cloud storage without taking the risk of losing confidentiality of data stored on them.

5.4. 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.

5.5. SimGrid

Participants: Georges 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 & L2C

Participants: Zhengxiong Hou, Cristian Klein, Vincent Lanore, Christian Pérez [correspondant], Vincent Pichon.

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^{2}C—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/L2C and HLCM/Charm++ (known as Gluon++).

L^{2}C (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^{2}C does not offer network transparency neither language transparency. Instead, L^{2}C lets the user choose between various kinds of interactions between components, some with ultra low overhead and others that support network transport. L^{2}C is extensible as additional interaction kinds can be added quite easily. L^{2}C currently supports C++, MPI and CORBA interactions. FORTRAN will be added in 2013.

L^{2}C 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++.

6. New Results

6.1. HPC Component Model

Participants: Zhengxiong Hou, Vincent Pichon, Christian Pérez.

6.1.1. L2C: A Low Level Component Model

We have proposed a low level component model (L^{2}C) that supports directly native connectors for typical scenarios of high performance computing, such as MPI, shared memory and method invocation [10]. We have applied it to a typical example of stencil computation, i.e., a 2-D Jacobi application with domain decomposition. The experimental results have shown that L^{2}C can achieve the equivalent performance as native implementations, while gaining benefits such as performance portability on the basis of the software component model.

6.1.2. Auto-tuning of Stencil Based Applications

We started modeling the performance of stencil applications on multi-core clusters. We focused in particular on a 2D Jacobi benchmark application and the NEMO application as well as memory bandwidth performance. We derived a tuning approach including data partitioning within one node, the selection of the number of threads within a multi-core node, a data partitioning for multi nodes, and the number of nodes for a multi-core cluster. This model is based on a set of experiments on machines of GRID'5000 and on Curie and Juqueen supercomputers. A paper presenting these results is in preparation.

6.2. Cooperative Resource Managers

Participants: Eddy Caron, Cristian Klein, Christian Pérez, Noua Toukourou.

6.2.1. Integration of SALOME with CooRM

We have continued the validation works of the CooRM RMS architecture [52]. To this end, we focused on the SALOME numerical simulation platform developed and used jointly by EDF and CEA. In 2012, we have mostly started the integration of CooRMv1 concepts in SALOME. CooRMv1 targets moldable applications and allows them to efficiently employ their custom resource selection algorithms. We have done the necessary changes in SALOME, thus obtaining a working prototype implementation. Thanks to this, SALOME applications could be published with a custom launcher (implementing a resource selection algorithm) so as to transparently launch applications efficiently, instead of having to leave this burden to the user.

6.2.2. A Distributed Resource Management Architecture for Moldable Applications

In 2011, we have proposed CooRMv1 [52], a centralized RMS architecture to efficiently support moldable applications. Having a centralized architecture is however undesirable for geographically-distributed resources such as Grids or multiple Clouds. For example, if there is a network failure, some users will not be able to access any resources, not even those that are located on their side of the bisection.

To this end, we extended CooRMv1 and proposed a distributed version of it, distCooRM, in collaboration with the Myriads team. It allows moldable applications to efficiently co-allocated resource managed by independent agents. Simulation results show that the approach is feasible and scales well for a reasonable number of applications. In other words, it presents good strong scalability, but not weak scalability, which we intend to address in future work.

6.2.3. A Resource Management Architecture for Fair Scheduling of Optional Computations

In collaboration with two teams from IRIT, we have identified a use-case that is currently badly supported. Some applications, such as Monte-Carlo simulations, contain optional computations: These are not critical, but completing them would improve the results. When executing these application on HPC resources, most resource managers, such as batch schedulers, require the user to submit a predefined number of computing requests. If the user submits too many requests, the platform might become overloaded, whereas if the user submits too few requests, then resources might be left idle.

To solve this issue, we proposed a resource management architecture, called DIET-ethic [42], which auto-tunes the number of optional requests. It improves user happiness, fairness and the number of completed requests, when compared to a system which does not support optional computations.

6.3. Large-Scale Data Management and Processing

Participants: José Saray, Bing Tang, Gilles Fedak, Anthony Simonet.

6.3.1. Data Management on Hybrid Distributed Infrastructure

The BITDEW framework addresses the issue of how to design a programmable environment for automatic and transparent data management on Grids, Clouds and Desktop Grids. BITDEW relies on a specific set of meta-data to drive key data management operations, namely life cycle, distribution, placement, replication and fault-tolerance with a high level of abstraction.

In collaboration with Mohamed Labidi, University of Sfax (Tunisia), we have developed a data-aware and parallel version of Magik, an application for Arabic writing recognition using the BITDEW middleware. We are targeting digital libraries, which require distributed computing infrastructure to store the large number of digitalized books as raw images and at the same time to perform automatic processing of these documents such as OCR, translation, indexing, searching, etc. [20].

In 2012, we have also surveyed P2P strategies (replication, erasure code, replica repair, hybrid storage), which provide reliable and durable storage on top of hybrid distributed infrastructures composed of volatile and stable storage. Following these simulation studies, we are implementing a prototype of the Amazon S3 storage on top of BitDew, which will provide reliable storage by using both Desktop free disk space and volunteered remote Cloud storage [25].

6.3.2. MapReduce Programing Model for Desktop Grid

MapReduce is an emerging programming model for data-intense applications proposed by Google, which has recently attracted a lot of attention. MapReduce borrows from functional programming, where programmer defines Map and Reduce tasks executed on large sets of distributed data. In 2010, we developed an implementation of the MapReduce programming model based on the BitDew middleware. Our prototype features several optimizations which make our approach suitable for large scale and loosely connected Internet Desktop Grid: massive fault tolerance, replica management, barriers-free execution, latency-hiding optimization as well as distributed result checking. We have presented performance evaluations of the prototype both against micro-benchmarks and real MapReduce applications. The scalability test achieved linear speedup on the classical WordCount benchmark. Several scenarios involving lagger hosts and host crashes demonstrated that the prototype is able to cope with an experimental context similar to real-world Internet [9].

In collaboration with the Huazhong University of Science & Technology (China), we have developed an emulation framework to assess MapReduce on Internet Desktop Grid. We have made extensive comparison on BitDew-MapReduce and Hadoop using GRID'5000 which show that our approach has all the properties desirable to cope with an Internet deployment, whereas Hadoop fails on several tests [22].

We have published a joint work in collaboration with Virginia Tech (USA), which is a presentation of two alternative implementations of MapReduce for Desktop Grids : Moon and Bitdew [37].

6.4. Computing on Hybrid Distributed Infrastructure

Participants: Simon Delamare, Gilles Fedak, José Saray, Anthony Simonet.

6.4.1. SpeQuloS: Providing Quality-of-Service to Desktop Grids using Cloud resources

EDGI is an FP7 European project, following the successful FP7 EDGeS project, whose goal is to build a Grid infrastructure composed of "Desktop Grids", such as BOINC or XtremWeb, where computing resources are provided by Internet volunteers, and "Service Grids", where computing resources are provided by institutional Grid such as EGI, gLite, Unicore and "Clouds systems" such as OpenNebula and Eucalyptus, where resources are provided on-demand. The goal of the EDGI project is to provide an infrastructure where Service Grids are extended with public and institutional Desktop Grids and Clouds.

The main limitation with the current infrastructure is that it cannot give any QoS support for applications running in the Desktop Grid (DG) part of the infrastructure. For example, a public DG system enables clients to return work-unit results in the range of weeks. Although there are EGI applications (e.g., the fusion community's applications) that can tolerate such a long latency most of the user communities want much shorter deadlines.

