IN PARTNERSHIP WITH:
CNRS
Ecole normale supérieure de Lyon
Université Claude Bernard (Lyon 1)

Activity Report 2019

Project-Team AVALON

Algorithms and Software Architectures for Distributed and HPC Platforms

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

RESEARCH CENTER
Grenoble - Rhône-Alpes

THEME
Distributed and High Performance Computing

Table of contents

Project-Team AVALON

Creation of the Team: 2012 February 01, updated into Project-Team: 2014 July 01

Keywords:

Computer Science and Digital Science:

A1.1.1. - Multicore, Manycore
A1.1.2. - Hardware accelerators (GPGPU, FPGA, etc.)
A1.1.4. - High performance computing
A1.1.5. - Exascale
A1.1.13. - Virtualization
A1.3.2. - Mobile distributed systems
A1.3.5. - Cloud
A1.3.6. - Fog, Edge
A1.6. - Green Computing
A2.1.6. - Concurrent programming
A2.1.7. - Distributed programming
A2.1.10. - Domain-specific languages
A2.5.2. - Component-based Design
A2.6. - Infrastructure software
A2.6.1. - Operating systems
A2.6.2. - Middleware
A2.6.3. - Virtual machines
A2.6.4. - Ressource management
A4.4. - Security of equipment and software
A6.2.7. - High performance computing
A7.1. - Algorithms
A7.1.1. - Distributed algorithms
A7.1.2. - Parallel algorithms
A8.2. - Optimization
A8.2.1. - Operations research
A8.2.2. - Evolutionary algorithms
A8.9. - Performance evaluation

Other Research Topics and Application Domains:

B1.1.7. - Bioinformatics
B3.2. - Climate and meteorology
B4.1. - Fossile energy production (oil, gas)
B4.2.2. - Fusion
B4.5. - Energy consumption
B4.5.1. - Green computing
B6.1.1. - Software engineering
B8.1.1. - Energy for smart buildings
B9.5.1. - Computer science

B9.7. - Knowledge dissemination
B9.7.1. - Open access
B9.7.2. - Open data
B9.8. - Reproducibility

1. Team, Visitors, External Collaborators

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2. Overall Objectives

2.1. Presentation

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 parallel and distributed applications. These large scale platforms based on the aggregation of large clusters (Grids), huge datacenters (Clouds) with IoT (Edge/Fog), collections of volunteer PCs (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 also have 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 multiple services providing mandatory features such as security, resource discovery, virtualization, load-balancing, monitoring, *etc.*

The goal of the AVALON team is to execute parallel and/or distributed applications on parallel and/or distributed resources while ensuring user and system objectives with respect to performance, cost, energy, security, *etc.* Users are generally not interested in the resources used during the execution. Instead, they are interested in how their application is going to be executed: the duration, its cost, the environmental footprint involved, *etc.* This vision of utility computing has been strengthened by the cloud concepts and by the short lifespan of supercomputers (around three years) compared to application lifespan (tens of years). Therefore a major issue is to design models, systems, and algorithms to execute applications on resources while ensuring user constraints (price, performance, *etc.*) as well as system administrator constraints (maximizing resource usage, minimizing energy consumption, *etc.*).

2.2. Objectives

To achieve the vision proposed in Section 2.1, the AVALON project aims at making progress to four complementary research axes: energy, data, component models, and application scheduling.

2.2.1. Energy Application Profiling and Modeling

AVALON will improve the profiling and modeling of scientific applications with respect to energy consumption. In particular, it will require to improve the tools that measure the energy consumption of applications, virtualized or not, at large scale, so as to build energy consumption models of applications.

2.2.2. *Data-intensive Application Profiling, Modeling, and Management*

AVALON will improve the profiling, modeling, and management of scientific applications with respect to CPU and data intensive applications. Challenges are to improve the performance prediction of parallel regular applications, to model and simulate (complex) intermediate storage components, and data-intensive applications, and last to deal with data management for hybrid computing infrastructures.

2.2.3. *Resource-Agnostic Application Description Model*

AVALON will design component-based models to capture the different facets of parallel and distributed applications while being resource agnostic, so that they can be optimized for a particular execution. In particular, the proposed component models will integrate energy and data modeling results. AVALON in particular targets OpenMP runtime as a specific use case.

2.2.4. *Application Mapping and Scheduling*

AVALON will propose multi-criteria mapping and scheduling algorithms to meet the challenge of automating the efficient utilization of resources taking into consideration criteria such as performance (CPU, network, and storage), energy consumption, and security. AVALON will in particular focus on application deployment, workflow applications, and security management in clouds.

All our theoretical results will be validated with software prototypes using applications from different fields of science such as bioinformatics, physics, cosmology, *etc.* The experimental testbeds GRID'5000, Leco, and Silecs will be our platforms of choice for experiments.

3. Research Program

3.1. Energy Application Profiling and Modeling

Despite recent improvements, there is still a long road to follow in order to obtain energy efficient, energy proportional and eco-responsible exascale systems by 2022. Energy efficiency is therefore a major challenge for building next generation large-scale platforms. The targeted platforms will gather hundreds of millions of cores, low power servers, or CPUs. Besides being very important, their power consumption will be dynamic and irregular.

Thus, to consume energy efficiently, we aim at investigating two research directions. First, we need to improve measurement, understanding, and analysis on how large-scale platforms consume energy. Unlike some approaches [24] that mix the usage of internal and external wattmeters on a small set of resources, we target high frequency and precise internal and external energy measurements of each physical and virtual resource on large-scale distributed systems.

Secondly, we need to find new mechanisms that consume less and better on such platforms. Combined with hardware optimizations, several works based on shutdown or slowdown approaches aim at reducing energy consumption of distributed platforms and applications. To consume less, we first plan to explore the provision of accurate estimation of the energy consumed by applications without pre-executing and knowing them while most of the works try to do it based on in-depth application knowledge (code instrumentation [27], phase detection for specific HPC applications [31], *etc.*). As a second step, we aim at designing a framework model that allows interaction, dialogue and decisions taken in cooperation among the user/application, the administrator, the resource manager, and the energy supplier. While smart grid is one of the last killer scenarios for networks, electrical provisioning of next generation large IT infrastructures remains a challenge.

3.2. Data-intensive Application Profiling, Modeling, and Management

Recently, the term “Big Data” has emerged to design data sets or collections so large that they become intractable for classical tools. This term is most time implicitly linked to “analytics” to refer to issues such as data curation, storage, search, sharing, analysis, and visualization. However, the Big Data challenge is not limited to data-analytics, a field that is well covered by programming languages and run-time systems such as Map-Reduce. It also encompasses data-intensive applications. These applications can be sorted into two categories. In High Performance Computing (HPC), data-intensive applications leverage post-petascale infrastructures to perform highly parallel computations on large amount of data, while in High Throughput Computing (HTC), a large amount of independent and sequential computations are performed on huge data collections.

These two types of data-intensive applications (HTC and HPC) raise challenges related to profiling and modeling that the AVALON team proposes to address. While the characteristics of data-intensive applications are very different, our work will remain coherent and focused. Indeed, a common goal will be to acquire a better understanding of both the applications and the underlying infrastructures running them to propose the best match between application requirements and infrastructure capacities. To achieve this objective, we will extensively rely on logging and profiling in order to design sound, accurate, and validated models. Then, the proposed models will be integrated and consolidated within a single simulation framework (SIMGRID). This will allow us to explore various potential “what-if?” scenarios and offer objective indicators to select interesting infrastructure configurations that match application specificities.

Another challenge is the ability to mix several heterogeneous infrastructures that scientists have at their disposal (*e.g.,* Grids, Clouds, and Desktop Grids) to execute data-intensive applications. Leveraging the aforementioned results, we will design strategies for efficient data management service for hybrid computing infrastructures.

3.3. Resource-Agnostic Application Description Model

With parallel programming, users expect to obtain performance improvement, regardless its cost. For long, parallel machines have been simple enough to let a user program use them given a minimal abstraction of their hardware. For example, MPI [26] exposes the number of nodes but hides the complexity of network topology behind a set of collective operations; OpenMP [30] simplifies the management of threads on top of a shared memory machine while OpenACC [29] aims at simplifying the use of GPGPU.

However, machines and applications are getting more and more complex so that the cost of manually handling an application is becoming very high [25]. Hardware complexity also stems from the unclear path towards next generations of hardware coming from the frequency wall: multi-core CPU, many-core CPU, GPGPUs, deep memory hierarchy, *etc.* have a strong impact on parallel algorithms. Parallel languages (UPC, Fortress, X10, *etc.*) is a first piece of the solution. However, they will still face the challenge of supporting distinct codes corresponding to different algorithms corresponding to distinct hardware capacities.

Therefore, the challenge we aim to address is to define a model, for describing the structure of parallel and distributed applications that enables code variations but also efficient executions on parallel and distributed infrastructures. Indeed, this issue appears for HPC applications but also for cloud oriented applications. The challenge is to adapt an application to user constraints such as performance, energy, security, *etc.*

Our approach is to consider component based models [32] 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 a component based model that enables to efficiently compute application mapping while being tractable. In particular, it has to provide an efficient support with respect to application and resource elasticity, energy consumption and data management. OpenMP runtime is a specific use case that we target.

3.4. Application Mapping and Scheduling

This research axis is at the crossroad of the AVALON team. In particular, it gathers results of the three other research axis. We plan to consider application mapping and scheduling addressing the following three issues.

3.4.1. Application Mapping and Software Deployment

Application mapping and software deployment consist in the process of assigning distributed pieces of software to a set of resources. Resources can be selected according to different criteria such as performance, cost, energy consumption, security management, *etc.* A first issue is to select resources at application launch time. With the wide adoption of elastic platforms, *i.e.,* platforms that let the number of resources allocated to an application to be increased or decreased during its execution, the issue is also to handle resource selection at runtime.

The challenge in this context corresponds to the mapping of applications onto distributed resources. It will consist in designing algorithms that in particular take into consideration application profiling, modeling, and description.

