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Activity Report 2011

Project-Team RESO

Protocols and softwares for very high-performance network

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

Table of contents

Project-Team RESO

Keywords: Self-Adaptive Systems, Quality Of Service, Metrology, Energy Consumption, High Speed Network

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2. Overall Objectives

2.1. Presentation of RESO

Overview. The RESO team belongs to the "Laboratoire de l'Informatique du Parallélisme" (LIP) - Unité Mixte de Recherche (UMR) CNRS-INRIA-ENS with Université Claude Bernard of Lyon. The research activities of RESO essentially fit the "communicating" scientific priority of INRIA strategic plan 2008-2012, but since 2010 we are also reinforcing some work in the lines of the challenge "modeling, simulating and optimizing complex dynamic systems". In this direction, RESO is focusing on resource management and communication protocols in the context of high speed networks and virtualized infrastructures (clouds). We apply our results to the domain of high demanding applications and Future Internet.

Objectives. As the use of networks for on-demand computing is gaining in the large Internet, new bandwidth and network resource sharing paradigms are necessary to enable a customized traffic delivery that is dependent of the originating application. The coordination of networking, computing and storage capacities requires the design, development and deployment of new resource management mechanisms ableautonomously identify, reserve, co-allocate and reconfigure the available resources. Eventually, this adaptive administration should turn possible to control the usage of shared resources to meet the volatility of the applications' demand.

The core of RESO's research activity lies in the development of such networking service, with special emphasis on:

- application-wise Quality of Service,
- traffic-aware transport protocols,
- energy consumption efficiency,
- network metrology.

All these interacting aspects have in common the same target, which is that of an efficient and dynamic network resource provisioning and scheduling.

One of the key challenge in this direction, is the provisioning of a secure, flexible, transparent and adapted transport infrastructure for high performance data access and processing. The resulting concept of *Network As a Service* aims at proposing context-aware solutions that autonomously adapt the allocated IT infrastructures to sustain the current needs or constraints of the Future Internet. This is one of the main motivations for RESO's outcomes.

Methodology. The RESO approach relies on the theoretical and practical analysis of the limitations of current network practices, to motivate the exploration of new paradigms that show more adapted to the emerging infrastructures. This research framework at the interface of a specific network context and a challenging application domain, induces a close interaction between these two layers. Our methodology is based on a deep evaluation of the functionalities and the performance of high speed infrastructures and on a study of the high end and original requirements prior to design and to evaluate the proposed solutions.

Schematically, our approach is organized into four major research axes :

Axis 1: Optimized protocol implementations and networking equipements. Since several years, virtualization of the operating system is used in end system to improve security, isolation, reliability and flexibility of the environments. These mechanisms becoming incontrovertible in large scale distributed system, we explore how the same can also be adapted and used in data transport networks and specifically in switching and routing equipments.

Axis 2: Quality of Service and Transport layer for Future Networks. The goal of this axis is to guarantee quality of service in machine/user to machine/user communication while using efficiently the resources of the future networks.

Axis 3: High Speed Network's traffic metrology, analysis and modelling. . This activity consists in measuring along time, the nature and the amount of exchanged information between the constituents of a system. It is then a matter of using the collected data to forecast the network load evolution, so as to anticipate congestion, and more widely, to guarantee a certain (probabilistic) Quality of Service, meliorating the resources usage.

Axis 4: Network Services for high demanding applications. this axis focuses on the application of the solutions to the grid context and on their implementation in a real environment such as the national research instrument Grid5000.

2.2. Highlights

- Three PhD students from RESO defended their work in 2011: Fabienne Anhalt (july 2011), Guilherme Koslovski (july 2011) and Anne-Cécile Orgerie (Sept. 2011).
- RESO was granted 2 new projects in 2011:
    - ANR Fetuses (start Jan 1, 2012)
    - FSN Magellan (kick-off December 2011, start February 2012)

3. Scientific Foundations

3.1. Expertise

We follow a transversal approach that goes from the assessment of the systems to the implementation of the proposed analytical networking solutions on large-scale realistic platforms. The RESO team leverages 2 main assets to work out the raised challenges :

- a multidisciplinary competence comprising:
    - specialists in the design and the implementation of protocol architectures for advanced high performance cluster networks, long distance networks and the Internet
    - specialists of distributed systems and algorithms (wireless)
    - researchers in statistical signal processing, performance evaluation and queuing theory,
    - an experimented computer engineering team.

- an original and pioneer experimental facility relying on a large scale, independent and fully reconfigurable network plate-form (Grid5000), and on a versatile and scalable metrology system which permits fine packet-grain captures at 10Gbps and the measurement of energy consumed by the processing nodes.

3.2. Optimized Protocol implementations and networking equipments

Participants: Laurent Lefèvre, Paulo Gonçalves, Jean-Patrick Gelas, Olivier Glück, Fabienne Anhalt, Guilherme Koslovski.

The key enabling factor of new network services is programmability at every level; that is the ability for new software capabilities to self-configure themselves over the network. We explore the concept, "dynamic programming enablers" for dynamic service driven configuration of communication resources. Dynamic programming enablers apply to an executable service that is injected and activated into the network system elements to create the new functionality at runtime. The basic idea is to enable trusted parties (users, operators, and service providers) to activate management-specific service and network components into a specific platform. We study mechanisms and infrastructures required to support these components. We aim at providing new functionality to services using Internet facilities, addressing the self-management operations in differentiated and integrated services. The goal is the enhancement of the creation and the management (customization, delivery, execution and stop) of Internet services.

3.3. Quality of Service and Transport layer for Future Networks

Participants: Isabelle Guérin-Lassous, Paulo Gonçalves, Thomas Begin, Laurent Lefèvre, Guilherme Koslovski, Anne-Cécile Orgerie, Thiago Abreu, Doreid Ammar.

Recently, network operators have observed profound changes in the daily traffic. The number of applications that generate traffic has tremendously grown up. Numerous delay-sensitive applications (*e.g.*, Telephony over IP) and resource-intensive applications (*e.g.*, streaming video) are constantly emerging. This steady increase of applications, combined with intensive use, has significantly affected the utilization level of networking resources, and it might, ultimately, cause significant network congestions and performance disruptions. Therefore, quality of service issues are still open problems that require adapted solutions.

We investigate quality of service solutions for future networks. In particular, we focus our studies on the evaluation of key parameters for quality of service solutions, like for instance the remaining available bandwidth for wireless networks or the use of routers' links in function of time and space. The integration of the dynamics of these parameters is one of our main goals. This work implies the design of algorithms and performance evaluation studies carried out analytically, by simulation or by experimentation.

3.4. Network services for high demanding applications

Participants: Laurent Lefèvre, Paulo Gonçalves, Olivier Glück, Jean-Patrick Gelas, Matthieu Imbert, Mohammed Diouri, Ashley Chonka.

In a grid environment, two key points in the communication layers have to be considered in order to execute efficiently high performance applications: the heterogeneity of high-speed interconnections composing the grid and the Wide Area Network used to achieve inter-site communications. Our expertise to explore new mechanisms for improving the application performance when executed on the grid, relies on MPI applications. In particular, we gained insights on how to mutualize the performances of several interconnected high-speed networks and how to leverage this factorization to improve a single execution outcome of a MPI application. As one major difficulty dwells in an efficient and reliable communication between the heterogeneous agents of a grid environment, we developed solid skills in handling communication mechanisms that are resilient to heterogeneous and long-distance interconnections.

3.5. Energy aware software components for large scale distributed systems

Participants: Laurent Lefèvre, Anne-Cecile Orgerie, Olivier Glück, Jean-Patrick Gelas, Mohammed Diouri, Ghislain Landry Tsafack, Olivier Mornard, Maxime Morel.