In 2011, we have developed the SpeQuloS middleware to solve this critical problem. Providing QoS features even in Service Grids is hard and not solved yet satisfactorily. It is even more difficult in an environment where there are no guaranteed resources. In DG systems, resources can leave the system at any time for a long time or forever even after taking several work-units with the promise of computing them. Our approach is based on the extension of DG systems with Cloud resources. For such critical work-units the SpeQuloS system is able to dynamically deploy fast and trustable clients from some Clouds that are available to support the EDGI DG systems. It takes the right decision about assigning the necessary number of trusted clients and Cloud clients for the QoS applications. In 2012, we have conducted extensive simulations to evaluate various strategies of Cloud resources provisioning. Results show that SpeQuloS improve the QoS of BoTs on three aspects: it reduces the makespan by removing the tail effect, it improves the execution stability and it allows to accurately predicts the BoT completion time [14], [21], [35]. The software have now been delivered to the partners and run in production in the European Desktop Grid Infrastructure.

6.4.2. Scheduling on Hybrid Distributed Computing Infrastructures

In collaboration with the Mircea Moca, from the Babes-Bolyai University of Cluj-Napoca (Romania), we have investigated new scheduling algorithms for pull-based scheduler, which relies on Promethee method. We have shown that these heuristics perform efficiently on three different kinds of infrastructures, namely Grids, Clouds and Desktop Grids [23].

6.5. Energy Efficiency in Large Scale Systems

Participants: Ghislain Landry Tsafack, Mohammed El Mehdi Diouri, Olivier Glück, Laurent Lefevre.

6.5.1. Energy Efficiency in HPC Systems

Modern high performance computing subsystems (HPC) – including processor, network, memory, and I/O — are provided with power management mechanisms. These include dynamic speed scaling and dynamic resource sleeping. Understanding the behavioral patterns of high performance computing systems at runtime can lead to a multitude of optimization opportunities including controlling and limiting their energy usage. We have proposed a general purpose methodology for optimizing energy performance of HPC systems considering processor, disk and network. We have relied on the concept of execution vector along with a partial phase recognition technique for on-the-fly dynamic management without any a priori knowledge of the workload. We have demonstrated the effectiveness of our management policy under two real-life workloads. Experimental results have shown that our management policy in comparison with baseline unmanaged execution saves up to 24% of energy with less than 4% performance overhead for our real-life workloads [28], [27], [26]. This work is done under the Large Scale Initiative Hemera project (Joint PhD between Avalon and IRIT (Toulouse) with J.-M. Pierson, P. Stolf and G. Da Costa).

6.5.2. Energy Considerations in Checkpointing and Fault Tolerance Protocols

Two key points should be taken into account in future exascale systems: fault tolerance and energy consumption. To address these challenges, we evaluated checkpointing and existing fault tolerance protocols from an energy point of view. We measured on a real testbed the power consumption of the main atomic operations found in these protocols: checkpointing, message logging and coordination. The results [16], [51] show that process coordination and RAM logging consume more power than checkpointing and HDD logging. However, the results we presented in Joules per Bytes for I/O operations, emphasize that checkpointing and HDD logging consume more energy than RAM logging because of the logging duration which is much more higher on HDD than on RAM . We have also shown that for identical nodes performing the same operation, the extra power cost due to this operation is the same. In general, we have learned that the power consumption of a node during a given operation remains constant during this operation. The power consumption of such a node is equal to its idle power consumption to which we add the extra power consumption due to the operation it is performing. Finally, we proposed to consider energy consumption as a criterion for the choice of fault tolerance protocols. In terms of energy consumption, we should promote message logging for applications exchanging small volumes of data and coordination for applications involving few processes. This work is a joint work with F. Cappello (Inria-UIUC-NCSA Joint Laboratory for Petascale Computing).

6.5.3. Towards a Smart and Energy-Aware Service-Oriented Manager for Extreme-Scale Applications

To address the issue of energy efficiency for exascale supercomputers, we proposed a smart and energy-aware service-oriented manager for exascale applications: SEASOMES [17]. This framework aggregates the various energy-efficient solutions to "consume less" energy and to "consume better". It involves both internal and external interactions with the various actors interfering directly or indirectly with the supercomputer. On the one hand, we recommended a more fine-grained collaboration between application and hardware resources in order to reduce energy consumption and provide sustainable exascale services. On the other hand, we suggested a cooperation between the user, the administrator, the resource manager and the energy supplier for the purpose of "consuming better".

6.6. Green-IT Innovation Analysis

Participant: Laurent Lefevre.

Green IT has recently appeared as a mandatory approach to take into account of energy efficiency in Information Technology. This research investigates the Green IT area and its opportunities for innovation. Main motivations for Green IT have been analyzed and we have proposed new definition of Green IT including social, environmental and economic concerns. We have proposed a new model of a virtuous circle that appears in Green IT: while Green IT has its own motivations, resulting research feeds other research field in a virtuous circle. Innovation in this particular sector paves the way for further innovation by means of original research not foreseen at first thoughts.

This analysis is joint work with IRIT (Toulouse - C. Herozog, J.-M. Pierson) [19].

6.7. Workflow Scheduling

Participants: Eddy Caron, Frédéric Desprez, Cristian Klein, Vincent Lanore, Sylvain Gault, Christian Pérez, Adrian Muresan, Frédéric Suter.

6.7.1. High-Level Waste Application Scheduling

Brought forward by EDF, a partner in the ANR COOP project, High-Level Waste is a multi-level application: It is composed of many moldable tasks, part of which are initially known. Some of these tasks may, with a certain probability, launch other tasks, which usually take longer. We have proposed several scheduling algorithms to optimize the performance of such applications, which are little studied in current literature. Experiments with simulations showed that considerable gains can be made, not only in terms of performance, but also performance portability. This work will be published in 2013 [31].

6.7.2. Elastic Scheduling for Functional Workflows

As a recent research direction we have focused on the development of an allocation strategy for budget-constrained workflow applications that target IaaS Cloud platforms. The workflow abstraction is very common amongst scientific applications. It is easy to find examples in any field from bioinformatics to geography. The reasons for the proliferation of workflow applications in science are various, from the building of applications on top of legacy code to modeling of applications that have an inherent workflow structure. The first workflow applications were composed of sequential tasks, but as computational units became more and more parallel, workflow applications have also evolved and are now formed of parallel tasks and, occasionally, parallel moldable tasks. The classic DAG structure of workflow applications has also changed as some applications need to perform refinement iteration, creating loop-like constructs.

We have considered a general model of workflow applications that permit non-deterministic transitions. We have elaborated two budget-constrained allocation strategies for this type of workflow. The problem is a bi-criteria optimization problem as we are optimizing both budget and workflow makespan [12].

For a practical validation of the work, we are currently working on the implementation of the budget-constrained scheduler as part of the Nimbus open source cloud platform. This is being tested with a cosmological simulation workflow application called *Ramses* (see Section 4.4). This is a parallel MPI application that, as part of this work, has been ported for execution on dynamic virtual platforms. This work has been done in the form of a two month internship at the Argonne National Laboratory, USA, under the guidance of Kate Keahey and has been accepted for poster presentation in the XSEDE 2012 conference.