A particular facet of this challenge is to propose scheduling algorithms for dynamic and elastic platforms. As the number of elements can vary, some kind of control of the platforms must be used accordingly to the scheduling.

3.4.2. Non-Deterministic Workflow Scheduling

Many scientific applications are described through workflow structures. Due to the increasing level of parallelism offered by modern computing infrastructures, workflow applications now have to be composed not only of sequential programs, but also of parallel ones. New applications are now built upon workflows with conditionals and loops (also called non-deterministic workflows).

These workflows cannot be scheduled beforehand. Moreover cloud platforms bring on-demand resource provisioning and pay-as-you-go billing models. Therefore, there is a problem of resource allocation for non-deterministic workflows under budget constraints and using such an elastic management of resources.

Another important issue is data management. We need to schedule the data movements and replications while taking job scheduling into account. If possible, data management and job scheduling should be done at the same time in a closely coupled interaction.

3.4.3. Software Asset Management

The use of software is generally regulated by licenses, whether they are free or paid and with or without access to their sources. The world of licenses is very vast and unknown (especially in the industrial world). Often only the general public version is known (a software purchase corresponds to a license). For enterprises, the reality is much more complex, especially for main publishers. We work on the OpTISAM software, a software offering tools to perform Software Asset Management (SAM) much more efficiently in order to be able to ensure the full compliance with all contracts from each software and a new type of deployment taking into account these aspects and other additional parameters like energy and performance. This work is built on an Orange™ collaboration.

3.4.4. Cloud deployment and reproducibility

As part of the scientific method, any researcher should be able to reproduce the experimentation in order to not only verify the result but also evaluate and compare this experimentation with other approaches. The need of a standard tool allowing researchers to easily generate, share and reproduce experiments set-up arises. In our research, through a Nokia collaboration, we created SeeDep [10], a framework aiming at being such a standard tool. By associating a generation key to a network experiment set-up, SeeDep allows for reproducing network experiments independently from the used infrastructure.

4. Application Domains

4.1. Overview

The AVALON team targets applications with large computing and/or data storage needs, which are still difficult to program, maintain, and deploy. Those applications can be parallel and/or distributed applications, such as large scale simulation applications or code coupling applications. Applications can also be workflow-based as commonly found in distributed systems such as grids or clouds.

The team aims at not being restricted to a particular application field, thus avoiding any spotlight. The team targets different HPC and distributed application fields, which brings use cases with different issues. This will be eased by our various collaborations: the team participates to the INRIA-Illinois Joint Laboratory for Petascale Computing, the Physics, Radiobiology, Medical Imaging, and Simulation French laboratory of excellence, the E-Biothon project, the INRIA large scale initiative Computer and Computational Sciences at Exascale (C2S@Exa), and to BioSyL, a federative research structure about Systems Biology of the University of Lyon. Moreover, the team members have a long tradition of cooperation with application developers such as CERFACS and EDF R&D. Last but not least, the team has a privileged connection with CC-IN2P3 that opens up collaborations, in particular in the astrophysics field.

In the following, some examples of representative applications that we are targeting are presented. In addition to highlighting some application needs, they also constitute some of the use cases that will used to valide our theoretical results.

4.2. Climatology

The 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. Simulations can be of different types: HPC applications (*e.g.,* the NEMO framework [28] for ocean modelization), code-coupling applications (*e.g.,* the OASIS coupler [33] for global climate modeling), or workflows (long term global climate modeling).

As for most applications the team is targeting, the challenge is to thoroughly analyze climate-forecasting applications to model their needs in terms of programing model, execution model, energy consumption, data access pattern, and computing needs. Once a proper model of an application has been set up, appropriate scheduling heuristics can be designed, tested, and compared. The team has a long tradition of working with CERFACS on this topic, for example in the LEGO (2006-09) and SPADES (2009-12) French ANR projects.

4.3. Astrophysics

Astrophysics is a major field to produce large volumes of data. For instance, the Vera C. Rubin Observatory (https://www.vro.org/) will produce 20 TB of data every night, with the goals of discovering thousands of exoplanets and of uncovering the nature of dark matter and dark energy in the universe. The Square Kilometer Array (http://www.skatelescope.org/) produces 9 Tbits/s of raw data. One of the scientific projects related to this instrument called Evolutionary Map of the Universe is working on more than 100 TB of images. The Euclid Imaging Consortium (https://www.euclid-ec.org/) will generate 1 PB data per year.

AVALON collaborates with the *Institut de Physique des deux Infinis de Lyon* (IP2I) laboratory on large scale numerical simulations in astronomy and astrophysics. Contributions of the AVALON members have been related to algorithmic skeletons to demonstrate large scale connectivity, the development of procedures for the generation of realistic mock catalogs, and the development of a web interface to launch large cosmological simulations on GRID'5000.

This collaboration, that continues around the topics addressed by the CLUES project (http://www.clues-project.org), has been extended thanks to the tight links with the CC-IN2P3. Major astrophysics projects execute part of their computing, and store part of their data on the resources provided by the CC-IN2P3. Among them, we can mention SNFactory, Euclid, or VRO. These applications constitute typical use cases for the research developed in the AVALON team: they are generally structured as workflows and a huge amount of data (from TB to PB) is involved.

4.4. Bioinformatics

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

The AVALON team is a member of BioSyL (http://www.biosyl.org), a Federative Research Structure attached to University of Lyon. It gathers about 50 local research teams working on systems biology. Moreover, the team cooperated with the French Institute of Biology and Chemistry of Proteins (IBCP http://www.ibcp.fr) in particular through the ANR MapReduce project where the team focuses on a bio-chemistry application dealing with protein structure analysis. AVALON has also started working with the Inria Beagle team (https://team.inria.fr/beagle/) on artificial evolution and computational biology as the challenges are around high performance computation and data management.

5. New Software and Platforms

5.1. DIET

Distributed Interactive Engineering Toolbox

KEYWORDS: Scheduling - Clusters - Grid - Cloud - HPC - Middleware - Data management.

FUNCTIONAL DESCRIPTION: Middleware for grids and clouds. Toolbox for the use and porting of intensive computing applications on heterogeneous architectures.

RELEASE FUNCTIONAL DESCRIPTION: - Native Google Drive Support for the data manager - Standardization of internal integer types. - New types (see Changelog for more information)

NEWS OF THE YEAR: New DIET release (DIET 2.11) is avaible since may 2019 Batch's GENCI support to use the GENCI resources

- Participants: Joel Faubert, Hadrien Croubois, Abdelkader Amar, Arnaud Lefray, Aurélien Bouteiller, Benjamin Isnard, Daniel Balouek, Eddy Caron, Eric Bois, Frédéric Desprez, Frédéric Lombart, Gaël Le Mahec, Guillaume Verger, Huaxi Zhang, Jean-Marc Nicod, Jonathan Rouzaud-Cornabas, Lamiel Toch, Maurice Faye, Peter Frauenkron, Philippe Combes, Philippe Laurent, Raphaël Bolze, Yves Caniou and Cyril Seguin
- Partners: CNRS - ENS Lyon - UCBL Lyon 1 - Sysfera
- Contact: Eddy Caron
- URL: http://graal.ens-lyon.fr/diet/

5.2. SimGrid

KEYWORDS: Large-scale Emulators - Grid Computing - Distributed Applications

SCIENTIFIC DESCRIPTION: SimGrid is a toolkit that provides core functionalities for the simulation of distributed applications in heterogeneous distributed environments. The simulation engine uses algorithmic and implementation techniques toward the fast simulation of large systems on a single machine. The models are theoretically grounded and experimentally validated. The results are reproducible, enabling better scientific practices.

Its models of networks, cpus and disks are adapted to (Data)Grids, P2P, Clouds, Clusters and HPC, allowing multi-domain studies. It can be used either to simulate algorithms and prototypes of applications, or to emulate real MPI applications through the virtualization of their communication, or to formally assess algorithms and applications that can run in the framework.

The formal verification module explores all possible message interleavings in the application, searching for states violating the provided properties. We recently added the ability to assess liveness properties over arbitrary and legacy codes, thanks to a system-level introspection tool that provides a finely detailed view of the running application to the model checker. This can for example be leveraged to verify both safety or liveness properties, on arbitrary MPI code written in C/C++/Fortran.

NEWS OF THE YEAR: There were 3 major releases in 2019: Python bindings were introduced, SMPI now partially supports some of the MPI/IO functions, a new model for Wifi networks was proposed, and the API for the simulation of storage resources was completely revisited. We also pursued our efforts to improve the documentation of the software, simplified the web site, and made a lot of bug fixing and code refactoring.

- Participants: Adrien Lèbre, Arnaud Legrand, Augustin Degomme, Florence Perronnin, Frédéric Suter, Jean-Marc Vincent, Jonathan Pastor, Luka Stanisic and Martin Quinson
- Partners: CNRS - ENS Rennes
- Contact: Martin Quinson
- URL: https://simgrid.org/

5.3. SeeDep

Seed based Deployment

KEYWORDS: Reproducibility - Deployment - Cloud

SCIENTIFIC DESCRIPTION: SeeDep aims at devising a new way where researchers can communicate in a comprehensive and accurate way the experimentation set-up used in their work. It lies on two components: (i) a public algorithm that generates experimentation networks, and (ii) a generation key (i.e. a seed) that can be shared which specifies the said network. Therefore, researchers only need to share (in their paper for instance) the “generation key” that corresponds to their experimentation network. With such key, any other researcher/professional will be able to re-generate a comprehensive and accurate model of the same network.

FUNCTIONAL DESCRIPTION: SeeDep is a framework aiming at generating, reproducing and deploying experiments set-up on different Cloud platforms.