In large scale distributed systems (Datacenters, Grids, Clouds and Networks) it is now a crucial challenge to propose software environments able to support recent improvements in green leverages (ON/OFF, DVFS...), to monitor and expose resource usage and to support energy efficient approaches. RESO explores the proposition of energy aware schedulers (in Orgerie's PhD), performance and energy prediction (in Tsafack's PhD), energy usage simulators (ECOFEN tool) and green exascale infrastructures (Diouri's PhD-) in the context of datacenters (PrimeEnergyIT project), clouds (CompatibleOne Project) and networks (GreenTouch project).

3.6. High Speed Network's metrology

Participants: Paulo Gonçalves, Laurent Lefèvre, Thomas Begin, Matthieu Imbert, Shubhabraya Roy, Ashley Chonka, Anne-Cécile Orgerie, Ghislain Landry Tsafack.

Metrology of wide-area computer networks (i.e. the deployment of a series of tools allowing for collecting relevant information regarding the system status), is a discipline recently introduced in the context of networks, and which undergoes constant developments. In our case, this activity consists in measuring along time and space: *(i)* the nature and the amount of exchanged information between the constituents of a system ; *(ii)* the energy consumption by the different equipments of the system. In the one hand, it is then a matter of using the collected data to forecast the network load evolution, so as to dynamically anticipate congestion, and more widely, to guarantee a given application dependent Quality of Service. On the other hand, we strive at optimizing the resources usage from an energy efficiency viewpoint and at designing transport protocols for green networking.

We ground our approach on our large scale, fully controllable and configurable experimental facility (Grid5000+MetroFlux [53]+ShowWatts+WattM) to validate, to better understand and to extend anterior results that were either heuristically observed or theoretically derived. Conversely, we perform realistic experiments, under prescribed and reproducible conditions, to get new insights into the statistical specificities of internet traffic, and to precisely identify the role of the network parameters [52].

3.7. Statistical signal processing

Participants: Paulo Gonçalves, Thomas Begin, Shubhabraya Roy.

From a statistical signal processing viewpoint, collected traces correspond to (multivariate) time series principally characterized by non-properties: non-gaussianity, non-stationarity, non-linearities, absence of a characteristic time scale (scale invariance). Our research activity is undertaking the development of reliable signal analysis and modeling tools aimed at identifying these (non-)properties in the specific context of computer network traffic. In the course, we intend to clarify the importance of granularity of measurements. More precisely, our interest lies in:

- Sampling theory;
- Large deviations principles;
- Estimation theory;
- Stochastic processes;
- Machine learning ;
- Multi-resolution analysis.

3.8. Performance evaluation

Participants: Thomas Begin, Paulo Gonçalves, Shubhabraya Roy.

Broadly speaking, performance evaluation aims at quantifying the behavior of a system. To do this, we frequently have to rely our analysis on a theoretical model rather than directly observing the behavior of the system. Several reasons may explain this choice: the system is not instrumented or not available for measurements, analytical results are often faster to obtain and brings more insight, the system may still be at prototype stage, etc.

Constructive modeling basically consists to mimic the internal operations of a system in a theoretical model. To hold the complexity of the model at a tractable level, it is common to represent complex internal mechanisms by random variables so that the resulting model is stochastic. The choice of distributions for random variables is often driven by the our expertise on the system. We attempt to devise models that can be represented as Markov chains or as queueing model as this will ease their subsequent resolution.

The resolution of the theoretical model provides numerical values for customary performance parameters such as the steady-state distribution of the number of requests (packets) in the system, the average throughput, the rate of losses, the mean utilization rate of a resources, etc. Regarding the nature of the model and its complexity, we set up entirely (sometimes approximate) analytical solutions, numerical solutions or discrete-event simulations to assess the values of the sought performance parameters.

4. Application Domains

4.1. Overview

RESO applies its research to the domains of high performance Cluster, Grid communications and more recently that of cloud networking. Existing GRID applications did already identify potential networking bottlenecks, either caused by conceptual or implementation specific problems, or missing service capabilities. Loss probability, important and incompressible latencies, dynamic behavior of network paths question profoundly models and technic used in parallel and distributed computing [51]. The particular challenge arises from a heavily distributed infrastructure with an ambitious end-to-end service demand. Provisioning end-to-end services with known and knowable characteristics in a large scale networking infrastructure requires a consistent service in an environment that spans multiple administrative and technological domains. The first bottleneck is often located at the interface between the local area network (LAN) and the wide area network (WAN). RESO conducted several actions in the field of Grid High Performance Networking in the context of the OGF, the European or National projects. These activities have been done in close collaboration with other INRIA and CNRS French teams (Grand Large, Mescal, Graal, Pops, Moais) involved in the GRID5000 and the Grid Explorer projects and other European teams involved in pfldnet and Glif communities.

4.2. Clouds

Virtual networks can be managed and configured flexibly and independently by different operators, creating thus a competitive environment for stimulating innovations. Being "dematerialized" in such a way, networks can be deployed on demand, configured, started, paused, saved, deleted, etc., like a topology of programmable objects, each representing a virtual switch, router or link. The flexibility introduced into the network provides the operator with options for topology reconfiguration, besides allowing it to play with the software stacks and protocols. Achieving such a high degree of decoupling, that leads to disruptive changes, is one of the ultimate goals of network virtualization – envisioned as a key to the 'future' of the Internet.

4.3. Green networks and green clouds

Energy consumption of large scale systems like networks is now becoming a limiting factor for their deployment. Proposing software solutions for supporting energy efficient approaches in networks is a real challenge. Under the context of the GreenTouch project, INRIA RESO is exploring various approaches for the design of realistic green networks. Activities concerning the energy efficiency of elastic platforms like Clouds, are also carried out at RESO (FUI CompatibleOne).

4.4. Wireless networks

Wireless networks are becoming essential networks that often form the last mile to the user. Not considering wireless networks in the global picture of networking may lead to incomplete studies. Therefore, in some problems, we integrate wireless networks in our studies. Due to the scarce resources, a careful control of the traffic as the use of efficient protocols are mandatory in order to achieve the same level of performance as the one obtained by all the current applications in wired networks.

4.5. Data and computing intensive applications

We test and validate our dynamic bandwidth reservation mechanisms in the context of a hight performance computing application distributed over a transnational link (France-Japan) and whose objective is the modeling and the visualization of turbulent airflow dynamics. Time sensitivity being a specific constraint of this application, it yields an interesting framework to evaluate the reactivity of our dynamic resource provisioning schemes and their ability at maintaining networking QoS for interactive communications.

5. Software

5.1. CloudWeaver suite

Participants: Paulo Gonçalves, Guilherme Koslovski, Fabienne Anhalt.

The following list of softwares, whose development was initiated at RESO, constitutes the main outcome of the research work delivered by Guilherme Koslovski (PhD, july 2011) [8] and Fabienne Anhalt (PhD, july 2011) [7]. These products are also part of the technological transfer to Lyatiss (headed by Pascale Vicat-Blanc); embedded in the *CloudWeaver Suite*, they implement the solutions for virtual resources orchestration and infrastructure services.

VXAlloc Dynamic allocation of virtual resources (Patent INPI:10/01626, 2010, Lyatiss, INRIA, ENS Lyon)

VXCap Partitioning of complex physicals infrastructures (Patent INPI:10/01624, 2010, Lyatiss, INRIA, ENS Lyon)

VxSwitch Virtualized switching fabric (Patent INPI:10/00368, 2010, Lyatiss, INRIA, ENS Lyon)

HiperNet Automatic configuration of virtual networks, by programming virtual routers and configuring virtual links according to service requirements (APPcode: IDDN.FR.001.260010.000.S.P.2009.000.10700, 2009, LYaTiss, INRIA ENS Lyon)

VXDL parser Interpretation and XML traduction of virtual infrastructures specifications (APPcode: IDDN.FR.001.260009.000.S.P.2009.000.10800)

Due to non disclosure agreement between INRIA and Lyatiss, access to these software is now submitted to patent restriction.