6.7.3. Self-Healing of Operational Workflow Incidents on Distributed Computing Infrastructures

Distributed computing infrastructures are commonly used through scientific gateways, but operating these gateways requires important human intervention to handle operational incidents. We have designed a self-healing process that quantifies incident degrees of workflow activities from metrics measuring long-tail effect, application efficiency, data transfer issues, and site-specific problems. These metrics are simple enough to be computed online and they make little assumptions on the application or resource characteristics. From their degree, incidents are classified in levels and associated to sets of healing actions that are selected based on association rules modeling correlations between incident levels. We specifically study the long-tail effect issue, and propose a new algorithm to control task replication. The healing process is parametrized on real application traces acquired in production on the European Grid Infrastructure. Experimental results obtained in the Virtual Imaging Platform show that the proposed method speeds up execution up to a factor of 4, consumes up to 26% less resource time than a control execution and properly detects unrecoverable errors.

This work is done in collaboration with Tristan Glatard and Rafael Ferreira Da Silva from CREATIS (UMR5220).

6.7.4. Scheduling for MapReduce Based Applications

We have worked on scheduling algorithms for MapReduce applications in Grids and Clouds as we aim at providing resource-efficient and time-efficient scheduling algorithms. This work is mainly done within the scope of the Map-Reduce ANR project.

A deliverable presenting the heuristics for scheduling data transfers derived from a previous work by Berlinska and Drozdowsky has been written [50]. A section of a collaborative paper has been written and the paper has been presented at the ICA CON conference [9], [4]. The results of the aforementioned heuristics that has been previously implemented in a visualization / simulation tool, has been summarized in a paper accepted for RenPar. Moreover, these algorithms and heuristics have been implemented in the MapReduce framework HoMR.

6.8. Performance Evaluation and Modeling

Participants: Eddy Caron, Frédéric Desprez, Matthieu Imbert, Georges Markomanolis, Jonathan Rouzaud-Cornabas, Frédéric Suter.

6.8.1. Time-Independent Log Format

Simulation is a popular approach to obtain objective performance indicators of platforms that are not at one's disposal. It may for example help the dimensioning of compute clusters in large computing centers. In many cases, the execution of a distributed application does not behave as expected, it is thus necessary to understand what causes this strange behavior. Simulation provides the possibility to reproduce experiments under similar conditions. This is a suitable method for experimental validation of a parallel or distributed application.

The tracing instrumentation of a profiling tool is the ability to save all the information about the execution of an application at run-time. Every scientific application executed computed instructions. The originality of our approach is that we measure the completed instructions of the application and not its execution time. This means that if a distributed application is executed on N cores and we execute it again by mapping two processes per core then we need N/2 cores and more time for the execution time of the application. An execution trace of an instrumented application can be transformed into a corresponding list of actions. These actions can then be simulated by SimGrid. Moreover the SimGrid execution traces will contain almost the same data because the only change is the use of half cores but the same number of processes. This does not affect the number of the completed instructions so the simulation time does not get increased because of the overhead. The GRID'5000 platform is used for this work and the NAS Parallel Benchmarks are used to measure the performance of the clusters.

Our main contribution is to propose of a new execution log format that is time-independent. This means that we decouple the acquisition of the traces from the replay. Furthermore we implemented a trace replay tool which relies on top of fast, scalable and validated simulation kernel of SimGrid. We proved that this framework applies for some of the NAS Parallel Benchmarks and we can predict their performance with a good accuracy. Moreover we improved the accuracy of the performance's prediction by applying different instrumentation configurations according to the requirements of our framework. Some performance issues of the executed benchmarks were taken under consideration for more accurate predictions. Also the simulator was reimplemented in order to have more accurate results and take advantage of the last SimGrid's simulation techniques. Finally we did a survey on many different tracing tools with regards to the requirements of our methodology which includes all the latest provided tools from the community. For the extreme cases where we used many nodes by mapping a lot of processes per core, some issues were indicated that we are trying to solve in order to be able to apply our methodology with less overhead. Also we plan to predict the performance of more benchmarks.

6.8.2. Dynamic Network Forecasting

In distributed systems the knowledge of the network is mandatory to know the available connections and their performance. Indeed, to be able to efficiently schedule network transfers on computing platforms such as clusters, grids or clouds, accurate and timely predictions of network transfers completion times are needed. We designed a new metrology and performance prediction framework called Pilgrim which offers a service predicting the completion times of current and concurrent TCP transfers. This service uses SimGrid to simulate the network transfers. Ongoing work is to obtain experimental results comparing the predictions obtained from Pilgrim to the real transfer completion times.

6.8.3. Amazon EC2 simulation

During this year, we have developed an extension of SimGrid to simulate multi-platforms Clouds: SimGrid Cloud Broker (SGCB). It simulates the suite of services provided by Amazon AWS: EC2 for virtual machines, S3 for key-value storage and EBS for block storage. SGCB allows to easily evaluate different resource selection policy but also to simulate an entire application running on a set of resources that come from multiple Clouds. As the billing mechanism is a crucial feature of the Clouds, SGCB is able to simulate it. For this, we extended SimGrid in order to do the accounting of all virtual resources used. With this accounting, we are able to simulate the process of billing as Amazon does it. We are working to increase the accuracy of our performance models, and therefore the validity of the results for different use cases.

6.9. Cloud Resource Management

Participants: Eddy Caron, Frédéric Desprez, Arnaud Lefray, Jonathan Rouzaud-Cornabas, Julien Carpentier, Jean-Patrick Gelas, Laurent Lefevre, Maxime Morel, Olivier Mornard, Francois Rossigneux.

6.9.1. Resource Provisioning for Federations of Clouds

Since the visit of Jose Luis Lucas Simarro, we have established a collaboration with the Distributed Systems Architecture Research Group at Complutense University of Madrid (Spain) on resource brokering strategies for multiples Clouds. The purpose is to design new strategies that are able to migrate services from a Cloud to another one. VM migration is done to save money when the price of running a given VM change. Indeed, in modern Clouds such as Amazon EC2, Spot Instances have dynamic prices that change based on the law of supply and demand. Most of the current solutions only take into account the cost of computation when migrating services between Clouds. However, when a service is migrated, we need to pay network traffic between the two Clouds and the storage of the Virtual Machine image in both Clouds during the migration. We are studying trough simulations different resource selection algorithms that take into account the cost of all resources: compute, storage, and network.

6.9.2. Energy Efficient Clouds

Within the projects CompatibleOne (Open Source Cloud Broker) and XLcloud (Energy Efficiency in OpenStack based clouds), we explore the design of energy aware and energy efficient cloud infrastructures. Monitoring of physical and virtual resources is injected into cloud frameworks. Systems based on such metrics are designed in order to benefit from energy usage knowledge in virtual machines mapping and precise accounting [13].

6.9.3. User Isolation

Inter-VM and virtual network isolation is weak in terms of both security and performance. Accordingly, it can not guarantee performance, security and privacy requirements. This is a serious issue as most of clouds are multi-tenant and users do not trust each other. By improving the resource allocation process, we show how these issue can be solved and thus the overall security of the clouds improved. Moreover, we show how a Cloud Service Provider (CSP) can let the users express their security requirements. We show that isolation requirements have a cost for the Cloud Service Providers but they can bill requirements as an additional service. By doing so, they will have a new resource of income and the users trust in their platforms will increase as they can express security requirements.

6.9.4. Cloud Security

Mandatory Access Control is really poorly supported by Cloud environments. Our work proposes extensions of the OpenNebula Cloud in order to provide an advanced MAC protection of the virtual machines hosted by the different nodes of the Cloud. Thus, unique SELinx security labels are associated with the virtual machines and their resources. The instantiations and migrations of the virtual machines maintain those unique security labels. Moreover, PIGA-Virt provides a unified way to control the information flows within a virtual machine but also between multiple virtual machines. SELinux controls the direct flows. PIGA-Virt adds advanced controls. Thus, a PIGA protection rule can control several direct and indirect flows. The benchmarks of PIGA-Virt show that our Trusted OpenNebula Cloud is efficient regarding the quality of the protection.