- Participants: Cyril Seguin and Eddy Caron
- Partner: Nokia Bell Labs
- Contact: Eddy Caron

5.4. libkomp

Runtime system libkomp

KEYWORDS: HPC - Multicore - OpenMP

FUNCTIONAL DESCRIPTION: libKOMP is a runtime support for OpenMP compatible with différent compiler: GNU gcc/gfortran, Intel icc/ifort or clang/llvm. It is based on source code initially developed by Intel for its own OpenMP runtime, with extensions from Kaapi software (task representation, task scheduling). Moreover it contains an OMPT module for recording trace of execution.

RELEASE FUNCTIONAL DESCRIPTION: Initial version

- Contact: Thierry Gautier
- URL: http://gitlab.inria.fr/openmp/libkomp

5.5. XKBLAS

KEYWORDS: BLAS - Dense linear algebra - GPU

FUNCTIONAL DESCRIPTION: XKBLAS is yet an other BLAS library (Basic Linear Algebra Subroutines) that targets multi-GPUs architecture thanks to the XKaapi runtime and with block algorithms from PLASMA library. The library offers a wrapper library able to capture calls to BLAS (C or Fortran). The internal API is based on asynchronous invocations in order to enable overlapping between communication by computation and also to better composed sequences of calls to BLAS.

This current version of XKBlas is the first public version and contains only BLAS level 3 algorithms, including XGEMMT:

XGEMM XGEMMT: see MKL GEMMT interface XTRSM XTRMM XSYMM XSYRK XSYR2K XHEMM XHERK XHER2K

For classical precision Z, C, D, S.

RELEASE FUNCTIONAL DESCRIPTION: XKBlas has following limitations:

0.1 versions: calls to BLAS kernels must be initiate by the same thread that initializes the XKBlas library.

- Participants: Thierry Gautier and João Vicente Ferreira Lima
- Contact: Thierry Gautier
- URL: https://gitlab.inria.fr/xkblas/versions

5.6. Concerto

KEYWORDS: Reconfiguration - Distributed Software - Component models - Dynamic software architecture

FUNCTIONAL DESCRIPTION: Concerto is an implementation of the formal model Concerto written in Python. Concerto aloows to : 1. describe the life-cycle and the dependencies of software components, 2. describe a components assembly that forms the overall life-cycle of a distributed software, 3. automatically reconfigure a Concerto assembly of components by using a set of reconfiguration instructions as well as a formal operational semantics.

- Partners: IMT Atlantique - LS2N - LIP
- Contact: Maverick Chardet
- URL: https://gitlab.inria.fr/VeRDi-project/concerto

5.7. Kwapi

KiloWatt API

KEYWORD: Power monitoring

FUNCTIONAL DESCRIPTION: Kwapi is a software framework dealing with energy monitoring of large scale infrastructures through heterogeneous energy sensors. Kwapi has been designed inside the FSN XLCloud project for Openstack infrastructures. Through the support of Hemera Inria project, kwapi has been extended and deployed in production mode to support easy and large scale energy profiling of the Grid5000 resources. Kwapi now supports high frequency powermeters of the Grid5000 Lyon platform.

RELEASE FUNCTIONAL DESCRIPTION: - many bugfixes - multiprocessing instead of multithreading - many optimizations

- Participants: François Rossigneux, Jean-Patrick Gelas, Laurent Lefèvre, Laurent Pouilloux, Simon Delamare and Matthieu Imbert
- Contact: Laurent Lefèvre
- URL: https://launchpad.net/kwapi

5.8. execo

KEYWORDS: Toolbox - Deployment - Orchestration - Python

FUNCTIONAL DESCRIPTION: Execo offers a Python API for asynchronous control of local or remote, standalone or parallel, unix processes. It is especially well suited for quickly and easily scripting workflows of parallel/distributed operations on local or remote hosts: automate a scientific workflow, conduct computer science experiments, perform automated tests, etc. The core python package is execo. The execo_g5k package provides a set of tools and extensions for the Grid5000 testbed. The execo_engine package provides tools to ease the development of computer sciences experiments.

RELEASE FUNCTIONAL DESCRIPTION: - misc python3 support fixes - basic documentation for wheezy compatible package build - remove some debug outputs - fix crash in processes conductor in some situations - improve/fix process stdout/stderr handlers - fix get_cluster_network_equipments - add a FAQ

- Participants: Florent Chuffart, Laurent Pouilloux and Matthieu Imbert
- Contact: Matthieu Imbert
- URL: http://execo.gforge.inria.fr

5.9. Platforms

5.9.1. Platform: Grid'5000

Participants: Laurent Lefèvre, Simon Delamare, David Loup, Christian Perez.

FUNCTIONAL DESCRIPTION

The Grid'5000 experimental platform is a scientific instrument to support computer science research related to distributed systems, including parallel processing, high performance computing, cloud computing, operating systems, peer-to-peer systems and networks. It is distributed on 10 sites in France and Luxembourg, including Lyon. Grid'5000 is a unique platform as it offers to researchers many and varied hardware resources and a complete software stack to conduct complex experiments, ensure reproducibility and ease understanding of results. In 2018, a new generation of high speed wattmeters has been deployed on the Lyon site. They allow energy monitoring with up to 50 measurements per second. In parallel, a new version of kwapi (software stack for energy monitoring) has been proposed and redesigned.

- Contact: Laurent Lefèvre
- URL: https://www.grid5000.fr/

5.9.2. Platform: Leco

Participants: Thierry Gautier, Laurent Lefèvre, Christian Perez.

FUNCTIONAL DESCRIPTION

The LECO experimental platform is a new medium size scientific instrument funded by DRRT to investigate research related to BigData and HPC. It is located in Grenoble as part of the the HPCDA computer managed by UMS GRICAD. The platform has been deployed in 2018 and was available for experiment since the summer. All the nodes of the platform are instrumented to capture the energy consumption and data are available through the Kwapi software.

- Contact: Thierry Gautier

5.9.3. Platform: SILECS

Participants: Laurent Lefèvre, Simon Delamare, Christian Perez.

FUNCTIONAL DESCRIPTION

The SILECS infrastructure (IR ministère) aims at providing an experimental platform for experimental computer Science (Internet of things, clouds, HPC, big data, *etc.*). This new infrastructure is based on two existing infrastructures, Grid'5000 and FIT.

- Contact: Christian Perez
- URL: https://www.silecs.net/

6. New Results

6.1. Energy Efficiency in HPC and Large Scale Distributed Systems

Participants: Laurent Lefèvre, Dorra Boughzala, Thierry Gautier.

6.1.1. Performance and Energy Analysis of OpenMP Runtime Systems with Dense Linear Algebra Algorithms

In the article [4], we analyze performance and energy consumption of five OpenMP runtime systems over a non-uniform memory access (NUMA) platform. We also selected three CPU-level optimizations or techniques to evaluate their impact on the runtime systems: processors features Turbo Boost and C-States, and CPU Dynamic Voltage and Frequency Scaling through Linux CPUFreq governors. We present an experimental study to characterize OpenMP runtime systems on the three main kernels in dense linear algebra algorithms (Cholesky, LU, and QR) in terms of performance and energy consumption. Our experimental results suggest that OpenMP runtime systems can be considered as a new energy leverage, and Turbo Boost, as well as C-States, impacted significantly performance and energy. CPUFreq governors had more impact with Turbo Boost disabled, since both optimizations reduced performance due to CPU thermal limits. An LU factorization with concurrent-write extension from libKOMP achieved up to 63% of performance gain and 29% of energy decrease over original PLASMA algorithm using GNU C compiler (GCC) libGOMP runtime. This paper was first published online in 2018-08-09.

6.1.2. Building and Exploiting the Table of Leverages in Large Scale HPC Systems

Large scale distributed systems and supercomputers consume huge amounts of energy. To address this issue, an heterogeneous set of capabilities and techniques that we call leverages exist to modify power and energy consumption in large scale systems. This includes hardware related leverages (such as Dynamic Voltage and Frequency Scaling), middleware (such as scheduling policies) and application (such as the precision of computation) energy leverages. Discovering such leverages, benchmarking and orchestrating them, remains a real challenge for most of the users. We have formally defined energy leverages, and we proposed a solution to automatically build the table of leverages associated with a large set of independent computing resources. We have shown that the construction of the table can be parallelized at very large scale with a set of independent nodes in order to reduce its execution time while maintaining precision of observed knowledge. In 2019 we have explored the leverage energy-efficient non-lossy compression for data-intensive applications [9].

6.2. HPC Component Models and Runtimes

Participants: Thierry Gautier, Christian Perez, Laurent Turpin, Marie Durand, Philippe Virouleau.

6.2.1. Fine-Grained MPI+OpenMP Plasma Simulations: Communication Overlap with Dependent Tasks

In the article [15], we demonstrate how OpenMP 4.5 tasks can be used to efficiently overlap computations and MPI communications based on a case-study conducted on multi-core and many-core architectures. The paper focuses on task granularity, dependencies and priorities, and also identifies some limitations of OpenMP. Results on 64 Skylake nodes show that while 64% of the wall-clock time is spent in MPI communications, 60% of the cores are busy in computations, which is a good result. Indeed, the chosen dataset is small enough to be a challenging case in terms of overlap and thus useful to assess worst-case scenarios in future simulations. Two key features were identified: by using task priority we improved the performance by 5.7% (mainly due to an improved overlap), and with recursive tasks we shortened the execution time by 9.7%. We also illustrate the need to have access to tools for task tracing and task visualization. These tools allowed a fine understanding and a performance increase for this task-based OpenMP+MPI code.

6.2.2. Patches to LLVM compiler

We propose two source code patches to LLVM https://reviews.llvm.org/D63196 and https://reviews.llvm.org/D67447 in order to improve performance of application using numerous fine grain tasks such as [15]. Patches were accepted in 2019.

6.3. Modeling and Simulation of Parallel Applications and Distributed Infrastructures

Participants: Eddy Caron, Zeina Houmani, Frédéric Suter.