5.2. Queueing-systems

Participant: Thomas Begin.

This tool aims at providing a simple web based interface to promote the use of our proposed solutions to numerically solve classical queueing systems. It currently implements the solution to get the distribution for the number of customers along with customary performance parameters for a queue with multiple servers, general arrivals, exponential services and a possibly finite buffer, (i.e., $Ph/M/c/N$-like queue). The steady-state solution to this queue is based on a simple and stable recurrence [50] and was performed in collaboration with Pr. Brandwajn (UCSC). We will include new features and new models to this tool in the near future. Associated URL is: http://queueing-systems.ens-lyon.fr

5.3. ECOFEN simulation framework

Participants: Anne-Cecile Orgerie, Laurent Lefevre.

The problem when evaluating new network architectures and protocols is that large testbed platforms are really expensive and difficult to manage. That is why we have designed ECOFEN whose user's entries are the network topology and traffic. Based on configurable measurements of different network component (routers, switches, NICs, etc.), it provides the power consumption of the overall network including the end-hosts as well as the power consumption of each equipment over time. The ECOFEN simulator supports green network leverages such as Adaptive Link Rate and on/off. The aim of ECOFEN is to compute and expose the energy consumed by a network under a given traffic. Firstly based on NS2 and now developed on NS3, this simulator has been made in collaboration with Dino Lopez-Pacheco [29].

6. New Results

6.1. Optimized protocols implementation and networking equipments

6.1.1. *Locating Virtual Infrastructures: Users and InP Perspectives*
Participants: Paulo Gonçalves, Guilherme koslovski.

This is a joint work with Pascale Vicat-Blanc (Lyatiss) and Sébastien Soudan (Lyatiss).

The Cloud Computing wave consolidates the on-demand provisioning of configurable virtual machines. Recent projects have proposed the extension of the original IaaS paradigm to provide dynamic virtual networks to interconnect virtual IT resources, composing Virtual Infrastructures (VIs). In this new scenario, users with different objectives and expectations can rent dynamically provisioned virtual infrastructures to execute their applications during a given time slot. VIs can be allocated anywhere on top of a distributed and virtualized substrate. This decoupling from the geographical location introduces concerns such as a latency increase in network communications (user's perspective), and the fragmentation of physical resources (Infrastructure Provider's - InP - perspective). This context motivates efforts to investigate and deploy new models and tools which consider the geographical location of virtual infrastructures. Our work concentrates on the allocation of VIs guided by both the user's and the InP's constraints. We propose a formulation of the allocation problem considering the user's expectations as well as the physical-substrate provider's goals. Our initial experiments demonstrate that it is possible to improve the quality of the virtual-infrastructure allocation (user perspective) while simultaneously decreasing the physical substrate's fragmentation and the substrate's cost.

6.1.2. *Energy-efficient reservation infrastructure for large-scale distributed systems*
Participants: Anne-Cécile Orgerie, Laurent Lefèvre, Guérin-Lassous Isabelle.

Over the past few years, the energy consumption of Information and Communication Technologies (ICT) has become a major issue. Nowadays, ICT accounts for 2% of the global CO_2 emissions, an amount similar to that produced by the aviation industry. Large-scale distributed systems (e.g. Grids, Clouds and high-performance networks) are often heavy electricity consumers because – for high-availability requirements – their resources are always powered on even when they are not in use. Reservation-based systems guarantee quality of service, allow for respect of user constraints and enable fine-grained resource management. For these reasons, in the context of Anne-Cecile Orgerie Phd (defended in September 2011), we proposed an energy-efficient reservation framework to reduce the electric consumption of distributed systems and dedicated networks. The framework, called ERIDIS, is adapted to three different systems: data centers and grids, cloud environments and dedicated wired networks. By validating each derived infrastructure, we show that significant amounts of energy can be saved using ERIDIS in current and future large-scale distributed systems [54].

6.1.3. *Energy efficiency in exascale infrastructures*
Participants: Mehdi Diouri, Olivier Gluck, Laurent Lefevre.

Joint work with F. Cappello (JLPC, joint laboratory between INRIA and NCSA).

In Diouri's PhD, we address the issue of energy efficiency for exascale supercomputers. We first proposed a green architecture for exascale systems gathering some new solutions to "consume less" energy and to "consume better". This architecture involves interactions with the different actors interfering directly or indirectly with the supercomputer: its user, its administrator, its resource manager and the energy supplier. Then we were interested into leaning on this green architecture in order to propose some green services that will be offered for applications that will run on exascale systems. Our approach consists in evaluating the power overhead induced by some existing services, and by proposing a green version of these services that takes into account the constraints imposed by the different actors involved. In 2011, we specifically aimed to apply our approach for fault tolerance protocols in their normal functioning stage and in case of failure. [38]

6.1.4. *Energy profiling and green leverages for high performance computing applications*
Participants: Ghislain Landry Tsafack, Jean-Patrick Gelas, Laurent Lefevre.

Ghislain Landry TSAFACK CHETSA has started his PhD in january 2011, within the framework of INRIA HEMERA project, on: "Energy profiling and green leverages for high performance computing applications" (co-advisement with Jean-Marc PIERSON and Patritia STOLF from IRIT). During the course of this first year, we have investigated the possibility of characterizing distributed applications considering their energy / power profile. We first carried out a set of experiments for a better understanding of the application's behavior and the impact that this behavior may have on its power consumption. Results led us to the assumption that any individual application run can be represented as a sequence of basic operations including computation, memory accesses, disk and network accesses over a given time period. We next relay on that assumption to define application's energy profile. Application's energy profile helps to prevent the fallout of any action that may be taken to reduce its power usage. To guarantee reasonable results, i.e., reduce energy with less performance degradation, we designed an energy prediction model capable of predicting power usage of a wide range of high performance computing (HPC) applications.

6.1.5. *Towards virtualized home gateways*
Participants: Jean-Patrick Gelas, Laurent Lefevre, Anne-Cecile Orgerie.

Joint work with Dino Lopez Pacheco (Univeristy of Nice) and Referi Assefa (Addis Abeba University, Ethiopia).

Virtualizing services located on end to end parts of the networks and making them available for a large number of applications and users is now becoming a real challenge. Within the scope of the GreenTouch project, we are exploring models, simulations tools (ECOFEN) and software prototypes able to demonstrate the impact of such approach in terms of energy reduction.

6.2. Quality of service and transport layer for future networks

6.2.1. *On the Impact of the Flow-Size Distribution's Tail Index on Network Performance with TCP Connections*
Participant: Paulo Gonçalves.

This is a joint work with Oana Goga (UPMC, Lip6) and Patrick Loiseau (Eurecom).

In this work, we studied the impact of the flow-size distribution on network performance in the case of a single bottleneck with finite buffer. To tackle the case where flows are transmitted with the TCP protocol, we use real experiments and ns-2 simulations. Our preliminary results show that the distribution's tail index impacts the performance in a more complex way than what is reported in existing literature. In particular, we exhibit situations where a heavier tail gives better performance for certain metrics. We argue that a main cause of our observed results is the transient behavior at the beginning of each flow.

6.2.2. *Available Bandwidth Estimation for Multihop Wireless Networks*
Participants: Isabelle Guérin Lassous, Van Nam Nguyen.

