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Université Rennes 1

Activity Report 2012

Project-Team DIONYSOS

Dependability Interoperability and
performance aNalySiS Of networkS

IN COLLABORATION WITH: Institut de recherche en informatique et systèmes aléatoires (IRISA)

RESEARCH CENTER
Rennes - Bretagne-Atlantique

THEME
Networks and Telecommunications

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Project-Team DIONYSOS

Keywords: Quality Of Experience, Monte Carlo Methods, Wireless Networks, Markovian Model, Rare Events

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2. Overall Objectives

2.1. Introduction

The main objectives of the project are the identification, the conception and the selection of the most appropriate network architectures of a communication service, as well as the development of computing and mathematical tools for the fulfillment of these tasks. These objectives lead to two types of complementary research fields: the systems' qualitative aspects (e.g. protocols' test and design) and the quantitative aspects which are essential to the correct dimensioning of these architectures and the associated services (performance, dependability, Quality of Service (QoS), Quality of Experience (QoE) and performability).

The DIONYSOS group works on different problems related to the design and the analysis of communication services. Such services require functionality specifications, decisions about where and how they must be deployed in a system, and the dimensioning of their different components. The interests of the project concern not only particular classes of systems but also methodological aspects.

Concerning the communication systems themselves, we focus on IP networks, at different levels. Concerning the types of networks considered, we mainly work in the wireless area, in particular on sensor networks, on Content Delivery Networks for our work around measuring the perceived quality, the main component of QoE, and on some aspects of optical networks. We also work on the assessment of interoperability between specific network components, which is essential to ensure that they interact correctly before they get deployed in a real environment. Our team contributes in providing solutions (methods, algorithms and tools) which help in obtaining efficient interoperability test suites for new generation networks. From the application point of view, we also have activities in network economics methodologies, a critical multi-disciplinary area for telecommunications providers, with many defying open problems for the near future.

For most of previous mentioned problems, our work concern their quantitative aspects. The quantitative aspects we are interested in are QoE, performance, dependability, performability, QoS, vulnerability, etc. We develop techniques for the evaluation of these different aspects of the considered systems through *models* and through *measurement techniques*. In particular, we develop techniques to measure in an automatic way the quality of a video or audio communication *as perceived by the final user*. The methods we work with go from discrete event simulation and Monte Carlo procedures to analytical techniques, and include numerical algorithms as well. Our main mathematical tools are stochastic processes in general and queuing models and Markov chains in particular, optimization techniques, graph theory, combinatorics, etc.

2.2. Highlights of the Year

We had two best paper awards in 2012, one on video delivery techniques (see 5.4 and the project VIPEER 7.2.3), and the other one on QoE for Femto cells (see 5.1).

BEST PAPERS AWARDS :

[73] **Network Friendly Video Distribution in International Conference on Network of the Future**. L. ZHE, K. SBAI, Y. HADJADJ-AOUL, A. GRAVEY, D. ALLIEZ, J. GARNIER, G. MADEC, G. SIMON, K. D. SINGH.

[71] **QoS/QoE Predictions-based Admission Control for Femto Communications in IEEE International Conference on Communication (ICC)**. T. TALEB, A. KSENTINI.

3. Scientific Foundations

3.1. Introduction

The scientific foundations of our work are those of network design and network analysis. Specifically, this concerns the principles of packet switching and in particular of IP networks (protocol design, protocol testing, routing, scheduling techniques), and the mathematical and algorithmic aspects of the associated problems, on which our methods and tools are based.

These foundations are described in the following paragraphs. We begin by a subsection dedicated to Quality of Service (QoS) and Quality of Experience (QoE), since they can be seen as unifying concepts in our activities. Then we briefly describe the specific sub-area of models' evaluation and about the particular multidisciplinary domain of network economics.

3.2. Quality of Service and Quality of Experience

Since it is difficult to develop as many communication solutions as possible applications, the scientific and technological communities aim towards providing general *services* allowing to give to each application or user a set of properties nowadays called “Quality of Service” (QoS), a terminology lacking a precise definition. This QoS concept takes different forms according to the type of communication service and the aspects which matter for a given application: for performance it comes through specific metrics (delays, jitter, throughput, ...), for dependability it also comes through appropriate metrics: reliability, availability, or vulnerability, in the case for instance of WAN (Wide Area Network) topologies, etc.

QoS is at the heart of our research activities: we look for methods to obtain specific “levels” of QoS and for techniques to evaluate the associated metrics. Our ultimate goal is to provide tools (mathematical tools and/or algorithms, under appropriate software “containers” or not) allowing users and/or applications to attain specific levels of QoS, or to improve the provided QoS, if we think of a particular system, with an optimal use of the resources available. Obtaining a good QoS level is a very general objective. It leads to many different areas, depending on the systems, applications and specific goals being considered. Our team works on several of these areas. We also investigate the impact of network QoS on multimedia payloads to reduce the impact of congestion.

Some important aspects of the behavior of modern communication systems have subjective components: the quality of a video stream or an audio signal, *as perceived by the user*, is related to some of the previous mentioned parameters (packet loss, delays, ...) but in an extremely complex way. We are interested in analyzing these types of flows from this user-oriented point of view. We focus on the *user perceived quality*, the main component of what is nowadays called Quality of Experience (in short, QoE), to underline the fact that, in this case, we want to center the analysis on the user. In this context, we have a global project called PSQA, which stands for Pseudo-Subjective Quality Assessment, and which refers to a methodology allowing to automatically measuring the QoE (see 3.2).

Another special case to which we devote research efforts in the team is the analysis of qualitative properties related to interoperability assessment. This refers to the act of determining if end-to-end functionality between at least two communicating systems is as required by the base standards for those systems. Conformance is the act of determining to what extent a single component conforms to the individual requirements of the standard it is based on. Our purpose is to provide such a formal framework (methods, algorithms and tools) for interoperability assessment, in order to help in obtaining efficient interoperability test suites for new generation networks, mainly around IPv6-related protocols. The interoperability test suites generation is based on specifications (standards and/or RFCs) of network components and protocols to be tested.

3.3. Stochastic modeling

The scientific foundations of our modeling activities are composed of stochastic processes theory and, in particular, Markov processes, queuing theory, stochastic graphs theory, etc. The objectives are either to develop numerical solutions, or analytical ones, or possibly discrete event simulation or Monte Carlo (and Quasi-Monte Carlo) techniques. We are always interested in models’ evaluation techniques for dependability and performability analysis, both in static (network reliability) and dynamic contexts (depending on the fact that time plays an explicit role in the analysis or not). We look at systems from the classical so-called *call level*, leading to standard models (for instance, queues or networks of queues) and also at the *burst level*, leading to *fluid models*.