This work is done in collaboration with Christian Toinard from LIFO/ENSI de Bourges.

6.10. Virtualizing Home Gateways at Large Scale

Participants: Jean-Patrick Gelas, Laurent Lefevre.

About 80-90% of the energy in today's wireline networks is consumed in the access network, with about 10 W per user being dissipated mostly by the customer premises equipment (CPE). Home gateway is a popular equipment deployed at the end of networks and supporting a set of heterogeneous services (from network to multimedia services). These gateways are difficult to manage for network operators and consume a lot of energy. This research explores the possibility to reduce the complexity of such equipment by moving services to some external dedicated and shared equipments. When combined to quasi passive CPE, this approach can reduce the energy consumption of wired networks infrastructures. This research is done within the GreenTouch initiative which aims to increase network energy efficiency by a factor of 1000 from current levels by 2015.

This work is done with collaboration with Addis Abeba University (Ethiopia) (M. Mulugeta and T. Assefa) [18].

6.11. Self-Adaptive Deployment

Participants: Eddy Caron, Maurice-Djibril Faye, Jonathan Rouzaud-Cornabas.

Software systems are increasingly expected to be self-adaptive. Such software systems have the capability to autonomously modify their behavior at run-time in response to changes in their environment. This capability may be included in the software systems at design time or later by external mechanisms. Therefore, along their development process multiple adaptation concerns must be considered, such as the response to changes in the utilization patterns, the need for alternative algorithms for implementing a function, or the diversity of the infrastructure. We have designed an architecture which aims to add self-adaptive capabilities to an existing middleware so that its deployment becomes self-adaptive. The framework uses external mechanisms for that purpose since this capability was not a native feature.

7. Partnerships and Cooperations

7.1. National Initiatives

7.1.1. FUI CompatibleOne Project, 2010-2012

Participants: Laurent Lefevre, Julien Carpentier, Maxime Morel, Olivier Mornard.

The project CompatibleOne (Nov 2010-Nov 2012) funded by the Fonds Unique Interministériel (FUI) is dealing with the building of a Cloud architecture open software stack.

CompatibleOne is an open source project with the aim of providing interoperable middleware for the description and federation of heterogeneous clouds comprising resources provisioned by different cloud providers. Services provided by Inria participation (module COEES) should allow to act on the system's core by offering a scenario for the broker using energy constraints. These constraints should allow virtual machines placement and displacement using energy profile. Collected data must be available for CO and other systems for future researches. We took part in the analysis of the specification of the system. Mainly, we are in charge of the energy efficiency module. We also had participation in several modules like COMONS (monitoring module), ACCORDS (brokering module), EZVM (virtualization module) and CONETS (networking module). To make energy measurement, we used hardware probes and we studied software probes too. We evaluated several probes providers like Eaton and Schleifenbauer which provide smart PDU (Power Distribution Unit). We also evaluated IPMI board provided by DELL, our computers manufacturer, and OmegaWatt, a small company which provides custom hardware for energy measurement.

In this project, our work is focused on the design and provisioning of energy aware and energy efficient components in order to include energy aspects in QoS, SLAs and billing in clouds architectures. We lead the task T3.4 on energy management and will participate in activities on virtual machines design and migration [13].

7.1.2. FSN XLcloud, 2012-2014

Participants: Jean-Patrick Gelas, Laurent Lefevre, Francois Rossigneux.

Focused on high-performance computing, the XLcloud collaborative project sets out to define and demonstrate a cloud platform based on *HPC-as-a-Service*. This is designed for computational intensive workloads, with interactive remote visualisation capabilities, thus allowing different users to work on a common platform. XLcloud project's members design, develop and integrate the software elements of a High Performance Cloud Computing (HPCC) System.

Expected results of the projects include : Functional and technical specification of the XLcloud platform architecture, open source API of the XLcloud platform, implementation of algorithms for 3D and video streaming display, prototype of the XLcloud platform including the support of on-demand virtual clusters and remote visualisation service, use cases for validation, illustrating the performance and suggesting future improvements.

XLcloud aims at overcoming some of the most important challenges of implementing operationally high performance applications in the Cloud. The goal is to allow partners of the project to take leadership position in the market, as cloud service providers, or as technology providers. XLcloud relies on a consortium of various partners (BULL (project leader), TSP, Silkan, EISTI, Ateme, Inria, CEA List, OW2, AMG.Lab).

In this project, the Avalon team investigates the issue of energy awareness and energy efficiency in OpenStack Cloud based platforms.

7.1.3. ANR ARPEGE MapReduce (Scalable data management for Map-Reduce-based data-intensive applications on cloud and hybrid infrastructures), 4 years, ANR-09-JCJC-0056-01, 2010-2013

Participants: Frédéric Desprez, Gilles Fedak, Sylvain Gault, Christian Pérez, Anthony Simonet.

MapReduce is a parallel programming paradigm successfully used by large Internet service providers to perform computations on massive amounts of data. After being strongly promoted by Google, it has also been implemented by the open source community through the Hadoop project, maintained by the Apache Foundation and supported by Yahoo! and even by Google itself. This model is currently getting more and more popular as a solution for rapid implementation of distributed data-intensive applications. The key strength of the MapReduce model is its inherently high degree of potential parallelism.

In this project, the AVALON team participates to several work packages which address key issues such as efficient scheduling of several MapReduce applications, integration using components on large infrastructures, security and dependability, and MapReduce for Desktop Grid.

7.1.4. ANR grant: COOP (Multi Level Cooperative Resource Management), 3.5 years, ANR-09-COSI-001-01, 2009-2013

Participants: Frédéric Desprez, Cristian Klein, Christian Pérez.

The main goals of this project are to set up a cooperation as general as possible between programming models and resource management systems and to develop algorithms for efficient resource selection. In particular, the project targets the SALOME platform and the GRID-TLSE expert-site (http://gridtlse.org/) as an example of programming models, and PadicoTM, DIET and XtreemOS as examples of communication manager, grid middleware and distributed operating systems.

The project is led by Christian Pérez.

7.1.5. ANR grant SPADES (Servicing Petascale Architectures and DistributEd System), 3.5 years, 08-ANR-SEGI-025, 2009-2012

Participants: Eddy Caron, Florent Chuffart, Frédéric Suter, Haiwu He.

Today's emergence of Petascale architectures and evolutions of both research grids and computational grids increase a lot the number of potential resources. However, existing infrastructures and access rules do not allow to fully take advantage of these resources. One key idea of the SPADES project is to propose a non-intrusive but highly dynamic environment able to take advantage of the available resources without disturbing their native use. In other words, the SPADES vision is to adapt the desktop grid paradigm by replacing users at the edge of the Internet by volatile resources. These volatile resources are in fact submitted via batch schedulers to reservation mechanisms which are limited in time or susceptible to preemption (best-effort mode).

One of the priorities of SPADES is to support platforms at a very large scale. Petascale environments are therefore particularly considered. Nevertheless, these next-generation architectures still suffer from a lack of expertise for an accurate and relevant use. One of the SPADES goal is to show how to take advantage of the power of such architectures. Another challenge of SPADES is to provide a software solution for a service discovery system able to face a highly dynamic platform. This system will be deployed over volatile nodes and thus must tolerate failures. SPADES will propose solutions for the management of distributed schedulers in Desktop Computing environments, coping with a co-scheduling framework.

7.1.6. ANR grant: USS SimGrid (Ultra Scalable Simulation with SimGrid), 3.8 years, ANR-08-SEGI-022, 2008-2012

Participants: Frédéric Desprez, Matthieu Imbert, Georges Markomanolis, Frédéric Suter.