Estimating the available bandwidth in IEEE 802.11-based multi-hop wireless networks is a very difficult task due to the medium sharing among contending nodes and collisions between hidden stations. Several methods have been proposed so far for these networks to compute the available bandwidth on wireless links. If some recent solutions such as ABE and IAB now take into account collisions and their impact on the mean backoff, none of them considers the packet retransmissions due to collisions, although these retransmissions have an impact on the available bandwidth. In this work, we have proposed a new available bandwidth estimation for multi-hop wireless networks called RABE (Retransmission-based Available Bandwidth). This method integrates the average number of retransmission attempts in the available bandwidth estimation, in addition to other relevant parameters like the idle periods durations and the collision probability. RABE has been evaluated

by simulation and the obtained results show that RABE can achieve a mean error ratio of 17% in comparison with the real measurement. Furthermore RABE is at least two times more accurate than ABE and ten times more accurate than IAB.

6.2.3. *On The Recovery Performance of Single- and Multipath OLSR in Wireless Multi-Hop Networks*
Participants: Inès Doghri, Isabelle Guérin Lassous.

In this work, we study and improve the recovery properties of single- and multipath routing strategies when facing network failure situations. In particular, we focus our study on two MANET routing protocols: OLSR and its multipath extension MP-OLSR. In various wireless multi-hop network environments, especially in multiple chain topologies, we define and evaluate the latency introduced by these protocols to find a new path after a link failure. Theoretical estimations and simulation results show that, under dual chain-topologies, this latency can be too long and incompatible with the needs of loss and delay constrained applications. As the source nodes cannot detect link failures immediately because of the delay incurred by the well-known nature of link state protocols in general, and of OLSR Topology Control (TC) messages in particular, these nodes keep sending packets along broken paths. We thus study the inconsistencies between the actual network topology and the nodes' own representation. After analyzing the consequences of this long latency, we seek to alleviate these problems with the introduction of adapted mechanisms. We propose three new different schemes and accordingly extend the original OLSR and MP-OLSR protocols in order to decrease the expected latency and improve the protocol performance. Simulation results show a steep decrease of the latency when using these new schemes in dual chain-topologies. We also discuss these results in terms of packet loss, end-to-end delay and overhead.

6.3. High Speed Network's traffic metrology and statistical analysis

6.3.1. *A long-range dependent model for network traffic with flow-scale correlations*
Participant: Paulo Gonçalves.

This is a joint work with Patrick Loiseau (Eurecom) and Pascale Vicat-Blanc (Lyatiss).

For more than a decade, it has been observed that network traffic exhibits long-range dependence and many models have been proposed relating this property to heavy-tailed flow durations. However, none of these models consider correlations at flow scale. Such correlations exist and will become more prominent in the future Internet with the emergence of flow-aware control mechanisms correlating a flow's transmission to its characteristics (size, duration, etc.). In our present work, we study the impact of the correlation between flow rates and durations on the long-range dependence of aggregate traffic. Our results extend those of existing models by showing that two possible regimes of long-range dependence exist at different time scales. The long-range dependence in each regime can be stronger or weaker than standard predictions, depending on the conditional statistics between the flow rates and durations. In the independent case, our proposed model consistently reduces to former approaches. The pertinence of our model is validated on real web traffic traces, and its ability to accurately explain the Hurst parameter is validated on both web traces and numerical simulations.

6.3.2. *A reccurent solution of Ph/M/c/N-like and Ph/M/c-like queues*
Participant: Thomas Begin.

This work has been accepted for publication by the Journal of Applied Probability [50] and was performed in collaboration with Pr. Brandwajn (UCSC).

We propose an efficient semi-numerical approach to compute the steady-state probability distribution for the number of requests at arbitrary and at arrival time instants in Ph/M/c-like systems in which in the inter-arrival time distribution is represented by an acyclic set of memoryless phases. Our method is based on conditional probabilities and results in a simple computationally stable recurrence. It avoids the explicit manipulation of potentially large matrices and involves no iteration. Due to the use of conditional probabilities, it delays the onset of numerical issues related to floating-point underflow as the number of servers and/or phases increases. For generalized Coxian distributions, the computational complexity of the proposed approach grows linearly with the number of phases in the distribution.

6.3.3. *A Markovian model based on SIR epidemic classification to reproduce the workload dynamics of a VoD server*

Participants: Shubhabrata Roy, Thomas Begin, Paulo Gonçalves.

We have devised a Markovian model, based on the SIR epidemic classification, to reproduce the workload dynamics that can be observed on a VoD (Video on Demand) server. This model basically relies on the dynamic between three distinct populations (i.e., current watchers, past watchers and potential watchers). It also embeds events with very low probability but high impact on its overall behavior corresponding to the occurrence of a flash crowd or the the buzz effect on a VoD server. The steady-state solution to this model has shown that it exhibits a behavior qualitatively close to what can be expected from a real-life VoD server. We have also shown that the workload process as delivered this model satisfies a large deviation principle. Our future work aims at taking advantage of this information to devise a new scheme for allocating available resources in a VoD server.

6.3.4. *A comparative study of existing MBAC using real network traces*

Participants: Doreid Ammar, Thomas Begin, Isabelle Guérin-Lassous.

We have evaluated the respective performance of several MBACs (Measurement-based admission control) using a realistic framework in which the pattern of the background traffic follows experimental traces collected on real-life networks. This study has allowed to highlight the respective discrepancies between MBACs in terms of easiness to implement and attained performance. This work will now focus on the design of a new MBAC based on a iteratively learned model.

6.3.5. *Graph Based Classification of Content and Users in Graph Based Classification of Content and Users in BitTorrent*

Participants: Paulo Gonçalves, Marina Sokol.

This is a joint work with Konstantin Avrachenkov (INRIA Maestro) and Arnaud Legout (INRIA Planete).

P2P downloads still represent a large portion of today's Internet traffic. More than 100 million users operate BitTorrent and generate more than 30% of the total Internet traffic. Recently, a significant research effort has been done to develop tools for automatic classification of Internet traffic by application. The purpose of our present work is to provide a framework for sub-classification of P2P traffic generated by the BitTorrent protocol. Unlike previous works, we cannot rely on packet level characteristics and on the standard supervised machine learning methods. The application of the standard supervised machine learning methods is based on the availability of a large set of parameters (packet size, packet inter-arrival time, etc.). Since P2P transfers are based on the same BitTorrent protocol we cannot use this set of parameters to classify P2P content and users. Instead we can make use of the bipartite user-content graph. This is a graph formed by two sets of nodes: the set of users (peers) and the set of contents (downloaded files). From this basic bipartite graph we also construct the user graph, where two users are connected if they download the same content, and the content graph, where two files are connected if they are both downloaded by at least one same user. The general intuition is that the users with similar interests download similar contents. This intuition can be rigorously formalized with the help of graph based semi-supervised learning approach.

6.3.6. *Generalized Optimization Framework for Graph-based Semi-supervised Learning*
Participants: Paulo Gonçalves, Marina Sokol.

This is a joint work with Konstantin Avrachenkov (INRIA Maestro).

We develop a generalized optimization framework for graph-based semi-supervised learning. The framework gives as particular cases the Standard Laplacian, Normalized Laplacian and PageRank based methods. We have also provided new probabilistic interpretation based on random walks and characterized the limiting behavior of the methods. The random walk based interpretation allows us to explain differences between the performances of methods with different smoothing kernels. It appears that the PageRank based method is robust with respect to the choice of the regularization parameter and the labelled data. We illustrate our theoretical results with two realistic datasets, characterizing different challenges: *Les Miserables* characters social network and Wikipedia hyper-link graph. The graph-based semi-supervised learning classifies the Wikipedia articles with very good precision and perfect recall employing only the information about the hyper-text links.

6.3.7. *On the estimation of the large deviations spectrum*
Participant: Paulo Gonçalves.