In recent years, our work on the design of the topologies of WANs led us to optimization techniques, in particular in the case of very large optimization problems, usually formulated in terms of graphs. The associated methods we are interested in are composed of simulated annealing, genetic algorithms, TABU search, etc. For the time being, we have obtained our best results with GRASP techniques.

Network pricing is a good example of a multi-disciplinary research activity half-way between applied mathematics, economy and networking, centered on stochastic modeling issues. Indeed, the Internet is facing a tremendous increase of its traffic volume. As a consequence, real users complain that large data transfers

take too long, without any possibility to improve this by themselves (by paying more, for instance). A possible solution to cope with congestion is to increase the link capacities; however, many authors consider that this is not a viable solution as the network must respond to an increasing demand (and experience has shown that demand of bandwidth has always been ahead of supply), especially now that the Internet is becoming a commercial network. Furthermore, incentives for a fair utilization between customers are not included in the current Internet. For these reasons, it has been suggested that the current flat-rate fees, where customers pay a subscription and obtain an unlimited usage, should be replaced by usage-based fees. Besides, the future Internet will carry heterogeneous flows such as video, voice, email, web, file transfers and remote login among others. Each of these applications requires a different level of QoS: for example, video needs very small delays and packet losses, voice requires small delays but can afford some packet losses, email can afford delay (within a given bound) while file transfer needs a good average throughput and remote login requires small round-trip times. Some pricing incentives should exist so that each user does not always choose the best QoS for her application and so that the final result is a fair utilization of the bandwidth. On the other hand, we need to be aware of the trade-off between engineering efficiency and economic efficiency; for example, traffic measurements can help in improving the management of the network but is a costly option. These are some of the various aspects often present in the pricing problems we address in our work. More recently, we have switched to the more general field of network economics, dealing with the economic behavior of users, service providers and content providers, as well as their relations.

4. Software

4.1. T3devKit testing toolkit and IPv6 test suites

Participants: Anthony Baire, César Viho.

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

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

4.2. Interoperability Assessment

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

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

4.3. Performance and dependability evaluation

Participants: Gerardo Rubino, Bruno Sericola, Bruno Tuffin.

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

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

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

5. New Results

5.1. Quality of Experience

Participants: Gerardo Rubino, Adlen Ksentini, Yassine Hadjadj-Aoul, Sofiene Jelassi, Sebastián Basterrech.

We continue the development of the PSQA technology (Pseudo-Subjective Quality Assessment) in the area of Quality of Experience (QoE). PSQA is today a stable technology allowing to build measuring modules capable of quantifying the quality of a video or an audio sequence, as perceived by the user, when received through an IP network. It provides an accurate and efficiently computed evaluation of quality. Accuracy means that PSQA gives values close to those than can be obtained from a panel of human observers, under a controlled subjective testing experiment, following an appropriate standard (which depends on the type of sequence or application). Efficiency means that our measuring tool can work in real time, if necessary. Observe that perceived quality is the main component of QoE. PSQA works by analyzing the networking environment of the communication and some the technical characteristics of the latter. It works without any need to the original sequence (as such, it belongs to the family of *no-reference* techniques).

It must be pointed out that a PSQA measuring or monitoring module is network dependent and application dependent. Basically, for each specific networking technology, application, service, the module must be built from scratch. But once built, it works automatically and efficiently, allowing if necessary its use in real time.

At the heart of the PSQA approach there is the statistical learning process necessary to develop measuring modules. So far we have been using Random Neural Networks (RNNs) as our learning tool (see [96] for a general description), but recently, we have started to explore other approaches. For instance, in the last ten years a new computational paradigm was presented under the name of *Reservoir Computing* (RC) [93] covering the main limitations in training time for recurrent neural networks while introducing no significant disadvantages. Two RC models have been developed independently and simultaneously under the name of *Liquid State Machine* (LSM) [95] and *Echo State Networks* (ESN) [93] and constitute today one of the basic paradigms for Recurrent Neural Networks modeling [94]. The main characteristic of the RC model is that it separates two parts: a static sub-structure called *reservoir* which involves the use of cycles in order to provide dynamic memory in the network, and a parametric part composed of a function such as a multiple linear regression or a classical single layer network. The reservoir can be seen as a dynamical system that expand the input stream in a space of states. The learning part of the model is the parametric one. In [38] we propose a new learning tool which merges the capabilities of Random Neural Networks (RNNs) with those of Reservoir Computing Models (RCMs). We keep some of the nice features of RNNs with the ability of RCMs in predicting time series values. Our tool is called Echo State Queueing Network. In the paper, we illustrate its performances in predicting, in particular, Internet traffic. We also worked on the bottleneck of the PSQA building process, from the time consuming point of view, the subjective test sessions. We proposed in [49] and [48] new PSQA modules for VoIP and SVC video, respectively. In [49], we used PESQ for replacing the subjective test in the training step of PSQA. This module is dedicated to iLBC and Speex codecs. Whereas in [48], we used VQM tool to evaluate the SVC video sequences to train PSQA.

In [31], a general presentation of our approach in Dionysos was given, together with some guidelines in looking for extensions able to deal with the evaluation of generic applications or services over the Internet.

We presented a tutorial on Quality of Experience in Qest'2012 [69], based on our past research results in evaluating the perceptual quality in voice or video applications, and on the current work performed in the QuEEN project.

Our perceptual quality work is being extended to investigate the quality of user experience including a large scope that involves human and technology factors. This work is conducted in the context of the Celtic-QuEEN project where a complete QoE monitoring platform is being designed. In Qest'2012 [69], we presented a tutorial on Quality of Experience based on our past research results in evaluating the perceptual quality in voice or video applications, and on the current work performed in QuEEN.

On the other hand, we continue our study of quality of temporally interrupted VoIP service frequently observed over wireless and data networks. A flagship paper regarding the perception of interruptions in the context of VoIP service is published in [53]. In [21] we presented a detailed state-of-the-art in the area.

5.2. Network Economics

Participants: Bruno Tuffin, Jean-Marc Vigne.

While pricing telecommunication networks was one of our main activities for the past few years, we are now dealing with the more general topic of *network economics* (see for instance [83]). We have tackled it from different sides: i) investigating how QoS or QoE can be related to users' willingness to pay, ii) investigating the consequences and equilibria due competition among providers in different contexts, iii) looking at the economics of applications, for example adword auctions for search engines, iv) studying the network neutrality issue, and v) the not so considered problem of search-neutrality.