6.3.1. Bridging Concepts and Practice in eScience via Simulation-driven Engineering

The CyberInfrastructure (CI) has been the object of intensive research and development in the last decade, resulting in a rich set of abstractions and interoperable software implementations that are used in production today for supporting ongoing and breakthrough scientific discoveries. A key challenge is the development of tools and application execution frameworks that are robust in current and emerging CI configurations, and that can anticipate the needs of upcoming CI applications. In [14] we presented WRENCH, a framework that enables simulation-driven engineering for evaluating and developing CI application execution frameworks. WRENCH provides a set of high-level simulation abstractions that serve as building blocks for developing custom simulators. These abstractions rely on the scalable and accurate simulation models that are provided by the SIMGRID simulation framework. Consequently, WRENCH makes it possible to build, with minimum software development effort, simulators that can accurately and scalably simulate a wide spectrum of large and complex CI scenarios. These simulators can then be used to evaluate and/or compare alternate platform, system, and algorithm designs, so as to drive the development of CI solutions for current and emerging applications.

6.3.2. Accurately Simulating Energy Consumption of I/O-intensive Scientific Workflows

While distributed computing infrastructures can provide infrastructure-level techniques for managing energy consumption, application-level energy consumption models have also been developed to support energy-efficient scheduling and resource provisioning algorithms. In [7], we analyze the accuracy of a widely-used application-level model that have been developed and used in the context of scientific workflow executions. To this end, we profile two production scientific workflows on a distributed platform instrumented with power meters. We then conduct an analysis of power and energy consumption measurements. This analysis shows that power consumption is not linearly related to CPU utilization and that I/O operations significantly impact power, and thus energy consumption. We then propose a power consumption model that accounts for I/O operations, including the impact of waiting for these operations to complete, and for concurrent task executions on multi-socket, multi-core compute nodes. We implement our proposed model as part of a simulator that allows us to draw direct comparisons between real-world and modeled power and energy consumption. We find that our model has high accuracy when compared to real-world executions. Furthermore, our model improves accuracy by about two orders of magnitude when compared to the traditional models used in the energy-efficient workflow scheduling literature.

6.4. Cloud Resource Management

Participants: Eddy Caron, Jad Darrous, Christian Perez.

6.4.1. On the Importance of Container Image Placement for Service Provisioning in the Edge

Edge computing promises to extend Clouds by moving computation close to data sources to facilitate short-running and low-latency applications and services. Providing fast and predictable service provisioning time presets a new and mounting challenge, as the scale of Edge-servers grows and the heterogeneity of networks between them increases. Our work [6] is driven by a simple question: can we place container images across Edge-servers in such a way that an image can be retrieved to any Edge-server fast and in a predictable time. To this end, we present KCBP and KCBP-WC, two container image placement algorithms which aim to reduce the maximum retrieval time of container images. KCBP and KCBP-WC are based on k-Center optimization. However, KCBP-WC tries to avoid placing large layers of a container image on the same Edge-server. Evaluations using trace-driven simulations show that KCBP and KCBP-WC can be applied to various network configurations and reduce the maximum retrieval time of container images by 1.1x to 4x compared to state-of-the-art placements (*i.e.,* Best-Fit and Random).

Data-intensive clusters are heavily relying on distributed storage systems to accommodate the unprecedented growth of data. Hadoop distributed file system (HDFS) is the primary storage for data analytic frameworks such as Spark and Hadoop. Traditionally, HDFS operates under replication to ensure data availability and to allow locality-aware task execution of data-intensive applications. Recently, erasure coding (EC) is emerging as an alternative method to replication in storage systems due to the continuous reduction in its computation overhead. We have conducted an extensive experimental study to understand the performance of data-intensive applications under replication and EC [5], [23]. We use representative benchmarks on the Grid'5000 testbed to evaluate how analytic workloads, data persistency, failures, the back-end storage devices, and the network configuration impact their performances. Our study sheds the light not only on the potential benefits of erasure coding in data-intensive clusters but also on the aspects that may help to realize it effectively.

6.5. Data Stream Processing on Edge Computing

Participants: Eddy Caron, Felipe Rodrigo de Souza, Marcos Dias de Assunção, Laurent Lefèvre, Alexandre Da Silva Veith.

6.5.1. Operator Placement for Data Stream Processing on Fog/Edge Computing

DSP (Data Stream Processing) frameworks are often employed to process the large amount of data generated by the increasing number of IoT devices. A DSP application is commonly structured as a directed graph, or dataflow, whose vertices are operators that perform transformations over the incoming data and edges representing the data dependencies between operators. Such applications are often deployed on the Cloud in order to explore the large number of available resources and its pay-as-you-go business model. Fog computing enables offloading operators from the cloud by placing them close to where the data is generated, whereby reducing the time to process data events. However, fog computing resources often have lower capacity than those available in the Cloud. When offloading operators from the Cloud, the scheduler needs to adjust their level of parallelism and hence decides on the number of operator instances to create during placement in order to achieve a given throughput. This gives rise to two interrelated issues, namely deciding the operators parallelism and computing their placement onto available resources [16].

While addressing the placement problem [8], we proposed an approach consisting of a programming model and real-world implementation of an IoT application. The results show that our approach can minimise the end-to-end latency by at least 38% by pushing part of the IoT application to edge computing resources. Meanwhile, the edge-to-cloud data transfers are reduced by at least 38%, and the messaging costs are reduced by at least 50% when using the existing commercial edge cloud cost models.

In addition, we have designed and validated a discrete event simulation for modelling and simulation of DSP applications on edge computing environments [3].

6.5.2. Multi-Objective Reinforcement Learning for Reconfiguring Data Stream Analytics on Edge Computing

As DSP applications are often long-running, their workload and the infrastructure conditions can change over time. When changes occur, the application must be reconfigured. The operator reconfiguration consists of changing the initial placement by reassigning operators to different devices given target performance metrics. We modelled the operator reconfiguration as a Reinforcement Learning (RL) problem and defined a multi-objective reward considering metrics regarding operator reconfiguration, and infrastructure and application improvement [11]. We also use Monte Carlo Tree Search to organise the episodes generated during simulation and training [12]. Experimental results show that reconfiguration algorithms that minimise only end-to-end processing latency can have a substantial impact on WAN traffic and communication cost. The results also demonstrate that when reconfiguring operators, RL algorithms improve by over 50% the performance of the initial placement provided by state-of-the-art approaches.

6.6. An Operational Tool for Software Asset Management Improvement

Participants: Eddy Caron, Arthur Chevalier.

6.6.1. Multi-objective algorithm that guarantees license compliance

We have developed a new feature to OpTISAM, an Orange™ software offering tools to perform Software Asset Management (SAM) much more efficiently in order to be able to ensure the full compliance with all contracts from each software and a new type of deployment taking into account these aspects and other additional parameters like energy and performance. Our new feature is a multi-objective algorithm for deploying services in the Cloud that guarantees license compliance while reducing energy consumption but maintaining reasonable performance. In both cases of use and with a significant set of 5000 servers, we were able to show our approach is close to the best values in each criterion while dropping less than 10% of performance each time while keeping a full compliance.

6.7. Platform

Participants: Thierry Gautier, Christian Perez, Simon Delamare, Laurent Lefèvre.

6.7.1. Gemini cluster based on DGX-1 high density computer

The LECO experimental platform is a new medium size scientific instrument funded by DRRT and Inria to investigate research related to BigData and HPC. It is bi-located in Grenoble as part of the the HPCDA computer managed by UMS GRICAD (deployed in 2018) and in Lyon as part of the Grid5K Gemini cluster. The Gemini cluster is composed of two DGX-1 high density computers for HPC and BigData. Each computers has 8 NVIDIA V100 GPGPU cards with 4 infiniband high speed network cards.

7. Bilateral Contracts and Grants with Industry

7.1. Bilateral Contracts with Industry

7.1.1. Nokia Bell Labs

AVALON has been actively collaborating with Nokia, formerly Alcatel-Lucent Bell Labs, in the framework of the Nokia/Alcatel-Lucent Inria Joint Laboratory. We was involved in the following Research Actions (Actions de Recherche (ADR) in French) of this laboratory. ADR Nokia Bell Labs /Inria: Procedural Generation of Networks for Security Research & Experimentations. The objective of this project is to address such challenge. We aim at devising a new way where researchers can communicate in a comprehensive and accurate way the experimentation set-up used in their work. The main objective would be to research and develop the procedural generation of credible network topologies and test beds resembling real operational infrastructures of various kinds (e.g. classical ICT, virtualized Cloud or SDN based, SCADA infrastructures etc.), as a method of creating data algorithmically as opposed to manually. This work is done with a postdoc position: Cyril Seguin.

7.1.2. MUMPS Technologies

AVALON has a collaboration with MUMPS Technologies. The funding is dedicated for Marie Durand during few months to make experimental validation of the interest of using XKBLAS library to let MUMPS software to gain in performance on multi-GPUs server.

7.2. Bilateral Grants with Industry

7.2.1. Orange

We have a collaboration with Orange. This collaboration is sealed through a CIFRE Phd grant. The research of the Phd student (Arthur Chevalier) focuses on placement and compliance aspects of software licenses in a Cloud architecture. Today, the use of software is regulated by licenses, whether they are free, paid for and with or without access to its sources. The number of licenses required for specific software can be calculated with several metrics, each defined by the software vendor. Our goal is to propose a deployment algorithm that takes into account different metrics.

8. Partnerships and Cooperations

8.1. Regional Initiatives

8.1.1. CPER

Participants: Thierry Gautier, Laurent Lefèvre, Christian Perez.

The LECO experimental platform is a new medium size scientific instrument deployed in Grenoble in 2018 and in Lyon in 2019. It was funded by the CPER 2015-2020 LECO++ to investigate research related to BigData and HPC.

8.1.2. Action Exploratoire Inria: EXODE

Participant: Thierry Gautier.