This is a joint work with Julien Barral (Univ. Paris 13)

We propose an estimation algorithm for large deviations spectra of measures and functions. The algorithm converges for natural examples of multifractals.

6.3.8. *Adaptive Multiscale Complexity Analysis of Fetal Heart Rate*
Participant: Paulo Gonçalves.

This is a joint work with Patrice Abry (ENS Lyon, CNRS) and Muriel Doret (Hospice civils de Lyon, Univ. Lyon 1)

Per partum fetal asphyxia is a major cause of neonatal morbidity and mortality. Fetal heart rate monitoring plays an important role in early detection of acidosis, an indicator for asphyxia. This problem is addressed in this paper by introducing a novel complexity analysis of fetal heart rate data, based on producing a collection of piecewise linear approximations of varying dimensions from which a measure of complexity is extracted. This procedure specifically accounts for the highly non-stationary context of labor by being adaptive and multiscale. Using a reference dataset, made of real *per partum* fetal heart rate data, collected *in situ* and carefully constituted by obstetricians, the behavior of the proposed approach is analyzed and illustrated. Its performance is evaluated in terms of the rate of correct acidosis detection versus the rate of false detection, as well as how early the detection is made. Computational cost is also discussed. The results are shown to be extremely promising and further potential uses of the tool are discussed.

7. Contracts and Grants with Industry

7.1. Contracts with Industry

7.1.1. *ADR "Semantic Networking" of INRIA Alcatel-Lucent Bell Labs joint laboratory (2008–2011)*
Participants: Isabelle Guerin-Lassous, Paulo Gonçalves, Thomas Begin, Doreid Ammar, Marina Sokol, Mohamad Jaber.

RESO participates in the ADR (Action de Recherche/Research Action) "Semantic Networking" (SEM- NET), one of the three ADRs of the INRIA ALCATEL-LUCENT BELL LABS joint laboratory. This ADR started on January 1st 2008 and will end in October 2012. I. Gue´rin Lassous and L. Noirie are the respective coordinator for INRIA and for ALTCATEL-LUCENT of the ADR SEMNET.

The new paradigm of "semantic networking" for the networks of the future brings together "flow-based networking", "traffic-awareness" and "self-management" concepts to get "plug-and-play" networks. The natural traffic granularity is the flow. RESO task is to elaborate on the admission control of flows in routers having in mind the current status of the network and the underlying applications. I. Guérin Lassous and T. Begin are co-advising the Phd work of D. Ammar. P. Gonçalves participates with Ph. Nain (INRIA project-team MAETSRO) to the supervision of the PhD thesis of M. Sokol (INRIA project-team MAESTRO), which aims at developing graph-based semi-supervised approaches applied to content- and user-based classifications in networks.

8. Partnerships and Cooperations

8.1. National Initiatives

8.1.1. ARC MISSION

Participants: Isabelle Guérin Lassous, Thomas Begin, Paulo Gonçalves.

The project MobIle SubStitutIOn Networks (MISSION) is focused on the performance study, the possibilities and the feasibility to deploy a fleet of mobile wireless routers to help a wired network that can not offered its services anymore. This project deals with the theoretical apsects as the practical aspects of such a deployment. From a theoretical point of view, one problem is to minimize the number of used routers while rebuilding the network to replace. The main difficulty lies in the possibility to offer the services provided by the wired network in a transparent way. The controlled mobility allows a redeployment or an adaptation of the built network according to the needs or to the on-going traffic on the network. This controlled mobility should improve the network performance.

8.1.2. GRID5000: ADT Aladdin

Participants: Laurent Lefèvre, Gelas Jean-Patrick, Olivier Glück, Paulo Gonçalves, Matthieu Imbert, Armel Soro, Olivier Mornard, Jean-Christophe Mignot, Diouri Mohammed, Orgerie Anne-Cécile.

ENS Lyon is involved in the GRID'5000 project, which is an experimental Grid platform gathering ten sites geographically distributed in France. ENS Lyon hardware contribution is done for now by two distinct set of computers. The Grid5000 of Lyon comprises now around 300 processors interconnected with the 10 Gbit per second network. Lyon site is nationaly recognized to gather the "networking expertize" with skilled researchers and engineers and dedicated networking equipments (Metroflux, GNET10...). Lyon site also hosts an important part of the Green Grid5000 infrastructure by hosting a set of 1500 wattmeters and exposing energy measurements to the Grid5000 community.

RESO is strongly involved in the choices of Grid5000's network components and architecture. Laurent Lefèvre is member of the national committee (comité de direction) of GRID'5000, of the Aladdin scientific committee and responsible of the Lyon site.

8.1.3. ANR RESCUE

Participants: Isabelle Guérin Lassous, Thomas Begin, Paulo Gonçalves, Thiago Abreu.

Access and metropolitan networks are much more limited in capacity than core networks. While the latter operate in over-provisioning mode, access and metropolitan networks may experience high overload due to evolution of the traffic or failures. In wired networks, some failures (but not all) are handled by rerouting the traffic through a backup network already in place. In developed countries, backup networks are adopted wherever possible (note that this is generally not the case for the links between end users and their local DSLAM). Such a redundant strategy may not be possible in emerging countries because of cost issues. When dedicated backup networks are not available, some operators use their 3G infrastructure to recover some specific failures; although such an alternative helps avoid full network outage, it is a costly solution. Furthermore, availability of 3G coverage is still mainly concentrated in metropolitan zones. When no backup networks are available, it would be interesting to deploy, for a limited time corresponding to the period of the problem (i.e., failure or traffic overload), a substitution network to help the base network keep providing services to users.

In the RESCUE project (2010-2013), we will investigate both the underlying mechanisms and the deployment of a substitution network composed of a fleet of dirigible wireless mobile routers. Unlike many projects and other scientific works that consider mobility as a drawback, in RESCUE we use the controlled mobility of the substitution network to help the base network reduce contention or to create an alternative network in case of failure. The advantages of an on-the-fly substitution network are manifold: Reusability and cost reduction; Deployability; Adaptability.

The RESCUE project addresses both the theoretical and the practical aspects of the deployment of a substitution network. From a theoretical point of view, we will propose a two-tiered architecture including the base network and the substitution network. This architecture will describe the deployment procedures of the mobile routing devices, the communication stack, the protocols, and the services. The design of this architecture will take into account some constraints such as quality of service and energy consumption (since mobile devices are autonomous), as we want the substitution network to provide more than a best effort service. From a practical point of view, we will provide a proof of concept, the architecture linked to this concept, and the necessary tools (e.g., traffic monitoring, protocols) to validate the concept and mechanisms of on-the-fly substitution networks. At last but not least, we will validate the proposed system both in laboratory testbeds and in a real-usage scenario.
http://rescue.lille.inria.fr/

8.1.4. *FUI CompatibleOne Project*

Participants: Laurent Lefèvre, Jean-Patrick Gelas, Olivier Mornard, Maxime Morel.

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.

In this project, RESO 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. RESO is leading the task T3.4 on energy management and will participate in activities on virtual machines design and migration.

CompatibleOne is an open source project with the aim of providing inter-operable middle-ware for the description and federation of heterogeneous clouds comprising resources provisioned by different cloud providers. Services provided by INRIA RESO 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. INRIA RESO 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. To allow the exploitation of these probes, we made a first version of a software library and file format for data and monitoring daemon. To allow the use of this system outside of CompatibleOne, we developed a complete monitoring system, which is now in use in IN2P3 data center. To make our tests and developments, we specified, bought, installed and deployed our cluster of 12 nodes. Finally, we participated in international manifestations like SuperComputing 2011 (Poster and demonstration on INRIA booth), Cloud and Green Computing 2011[46].

8.1.5. *FSN Magellan Project*

Participants: Laurent Lefèvre, Jean-Patrick Gelas.