On the first item, we have studied in [78] how utility functions can be related to QoE recent research. Indeed, a logarithmic version of utility usually serves as the standard example due to its simplicity and mathematical tractability. We argue that there are much more (and better) reasons to consider logarithmic utilities as really paradigmatic, at least when it comes to characterizing user experience with specific telecommunication services. We justify this claim and demonstrate that, especially for Voice-over-IP and mobile broadband scenarios, there is increasing evidence that user experience and satisfaction follows logarithmic laws. Finally, we go even one step further and put these results into the broader context of the Weber-Fechner Law, a key principle in psychophysics describing the general relationship between the magnitude of a physical stimulus and its perceived intensity within the human sensory system.

A notable part of our activity has been related to competition among telecommunication providers, mainly within the framework of the ANR CAPTURES project ending this year. The goal is to improve most of the pricing models analysis which only deal with a single provider while competition (that is observed in the telecommunication industry) can drive to totally different outcomes. A general view of some of our results is summarized in [77]. A general model of competition in loss networks is described and analyzed in [25] as a two-levels game: at the smallest time scale, users' demand is split among providers according to Wardrop principle, depending on the access price and available QoS (depending itself on the level of demand at the provider); at the largest time scale, providers play a pricing game, trying non-cooperatively to maximize their revenue. A striking result is that this game leads to the same outcome than if providers were cooperatively trying to maximize social welfare: the so-called *price of anarchy* is equal to one. In [59], we present a similar model of competition on prices between two telecommunication service providers sharing an access resource, which can for example be a single WiFi spectrum. We again obtain a two-level game corresponding to two time scales of decisions: at the smallest time scale, users play an association game by choosing their provider (or none) depending on price, provider reputation and congestion level; at the largest time scale, providers compete on prices. We show that the association game always has an equilibrium, but that several equilibria can exist. The pricing game is then solved by assuming that providers are risk-averse and try to maximize the minimal revenue they can get at a user equilibrium. We illustrate what can be the outcome of this game and that there are situations for which providers can co-exist.

Network economics is not only about ISPs, it also deals with the application side. In order to make money, many service providers base their revenue on advertisement. Search engines for example get revenue thanks to adword auctions, where commercial links are proposed and charged to advertisers as soon as the link is clicked through. The strategies of the search engine and advertisers are described and analyzed in [24].

A new issue on which most of our work has focused in 2012 is related to the *network neutrality debate*. This debate comes from the increasing traffic asymmetry between Internet Service Providers (ISPs), mainly due to some prominent and resource consuming content providers (Cps) which are usually connected to a single ISP. Thus the ISPs to whom those CPs are not directly connected have started to wonder why distant CPs should not be charged by them, with the threat of their traffic not being delivered if they do not accept to pay, or their quality of service decreased. In [79], we have described and analyzed the respective arguments of neutrality proponents and opponents, and we have also participated to Inria's response to the ARCEP consultation on the topic [90]. We have reviewed in [50], [85] the economic transit agreements between ISPs in order to determine their best strategy. We have defined a model with two ISPs, each providing direct connectivity to a fixed proportion of the content and competing in terms of price for end users, who select their ISP based on the price per unit of available content. We have analyzed and compared, thanks to game-theoretic tools, three different situations: the case of peering between the ISPs, the case where ISPs do not share their traffic (exclusivity arrangements), and the case where they fix a transfer price per unit of volume. The impact on the network neutrality debate is then discussed. An analysis with a hierarchy of providers, with separated backbone providers and access providers, is performed in [89]. We also remarked that while there have been many studies discussing the advantages and drawbacks of neutrality, there is no game-theoretical work dealing with the observable situation of competitive ISPs in front of a (quasi-)monopolistic CP. Though, this is a typical situation that is condemned by ISPs and, according to them, another reason of the non-neutrality need. We have developed and analyzed in [40], [84] two different models describing the relations between two competitive ISPs and a single CP, played as a three-level game corresponding to three different time scales. At the largest time scale, side payments (if any) are determined. At a smaller time scale, ISPs decide their (flat-rate) subscription fee (toward users), then the CP chooses the (flat-rate) price to charge users. Users finally select their ISP (if any) using a price-based discrete choice model in [84] or following Wardrop principle in [40], and decide whether to also subscribe to the CP service. The game is analyzed by backward induction. As a conclusion, we obtain among other things that non-neutrality may be beneficial to the CP, and not necessarily to ISPs, unless the side payments are decided by ISPs (through a non-cooperative game). Another specific scenario is studied in [51], where the impact of wholesale prices is examined in a context where the end customer access both free content and pay-per-use content, delivered by two different providers through a common network provider. We formulate and solve the game between the network provider and the pay-per-use content provider, where both use the price they separately charge the end customer with as a leverage to maximize their profits. In the neutral case (the network provider charges equal wholesale prices to the two content providers), the benefits coming from wholesale price reductions are largely retained by the pay-per-use content provider. When the free content provider is charged more than its pay-per-use competitor, both the network provider and the pay-per-use content provider see their profit increase, while the end customer experiences a negligible reduction in the retail price.

If network neutrality has recently attracted a lot of attention, *search neutrality* is also becoming a vivid subject of discussion because a non-neutral search may prevent some relevant content from being accessed by users. We propose in [88] to model two situations of a non-neutral search engine behavior, which can rank the link propositions according to the profit a search can generate for it, instead of just relevance: the case when the search engine owns some content, and the case when it imposes a tax on organic links, a bit similarly to what it does for commercial links. We analyze the particular (and deterministic) situation of a single keyword, and describe the problem for the whole potential set of keywords. In [52], we analyze one behavior that results in search bias: the payment by content providers to the search engine in order to improve the chances to be located (and accessed) by a search engine user. A simple game theory-based model is presented, where both a search engine and a content provider interact strategically, and the aggregated behavior of users is modeled by a demand function. The output of each stakeholder when the search engine is engaged in such a non-neutral behavior is compared with the neutral case when no such side payment is present.

5.3. Wireless Networks

Participants: Adlen Ksentini, Yassine Hadjadj-Aoul, Bruno Sericola.