In biology, the vast majority of systems can be modeled as ordinary differential equations (ODEs). Modeling more finely biological objects leads to increase the number of equations. Simulating ever larger systems also leads to increasing the number of equations. Therefore, we observe a large increase in the size of the ODE systems to be solved. A major lock is the limitation of ODE numerical resolution software (ODE solver) to a few thousand equations due to prohibitive calculation time. The AEx ExODE tackles this lock via 1) the introduction of new numerical methods that will take advantage of the mixed precision that mixes several floating number precisions within numerical methods, 2) the adaptation of these new methods for next generation highly hierarchical and heterogeneous computers composed of a large number of CPUs and GPUs. For the past year, a new approach to Deep Learning has been proposed to replace the Recurrent Neural Network (RNN) with ODE systems. The numerical and parallel methods of ExODE will be evaluated and adapted in this framework in order to improve the performance and accuracy of these new approaches.

8.2. National Initiatives

8.2.1. Inria Large Scale Initiative

8.2.1.1. DISCOVERY, DIStributed and COoperative management of Virtual EnviRonments autonomouslY, 4 years, 2015-2019

Participants: Maverick Chardet, Jad Darrous, Christian Perez.

To accommodate the ever-increasing demand for Utility Computing (UC) resources, while taking into account both energy and economical issues, the current trend consists in building larger and larger Data Centers in a few strategic locations. Although such an approach enables UC providers to cope with the actual demand while continuing to operate UC resources through centralized software system, it is far from delivering sustainable and efficient UC infrastructures for future needs.

The DISCOVERY initiative aims at exploring a new way of operating Utility Computing (UC) resources by leveraging any facilities available through the Internet in order to deliver widely distributed platforms that can better match the geographical dispersal of users as well as the ever increasing demand. Critical to the emergence of such locality-based UC (LUC) platforms is the availability of appropriate operating mechanisms. The main objective of DISCOVERY is to design, implement, demonstrate and promote the LUC Operating System (OS), a unified system in charge of turning a complex, extremely large-scale and widely distributed infrastructure into a collection of abstracted computing resources which is efficient, reliable, secure and at the same time friendly to operate and use.

To achieve this, the consortium is composed of experts in research areas such as large-scale infrastructure management systems, network and P2P algorithms. Moreover two key network operators, namely Orange and RENATER, are involved in the project.

By deploying and using such a LUC Operating System on backbones, our ultimate vision is to make possible to host/operate a large part of the Internet by its internal structure itself: A scalable set of resources delivered by any computing facilities forming the Internet, starting from the larger hubs operated by ISPs, government and academic institutions, to any idle resources that may be provided by end-users.

8.2.1.2. HAC SPECIS, High-performance Application and Computers, Studying PErformance and Correctness In Simulation, 4 years, 2016-2020

Participants: Dorra Boughzala, Idriss Daoudi, Thierry Gautier, Laurent Lefèvre, Frédéric Suter.

Over the last decades, both hardware and software of modern computers have become increasingly complex. Multi-core architectures comprising several accelerators (GPUs or the Intel Xeon Phi) and interconnected by high-speed networks have become mainstream in HPC. Obtaining the maximum performance of such heterogeneous machines requires to break the traditional uniform programming paradigm. To scale, application developers have to make their code as adaptive as possible and to release synchronizations as much as possible. They also have to resort to sophisticated and dynamic data management, load balancing, and scheduling strategies. This evolution has several consequences:

First, this increasing complexity and the release of synchronizations are even more error-prone than before. The resulting bugs may almost never occur at small scale but systematically occur at large scale and in a non deterministic way, which makes them particularly difficult to identify and eliminate.

Second, the dozen of software stacks and their interactions have become so complex that predicting the performance (in terms of time, resource usage, and energy) of the system as a whole is extremely difficult. Understanding and configuring such systems therefore becomes a key challenge.

These two challenges related to correctness and performance can be answered by gathering the skills from experts of formal verification, performance evaluation and high performance computing. The goal of the HAC SPECIS Inria Project Laboratory is to answer the methodological needs raised by the recent evolution of HPC architectures by allowing application and runtime developers to study such systems both from the correctness and performance point of view.

8.3. European Initiatives

8.3.1. FP7 & H2020 Projects

8.3.1.1. Energy oriented Centre of Excellence for computing applications (EoCoE-II)

Participants: Thierry Gautier, Christian Perez.

Program: H2020 RIA european project, call H2020-INFRAEDI-2018-1

Project acronym: EoCoE-II

Project title: Energy oriented Centre of Excellence for computing applications

Duration: 2018-2021

Coordinator: CEA

Other partners: CEA, FZJ, ENEA, BSC, CNRS, Inria, CERFACS, MPG, FRAUNHOFER, FAU, CNR, UNITN, PSNC, ULB, UBAH, CIEMAT, IFPEN, DDN, RWTH, UNITOV

Abstract: Europe is undergoing a major transition in its energy generation and supply infrastructure. The urgent need to halt carbon dioxide emissions and prevent dangerous global temperature rises has received renewed impetus following the unprecedented international commitment to enforcing the 2016 Paris Agreement on climate change. Rapid adoption of solar and wind power generation by several EU countries has demonstrated that renewable energy can competitively supply significant fractions of local energy needs in favourable conditions. These and other factors have combined to create a set of irresistible environmental, economic and health incentives to phase out power generation by fossil fuels in favour of decarbonized, distributed energy sources. While the potential of renewables can no longer be questioned, ensuring reliability in the absence of constant conventionally powered baseload capacity is still a major challenge.

The EoCoE-II project will build on its unique, established role at the crossroads of HPC and renewable energy to accelerate the adoption of production, storage and distribution of clean electricity. How will we achieve this? In its proof-of-principle phase, the EoCoE consortium developed a comprehensive, structured support pathway for enhancing the HPC capability of energy-oriented numerical models, from simple entry-level parallelism to fully-fledged exascale readiness. At the top end of this scale, promising applications from each energy domain have been selected to form the basis of 5 new Energy Science Challenges in the present successor project EoCoE-II that will be supported by 4 Technical Challenges

8.3.1.2. PRACE 6th Implementation Phase Project (PRACE6-IP)

Participants: Marcos Dias de Assunção, Laurent Lefèvre, Christian Perez.

Program: H2020 RIA european project, call H2020-INFRAEDI-2018-1

Project acronym: PRACE-6IP

Project title: PRACE 6th Implementation Phase Project

Duration: May 2019-Dec 2021

Coordinator: FZJ

Other partners: HLRS, LRZ, GENCI, CEA, CINES, CNRS, IDRIS, Inria, EPCC, BSC, CESGA, CSC, ETH-CSCS, SURFsara, KTH-SNIC, CINECA, PSNC, CYFRONET, WCNS, UiOsingma2, GRNET, UC-LCA, Univ MINHO, ICHEC, UHEM, CASTORCm NCSA, IT4I-VSB, KIFU, UL, CCSAS, CENAERO, Univ Lux, GEANT

Abstract: PRACE, the Partnership for Advanced Computing is the permanent pan-European High Performance Computing service providing world-class systems for world-class science. Systems at the highest performance level (Tier-0) are deployed by Germany, France, Italy, Spain and Switzerland, providing researchers with more than 17 billion core hours of compute time. HPC experts from 25 member states enabled users from academia and industry to ascertain leadership and remain competitive in the Global Race. Currently PRACE is finalizing the transition to PRACE 2, the successor of the initial five year period. The objectives of PRACE-6IP are to build on and seamlessly continue the successes of PRACE and start new innovative and collaborative activities proposed by the consortium. These include: assisting the development of PRACE 2; strengthening the internationally recognised PRACE brand; continuing and extend advanced training which so far provided more than 36 400 person·training days; preparing strategies and best practices towards Exascale computing, work on forward-looking SW solutions; coordinating and enhancing the operation of the multi-tier HPC systems and services; and supporting users to exploit massively parallel systems and novel architectures. A high level Service Catalogue is provided. The proven project structure will be used to achieve each of the objectives in 7 dedicated work packages. The activities are designed to increase Europe's research and innovation potential especially through: seamless and efficient Tier-0 services and a pan-European HPC ecosystem including national capabilities; promoting take-up by industry and new communities and special offers to SMEs; assistance to PRACE 2 development; proposing strategies for deployment of leadership systems; collaborating with the ETP4HPC, CoEs and other European and international organisations on future architectures, training, application support and policies. This will be monitored through a set of KPIs.

8.4. International Initiatives

8.4.1. Inria International Labs

8.4.1.1. Joint Laboratory for Extreme Scale Computing (JLESC) (2014-2023)

Participants: Thierry Gautier, Christian Perez.

Partners: NCSA (US), ANL (US), Inria (FR), Jülich Supercomputing Centre (DE), BSC (SP), Riken (JP).
The purpose of the Joint Laboratory for Extreme Scale Computing (JLESC) is to be an international, virtual organization whose goal is to enhance the ability of member organizations and investigators to make the bridge between Petascale and Extreme computing. The founding partners of the JLESC are Inria and UIUC. Further members are ANL, BSC, JSC and RIKEN-AICS.

JLESC involves computer scientists, engineers and scientists from other disciplines as well as from industry, to ensure that the research facilitated by the Laboratory addresses science and engineering's most critical needs and takes advantage of the continuing evolution of computing technologies.

Inria@EastCoast
Associate Team involved in the International Lab:

8.4.1.2. SUSTAM

Title: Sustainable Ultra Scale compuTing, dAta and energy Management

International Partner (Institution - Laboratory - Researcher):

Start year: 2017

See also: http://avalon.ens-lyon.fr/sustam

The SUSTAM associate team will focus on the joint design of a multi-criteria orchestration framework dealing with resources, data and energy management in an sustainable way. The SUSTAM associated team will enable a long-term collaboration between the Inria Avalon team and the Rutgers Discovery Informatics Institute (RDI2) from Rutgers University (USA).

8.5. International Research Visitors

8.5.1. Visits of International Scientists

Carlos Henrique Cardonha, IBM Research Brazil, from Jun 2019 until Jul 2019.

Jean-Philippe Aboumou, SAHAM Life Insurance, from Oct 2019.