The USS-SimGrid project aims at Ultra Scalable Simulations with SimGrid. This tool is leader in the simulation of HPC settings, and the main goal of this project is to allow its use in the simulation of desktop grids and peer-to-peer settings. The planned work is to improve the models used in SimGrid (increasing their scalability and easing their instantiation), provide associate tools for experimenters (result analysis assistants and test campaign managers), and increase the simulation kernel scalability by parallelization and optimization. The project also aims at producing a scientific instrument directly usable by a large community and is well adapted to the needs of various users.

7.1.7. ANR grant: SONGS (Simulation Of Next Generation Systems), 4 years, ANR-12-INFRA-11, 2012-2015

Participants: Frédéric Desprez, Georges Markomanolis, Jonathan Rouzaud-Cornabas, Frédéric Suter.

The last decade has brought tremendous changes to the characteristics of large scale distributed computing platforms. Large grids processing terabytes of information a day and the peer-to-peer technology have become common even though understanding how to efficiently such platforms still raises many challenges. As demonstrated by the USS SimGrid project, simulation has proved to be a very effective approach for studying such platforms. Although even more challenging, we think the issues raised by petaflop/exaflop computers and emerging cloud infrastructures can be addressed using similar simulation methodology.

The goal of the SONGS project is to extend the applicability of the SimGrid simulation framework from Grids and Peer-to-Peer systems to Clouds and High Performance Computation systems. Each type of large-scale computing system will be addressed through a set of use cases and lead by researchers recognized as experts in this area.

Any sound study of such systems through simulations relies on the following pillars of simulation methodology: Efficient simulation kernel; Sound and validated models; Simulation analysis tools; Campaign simulation management.

7.1.8. ANR JCJC: Clouds@Home (Cloud Computing over Unreliable, Shared Resources), 4 years, ANR-09-JCJC-0056-01, 2009-2012

Participants: Gilles Fedak, Bing Tang.

Recently, a new vision of cloud computing has emerged where the complexity of an IT infrastructure is completely hidden from its users. At the same time, cloud computing platforms provide massive scalability, 99.999% reliability, and improved performance at relatively low costs for complex applications and services. This project, lead by D. Kondo from Inria MESCAL investigates the use of cloud computing for large-scale and demanding applications and services over unreliable resources. In particular, we target volunteered resources distributed over the Internet. In this project, G. Fedak leads the Data management task (WP3).

7.1.9. Inria ADT BitDew, 2 years, 2010-2012

Participants: Gilles Fedak, José Saray.

ADT BitDew is an Inria support action of technological development for the BitDew middleware. Objectives are several fold : i/ provide documentation and education material for end-users, ii/ improve software quality and support, iii/ develop new features allowing the management of Cloud and Grid resources.

7.1.10. Inria ADT Aladdin, 4 years, 2008-2014

Participants: Simon Delamare, Frédéric Desprez, Matthieu Imbert, Laurent Lefèvre, Christian Pérez.

ADT ALADDIN is an Inria support action of technological development which supports the GRID'5000 instrument. Frédéric Desprez is leading this action (with David Margery from Rennes as the Technical Director).

7.1.11. Inria Large Scale Initiative HEMERA, 4 years, 2010-2013

Participants: Daniel Balouek, Christian Pérez, Laurent Pouilloux.

Hemera deals with the scientific animation of the GRID'5000 community. It aims at making progress in the understanding and management of large scale infrastructure by leveraging competences distributed in various French teams. Hemera contains several scientific challenges and working groups. The project involves around 24 teams located in all around France.

C. Pérez is leading the project; D. Balouek and L. Pouilloux are managing scientific challenges on GRID'5000.

7.2. European Initiatives

7.2.1. FP7 Projects

7.2.1.1. EDGI

Title: EDGI: European Desktop Grid Initiative

Type: CAPACITIES (Infrastructures)

Instrument: Combination of COLLABORATIVE PROJECTS and COORDINATION and SUPPORT ACTIONS (CPCSA)

Duration: June 2010 - May 2012

Coordinator: MTA SZTAKI (Hungary)

Others partners: CIEMAT, ES; Fundecyt, ES; University of Westminster, UK; Cardiff University, UK; University of Coimbra, PT; CNRS, FR, AlmerGrid, NL

See also: http://edgi-project.eu/

Abstract: The project EDGI will develop middleware that consolidates the results achieved in the EDGeS project concerning the extension of Service Grids with Desktop Grids in order to support EGI and NGI user communities that are heavy users of DCIs and require extremely large number of CPUs and cores. EDGI will go beyond existing DCIs that are typically cluster Grids and supercomputer Grids, and will extend them with public and institutional Desktop Grids and Clouds. EDGI will integrate software components of ARC, gLite, Unicore, BOINC, XWHEP, 3G Bridge, and Cloud middleware such as OpenNebula and Eucalyptus into SG$\rightarrow$ DG $\rightarrow$ Cloud platforms for service provision and as a result EDGI will extend ARC, gLite and Unicore Grids with volunteer and institutional DG systems. In this project, G. Fedak is the Inria representative and lead the JRA2 work package which is responsible for providing QoS to Desktop Grids.

7.2.1.2. PRACE 2IP

Title: PRACE – Second Implementation Phase Project

Type: Integrated Infrastructure Initiative Project (I3)

Instrument: Combination of Collaborative projects and Coordination and support action

Duration: September 2011 - August 2013

Coordinator: Thomas Lippert (Germany)

Others partners: Jülich GmbH, GCS, GENCI, EPSRC, BSC, CSC, ETHZ, NCF, JKU, Vetenskapsradet, CINECA, PSNC, SIGMA, GRNET, UC-LCA, NUI Galway, UYBHM, CaSToRC, NCSA, Technical Univ. of Ostrava, IPB, NIIF

See also: http://prace-ri.eu

Abstract: The purpose of the PRACE RI is to provide a sustainable high-quality infrastructure for Europe that can meet the most demanding needs of European HPC user communities through the provision of user access to the most powerful HPC systems available worldwide at any given time. In tandem with access to Tier-0 systems, the PRACE-2IP project will foster the coordination between national HPC resources (Tier-1 systems) to best meet the needs of the European HPC user community. To ensure that European scientific and engineering communities have access to leading edge supercomputers in the future, the PRACE-2IP project evaluates novel architectures, technologies, systems, and software. Optimizing and scaling of application for Tier-0 and Tier-1 systems is a core service of PRACE.

Inria participates to Work Package 12 which is about novel programming techniques.

7.2.1.3. PaaSage

Title: PaaSage: Model-based Cloud Platform Upperware

Type: Seventh Framework Programme

Instrument: Collaborative project

Duration: October 2012 - September 2016 (48 months)

Coordinator: Pierre Guisset (GEIE ERCIM)

Others partners: SINTEF, STFC, HLRS, University of Stuttgart, Inria, CETIC, FORTH, be.wan, EVRY, SysFera, Flexiant, Lufthansa Systems, AG GWDG, Automotive Simulation Center Stuttgart e.V.

See also: http://paasage.eu

Abstract: PaaSage will deliver an open and integrated platform, to support both deployment and design of Cloud applications, together with an accompanying methodology that allows model-based development, configuration, optimization, and deployment of existing and new applications independently of the existing underlying Cloud infrastructures. Specifically it will deliver an IDE (Integrated Development Environment) incorporating modules for design time and execution time optimizations of applications specified in the CLOUD Modeling Language (CLOUD ML), execution-level mappers and interfaces and a metadata database.