Long Term Evolution (LTE) represents the next generation of Cellular networks or 4G. It allows increasing the data rate and hence services that can be proposed to users. A notable part of activity in cellular networks and particularly in LTE, is related to increasing the user QoE. Due to their numerous advantages, current trends show a growing number of femtocell deployments. However, femtocells would become less attractive to the general consumers if they cannot keep up with the service quality that the macro cellular network should provide. Given the fact that the quality of mobile services provided at femtocells depends largely on the level of congestion on the backhaul link, in [71] we introduced a flow mobility/handover admission control method that makes decisions on layer-three handovers from macro network to femtocell network and/or on entire or partial flow mobility between the two networks based on predicted QoS taking into account metrics such as network load/congestion indications and based on predicted QoE metrics. In [70], we proposed a complete framework that anticipates QoS/QoE (Quality of Experience) degradation and proactively defines policies for LTE-connected cars (UEs) to select the most adequate radio access out of WiFi and LTE. For a particular application, the proposed framework considers the application type, the mobility feature (e.g., speed, user mobility entire/partial path, user final/intermediate destination), and the traffic dynamics over the backhauls of both LTE and WiFi networks in order to predict and allow the UE to select the best network that maximizes user QoE throughout the mobility path.

In [33],[23] we considered LTE networks as candidates for hosting the Machine to Machine communication (or Machine Type Communication in the 3GPP jargon). One of the most important problems posed by this kind of traffic is congestion. Congestion concerns all the parts of the network, both the radio and the core networks impacting both the user data and the control planes. In these works, we proposed a congestion aware admission control solution that selectively rejects signaling messages from MTC devices at the radio access network following a probability that is set based on a proportional integrative derivative (PID) controller (from control theory) reflecting the congestion level of a relevant core network node.

Another part of our activities in wireless network are related to energy saving. Indeed, one of the biggest problem today in the wireless world is that wireless devices are battery driven, which reduce their operating lifetime. We addressed the energy issue in wireless network for two different contexts: (i) rich media (such as VoIP) delivery in Wireless LAN; (ii) Wireless Sensor Network (WSN).

In WLAN, mobile stations conserve energy by maximizing the sleep mode periods of the wireless interfaces. Despite of its efficiency, this mode is incompatible with real-time applications and media streaming, like VoIP. In fact, maximizing the sleep mode periods is directly translated into an increased delay, which induces packets losses when exceeding certain thresholds (e.g. buffer overflow and late packet loss), and may severely degrade the perceived user's QoE. We first review a clear state of the art on energy saving for mobiles communication [22]. Then, in [56], we showed the relation between user QoE and the sleep period in the context of Voice over Wireless Lan (VoWLAN). The system was modeled and controlled using a PID controller, which computes the sleep period enabling to reach a QoE reference value. Thus, we achieved the trade-off between energy consumption and QoE.

On the other hand, Wireless Sensor Networks (WSN) protocols focus primarily on power conservation, because of the limited capacity of the sensor nodes' batteries. In [64] we addressed the case of using radio diversity in WSN (more than one antenna). In this work, we proposed a scheme for radio diversity that can balance, depending on the traffic nature in the network, between minimizing the energy consumption or minimizing the end-to-end delay. The proposed scheme combines the benefit of two metrics, which aim separately to minimize the energy consumption, and to minimize delay when delivering packets to the end-user. In [57], we worked on the localization problem in WSN by introducing a new way to determine the sensors' residence area. Our new localization algorithm is based on the geometric shape of half-symmetric lens. In [81] we developed a performance analysis of a compression scheme designed to save energy, for specific types of WSN.

In [55], we presented the DVB-T2 simulation module for OPNET. Note that this module is the only available implementation of DVB-T2 in network simulators.

5.4. Information-Centric Networks

Participants: Yassine Hadjadj-Aoul, Gerardo Rubino, Leila Ghazzai.

The rise of popularity of video streaming services has resulted in increased volumes of network traffic, which in turn have created Internet bottlenecks leading to perceived quality degradations. One of the recognized good ways to tackle this type of congestion is to make the contents available inside ISPs' networks. We thus proposed, in [73] a network-friendly content delivery architecture that considers the complex video distribution chain and its associated business models. This comprehensive architecture allows a network operator to fully engineer video traffic distribution in order to both alleviate peering links' workload and improve delivered QoS. This proposal is fully compatible with Adaptive Bitrate Streaming (ABS) architectures, which are currently used to distribute video in the Internet.

The Content providers are increasingly becoming interested in evaluating the performance of such streaming protocol from the final users' perspective. Indeed, more importance is being attached to the quality as perceived by the final users, or Quality of Experience (QoE), as compared to just Quality of Service. Thus, we addressed in [68] the problem of estimating the QoE of video streaming in TCP/IP networks. As a solution, we designed an automatic no-reference QoE estimation module for HTTP video streaming using TCP and H.264 video codec. The proposed approach is different from the existing ones as it addresses the problem of measuring QoE in the combined case of adaptive video bitrates and the use of a reliable transport protocol. This is the case of the adaptive streaming over HTTP.

On the other hand, as introduced by ICN's content caching mainly addresses the management of the content in a particular cache, while the content replication consists in disseminating data in its way to the destination. The benefits of contents' replication can be completely cancelled with a bad caching technique. Thus, we proposed, in [75], to analyse the interaction existing between caching strategies and content replication.

5.5. Interoperability assessment and Internet of Things

Participants: César Viho, Nanxing Chen, Anthony Baire.

The Internet of Things (IoT) brings new challenges to interoperability assessment by introducing the necessity to deal with non reliable environments connecting plenty billions of objects widely distributed. In this context, the IETF Constrained Application Protocol (CoAP) has been designed, which is an application-layer protocol on keeping in mind the various issues of constrained environment to realize interoperations with constrained networks and nodes.

As one of the most important protocol for the future Internet of Things, the number of smart objects using CoAP is expected to grow substantially. For CoAP applications to be widely adopted by the industry, interoperability testing is required to ensure that CoAP implementations from different vendors work well together. Therefore, in the recent period, we propose an interoperability testing methodology using a *passive* approach. Contrary to the classical testing method used in conventional interoperability testing events, which is done by actively stimulating the implementations and verifying the outputs, we apply passive testing. It is a technique based only on observation [47]. Its non-intrusive nature makes it appropriate for interoperability testing, especially in the context of IoT. We have also developed a tool that implement this passive method that has been used successfully to test CoAP implementations during the two CoAP Plugtest interoperability sessions organized by ETSI and IPSO Alliance [44]. Our contributions and originality of this work published in [46] are three-fold: (i) A new testing method using a passive approach. (ii) As IoT implies providing services in lossy networks, we also take into account fundamental CoAP implementations interoperability testing in lossy context. (iii) Contrary to manual verification used in conventional interoperability testing events, the verification procedure has been automatized by a test validation tool, which increases the test efficiency while reducing testing time and costs.