8.5.1.1. Internships

Ibrahim Jouwad, M2, *Optimisation de la migration d'un ensemble de machines virtuelles dans un datacentre à l'aide d'un graphe d'états*

Laurent Turpin, M2, *Formalisation de paramètres, evaluation de performance et auto-configuration d'une application HPC en mémoire partagée : application au simulateur Aevol*

Josee Alvine Kouamen, M2, *Prise en main d'une infrastructure cloud et Big data pour l'analyse des fraudes a la simbox*

Zakaria Fraoui, *Distributed Stream Processing in the Edge: The Internet of Things Usecase*

Mohamed Hamnache, PFE, *Optimisation d'un environnement de calculs distribués pour la bio-informatique*

Alice Andres, M1, *Cloud vs Edge: fighting for energy !*

Adrien Berthelot, M1, *Revisiting low tech IT protocols*

Pierre Jacquot, L3, *Analysis of DDFacet/KillMS pipeline*

Marouane Azzouz, IUT, *Mode clients/serveur pour le projet CartomENSia*

9. Dissemination

9.1. Promoting Scientific Activities

9.1.1. Scientific Events: Organisation

9.1.1.1. General Chair, Scientific Chair

Eddy Caron

- served as Co-Chair of SPCLOUD 2019, July 15-19, 2019 Dublin, Ireland.
- served as Local Organizing Committee of SRDS 2019, October 1-4, 2019 Lyon. France.

Laurent Lefèvre was :

- Co-organizer of colloquium : "Atteindre les ODD en combinant leviers technologiques et computationnels, économie circulaire et transdisciplinarité. Mission impossible ?", with Centre Jacques Cartier, UQAM, Inria, GDS CNRS EcoInfo, UQAM, Montreal, Canada, November 4-5, 2019
- Co Special Session Organizer of Special Session on High Performance Computing Benchmarking and Optimization (HPBench 2019), during HPCS conference, Dublin, Ireland, July 15-19, 2019
- Co-organizer of GreenDays@Anglet : How people and machines can reduce their environmental impacts ?, Anglet, France, June 24-25, 2019

Christian Perez served as Awards Co-Chair of HPCS 2019, July 15-19, 2019 Dublin, Ireland.

9.1.1.2. Member of the Organizing Committees

Laurent Lefevre was member of the Organizing Committee of the TILECS Workshop (Grenoble, 3-4 Jul 2019).

Christian Perez was member of the Organizing Committee of the French Journées Calcul Données (Toulouse, 9-11 Oct 2019), and the TILECS Workshop (Grenoble, 3-4 Jul 2019).

9.1.2. Scientific Events: Selection

9.1.2.1. Member of the Conference Program Committees

E. Caron was member of the program committees of CLOSER'2019, Compas'19

C. Perez was member of the program committees of CCGRID'19, HPCS'19, ICPP'10, ParCo'19, SC'19, and Compas'19.

F. Suter served in the program committees of ICPP, CCGrid, e-science, ICA3PP, WORKS, and HeteroPar.

M. Dias de Assuncao was member of the program committees of CCGrid'19, UCC'19, and CloudCom'19.

9.1.3. Journal

9.1.3.1. Reviewer - Reviewing Activities

E. Caron reviewed an article for IEEE Transactions on Sustainable Computing (TSUSC) and an article for IEEE Transactions on Parallel and Distributed Systems (TPDS)

C. Perez reviewed an article for Future Generation Computer Systems.

F. Suter reviewed articles for Future Generation Computer Systems.

M. Dias de Assuncao reviewed articles for Future Generation Computer Systems, IEEE Transactions on Parallel and Distributed Systems, Cluster Computing and Journal of Network and Computer Applications.

9.1.4. Invited Talks

- Laurent Lefèvre gave the following invited talks in 2019 :
  - "Impacts environnementaux du numérique: rien de bon pour la planète ! Comment aller vers plus d'efficacité et de sobriété dans la phase d'usage ?", Entretiens Jacques Cartier, Montreal, Canada, November 4, 2019
  - "Impacts énergétiques et environnementaux du numérique dans les environnements urbains",Journée scientifique sur L'énergie dans les environnements urbains, Montpellier, France, October 10, 2019
  - "Une brève histoire du Green IT (informatique verte) : espoirs, challenges, risques", Café Gourmand du LIP, ENS Lyon, France, October 8, 2019
  - "L'usage des TICs - Consommation, efficacité et proportionnalité des TICs : focus sur usages DCs/Net et quelques propositions venant de la recherche", ENSIMAG, Grenoble, October 4, 2019
  - "Le numérique et ses impacts: C'est bon pour la planète ?", Meetup IBM Ecologie du numérique: facture énergétique de l'IA, Lyon, France, October 1, 2019
  - "Impact du numérique: focus sur les consommations en phase d'usage - Faire plus avec moins: à la recherche de proportionnalité et d'efficacité énergétique en phase d'usage", ANF 2019 EcoInfo, Autrans, France, September 25, 2019
  - "Mesures et efficacité énergétique sur plate-forme expérimentale - The G5K Green Tour", TGIR Visit, Lyon, France, July 5, 2019
  - "Mesures et efficacité énergétique sur plate-forme expérimentale - The G5K Green Tour", with Georges Da Costa, TILECS Workshop, Grenoble, France, July 4, 2019
  - "Eco-design or data centres collapse : - environmental impact of digital - 3 scenarii - GreenIT challenges and role", Colloque "Les limites de la croissance de la smart city:espaces et énergies des infrastructures numériques", Ecole d'architecture de la ville et des territoires, Marne la Vallée, France, June 5, 2019
  - "Numérique et ses impacts: C'est bon pour la planète ? de la grenouille au colibri...", Lycée St Charles, Rillieux la Pape, France, April 5, 2019
  - "Faire plus avec moins: à la recherche de proportionnalité et d'efficacité énergétique en phase d'usage", Séminaire du Département Informatique de l'ENS de Lyon (SIESTE), Lyon, France, March 12, 2019
  - "Les impacts environnementaux du numérique/EcoInfo/Réflexions Grenobloises/EcoInfo++", with Sophie Quinton, Comité des Projets Inria Rhone-Alpes, Montbonnot, February 12, 2019

9.1.5. Scientific Expertise

C. Perez reviewed two projects for PHC programmes.

Olivier Glück is member of the CNU (Conseil National des Universités) section 27 (Computer Science). He participated to the 2019 "Qualifications" session and "Suivi de carriere" session.

9.1.6. Research Administration

Eddy Caron is Deputy Director in charge of call for projects, research transfert and international affairs since September 2017 for the LIP. He is co-leader of the Distributed system and HPC team of the FIL (Fédération Informatique de Lyon).

Olivier Glück is member of the "Conseil Académique" of Lyon 1 University and Lyon University.

Laurent Lefevre is a member of the executive board and the sites committee of the Grid'5000 Scientific Interest Group. He is the scientific leader of the Grid'5000 Lyon site. He is animator and co-chair of the transversal action on "Energy" of the French GDR RSD ("Réseaux et Systèmes Distribués"). He is member of the scientifc advisory board of the Digital League cluster (Région Rhone Alpes). He is elected member in the LIP laboratory council (ENS Lyon).

Christian Perez represents INRIA in the overview board of the France Grilles Scientific Interest Group. He is a member of the executive board and the sites committee of the Grid'5000 Scientific Interest Group and member of the executive board of the Silecs testbed. He is a member of the Inria Grenoble Rhône-Alpes Strategic Orientation Committee. He is in charge of exploring potential scientific collaborations between INRIA and SKA France.

9.2. Teaching - Supervision - Juries

9.2.1. Teaching

Licence: Eddy Caron, Projet 1, 48h, L3, ENS de Lyon. France.

Master: Eddy Caron, Projet Intégré, 42h, M1, ENS de Lyon. France.

Master: Eddy Caron, Système distribués, 30h, M1, ENS de Lyon. France.

Licence: Yves Caniou, Algorithmique programmation impérative initiation, 48h, niveau L1, Université Claude Bernard Lyon 1, France.

Licence: Yves Caniou, Pratique d'Unix, 4h, niveau L1, Université Claude Bernard Lyon 1, France.

Licence: Yves Caniou, Programmation Concurrente, 35h and Responsible of UE, niveau L3, Université Claude Bernard Lyon 1, France.

Licence: Yves Caniou, Projet Informatique, 6h, niveau L3, Université Claude Bernard Lyon 1, France.

Licence: Yves Caniou, Réseaux, 36h, niveau L3, Université Claude Bernard Lyon 1, France.

Licence, Yves Caniou, Responsable mission pédagogique particulière, 3h, L3, Université Claude Bernard Lyon 1, France.

Master: Yves Caniou, Projet pour l'Orientation en Master, 3h, niveau M1, Université Claude Bernard Lyon 1, France.

Master: Yves Caniou, Responsible of Master SRIV (Systèmes, Réseaux et Infrastructures Virtuelles), 30h, niveau M2, Université Claude Bernard Lyon 1, France.

Master: Yves Caniou, Projet Bibliographie et Certifications, 1.5h and Responsible of UE, niveau M2, Université Claude Bernard Lyon 1, France.

Master: Yves Caniou, Gestion et supervision d'un parc, 4.5h and Responsible of UE, niveau M2, Université Claude Bernard Lyon 1, France.

Master: Yves Caniou, Sécurité, 27h and Responsible of UE, niveau M2, Université Claude Bernard Lyon 1, France.

Master: Yves Caniou, Systèmes Avancés, 4.5h, niveau M2, Université Claude Bernard Lyon 1, France.

Master: Yves Caniou, Approfondissement Scientifique, 6h, niveau M2, Université Claude Bernard Lyon 1, France.

Master: Yves Caniou, Projet pour l'Orientation en Master, 3h, niveau M1, Université Claude Bernard Lyon 1, France.

Master: Yves Caniou, Responsible of alternance students, 42h, niveau M1, Université Claude Bernard Lyon 1, France.