The project Magellan has been accepted in December 2011. The official beginning will be mid-february 2012.

8.1.6. *ANR PETAFLOW*

Participants: Paulo Gonçalves, Matthieu Imbert, Anne-Cécile Orgerie, Ashley Chonka.

This ANR (Appel Blanc International) started in october 2009 and will end in september 2012. It is a collaborative project between the GIPSA Lab (Grenoble), MOAIS (INRIA Grenoble), RESO (INRIA Grenoble), the University of Osaka (the Cybermedia Center and the Department of Information Networking) and the University of Kyoto (Visualization Laboratory).

We aim at proposing network solutions to guarantee the Quality of Service (in terms of reliability level and of transfer delay properties) of a high speed, long-distance connection used in an interactive, high performance computing application. Another specificity of this application is the peta-scale volume of the treated data corresponding to the upper airway flow modeling.

http://petaflow.gforge.inria.fr/

8.1.7. ANR DMASC

Participant: Paulo Gonçalves.

Started in october 2008, this ANR project, leaded by J. Barral (Univ. Paris 13), is a partnership between INRIA (Sisyphe and Reso), university of Paris 12 and Paris 13 and Paris Sud (équipe d'accueil EA 4046 Service de Réanimation Médicale CHU de Bicêtre).

Its main objective is to develop advanced multifractal analysis tools, from mathematically ground results to efficient estimators. We apply these methods to the analysis, to the modeling and to the classification (for non invasive diagnoses) of cardio-vascular systems.

http://www-rocq.inria.fr/~barral/DMASC.html

8.2. European Initiatives

8.2.1. FP7 Projects

8.2.1.1. GEYSERS

Title: Generalsed Architecture for dynamic infrastructure services

Type: COOPERATION (ICT)

Defi: The Network of the Future

Instrument: Integrated Project (IP)

Duration: January 2010 - December 2012

Coordinator: Interoute (Italy)

Others partners: Interoute (Italy), martel Martel GmbH (Switzerland), ADVA AG Optical Networking (Germany), SAP AG (Germany), Alcatel-Lucent Italia S.p.A. (Italy), Telefónica I+D (Spain), Telekomunikacja Polska S.A. (Poland), Instytut Chemii Bioorganicznej PAN, Poznan Supercomputing and Networking Centre (Poland), Nextworks s.r.l (Italy), Fundació i2CAT, Internet i Innovació Digital a Catalunya (Spain), Universiteit van Amsterdam (The Netherlands), University of Essex (UK), Research and Education Society in Information Technologies (Greece), Technical University of Braunschweig (Germany), Interdisciplinary Institute for BroadBand Technology VZW (belgium), Indian Institute of Technology (India), LYaTiss (France), ADVA Optica Networking Sp.zo.o. (Poland)

Abstract: GEYSERS's vision is to qualify optical infrastructure providers and network operators with a new architecture, to enhance their traditional business operations. Optical network infrastructure providers will compose logical infrastructures and rent them out to network operators; network operators will run cost-efficient, dynamic and mission-specific networks by means of integrated control and management techniques. GEYSERS's concept is that high-end IT resources at users' premises are fully integrated with the network services procedures, both at the infrastructure-planning and connection-provisioning phases. Following this vision, GEYSERS will specify and implement a novel optical-network architecture able to support 'Optical Network + Any-IT' resource provisioning seamlessly and efficiently. Energy-consumption metrics for the end-to-end service routing are part of this efficiency. GEYSERS proposes to:

- Specify and develop mechanisms that allow infrastructure providers to partition their resources (optical network and/or IT), compose specific logical infrastructures and offer them as a service to network operators. This will be done overcoming the current limitations of networks/domain segmentation, and will support dynamic and on-demand changes in the logical infrastructures

- Specify and develop a Network Control Plane for the optical infrastructure, by extending standard solutions (ASON/GMPLS and PCE), able to couple optical network connectivity and IT services automatically and efficiently, and provide them in 1 step, dynamically and on-demand, including infrastructure re-planning mechanisms.

These achievements will enable infrastructure providers, network operators and application providers to participate in new business scenarios where complex services with complex attributes and strict bandwidth requirements can be offered economically and efficiently to users and applications. GEYSERS's outcomes will be validated in an EU-wide optical network test-bed.

8.2.1.2. SAIL

Title: Scalable and Adaptive Internet Solutions

Type: COOPERATION (ICT)

Defi: The Network of the Future

Instrument: Integrated Project (IP)

Duration: August 2010 - January 2013

Coordinator: Ericsson (Sweden)

Others partners: Ericsson AB (Sweden), Alcatel-Lucent Deutschland (Germany), Nokia Siemens Networks OY(Finland), NEC Europe LTD (United Kingdom), France Telecom SA(France), Telefónica Investigacion y Desarrollo (Spain), Telecom Italia (Italy), Portugal Telecom Inovação (Portugal), Swedish institute of Computer science (Sweden), Instituto Superior Tecnico Address (Portugal), Universitaet Paderborn (Germany), Aalto-Korkeakoulusäätiö (Finland), Kungliga Tekniska Högskolan (Sweden), Fraunhofer Gesellschaft zur Förderung der angewandten Forschung (Germany),Universitaet Bremen (Germany), Hewlett-Packard Limited (United Kingdom), Fundación Tecnalia Research and Innovation (Spain), Institut Telecom (France), Technion – Israel Institute of Technology (Israel), DOCOMO Communication Laboratoties Europe (Germany), The Provost Fellows & Scholars of the College of the Holy and undivided Trinity of Queen Elizabeth (Ireland), National ICT Australia Limited (Australia), Universidad de Cantabria (Spain), Lyatiss (France)

See also: https://twiki.verkstad.net/bin/view/Main/WebHome

Abstract: SAIL's objective is the research and development of novel networking technologies using proof-of-concept prototypes to lead the way from current networks to the Network of the Future. SAIL leverages state of the art architectures and technologies, extends them as needed, and integrates them using experimentally-driven research, producing interoperable prototypes to demonstrate utility for a set of concrete use-cases. SAIL reduces costs for setting up, running, and combining networks, applications and services, increasing the efficiency of deployed resources (e.g., personnel, equipment and energy). SAIL improves application support via an information-centric paradigm, replacing the old host-centric one, and develops concrete mechanisms and protocols to realize the benefits of a Network of Information (NetInf). SAIL enables the co-existence of legacy and new networks via virtualization of resources and self-management, fully integrating networking with cloud computing to produce Cloud Networking (CloNe). SAIL embraces heterogeneous media from fibre backbones to wireless access networks, developing new signaling and control interfaces, able to control multiple technologies across multiple aggregation stages, implementing Open Connectivity Services (OConS). SAIL also specifically addresses cross-cutting themes and non-technical issues, such as socio-economics, inclusion, broad dissemination, standardization and network migration, driving new markets, business roles and models, and increasing opportunities for both competition

and cooperation. SAIL gathers a strong industry-led consortium of leading operators, vendors, SME, universities and research centers, with a valuable experience acquired in previous FP7 projects, notably 4WARD. The impact will be a consensus among major European operators and vendors on a well-defined path to the Network of the Future together with the technologies required to follow that path.