5.6. Performance Evaluation of Distributed Systems

Participants: Bruno Sericola, Gerardo Rubino, Laura Aspirot, Romaric Ludinard.

In [92] and [13], we consider the behavior of a stochastic system composed of several identically distributed, but non independent, discrete-time absorbing Markov chains competing at each instant for a transition. The competition consists in determining at each instant, using a given probability distribution, the only Markov chain allowed to make a transition. We analyze the first time at which one of the Markov chains reaches its absorbing state. We obtain its distribution and its expectation and we propose an algorithm to compute these quantities. We also exhibit the asymptotic behavior of the system when the number of Markov chains goes to infinity. Actually, this problem comes from the analysis of large-scale distributed systems and we show how our results apply to this domain.

In [14], we present an in-depth study of the dynamicity and robustness properties of large-scale distributed systems, and in particular of peer-to-peer systems. When designing such systems, two major issues need to be faced. First, population of these systems evolves continuously (nodes can join and leave the system as often as they wish without any central authority in charge of their control), and second, these systems being open, one needs to defend against the presence of malicious nodes that try to subvert the system. Given robust operations and adversarial strategies, we propose an analytical model of the local behavior of clusters, based on Markov chains. This local model provides an evaluation of the impact of malicious behaviors on the correctness of the system. Moreover, this local model is used to evaluate analytically the performance of the global system, allowing to characterize its global behavior with respect to its dynamics and to the presence of malicious nodes, and then to validate our approach.

Monitoring a system is the ability of collecting and analyzing relevant information provided by the monitored devices so as to be continuously aware of the system's state. However, the ever growing complexity and scale of systems makes both real time monitoring and fault detection a quite tedious task. The usually adopted option is to focus solely on a subset of information states, so as to provide coarse-grained indicators. As a consequence, detecting isolated failures or anomalies is a quite challenging issue. In [34], we propose to address this issue by pushing the monitoring task at the edge of the network. We present a peer-to-peer-based architecture, which enables nodes to self-organize according to their "health" indicators. By exploiting both temporal and spatial correlations that exist between a device and its vicinity, our approach guarantees that only isolated anomalies (an anomaly is isolated if it impacts solely a monitored device) are reported on the fly to the network operator. We show that the end-to-end detection process, i.e., from the local detection to the management operator reporting, requires a logarithmic number of messages in the size of the network. This work led to the patent [91] with Technicolor.

In [66] we continued previous efforts in the design of peer-to-peer networks for transmitting video content. In the past, we develop tools allowing a perceptual quality-based design tool. In [66], we explore an architectural idea where the video stream is decomposed in sequential sets of chunks that we call "windows". The paper explores some aspects of the performance of such a transmission scheme. The techniques used are Markovian models which are simulated, and deterministic dynamical systems that allow for some equilibrium analysis.

5.7. Monte Carlo

Participants: Bruno Tuffin, Gerardo Rubino, Pablo Sartor.

We maintain a research activity in different areas related to dependability, performability and vulnerability analysis of communication systems, using both the Monte Carlo and the Quasi-Monte Carlo approaches to evaluate the relevant metrics. Monte Carlo (and Quasi-Monte Carlo) methods often represent the only tool able to solve complex problems of these types. However, when the events of interest are rare, simulation requires a special attention, to accelerate the occurrence of the event and get unbiased estimators of the event of interest with a sufficiently small relative variance. This is the main problem in the area. Dionysos' work focuses then in dealing with the rare event situation.

In [72] we have overviewed how the zero-variance importance sampling can be approximated in classical reliability problems. In general, we look for estimators such that the relative accuracy of the output is “controlled” when the rarity is getting more and more critical. Different robustness properties of estimators have been defined in the literature. However, these properties are not adapted to estimators coming from a parametric family for which the optimal parameter is random due to a learning algorithm. These estimators have random accuracy. For this reason, we motivate in [65] the need to define probabilistic robustness properties. We especially focus on the so-called probabilistic bounded relative error property. We additionally provide sufficient conditions, both in general and in Markov settings, to satisfy such a property, and hope that it will foster discussions and new works in the area.

In [43] and [18] we present results concerning the evaluation using Monte Carlo techniques, of a specific reliability metric for communication networks, based not only on connectivity properties, as in the classical network reliability measure, but also in the lengths of the paths. In [43], we propose bounds of the metric that can be used to derive a variance reduction technique. In [18], we describe techniques to analyze what could be called performability aspects of networks also based on the number of hops between sources and terminals. Let us also mention here our publication [16], where we discuss the exact computation of these new types of metrics, and [29], where other related combinatorial problems are discussed (here, optimization problems also based on connectivity properties, from the design point of view). In [17], we propose a new version of the RVR principle, leading to a variance reduction technique for the classic network reliability problem. Paper [28] proposes a splitting algorithm for the same problem. The approach is quite straightforward, after the static problem is transformed into a dynamic one using the well known Creation Process. In [42] we explore a very general conditioning-based approach, including as a particular case the family of splitting procedures. We explore this idea through the analysis of dependability properties of complex systems using Markov models.

When looking specifically at static network reliability models, as described in the previous paragraph, it is often typically assumed that the failures of their components are independent. This assumption allows for the design of efficient Monte Carlo algorithms that can estimate the network reliability in settings where it is a rare-event probability. Despite this computational benefit, independent component failures is frequently not a realistic modeling assumption for real-life networks. In [39] we show how the splitting methods for rare-event simulation can be used to estimate the reliability of a network model that incorporates a realistic dependence structure via the Marshal-Olkin copula.

In [15], we present a versatile Monte Carlo method for estimating multidimensional integrals, with applications to rare-event probability estimation. The method fuses two distinct and popular Monte Carlo simulation methods, Markov chain Monte Carlo and importance sampling, into a single algorithm. We show that for some applied numerical examples the proposed Markov Chain importance sampling algorithm performs better than methods based solely on importance sampling or MCMC.

Finally, in two presentations [67] and [32] we discuss the main problems when analyzing rare events using Monte Carlo methods, focusing on robustness properties of the corresponding estimators.

5.8. Analytic models

Participants: Bruno Sericola, Gerardo Rubino, Raymond Marie, Laura Aspirot.