7.2.2. Collaborations in European Programs, except FP7

Program: Celtic-Plus

Project acronym: SEED4C

Project title: Security Embedded Element and Data privacy for the Cloud.

Duration: 2012-2015

Coordinator: Bertrand Marquet (Alcatel-Lucent lab)

Other partners: Gemalto, ENSI Bourges, Inria, Wallix, VTT Technical Research centre of Finland, Mikkelin Puhelin Oyj, Cygate, Nokia Siemens Networks, Finceptum OY (Novell), Solacia, Innovalia Association, Nextel, Software Quality Systems, Ikusi, Vicomtech, Biscaytik

Abstract: SEED4C is a Celtic-Plus project: an industry-driven European research initiative to define, perform and finance through public and private funding common research projects in the area of telecommunications, new media, future Internet, and applications and services focusing on a new "Smart Connected World" paradigm. Celtic-Plus is a EUREKA ICT cluster and is part of the intergovernmental EUREKA network.

The cloud security challenge not only reflects on the secure running of software on one single machine, but rather on managing and guaranteeing security of a computer group or cluster seen as a single entity. Seed4C focus is to evolve from cloud security with an isolated point or centralized points of enforcement for security to cloud security with cooperative points of enforcement for security.

Program: COST

Project acronym: COST IC804

Project title: : Energy efficiency in Large Scale Distributed Systems

Duration: 2009-2013

Coordinator: J.M. Pierson (IRIT)

Other partners: 26 research institute and countries

Abstract: The COST Action IC0804 proposes realistic energy-efficient alternate solutions to share IT distributed resources. As large scale distributed systems gather and share more and more computing nodes and Storage resources, their energy consumption is exponentially increasing. While much effort is nowadays put into hardware specific solutions to lower energy consumptions, the need for a complementary approach is necessary at the distributed system level, i.e. middleware, network and applications. This Action characterizes the energy consumption and energy efficiencies of distributed applications. Then based on the current hardware adaptation possibilities and innovative algorithms it proposes adaptive and alternative approaches taking into account the energy saving dimension of the problem. This Action also characterizes the trade-off between energy savings and functional and non-functional parameters, including the economic dimension. Deliverables includes workshop proceedings, books, good practice leaflets fostering consciousness rise at ICT researchers, scientists, managers and users levels. Finally, benefits addresses scientific and societal needs.

Program: COST

Project acronym: IC0805

Project title: Open Network for High-Performance Computing on Complex Environments (ComplexHPC)

Duration: 2009-2013

Coordinator: Emmanuel Jeannot (Inria Bordeaux - Sud Ouest)

Other partners: 26 research institute and countries

Abstract: The main objective of the Action is to develop an integrated approach for tackling the challenges associated with heterogeneous and hierarchical systems for High Performance Computing.

Program: Intelligent Energy in Europe

Project acronym: PrimeEnergyIT

Project title: PrimeEnergyIT: Efficient Data Centers

Duration: 2010-2012

Coordinator: B. Schappi (Austrian Energy Agency)

Other partners: organisme, labo (pays)

Abstract: The increasing use of powerful IT services in all public and private service sectors as for example administration, health services and entertainment has lead to a growing energy demand for centralized IT equipment in data centers and central IT units of companies. According to EU and US studies this trend will continue unless energy efficient technology and efficient operation of equipment is broadly implemented. Business-as-usual would lead to a doubling of energy consumption within a few years thereby also significantly increasing energy costs in data centers. The implementation of energy efficient technologies and optimized hardware operation however allows energy and cost savings of up to 60%. PrimeEnergyIT supports the market development and demand for energy efficient central IT hardware and infrastructure providing tools and services for IT and infrastructure managers, consultants and other relevant experts. The PrimeEnergyIT initiative is operated by an international consortium of national agencies and research institutions in cooperation with a number of associate partners from industry [44], [36].

7.3. International Initiatives

7.3.1. Participation In International Programs

7.3.1.1. Inria-UIUC-NCSA Joint Laboratory for Petascale Computing

Participants: Eddy Caron, Frédéric Desprez, Mohammed El Mehdi Diouri, Olivier Glück, Cristian Klein, Vincent Lanore, Laurent Lefevre, Christian Pérez, Jonathan Rouzaud-Cornabas.

The Joint Laboratory for Petascale Computing focuses on software challenges found in complex high-performance computers. The Joint Laboratory is based at the University of Illinois at Urbana-Champaign and includes researchers from the French national computer science institute called Inria, Illinois' Center for Extreme-Scale Computation, and the National Center for Supercomputing Applications. Much of the Joint Laboratory's work will focus on algorithms and software that will run on Blue Waters and other petascale computers.

7.3.1.2. PICS CNRS 5473: Dimensioning through Simulation

Participants: Frédéric Desprez, Georges Markomanolis, Frédéric Suter.

This International Scientific Collaboration Project with the University of Hawai'i at Manoa (2009-2012) aims at comparing, solidifying and integrating within a single framework, namely SimGrid, several approaches to dimension infrastructures thanks to simulation.

7.3.1.3. GreenTouch

Participants: Laurent Lefevre, Jean-Patrick Gelas.

GreenTouch is a consortium of leading Information and Communications Technology (ICT) industry, academic and non-governmental research experts dedicated to fundamentally transforming communications and data networks, including the Internet, and significantly reducing the carbon footprint of ICT devices, platforms and networks.

In this project, we explore the design of virtual home gateway at large scale [18], [29] and participate in the SEASON project.

7.4. International Research Visitors

7.4.1. Visits of International Scientists

- L. Lefevre: Hosting Teferi Assefa, PhD student from Addis Abeba University Ethiopia (from sept to dec. 2012) - Joint work on Virtualization of Virtual Home Gateways in link with the GreenTouch initiative.
- G. Fedak: Hosting Matei Ripenau, ENS Visiting Professor from University of British Columbia (Canada). Joint work on large-scale data management. Hosting Mircea Moca, lecturer University of Babes Bolaj, Romania. Joint work on scheduling for hybrid distributed infrastructure.

7.4.1.1. Internships

- F. Suter: Hosting 2 Short Term Scientific Missions in the context of the COST Action IC0805. H. Arabnejab (University of Porto, Portugal) and Z. Papazachos (University of Thessaloniki, Greece).
- G. Fedak: Hosting Asma Ben Cheick (Msc, Faculté des sciences de Tunis), 1 month, Haidau Andrei, University of Cluj-Napoca, 3 months.
- F. Desprez, J. Rouzaud-Cornabas: Hosting Jose Luis Lucas, PhD student from Madrid (Spain), 3 months. Joint work on the resource provisioning in Clouds taking into account performance and cost.