8.2.1.3. PrimeEnergyIT

Title: SPEC on "Security and Privacy Concerns in Energy Efficient Computing"

Type: COOPERATION (ICT)

Defi: Future Internet Experimental Facility and Experimentally-driven Research

Instrument: Intelligent Energy in Europe

Duration: 2010-2012

Coordinator: Electricity of Austria

Others partners: Berlin Energy Agency, Berlin Institute of Technology, BIO Intelligence Service, Politecnico di Milano, GAIA, ICLEI, University of Coimbra, Seven

Abstract:

The fast development of IT services and IT performance in many areas of the public and private service sector (e.g. administration, health services, entertainment etc.). has led to a rapid increase of energy consumption and energy costs for central IT equipment. EU and US studies (IEE E-Server project 2007, EPA 2007) have shown a strong increase of energy consumption of central IT-hardware and infrastructure during the last years and a growing trend is expected for the future. For EU-27 the energy consumption of central IT hardware and infrastructure (incl. servers, storage, network equipment, cooling) was calculated to 40TWh/a which is equal to 1,5% of the EU electricity consumption. If business-as-usual is continued in the next years a doubling of energy consumption to 80 TWha is expected to occur by 2012 already. A broad implementation of energy efficient technology in the EU however would allow a reduction of energy demand of about 60% compared to the business as usual scenario. Energy efficient technology is available but needs to be broadly implemented in the demand side market. To exploit the enormous saving potentials concerted action is needed across the EU member states. Measures to support energy efficient market development for central IT equipment have been started only recently in 2007. Thus compared to many other areas of technology (lighting, heating, client side IT etc.) activities to support sustainable solutions are quite new and more concerted action is needed to reach a good market impact. The major first initiatives at EU-level were The Green Grid, the Energy Star for servers, the Code of Conduct and the IEE E-Server project. These programmes started to develop guidelines, tools and criteria to support energy efficiency in data centres. However so far only part of the relevant products and technologies could be covered and energy efficiency criteria as well as market supporting instruments are still at an early stage of development and implementation. The proposed project is designed to further enforce energy efficient market development for central IT equipment based on the previous initiatives and with a focus on so far largely uncovered IT hardware including storage and network equipment as well as new power management technologies. The longer term objectives to be supported by the project are to avoid an annual energy consumption of 70TWha in the EU by 2015 compared to business as usual, to support the development of internationally accepted energy efficiency criteria and standards for central IT equipment and to implement energy efficiency as a key target for the major supply and demand side target groups. These goals shall be supported by the further development of energy efficiency criteria to be considered by the demand and supply side market, by the evaluation and demonstration of most energy efficient technology in best practise and by the development and implementation of education, certification and procurement concepts as major instruments to drive the market. The PrimeEnergyIT project deals with :

- The development and implementation of hardware and service based energy efficiency criteria as major tools to support IT and infrastructure managers in the selection and management of IT hardware and cooling equipment
- The demonstration and evaluation of energy efficient IT solutions in best practise
- Education and training of IT managers and experts to support energy efficient procurement and management
- Implementation of energy efficiency criteria for central IT equipment and cooling in public procurement

INRIA RESO has been mailny involved in energy efficiency criteria in the context of storage for small and medium datacenters.

8.2.1.4. EuroNF JRA.S.1.44 project SPEC

Title: SPEC on "Security and Privacy Concerns in Energy Efficient Computing"

Type: JRA

Defi: Future Internet Experimental Facility and Experimentally-driven Research

Instrument: EuroNef Project

Duration: 2011

Coordinator: University of Passau (Germany)

Others partners: University of Vienna, CERTH (Greece)

Abstract: To design highly energy efficient systems is one of the most important design goals which are under investigation currently. The underlying motifs to design such systems are economical as well as environmental in nature. However, it has been identified that while focusing solely on energy efficiency mechanisms, the other design parameters must also be considered to achieve a well balanced system. Security and privacy aspects are among those very important parameters. This SJRP focuses on the security and privacy aspects involved in the application of modern energy efficiency mechanisms. We focus on two of the key technologies including virtualization for energy efficiency and smart metering. In first part of the project, we investigate the security issues within virtualized environments for energy efficiency while the second part focus on the end user privacy concerns when monitoring physical resources in clouds.

8.2.1.5. COST Action IC804

Title: IC804 COST ACtion on "Energy efficiency for large scale distributed systems"

Type: European COST Action

Duration: 2009-2013

Coordinator: University of Toulouse

Others partners: 20 countries

Abstract: The main objective of the Action is to foster original research initiatives addressing energy awareness/saving and to increase the overall impact of European research in the field of energy efficiency in distributed systems. The goal of the Action is to give coherence to the European research agenda in the field, by promoting coordination and encouraging discussions among the individual research groups, sharing of operational know-how (lessons-learned, problems found during practical energy measurements and estimates, ideas for real-world exploitation of energy aware techniques, etc.). The Action objectives can be summarized on scientific and societal points of view: sharing and merging existing practices will lead the Action to propose and disseminate innovative approaches, techniques and algorithms for saving energy while enforcing given Quality of Service (QoS) requirements. Laurent Lefèvre is Management Committee member and French representative in this COST action.

8.3. International Initiatives

8.3.1. Visits of International Scientists

In the context of EuroNef project Spec Action, INRIA RESO has hosted Thomas Treutner form University of Vienna (Austria) during 2 weeks in July 2011. With RESO researchers, he has explored the topic of privacy in clouds when energy monitoring is performed. This collaboration has resulted in an international publication [26].

9. Dissemination

9.1. Animation of the scientific community

Paulo Gonçalves

- – Editorial board: EURASIP, officier of the Local Liaison Board
- – Reviewing committee: IEEE Trans. on Signal Processing, Colloque GRETSI,

Laurent Lefèvre

- – Conference and events organization :
  - * Co-Organization of INRIA Booth in SuperComputing 2011, Seattle, WA, USA, November 12-18, 2011
  - * Co-organizer of Entretiens Jacques Cartier : Colloquium on "Information and Communications Technologies: Are they Green ?", Montreal, Canada, October 3-4, 2011
  - * Co-organizer of the Half day on "Public procurement of Energy efficient datacenters - Achats publics de datacentres efficaces du point de vue énergétique", Paris, France, June 16, 2011
  - * Co-organizer of the Green Days @ Paris event: "Energy efficiency : how to apply our models and solutions in production infrastructures ?", Paris, France, May 31 and June 1, 2011
  - * Workshop co-chair of SUNSET2011 : Workshop on Sustainable Networking during Networking 2011 conference , Valencia, Spain, May 13, 2011
- – Program committee: SuperComputing 2011, Renpar 2011, Second International Conference on Energy-Efficient Computing and Networking, Track on Green/Power-Aware Design and Optimization (PADO), The 9th Australasian Symposium on Parallel and Distributed Computing (AusPDC2011)
- – Steering committee: Grid 2011: 12th IEEE/ACM International Conference on Grid Computing - CCGrid 2011 : 11th IEEE/ACM International Symposium on Cluster, Cloud and Grid Computing
- – University committee: 1 review of PhD thesis
- – national expertise: CNU section 27 - Member of the Eco-info group - Member of Hemera INRIA Large Wingspan project : co-leader of the Working group : Energy Efficient Large Scale Experimental Distributed Systems and of the scientific challenge : Energy profiling of large scale applications
- – public dissemination: Contribution to the paper "Internet Géant énergivore" - Okapi journal, April 2011 - Green-Net project nominated as one of the best innovations in Green-IT for the "Prix de la Croissance Verte Numérique", France, November 2011

Isabelle Guérin Lassous

– Editorial board: Computer Communications (Elsevier), Ad Hoc Networks (Elsevier) and Discrete Mathematics and Theoretical Computer Science.

– Conference Organization: General chair of of ACM PE-WASUN 2011 (Eighth ACM International Symposium on Performance Evaluation of Wireless Ad Hoc, Sensor, and Ubiquitous Networks - October 2011, Miami Beach, FL, USA)

– Program committee: Globecom'11, SSS'11, MUE'11, HotMesh'11, MedHocNet'11, IPDPS'11, PerSens'11, PECSS'11, Algotel'11 and CFIP'11.