Fluid models are powerful tools for evaluating the performance of packet telecommunication networks. By masking the complexity of discrete packet based systems, fluid models are in general easier to analyze and yield simple dimensioning formulas. Among fluid queuing systems, those with arrival rates modulated by Markov chains are very efficient to capture the burst structure of packet arrivals, notably in the Internet because of bulk data transfers. By exploiting the Markov property, very efficient numerical algorithms can be designed to estimate performance metrics such the overflow probability, the delay of a fluid particle or the duration of a busy period. In [76], we analyze the transient behaviour of a fluid queue driven by a general ergodic birth and death process using spectral theory in the Laplace transform domain. These results are applied to the stationary regime and to the busy period analysis of that fluid queue.

In [36], another type of fluid model is considered. We present preliminary results on the analysis of a Machine Repairman Model when the number of machines goes to infinity. The analysis is based on identifying appropriate fluid limits of the associated stochastic processes. We are currently working on the analysis of the speed of the convergence of these stochastic processes towards their fluid limits.

In [19], we present an approximate method for the transient analysis of stiff CTMC. The origin of the method is due to S. M. Ross who proposed to approximate the transient probability at a deterministic time t by the value of the transient probability at a random time X where X is an Erlang random variable having expectation t . The major contributions of the paper are the use of new numerical techniques to solve the basic equations of the original method and the extension of the method to reward measures. We also conduct an experimental evaluation of the resulting errors using non-trivial examples.

In [86], we presented an extension of ROBDDs that is able to accommodate certain dependencies among their (Boolean) variables. In particular, this extension shows evidence of being applicable to evaluating the dependability (reliability, availability) of systems whose structures are representable by a Boolean function. This extension consists of three main parts. The first part is the notion of a phratry with its associated new definitions and constraints. The second part consists of the adaptation and complementation of the original rules used in the construction of ROBDDs. The final part concerns additional custom-made steps needed to determine the functional valuations that are specific to solving measure in question.

The survivability of a system being its ability to function during and after a failure, we developed in [63] a model to study the power distribution in smart grids during the (transient) period that starts after a failure till the system fully recovers. The proposed model bridges power flow modeling of reactive power compensation with performability/survivability modeling of automation distribution networks. We use a Markov chain to characterize the phased recovery of the system after a failure. Then, we associate with each state of the Markov chain a set of corresponding rewards to characterize the active and reactive power supplied and demanded in that state. We connect the survivability model with an availability model, to produce a generalization of the System Average Interruption Duration Index (SAIDI) and the Customer Average Interruption Duration Index (CAIDI), which are two of the most important power grid reliability metrics. The survivability model allows us to obtain closed form expressions for the SAIDI and related metrics.

In [62], we consider the case of important systems located on operational sites far away from logistic support forces, either because the operational site is in an inhospitality place, or because it is not profitable to maintain a dedicated team on the operational site. Due to the importance of the systems, some service level agreement has been signed, including conditional financial clauses. To take into account such a situation, a preventive maintenance is realized according to projected calendars. The paper shows that, given that the life-times of equipments are supposed to be Erlang- k distributed, it is optimal to realize a preventive maintenance, as long as the ratio of the two intervention costs C_p/C_c is lower than the ratio $(k-1)/k$, C_p being the cost of a preventive maintenance intervention and C_c being the cost of a curative maintenance intervention (because of excessive delay, there is a significant penalty associated with each curative maintenance intervention). The methodology to compute the optimal value of the period T^* and the corresponding optimal cost per time unit are presented, for a given value of the ratio C_p/C_c . An extended version of this work has been accepted for publication in a journal ([26]).

The study [60] focuses on the determination of the probability distributions of two random variables, the asymptotic “up-time” and “down-time” of a system for the sake of potential “Service Level Agreement”. In these new generation agreements, penalizations can be enforced for a too long “down-time” or for a too short “up-time”. First, we determine the probability distributions of the two random variables “up-time” and “down-time”, for a system with a general structural function. Second, we point out the importance of rare events such as the backorders in the contribution of a large tail distribution of the down-time. Respectively, we exhibit the importance of redundant structures and also of sub-system hyper-exponential lifetimes in the existence of short up-times, with respect to the mean up-time value of the system.

The study [61] deals with the determination of spares of systems of systems of the same type (such as fleet of aircraft, fleet of ship). For a multi-site workshop and multi-level of repair organization, we present an optimization algorithm using the criteria of expected number of backorders as local objective. With respect to

a previous algorithm based only on the criteria of the global availability of the system, the new algorithm is, for large maintenance systems, very efficient, in terms of execution time and in of data manipulation.

The study [41] concerns the performance evaluation of crisis management systems with respect to the dimensioning of the system. By definition, a crisis has no steady state and the study must be done on the transient behavior. A faithful model was built (in ALTARICA) and solved thanks to simulation. Our own participation was mainly to determine the number of objects to create such that the simulation ends successfully with a high probability, before running out of available objects.

Last, in [54] we continue the exploration of the concept of duality proposed by Anderson, applied to the analysis of the transient behavior of queueing systems. This work analyzes the transient distribution of the number of customers in a Restart Markovian queue, where together with “typical” customers other signals arrive to the queue having as a consequence the removal of all the customers present in the system.

6. Bilateral Contracts and Grants with Industry

6.1. ADR Selfnets

Participant: Bruno Tuffin.

We participate to the common lab ALU-Inria within the “Action de Recherche” SELFNETS, on pricing issues in inter-domain. The goal is to produce economic incentives for intermediate autonomous systems to forward the traffic of concurrent providers and to analyze the handover between mobile providers from an economic point of view.

6.2. Cifre contract on QoE-aware network adaptation

Participants: Adlen Ksentini, Gerardo Rubino.

This is a Cifre contract (2009-2012) (PhD thesis supervision) with Viotech Communication, on network adaptation for multimedia traffic by using QoE metrics. This work is done in the context of the FP7 ALICANTE project.

6.3. Cifre contract on LOCARN: Low Opex and Capex Architecture for Resilient Networks

Participants: Adlen Ksentini, Bruno Sericola, Yassine Hadjadj-Aoul.

This is a Cifre contract (2012-2015) (PhD thesis supervision) with Orange labs., on evaluating and developing a new plug-and-play routing protocol (called Low Opex and Capex Architecture for Resilient Networks – LOCARN), which do not require any network management and configuration.

6.4. Data-aggregation for large-scale distributed networks

Participants: Bruno Sericola, Romaric Ludinard.