Master: Laurent Lefèvre, Parallélisme, 12h, niveau M1, Université Lyon 1, France.

Master: Laurent Lefèvre, Réseaux avancés, 24h, niveau M2, IGA Casablanca, Morocco.

Licence: Olivier Glück, Licence pedagogical advisor, 30h, niveaux L1, L2, L3, Université Lyon 1, France.

Licence: Olivier Glück, Introduction Réseaux et Web, 54h, niveau L1, Université Lyon 1, France.

Licence: Olivier Glück, Bases de l'architecture pour la programmation, 23h, niveau L1, Université Lyon 1, France.

Licence: Olivier Glück, Algorithmique programmation impérative initiation, 56h, niveau L1, Université Lyon 1, France.

Licence: Olivier Glück, Réseaux, 2x70h, niveau L3, Université Lyon 1, France.

Master: Olivier Glück, Réseaux par la pratique, 10h, niveau M1, Université Lyon 1, France.

Master: Olivier Glück, Responsible of Master SRIV (Systèmes, Réseaux et Infrastructures Virtuelles) located at IGA Casablanca, 20h, niveau M2, IGA Casablanca, Maroc.

Master: Olivier Glück, Applications systèmes et réseaux, 30h, niveau M2, Université Lyon 1, France.

Master: Olivier Glück, Applications systèmes et réseaux, 24h, niveau M2, IGA Casablanca, Maroc.

Master: Olivier Glück, Administration des Systèmes et des Réseaux, 16h, niveau M2, Université Lyon 1, France.

Master: Olivier Glück, DIU Enseigner l'Informatique au Lycée, 50h, Formation continue, Université Lyon 1, France.

Licence : Frédéric Suter, Programmation Concurrente, 50.66, L3, Université Claude Bernard Lyon 1, France

Master : Frédéric Suter, DIU Enseigner l'Informatique au Lycée, 30, M2, Université Claude Bernard Lyon 1, France

9.2.2. Supervision

PhD: Alexandre Da Silva Veith: *Quality of Service Aware Mechanisms for (Re)Configuring Data Stream Processing Applications on Highly Distributed Infrastructure*, 23 sept. 2019, Labex MiLyon, Laurent Lefèvre (dir), Marcos Dias de Assunção (co-dir) (2016-2019).

PhD: Jad Darrous, *Geo-distributed storage for distributed Cloud*, 17 dec. 2019, Inria, Gilles Fedak (dir) until Aug. 2017 then Christian Perez (dir), Shadi Ibrahim (co-dir).

PhD in progress: Dorra Boughzala, *Simulating Energy Consumption of Continuum Computing between Heterogeneous Numerical Infrastructures in HPC*, IPL Hac-Specis Inria, Laurent Lefèvre (dir) , Martin Quinson and Anne-Cécile Orgerie (Myriads, Rennes, co-dir) (since december 2017).

PhD in progress: Aurélie Kong-Win-Chang: *Techniques de résilience pour l'ordonnancement de workflows sur plates-formes décentralisées (cloud computing) avec contraintes de sécurité*, Yves Robert (dir, ROMA, ÉNS-Lyon), Eddy Caron (co-dir) et Yves Caniou (co-dir).

PhD in progress: Arthur Chevalier, *Optimisation du placement des licences logiciel des fonctions réseau dans le Cloud pour un déploiement économique et efficace*, Eddy Caron (dir), Noëlle Baillon (co-dir, Orange) (since October 2017).

PhD in progress: Zeina Houmani, *A Data-driven microservices architecture for Deep Learning applications*, Eddy Caron (dir), Daniel Balouek-Thomert (Rutgers University) (since oct. 2018).

PhD pended: Aurélie Kong-Win-Chang: *Techniques de résilience pour l'ordonnancement de workflows sur plates-formes décentralisées (cloud computing) avec contraintes de sécurité*, Yves Robert (dir, ROMA, ÉNS-Lyon), Eddy Caron (co-dir) et Yves Caniou (co-dir) (since september 2016).

PhD in progress: Felipe Rodrigo De Souza, *Networking Provisioning Algorithms for Highly Distributed Data Stream Processing*, École Doctorale, Eddy Caron (dir), Marcos Dias de Assunção (co-dir) (since October 2017).

PhD in progress: Laurent Turpin,*Mastering Code Variation and Architecture Evolution for HPC application*, October 2019, Christian Perez (Inria, AVALON team, dir), Jonathan Rouzaud-Cornabas (INSA, Beagle team, co-dir) and Thierry Gautier (Inria, AVALON team, co-dir).

PhD in progress: Idriss Daoudi,*Simulating OpenMP program*, October 2018, Olivier Aumage (Inria, Storm team, Bordeaux, dir) and Thierry Gautier (Inria, AVALON team, co-dir).

PhD in progress: Vo Quoc Bao Bui, *Extended Para-Virtualization*, 2017, Alain Tchana (dir), Daniel Hagimont (INPT, co-dir)

PhD in progress: Barbe Thystere Mvondo Djob, *Improvement of the privileged domain in virtualized systems*, 1 fev 2018, Alain Tchana (dir), Noel De Palma (UGA, co-dir)

PhD in progress: Celestine Stella Ndonga Bitchebe, *Hardware features for virtualization*, 1 mars 2019, Alain Tchana (dir).

PhD in progress: Patrick Lavoisier Wapet, *Illegitimate app detection in mobile phones* , 1 oct. 2017, Alain Tchana (dir), Daniel Hagimont (INPT, co-dir).

9.2.3. Juries

Thierry Gautier was examiner of the PhD defense committee of Andrés Antón Rey Villaverde, Universidad Complutense de Madrid, Spain (November 22, 2019).

Laurent Lefèvre was

- examiner of the PhD defense of Fatma Ezzahra SALEM : "Management of Advanced Sleep Modes for Energy-Efficient 5G Networks", Institut Polytechnique de Paris, Telecom Paris Sud, December 20, 2019
- reviewer of the PhD of Maroua Haddad : "Sizing and management of a hybrid renewable energy system for data centers supply", University of Franche-Comté, November 28, 2019
- examiner of the PhD defense of Léo Grange : "Datacenter Management for on-site Intermittent and Uncertain Renewable Energy Sources", IRIT, Toulouse, October 3, 2019
- president of the PhD defense committee and examiner of of the PhD defense of Silvina Caino Lores : "On the Convergence of Big Data Analytics and High-Performance Computing: A Novel Approach for Runtime Interoperability", Universidad Carlos III de Madrid, Spain, July 8, 2019
- examiner of the PhD defense of Chaopeng Guo : "Energy-efficient Resource Provisioning for Cloud Database", IRIT, Toulouse, June 14, 2019
- reviewer of the PhD of Christian Heinrich : "Modeling, Prediction and Optimization of Energy Consumption of MPI Applications using SimGrid", Laboratoire Informatique de Grenoble, May 21, 2019

Christian Perez was

- president of the HdR defense committee of Alexandru Costan, ENS Rennes, France, March 14th, 2019.
- reviewer and member of the HdR defense committee of Xavier Etchevers, Université Grenoble Alpes, France, Nov 29th, 2019.
- reviewer and member of the HdR defense committee of Guillaume Mercier, Université de Bordeaux, France, Dec 4th, 2019.

- reviewer and member of the PhD defense committee of Ksander Ejjaaouani, Université de Strasbourg, France, Oct 25th, 2019.
- reviewer and member of the PhD defense committee of Georgios Christodoulis, Université Grenoble Alpes, France, Dec 5th, 2019.
- member of the PhD defense committee of Michael Mercier, Université Grenoble Alpes, France, July 1st, 2019.
- member of the PhD defense committee of Mohammad Mahdi Bazm, Université de Nantes, France, July 8th, 2019.
- member of the PhD defense committee of Cedric Deffo Sikounmo, Université Grenoble Alpes, France, Dec 18th, 2019.
- member of the final PhD committee for 7 PhD students of the University of Pisa (Italy), March 8th, 2019: Giovanna Broccia, Giulio Masetti, Luca Pedrelli, Giulio Ermanno Pibiri, Marco Ponza, Manuele Sabbadin, and Massimo Torquati,

Frédéric Suter was president of the PhD defense committee of Michael Mercier, Université Grenoble Alpes, France, July 1st, 2019.

9.3. Popularization

Yves Caniou est co-fondateur et co-organisateur du Campus du Libre, un événement autour du Libre dont l'objectif est de partager différents aspects du libre et des communs, allant par exemple du logiciel libre (Linux, Firefox, *etc.*) aux espaces communs gérés collaborativement (Wikipedia, OpenStreetMap).
La 2e édition s'est déroulée la journée du samedi 23 novembre 2019.

9.3.1. Articles and contents

- Interviews in order to popularize
  - Laurent Lefèvre was interviewed for the following dissemination media:
    - "En 2025, le numérique pourrait polluer autant que l'automobile", Le guide MAG2lyon du Développement Durable, December 2019
    - Radio show "Le numérique et ses impacts", Radio Fréquence Paris Plurielle, December 20, 2019
    - "L'insoutenable croissance du numérique", Alternatives Economiques, December 19, 2019
    - "Le streaming en expansion, son empreinte écologique aussi", Agence France Presse Dossier, October 28, 2019 - Reprint in Le Soleil, La Presse and le Quotidien (Canada, 28/10/2019), L'écho (France, 28/10/2019), Sciences et Avenir (France, 28/10/2019), L'OBS (France, 28/10/2019), Ouest France (France, 28/10/2019), Le Progrès (France 18/11/2019), DerStandard (Germany, 1/11/2019, "Gratis und ohne Anmeldung: Videostreaming-Dienst Apple TV+ gestartet"), Tierwelt (Germany, 3/11/2019, "STREAMING UND CO2 - Serienjunkies als Klimasunder")
    - "Mail, streaming, cloud... 20 gestes pour réduire sa pollution numérique", Business Insider France, October 29, 2019
    - Radio show "Le téléphone sonne", France Inter, August 16, 2019
    - "Guide Consommation Responsable - 3 gestes pour adopter une consommation numérique responsable", Institut National de la Consommation (INC), May 29, 2019
    - "Stocker trop de photos et de mails crée aussi de la pollution", Journal de Saone et Loire, after the Festival sans Decoder of Dompierre les Ormes, May 21, 2019

  * "Pollution numérique : comment réduire ses effets au quotidien ?", TV5 Monde, January 18, 2019

9.3.2. Education

- Yves Caniou is responsible of the LPI Certification at Université Claude Bernard Lyon 1. Further discussions are in progress concerning the proposed tools and redaction of courses/questions.
- Olivier Glück was in charge of one course in DIU Enseigner l'Informatique au Lycée, 50h, Formation continue, Université Lyon 1, France.