– University committee: Member of the Department council of University Lyon 1, 4 reviews of PhD thesis, 2 reviews of HDR thesis

– national expertise: CNU section 27, International program for French Research Ministry

Thomas Begin

– University committee: Member of the LIP laboratory council since February 2010, Member of one PhD jury

Olivier Glück

– 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, Member of one PhD jury

Jean-Patrick Gelas

– Reviewing committee: HPPAC 2009, COMCOM 2009, E2GC2 2009, Grid 2010, E2GC2 2010, GreenCom 2010.

– Program committee: Energy Efficient Grids, Clouds and Clusters Workshop (E2GC2 2009 and 2010) ; The Fifth Workshop on High-Performance, Power-Aware Computing (HPPAC 2009)

– University committee: Master (M2) jury.

– National expertise: ANR programme Arpège (2010)

9.2. Teaching

Thomas Begin

Licence : Réseaux, 18 heures, niveau L3, Université Lyon 1, France

Master : Réseaux, 60 heures, niveau M1, Université Lyon 1, France

Master : Réseaux avancés : architecture et protocoles, 12 heures, niveau M2, ENS Lyon, France

Master : Réseaux avancés, 56 heures, niveau M2, Université Lyon 1, France

Master : Architecture des réseaux, 18 heures, niveau M2, Université Lyon 1, France

Jean-Patrick Gelas

Master : Réseaux avancés : IPv6 and IP routing, 40 h, niveau M2, Université Lyon 1, France

Master : Architecture des réseaux : Router under the hood, 6h, niveau M2, Université Lyon 1, France

Master : Systèmes d'exploitation, 24h, niveau M2, Université Lyon 1, France

Master : Réseaux, 35h, niveau M2, Université Lyon 1, France

Master : Systèmes et logiciels embarqués, 45h, niveau M2, Université Lyon 1, France

Paulo Gonçalves

Master : Responsible for the teaching axis "Models and Optimization for Emergent Infrastructure". Master (M1/M2) of the Department of Computer Sciences, ENS Lyon (*Informatique fondamentale*)

Olivier Glück

Licence : Initiation Réseaux, 9 heures, niveau L2, Université Lyon 1, France

Licence : Réseaux, 2x70 heures, niveau L3, Université Lyon 1, France

Master : Services et Protocoles Avancés sur Internet, 30 heures, niveau M2, Université Lyon 1, France

Master : Administration des Systèmes et des Réseaux, 16 heures, niveau M2, Université Lyon 1, France

Master : Réseaux avancés : architecture et protocoles, 6 heures, niveau M2, ENS Lyon, France

Isabelle Guérin Lassous

Master : Réseaux ad hoc, 12 heures, niveau M1, Université Lyon 1, France

Master : Qualité de Service et Systèmes Communicant Multimédia, 40 heures, niveau M2, Université Lyon 1, France

Master : Réseaux du Futur, 5 heures, niveau M2, Université Lyon 1, France

Master : Réseaux, 21 heures, niveau M2, Université Lyon 1, France

Master : Réseaux sans Fil, 33 heures, niveau M2, Université Lyon 1, France

Master : Outils pour la recherche, 4 heures, niveau M2, Université Lyon 1, France

Master : Qualité de Service et Contrôle de Trafic, 30 heures, niveau M2, Ecole Supérieure d'Ingénieurs Réunion Océan Indien

Master : Réseaux sans Fil, 10 heures, niveau M2, Ecole Supérieure d'Ingénieurs Réunion Océan Indien

Laurent Lefèvre

Master : Advanced Networks : green, autonomic and robust networks, 48 heures, niveau M2, Addis Abeba University, Ethiopia

Master : Réseaux avancés : architecture et protocoles, 6 heures, niveau M2, ENS Lyon, France

PhD : Anne-Cécile Orgerie, "An Energy-Efficient Reservation Framework for Large-Scale Distributed Systems", École Doctorale Informatique et Mathématiques, Université Lyon 1 et ENS Lyon. Sept. 27, 2011, I. Guérin Lassous (Dir.), L. Lefèvre (co-Dir.).

PhD : Guilherme Koslovski, "Dynamically provisioned virtual infrastructures: specification, allocation and execution", École Doctorale Informatique et Mathématiques, Université Lyon 1 et ENS Lyon. Jul. 8, 2011, P. Gonçalves (Dir. from June 2010), P. Vicat-Blanc (Dir. until June 2010)

PhD : Fabienne Anhalt, "Virtualisation des équipements réseau : Partage des ressources, performance et applications", École Doctorale Informatique et Mathématiques, Université Lyon 1 et ENS Lyon. Jul. 7, 2011, P. Gonçalves (Dir. from June 2010), P. Vicat-Blanc (Dir. until June 2010)

PhD in progress : Doreid Ammar, "Knowledge plane for semantic networking", Oct. 1, 2009, I. Guérin-Lassous (Dir.) and T. Begin

PhD in progress : Thiago Abreu, "Integration of traffic awareness in substitution networks", Mar. 1, 2011, I. Guérin-Lassous (Dir.) and T. Begin

PhD in progress : Shubhabrata Roy, "Dynamic Resource Management in Cloud Networking", Dec. 7, 2010, P. Gonçalves (Dir.) and T. Begin

PhD in progress : Marina Sokol, "Clustering and learning techniques for trafic / user classification", Oct. 1, 2009, Ph. Nain (Dir. from Oct. 2011) and P. Gonçalves (Dir. until Oct. 2011, now co-dir., K. Avrachenkov was co-director until Oct. 2011).

PhD in progress : Inès Doghri, "Multipath Techniques for Heterogeneous Multihop Wireless Networks", Dec. 15, 2008, I. Guérin Lassous (Dir.) and L. Reynaud (Orange)

PhD in progress : Mohammed Diouri, "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

PhD in progress : Ghislain Tsafack Chetsa, "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.)

PhD in progress : Van Nam Nguyen, "Quality of Service in Heterogeneous Networks", Dec. 15, 2009, I. Guérin Lassous (Dir.) and V. Moraru (IFI, Vietnam)

9.3. Invited presentations

Paulo Gonçalves

Fractals and Related Fields II, Porquerolles (France), June 13-17, 2011. Invited speaker.

Séminaire Cristolien d'Analyse Multifractale (SCAM), Université Paris XII, Sept. 22, 2011. Invited seminar.

Olivier Glück

Reducing energy consumption of fault tolerance algorithms, The 6th workshop of the INRIA-Illinois Joint Laboratory for Petascale Computing, Urbana (USA), November 21-23, 2011. Invited speaker.

Isabelle Guérin Lassous

QoS issues in multihop wireless networks, UPC, Barcelona (Spain), June 6-10, 2011, Invited seminar (4 days).

10. Bibliography

Major publications by the team in recent years

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Doctoral Dissertations and Habilitation Theses

[7] F. ANHALT. *Network virtualization: performance, sharing and applications*, ENS-Lyon, Université de Lyon, July 2011.

[8] G. KOSLOVSKI. *Dynamically provisioned virtual infrastructures: specification, allocation and execution*, ENS-Lyon, Université de Lyon, July 2011.

[9] A.-C. ORGERIE. *An Energy-Efficient Reservation Framework for Large-Scale Distributed Systems*, École Normale Supérieure de Lyon - France, Sept. 2011.

Articles in International Peer-Reviewed Journal

[10] J. BARRAL, P. GONÇALVES. *On the estimation of the large deviations spectrum*, 2011, vol. 144, n° 6, p. 1256-1283.

[11] O. GOGA, P. LOISEAU, P. GONÇALVES. *On the Impact of the Flow-Size Distribution's Tail Index on Network Performance with TCP Connections*, in "ACM SIGMETRICS Performance Evaluation Review", October 2011, Special Issue on IFIP PERFORMANCE 2011.

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