We started a 3-year (2011 – 2014) bilateral project with Technicolor R & D, France, on data-aggregation for large-scale distributed networks. Along with the ubiquity of data and computing devices, comes the complexity of extracting and gathering relevant information for management purposes. The very distributed nature of sources of data (be they partially local applications at user’s place, or hardware as gateways), as well as their ever increasing number prohibit a systematic and exhaustive gathering on a single (or few) central server for offline analysis. In this context, collaborative data aggregation, where some computing resources collaborate securely to provide digests, appears as an interesting application for both scalability and efficiency. Moreover, collecting information at a large scale pose the problem of privacy and data aggregation may allow preserving the privacy while collecting data.

6.5. IPChronos

Participants: Sofiane Moad, Pantelis Frangoudis, Yassine Hadjadj-Aoul, Adlen Ksentini, Bruno Sericola.

We are working in the 2-years (September 2011 – September 2013) FUI Project IPChronos, where the main focus is in the use of the IEEE 1588 synchronization protocol over IP. Our contribution focuses on developing analytical models to estimate, basing on the IEEE 1588 protocol, the end-to-end delay. IPChronos is led by ORALIA SPECTRACOM, and the partners are IPlabel and our team.

6.6. Celtic QuEEN

Participants: Sofiene Jelassi, Gerardo Rubino.

We started a 3-year Celtic project (end 2011-end 2014) called QuEEN: Quality of Experience Estimators in Networks. The project objectives are: to develop automatic QoE measure modules for Web services and applications, and to organize these measure modules as a network of cooperative agents in order to allow each member to take advantage of the measures of the others. Dionysos is involved in most of the activities of the project, and it is expected that QuEEN will benefit from our experience in developing the PSQA technology. QuEEN is a large project (22 European partners); the project leader is Orange Labs, in Sophia Antipolis.

7. Partnerships and Cooperations

7.1. Regional Initiatives

7.1.1. ARED Région Bretagne

Participant: Bruno Tuffin.

ARED contract (with Région Bretagne) for the PhD thesis of Sagga Samira on rare event simulation with applications in telecommunications.

7.2. National Initiatives

7.2.1. ARC MENEUR

Participant: Bruno Tuffin.

We coordinate an Inria Cooperative Research Action on Network Neutrality, called MENEUR (“Modélisation en Économie des réseaux et NEUtRalité du Net”). This action runs over 2011–2012 with Inria teams MAE-STRO and MESCAL, Orange Labs, ALU-Bell Labs France, Telecom Bretagne, FTW (Austria), Columbia University and Penn State University.

The goal of this project is to study the interest of network neutrality, a topic that has recently gained a lot of attention. The project aims at elaborating mathematical models that will be analyzed to investigate its impact on users, on social welfare and on providers’ investment incentives, among others, and eventually propose how (and if) network neutrality should be implemented.

See http://www.irisa.fr/dionysos/pages_perso/tuffin/MENEUR/

7.2.2. ANR CAPTURES

Participant: Bruno Tuffin.

We coordinate the ANR Verso CAPTURES: Competition Among Providers for Telecommunication Users: Rivalry and Earning Stakes.

ANR project Dec. 2008- Nov. 2012, in cooperation with Telecom Bretagne and France Telecom R&D.

The goal of this project is to deal with competition among providers in telecommunications. We need to study the distribution of customers among providers as a first level of game, and then to focus on a second higher level, the price and QoS war. See <http://captures.inria.fr/>

7.2.3. ANR VIPEER

Participants: Yassine Hadjadj-Aoul, Gerardo Rubino.

VIPEER is a 3-year ANR project (end 2009-end 2012). VIPEER stands for Video Traffic Engineering in an Intra-Domain Context using Peer-to-Peer Paradigms. The VIPEER project proposes to develop a distributed Content Delivery Network (dCDN) that combines classic CDN technologies with P2P concepts. Our main application in the project is IPTV. Dionysos will mainly cover the QoE assessments activities of VIPEER. Our partners are Télécom Bretagne, Eurecom, Envivio, Orange Labs and NDS Technologies.

7.3. European Initiatives

7.3.1. FP7 Projects

7.3.1.1. FP7 PROBE-IT

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

PROBE-IT is a two years European project that aims at supporting exploitation of European research advances in IoT deployments. The work plan is split in three main areas : benchmarking, roadmap and interoperability testing. PROBE-IT comprises ten international partners from Europe, China, Brazil and Africa. Dionysos is leader of the work-package WP4 dedicated to testing roadmap and solutions to provide stakeholders with elements to validate technologies conformance and interoperability. See <http://www.probe-it.eu>.

7.3.2. Collaborations in European Programs, except FP7

7.3.2.1. NoE EuroNF

Participants: Gerardo Rubino, Bruno Tuffin.

EuroNF Euro-NF is a Network of Excellence on the Network of the Future, formed by 35 institutions (from the academia and industry) from 16 countries. Its main target is to integrate the research effort of the partners to be a source of innovation and a think tank on possible scientific, technological and socio-economic trajectories towards the network of the future. It has started in January 2008 and is ended in June 2012 (see http://euronf.enst.fr/en_accueil.html) .

Bruno Tuffin is the Inria team leader in this project.

The group is contributing to the following working packages (Joint Research Activities):

- WP.JRA.2.2: Traffic Engineering, Mechanisms and Protocols for Controlled Bandwidth Sharing;
- WP.JRA.2.4: Routing and Traffic Management in a Multi-Provider Context;
- WP.JRA.2.5: Design of Optimal Highly Dependable Networks;
- WP.JRA.3.2: SLAs, Pricing, Quality of Experience;
- WP.JRA.3.3: Cost Models.

7.3.2.2. INNIS project

Participant: Bruno Tuffin.

Program: Euro-NF NoE

Project acronym: INNIS

Project title: Impacts of Network Neutrality on the Internet Stakeholders

Duration: November 2011 – June 2012

Coordinator: Bruno Tuffin, Dionysos

Other partners: TELECOM Bretagne, the polytechnic University of Valencia (Spain), the University of Rome 2, and the Italian Data Protection Authority

7.3.3. Collaborations with Major European Organizations

Partner 1: FTW, Vienna (Austria)

We work with FTW on network economics.

Partner 1: Vrije University (The Netherlands)

We work with Vrije University on rare event simulation.