8. Dissemination

8.1. Scientific Animation

Eddy Caron

- Program Committee Membership (international conferences and workshops): SOAC 2012 (International Workshop on Service-Oriented Architecture and Cloud Computing within ICACCI2013), Cloud & Grid2012 (The 2012 International Workshop on Cloud and Grid Interoperability (Cloud&Grid 2012)), CLOSER 2012 (2nd International Conference on Cloud Computing and Services Science), HCW 2012 (21st International Heterogeneity in Computing Workshop in conjunction with IPDPS 2012), SC12 Tutorials
- Program Committee Membership (national conferences and workshops): Realis (Reproductibilité expérimentale pour l'informatique en parallélisme, architecture et système – 1ère édition within ComPAS'2013)

Frédéric Desprez

- Program Committee Membership (international conferences and workshops): BDMC (1st Workshop on Big Data Management in Clouds held in conjunction with the EuroPar 2012 conference), Federatedclouds (Workshop on Cloud Services and the 8th Open Cirrus Summit), CGWS'2012 within EuroPAR, CLOSER 2012 (2nd International Conference on Cloud Computing and Services Science), ICA CON 2012 (1st International Conference of the IBM Cloud Academy), CCGRID 2012 (12th IEEE International Symposium on Cluster, Cloud and Grid Computing), HPGC 2012 (FTRA International Workshop on Human centric computing, P2P, Grid and Cloud computing), VTDC Workshop (5th International Workshop on Virtualization Technologies in Distributed Computing (within HPDC 2012)), LaSCoG'2012 (8th Workshop on Large Scale Computations on Grids), 3PGCIC (7th International Conference on P2P, Parallel, Grid, Cloud, and Internet Computing, Victoria, Canada, Nov.2012), ICPADS 2012 (18th IEEE International Conference on Parallel and Distributed Systems), CFSE (Conférence Française en Systèmes d'Exploitation), CloudCom 2012 (Services and Applications track of IEEE CloudCom 2012), Grid'12 (The 13th ACM/IEEE International Conference on Grid Computing)
- Program Committee Membership (national conferences and workshops): CFSE (Conférence Française en Systèmes d'Exploitation)

Gilles Fedak

- Publicity Chair 13th IEEE/ACM International Conference on Grid Computing Grid'12, Beijing, China, 2012
- Co-chair Third International Workshop on the MapReduce Programing Model and its Application (MapReduce 2012), in conjunction with HPDC'12, Delft, Nederlands, 2012
- Program Committee Membership: 13th IEEE/ACM International Conference on Grid Computing (Grid'12), ACM Symposium on High-Performance Parallel and Distributed Computing (HPDC'2012), International Conference on Computer Communication Networks(ICCCN), track on Grid and Cloud Computing (GCC), 8th IEEE International Conference on eScience (eScience 2012), 4th IEEE International Conference on Cloud Computing Technology and Science (CloudCom 2012), 12th IEEE International Conference on Scalable Computing and Communications (ScalCom-12), 20th Euromicro International Conference on Parallel, Distributed and Network-Based Processing (PDP'12),

Jean-Patrick Gelas

- Reviewing committee: CCGrid2012
- University committee: Master (M2 CCI) jury

Olivier Glück

- Reviewing committee: CCGrid2012
- University committee: Member of the CEVU (Conseil des Etudes et de la Vie Universitaire) of University Lyon 1, Member of the UFR Faculté des Sciences et Technologies faculty council of University Lyon 1, Member of the computer science department council of University Lyon 1

Laurent Lefevre

- Program Vice-Chair of the track "Cluster, Grid and Cloud Computing" in the The 12th IEEE International Conference on Scalable Computing and Communications (ScalCom 2012), Changzhou, China, December 17-20, 2012
- Program Chair of the The IEEE International Conference on Green Computing and Communications (GreenCom 2012) , Besancon, France, November 20-23, 2012
- Co-organizer of Entretiens Jacques Cartier : Colloquium on "Towards ecological and energy efficient Information and Communication Technology - Vers des Technologies de l'Information écologiques et efficaces en consommation énergétique", Lyon, France, November 19-20, 2012

- Co-Organization of Inria Booth in SuperComputing 2012, Salt Lake City, USA, November 10-16, 2012
- Co PC Chair of Cloud&Grid 2012 : The Second International Workshop on Cloud and Grid Interoperability, Gwangju, Korea, 6-8 September 2012
- Co PC Chair of the 14th IEEE International Conference on High Performance Computing and Communications (HPCC-2012), Liverpool, UK, 25-27 June, 2012
- Steering Comittee Member of : IEEE TCSC Technical Area in Green Computing, CCGrid 2012 : 12th IEEE/ACM International Symposium on Cluster, Cloud and Grid Computing
- Program Committee Member of the following international conferences : The 6th International Conference on Network and System Security (NSS 2012), 5th IEEE/ACM International Conference on Utility and Cloud Computing (UCC 2012), Third International Conference on Energy-Aware High Performance Computing, ICT-GLOW 2012: 2nd International Conference on ICT as Key Technology for the Fight against Global Warming, HP-PAC2012: The Eight Workshop on High-Performance, Power-Aware Computing, CCGrid 2012 : 12th IEEE/ACM International Symposium on Cluster, Cloud and Grid Computing, E-Energy 2012 : the third International Conference on Future Energy System, PMAM 2012 : The 2012 International Workshop on Programming Models and Applications for Multicores and Manycores, The 10th Australasian Symposium on Parallel and Distributed Computing (AusPDC2012)
- Program Committee Member of the following national conference : NOTERE / CFIP : Nouvelles technologies de la répartition / Colloque francophone sur l'ingénierie des protocoles,

Christian Pérez

- Program Committee Membership: 20th High Performance Computing Symposium (HPC 2012), 10th International Conference on Service Oriented Computing (ICSOC 2012), Conference for Young Scientists "Facing the Multicore-Challenge III".
- Reviewer for the 12th IEEE/ACM International Symposium on Cluster, Cloud and Grid Computing (CCGrid 2012), 5th International Conference on Cloud Computing (IEEE Cloud 2012).

Frédéric Suter

- Program Committee Membership (international conferences and workshops): CLOSER 2012 (2nd International Conference on Cloud Computing and Services Science), VTDC Workshop (5th International Workshop on Virtualization Technologies in Distributed Computing (within HPDC 2012)), LaSCoG'2012 (8th Workshop on Large Scale Computations on Grids), Vecpar 2012 (10th International Meeting on High-Performance Computing for Computational Science), MAPREDUCE2012 (Third International Workshop on MapReduce and its Applications).
- Program Committee Membership (national conferences and workshops): Realis (Reproductibilité expérimentale pour l'informatique en parallélisme, architecture et système – 1ère édition within ComPAS'2013)

8.2. Teaching - Supervision - Juries

8.2.1. Teaching

Master: Eddy Caron, Grid and Cloud Computing, 14 hours, M2, ENS Lyon, France

Master: Eddy Caron, Distributed System, 39 hours, M1, ENS Lyon, France

Master: Eddy Caron, Engineering Software, 39 hours, M1, ENS Lyon, France

Master: Eddy Caron, Grids, 8 hours, M2 RTS, INSA, France

Master: Frd´éric Desprez, Parallel Computing, 30h, M1, Université Lyon 1, France
Master : Jean-Patick Gelas, Réseaux avancés : IPv6 and IP routing, 40h, niveau M2, Université Lyon 1, France
Master : Jean-Patick Gelas, Architecture des réseaux : Router under the hood, 6h, niveau M2, Université Lyon 1, France
Master : Jean-Patick Gelas, Systèmes d'exploitation, 24h, niveau M2, Université Lyon 1, France
Master : Jean-Patick Gelas, Réseaux, 35h, niveau M2, Université Lyon 1, France
Master : Jean-Patick Gelas, Systèmes et logiciels embarqués, 45h, niveau M2, Université Lyon 1, France
Licence : Olivier Glück, Initiation Réseaux, 2x9h, niveau L2, Université Lyon 1, France
Licence : Olivier Glück, Réseaux, 2x70h, niveau L3, Université Lyon 1, France
Licence : Olivier Glück, Réseaux, 60h, niveau L3, Université des Sciences de Ho Chi Minh ville, Vietnam
Master : Olivier Glück, Services et Protocoles Avancés sur Internet, 40h, niveau M2, Université Lyon 1, France
Master : Olivier Glück, Administration des Systèmes et des Réseaux, 16h, niveau M2, Université Lyon 1, France
Master : Laurent Lefevre, Green Networking, 16h, M2, Ecole Normale Supérieure de Lyon, France
Master : Laurent Lefevre, Operating Systems, 39h, MASTER Informatique Spćialité Compétence Complémentaire en Informatique, Université Claude Bernard, Lyon1, France
Master : Christian Pérez, Grid and Cloud Computing, 14h, M2, Ecole Normale Supérieure de Lyon, France