9.3.3. Panels

- Laurent Lefèvre was invited in the following panels in 2019 :
  - The "Empreinte écologique du numérique - Ecological footprint of digital world", Festival sans Decoder, Dompierre les Ormes, May 19, 2019
  - The "Energie numérique: ennemie ou alliée de l'écologie", Ateliers Sciences et Citoyens, Les rencontres du CNRS, Poitiers, April 2, 2019

10. Bibliography

Publications of the year

Doctoral Dissertations and Habilitation Theses

[1] J. DARROUS. *Scalable and Efficient Data Management in Distributed Clouds: Service Provisioning and Data Processing*, Ecole normale supérieure de lyon - ENS LYON, December 2019, https://hal.inria.fr/tel-02501316

[2] A. DA SILVA VEITH. *Quality of Service Aware Mechanisms for (Re)Configuring Data Stream Processing Applications on Highly Distributed Infrastructure*, ENS Lyon, CNRS & Inria ; LIP - Laboratoire de l'Informatique du Parallélisme, September 2019, https://hal.inria.fr/tel-02385744

Articles in International Peer-Reviewed Journals

[3] G. AMARASINGHE, M. DIAS DE ASSUNCAO, A. HARWOOD, S. KARUNASEKERA. *ECSNeT++ : A simulator for distributed stream processing on edge and cloud environments*, in "Future Generation Computer Systems", November 2019, pp. 1-18, forthcoming [*DOI :* 10.1016/J.FUTURE.2019.11.014], https://hal.inria.fr/hal-02369500

[4] J. V. FERREIRA LIMA, I. RAÏS, L. LEFÈVRE, T. GAUTIER. *Performance and Energy Analysis of OpenMP Runtime Systems with Dense Linear Algebra Algorithms*, in "International Journal of High Performance Computing Applications", 2019, vol. 33, n^o 3, pp. 431-443 [*DOI :* 10.1177/1094342018792079], https://hal.inria.fr/hal-01957220

International Conferences with Proceedings

[5] J. DARROUS, S. IBRAHIM, C. PÉREZ. *Is it time to revisit Erasure Coding in Data-intensive clusters?*, in "MASCOTS 2019 - 27th IEEE International Symposium on the Modeling, Analysis, and Simulation of Computer and Telecommunication Systems", Rennes, France, IEEE, October 2019, pp. 165-178 [*DOI :* 10.1109/MASCOTS.2019.00026], https://hal.inria.fr/hal-02263116

[6] J. DARROUS, T. LAMBERT, S. IBRAHIM. *On the Importance of Container Image Placement for Service Provisioning in the Edge*, in "ICCCN 2019 - 28th International Conference on Computer Communications and Networks", Valencia, Spain, IEEE, July 2019, pp. 1-9 [*DOI :* 10.1109/ICCCN.2019.8846920], https://hal.inria.fr/hal-02134507

[7] R. FERREIRA DA SILVA, A.-C. ORGERIE, H. CASANOVA, R. TANAKA, E. DEELMAN, F. SUTER. *Accurately Simulating Energy Consumption of I/O-intensive Scientific Workflows*, in "ICCS 2019 - International Conference on Computational Science", Faro, Portugal, ICCS 2019 - International Conference on Computational Science, Springer, June 2019, pp. 138-152 [*DOI :* 10.1007/978-3-030-22734-0_11], https://hal.archives-ouvertes.fr/hal-02112893

[8] E. GIBERT RENART, A. DA SILVA VEITH, D. BALOUEK-THOMERT, M. DIAS DE ASSUNCAO, L. LEFÈVRE, M. PARASHAR. *Distributed Operator Placement for IoT Data Analytics Across Edge and Cloud Resources*, in "CCGrid 2019 - 19th Annual IEEE/ACM International Symposium in Cluster, Cloud, and Grid Computing", Larnaca, Cyprus, May 2019, pp. 1-10 [*DOI :* 10.1109/CCGRID.2019.00060], https://hal.inria.fr/hal-02103942

[9] I. RAÏS, D. BALOUEK-THOMERT, A.-C. ORGERIE, L. LEFÈVRE, M. PARASHAR. *Leveraging energy-efficient non-lossy compression for data-intensive applications*, in "HPCS 2019 - 17th International Conference on High Performance Computing & Simulation", Dublin, Ireland, HPCS 2019 - 17th International Conference on High Performance Computing & Simulation, July 2019, pp. 1-7, https://hal.archives-ouvertes.fr/hal-02179621

[10] C. SÉGUIN, E. CARON, S. DUBUS. *SeeDep: Deploying Reproducible Application Topologies on Cloud Platform*, in "CLOSER 2019 - 9th International Conference on Cloud Computing and Services Science", Heraklion, Greece, May 2019, vol. 1, pp. 363-370 [*DOI :* 10.5220/0007721103630370], https://hal.archives-ouvertes.fr/hal-02119654

[11] A. DA SILVA VEITH, F. R. DE SOUZA, M. DIAS DE ASSUNCAO, L. LEFÈVRE, J. C. S. DOS ANJOS. *Multi-Objective Reinforcement Learning for Reconfiguring Data Stream Analytics on Edge Computing*, in "ICPP 2019 - 48th International Conference on Parallel Processing", Kyoto, Japan, ACM, August 2019, pp. 1-10 [*DOI :* 10.1145/3337821.3337894], https://hal.inria.fr/hal-02140844

[12] A. DA SILVA VEITH, M. DIAS DE ASSUNCAO, L. LEFÈVRE. *Monte-Carlo Tree Search and Reinforcement Learning for Reconfiguring Data Stream Processing on Edge Computing*, in "SBAC-PAD 2019 - International Symposium on Computer Architecture and High Performance Computing", Campo Grande, Brazil, October 2019, pp. 1-8, https://hal.inria.fr/hal-02305472

National Conferences with Proceedings

[13] D. DELABROYE, S. DELAMARE, D. LOUP, L. NUSSBAUM. *Remplacer un routeur par un serveur Linux : retour d'expérience des passerelles d'accès à Grid'5000*, in "JRES - Journées Réseaux de l'Enseignement et de la Recherche", Dijon, France, December 2019, https://hal.inria.fr/hal-02401684

Conferences without Proceedings

[14] R. FERREIRA DA SILVA, H. CASANOVA, R. TANAKA, F. SUTER. *Bridging Concepts and Practice in eScience via Simulation-driven Engineering*, in "BC2DC 2019 - Workshop on Bridging from Concepts to Data and Computation for eScience", San Diego, CA, United States, September 2019, pp. 1-6, https://hal.archives-ouvertes.fr/hal-02329541

[15] J. RICHARD, G. LATU, J. BIGOT, T. GAUTIER. *Fine-Grained MPI+OpenMP Plasma Simulations: Communication Overlap with Dependent Tasks*, in "Euro-Par 2019: Parallel Processing - 25th International Conference on Parallel and Distributed Computing", Göttingen, Germany, Springer, August 2019, pp. 419-433 [*DOI :* 10.1007/978-3-030-29400-7_30], https://hal-cea.archives-ouvertes.fr/cea-02404825

[16] F. RODRIGO DE SOUZA, M. DIAS DE ASSUNCAO, E. CARON. *A Throughput Model for Data Stream Processing on Fog Computing*, in "HPCS 2019 - 17th International Conference on High Performance Computing & Simulation", Dublin, Ireland, July 2019, pp. 1-7, https://hal.archives-ouvertes.fr/hal-02140851

Scientific Books (or Scientific Book chapters)

[17] A. OLEKSIAK, L. LEFÈVRE, P. ALONSO, G. DA COSTA, V. DE MAIO, N. FRASHERI, V. GARCIA, J. GUERRERO, S. LAFOND, A. LASTOVETSKY, R. R. MANUMACHU, B. MUITE, A.-C. ORGERIE, W. PIATEK, J.-M. PIERSON, R. PRODAN, P. STOLF, E. SHEME, S. VARRETTE. *Energy aware ultrascale systems*, in "Ultrascale Computing Systems", Institution of Engineering and Technology, January 2019, pp. 127-188 [*DOI :* 10.1049/PBPC024E_CH], https://hal.inria.fr/hal-02163289

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[18] F. BERTHOUD, P. GUITTON, L. LEFÈVRE, S. QUINTON, A. ROUSSEAU, J. SAINTE-MARIE, C. SERRANO, J.-B. STEFANI, P. STURM, E. TANNIER. *Sciences, Environnements et Sociétés : Rapport long du groupe de travail MakeSEnS d'Inria*, Inria, October 2019, https://hal.inria.fr/hal-02340948

[19] C. DIGUET, F. LOPEZ, L. LEFÈVRE. *L'impact spatial et énergétique des data centers sur les territoires*, ADEME, Direction Villes et territoires durables, 2019, pp. 1-141, https://hal.archives-ouvertes.fr/hal-02133607

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[20] T. GIVARO GROUP. *Givaro*, June 2019, Version : 4.1.1
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[23] J. DARROUS, S. IBRAHIM. *Enabling Data Processing under Erasure Coding in the Fog*, August 2019, 1 p. , ICPP 2019 - 48th International Conference on Parallel Processing, Poster, https://hal.inria.fr/hal-02388835

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