8.2.2. Supervision

PhD & HdR

- Vincent Pichon, PhD defended October 5th, 2012, *Contribution à la conception à base de composants logiciels d'applications scientifiques parallèle*, André Ribes (EDF R&D, co-dir), C. Pérez (dir), [3].
- Cristian Klein, PhD defended November 29th, 2012, *Cooperative Resource Management for Parallel and Distributed Systems*, C. Pérez, [1].
- Adrian Muresan, PhD defended December 10th, 2012, *Scheduling and deployment of large-scale applications on Cloud platforms*, E. Caron (co-dir), F. Desprez (dir), [2].
- Mohammed Diouri , PhD in progress, *Performances and low energy consumption for distributed applications executed on exascale systems*, Oct. 1, 2010, I. Guérin Lassous (Dir.) and L. Lefèvre and O. Glück
- Maurice Djibril Faye, PhD in progess *Déploiement auto-adaptatif d'intergiciel sur plateforme élastique*, Eddy Caron (dir), Ousmane Thiaré (Université Gaston Berger, St Louis, Sénégal, co-dir)
- Sylvan Gault, PhD in progress, *Ordonnancement de tâches avec le modèle MapReduce*, F. Suter (co-dir), F. Desprez (dir)
- Vincent Lanore, PhD in progress, *Adaptation et dynamicité dans les modèles à composants logiciels pour les applications scientifiques*, C. Pérez.
- Arnaud Lefray , PhD in progess, *Mission fonctionnelle et de sécurité dans une informatique en nuage*, Eddy Caron (dir), Christian Toinard (ENSIB, co-dir)
- Anthony Simonet , PhD in progress, *Large scale data management in hybrid distributed computing infrastructures* G. Fedak
- Ghislain Tsafack Chetsa, PhD in progress, *Energy profile and green levers for applications and services over large scale and distributed infrastructures*, (2011-2014), L. Lefèvre (Dir.) and J.-M. Pierson (IRIT, co-dir.)
- Georges Markomanolis, PhD in progress, *Environnement de simulation pour l'aide au dimensionnement de grilles de calcul* , F. Suter (co-dir), F. Desprez (dir)

8.2.3. Juries

- Frédéric Desprez, HDR reviewer of Marc Baboulin, *Fast and reliable solutions for numerical linear algebra solvers in high-performance computing*, LRI, November 2012; PhD reviewer of Simplice Donfack, *Methods and algorithms for solving linear systems of equations on massively parallel computers*, LRI, June 2012; of Rodrigue Chakode, *Environnement d'excútion pour des services de calcul à la demande sur des grappes mutualisées*, Grenoble, June 2012; of Lamiel Toch, *Contributions aux techniques d'ordonnancementsur plates-formes parallèles ou distribuées*, Besançon, November 2012; of Yrjö Raivio, *Techno-Economic Analysis of Novel Opportunities for Mobile Networks – Open Innovation and Cloud Computing*, Helsinki, December 2012; PhD defense committee member of Xavier Etchevers, *Déploiement d'applications patrimoniales en environnements de type informatique dans le nuage*, Grenoble, December 2012.
- Gilles Fedak, PhD external reviewer of Ian Kelley, *Data Management in Dynamic Distributed Computing Environment* UK, November 2012
- Laurent Lefevre, PhD reviewer of Marco Guazzone *Power and Performance Management in Cloud Computing Systems*, University of Torino, Italy, February 2012
- Christian Pérez, PhD reviewerof Ahmed Turki, *Un modèle pour la composition d'applications de visualisation et d'interaction continue avec des simulations scientifiques*, University of Orleans, March 2012; of André Lage Freitas, *Autonomous Service Execution Driven by Service Level Agreements*, INSA Rennes, March 2012; of Javier Rojas Balderrama, *Gestion du cycle de vie de services déployés sur une infrastructure de calcul distribué en neuroinformatique*, University of Nice Sophia Antipolis, April 2012; of Jérmˆe Clet-Ortega, *Exploitation efficace des architectures parallèles de type grappes de NUMA à l'aide de modèles hybrides de programmation*, University of Bordeaux I, April 2012; of Héctor Fernández, *Flexible Coordination through the Chemical Methaphor for Services Infrastructure*, University of Rennes I, June 2012; of Mihai Alexandru, *Efficient large electromagnetic simulation based on hybrid TLM and modal approach on grid computing and supercomputer*, University of Toulouse, December 2012.

8.3. Popularization

Laurent Lefevre :

- Co-organizer of the Rencontres Inria Industrie : Sciences Numériques et efficacité énergétique - Numerical Sciences and energy efficiency, Inria Montbonnot, France, March 8, 2012
- Co-organizer of the Second Half day on "Public procurement of Energy efficient datacenters - Achats publics de datacentres efficaces du point de vue énergétique", within the PrimeEnergyIt Project, with BIO Intelligence Service company, Paris, France, February, 10, 2012
- Co-organizer of the Green Days @ Lyon event: "Energy efficiency : how to monitor and impact on applications ?", Lyon, France, January 19-20, 2012
- Member of "Comité de Pilotage" for the collaborative writing of a Ademe Book on "Guide Sectoriel 2012 : Réalisation d'un bilan des émissions de gaz à effet de serre", 146 pages, January 2012
- "L'émergence du Green-IT, pour une informatique plus verte" : Article and Interview for 20 ans Inria Rhone Alpes, Laurent Lefevre and Bel Dumé, November 15, 2012
- "Le Green IT se réfugie au Nord !" : Brève Inria; "Le saviez-vous ?", Laurent Lefevre and Christophe Castro, May 10, 2012
- Interview for the paper "Comment se chauffer avec les *data centers*", Les Echos, April 2012

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Publications of the year

Doctoral Dissertations and Habilitation Theses

[1] C. KLEIN. *Cooperative Resource Management for Parallel and Distributed Systems*, École Normale Supérieure de Lyon - University of Lyon, nov 2012.

[2] A. MURESAN. *Scheduling and deployment of large-scale applications on Cloud platforms*, École Normale Supérieure de Lyon - University of Lyon, dec 2012.

[3] V. PICHON. *Contribution à la conception à base de composants logiciels d'applications scientifiques parallèle*, École Normale Supérieure de Lyon - University of Lyon, oct 2012.

Articles in International Peer-Reviewed Journals

[4] G. ANTONIU, J. BIGOT, C. BLANCHET, L. BOUGÉ, F. BRIANT, F. CAPPELLO, A. COSTAN, F. DESPREZ, G. FEDAK, S. GAULT, K. KEAHEY, B. NICOLAE, C. PÉREZ, A. SIMONET, F. SUTER, B. TANG, R. TERREUX. *Towards Scalable Data Management for Map-Reduce-based Data-Intensive Applications on Cloud and Hybrid Infrastructures*, in "International Journal of Cloud Computing (IJCC)", 2013, To appear, http://hal.inria.fr/hal-00767029.

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International Conferences with Proceedings

[8] Z. AFOULKI, A. BOUSQUET, J. BRIFFAUT, J. ROUZAUD-CORNABAS, C. TOINARD. *MAC protection of the OpenNebula Cloud environment*, in "High Performance Computing and Simulation (HPCS), 2012 International Conference on", Madrid, Spain, 2012, p. 85 -90 [*DOI :* 10.1109/HPCSIM.2012.6266895], http://hal.inria.fr/hal-00766727.

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