7.4. International Initiatives

7.4.1. Inria Associate Teams

7.4.1.1. MOCQUASIN

Title: Monte Carlo and Quasi-Monte Carlo for rare event simulation

Inria principal investigator: Bruno Tuffin

International Partner (Institution - Laboratory - Researcher):

University of Montreal (Canada) – Département d'informatique et recherche opérationnelle – Pierre L'Ecuyer

Duration: 2008 - 2013

See also: http://www.irisa.fr/dionysos/pages_perso/tuffin/MOCQUASIN/

The goal of MOCQUASIN is to design efficient Monte Carlo and quasi-Monte Carlo simulation methods and to apply them to models in telecommunications. Simulation is indeed often the only method to analyse complex and/or large systems, but also suffers from inefficiency. Two specific situations on which we will focus are rare events, and revenue management. In the two cases, we want to deal with dependent individual events or decisions, a realistic situation requiring adapted solution techniques. The inefficiency of the standard simulation is a known issue to compute the probability of rare event since getting it only once requires in average a long simulation time, but most of the literature has up to now assumed independence in the models. The other framework, revenue management in telecommunications, is the situation of providers trying to define valid offers and capacity investments in front of complex demand models. Here too, a change in the decision of an actor has an impact on the others that has to be taken into account.

7.4.2. Inria International Partners

Our other main international partners are:

- José Blanchet (from Columbia University) and Peter Glynn (from Stanford University), on rare event simulation
- Peter Reichl (from FTW, Vienna, Austria), on pricing and security issues
- Héctor Cancela and Franco Robledo (from Univ. of the Republic, Montevideo, Uruguay), on simulation issues
- Tarik Taleb (from NEC Europe), on LTE issues
- Alan Krinik (from CalPoly, California, USA), on transient analysis of Markovian queues
- Reinaldo Vallejo (from UFSM, Valparaíso, Chile), on solving techniques for Markov models

7.4.3. CNRS/NFSC IRON

Title: Ensuring Interoperability of new generation networks (IRON)

Principal investigator: César Viho

International Partner:

Institution: BUPT Beijing Univ. of Post and Telecommunication (China)

Inria: Dionysos

Researcher: Pr. Xiaohong Huang

Duration: 01/01/2012 - 31/12/2012

Abstract: Future networks will continue to be heterogeneous. The risk of non-interoperability will increase. This may lead to unavailability of some critical network services, for instance in emergency management, etc. It is important to guarantee that network components will interoperate. One important way among others is to provide efficient testing methodology that help in guaranteeing interoperability of the underlying protocols. The classical testing approach of a single testing system dealing with all tested components and the test execution is no more applicable. To be more confident in the real interoperability of these components, testing has to be done in a close to real operational environment that may be unreliable. Thus, this project aims at providing interoperability testing solutions for distributed communicating systems in unreliable environments.

7.4.4. Participation In International Programs

7.4.4.1. STIC Algérie

Program: DGRSDT Inria Algeria

Title: Réseaux de capteurs

Inria principal investigator: Adlen Ksentini

International Partner (Institution - Laboratory - Researcher):

Centre de Recherche sur l'Information Scientifique et Technique (Algeria)

Duration: Jan 2011 - Dec 2012

7.5. International Research Visitors

7.5.1. Visits of International Scientists

7.5.1.1. Professors

Pr. Xiaohong Huang

Subject: Ensuring Interoperability of new generation networks (IRON)

Institution: BUPT Beijing Univ. of Post and Telecommunication (China)

Duration: 15/09/2012 - 30/09/2012

7.5.1.2. Internships

Leila GHAZZAI (from Feb 2012 until Aug 2012)

Subject: Caching strategies for adaptive video streaming over Content Centric Networks

Institution: Ecole Nationale des Sciences de l'Informatique (Tunisia)

Abhimanyu PANWAR (from May 2012 until Jul 2012)

Subject: Video on Demand over a distributed Content Distribution Network

Institution: IIT Bhubaneswar (India)

8. Dissemination

8.1. Scientific Animation

8.1.1. *International memberships*

- R. Marie and G. Rubino are members of the IFIP WG 7.3 (Working Group in Computer Performance Modeling and Analysis).
- Gerardo Rubino is a member of the Technical Committee on Multimedia Communications of IEEE.

8.1.2. *Seminar presentations*

- B. Tuffin. Title: "Adword auctions: impact of ranking strategies and competition on search engines revenues". Vrije Universiteit Amsterdam, The Netherlands, January 2012.
- B. Tuffin (joint work with P. Maillé and P. Coucheney). Title: "Introduction to the Network Neutrality Debate. Description of a related model of ISP Inter-Relations: Traffic Exchange, Revenue Sharing, and Disconnection Threat". Université de Montréal, Canada, Nov. 2012.
- B. Tuffin (joint work with P. Maillé and P. Coucheney). Title: "Introduction to the Network Neutrality Debate. Description of a related model of ISP Inter-Relations: Traffic Exchange, Revenue Sharing, and Disconnection Threat". The Chinese University of Hong-Kong, Nov. 2012.
- G. Rubino. Title: "Introduction to Quality of Experience". D2 Department, IRISA, Rennes, France. June 2012.
- G. Rubino. Title: "Time-dependent behavior of Markovian queues". Electrical Engineering, Engineering School, University of the Republic, Montevideo, Uruguay. Oct. 2012.
- G. Rubino. Title: "Time-dependent behavior of Markovian queues". Université de Montréal, Canada. Nov. 2012.

8.1.3. *Editorial activity*

- Raymond Marie is Associate Editor for Performance Evaluation.
- Bruno Tuffin is associate Editor for INFORMS Journal on Computing.
- Bruno Tuffin is associate Editor for Mathematical Methods of Operations Research.
- Bruno Tuffin is associate Editor for ACM Transactions on Modeling and Computer Simulation.
- Bruno Tuffin was the co-coordinator of the "Analysis" track at the Winter Simulation Conference (WSC'12), Berlin, Germany, December 9-12, 2012. It will be the first time this event leaves North America.
- Bruno Sericola is associate editor for The Open Operational Research Journal.
- Bruno Sericola is associate editor for International Journal of Stochastic Analysis.
- Bruno Sericola is associate editor for ISRN Probability and Statistics.
- Adlen Ksentini is Associate Editor of Hindawi International Journal of Digital Multimedia Broadcasting
- Yassine Hadjadj-Aoul is a member of the editorial board of the International Journal of Computer Networks (IJCN)

8.1.4. *Program committees*

Bruno Tuffin served as TPC member for

- 2nd International Conference on Simulation and Modeling Methodologies, Technologies and Applications (SIMULTECH), Roma, Italy, 28-31 July 2012.
- 8th Euro-NF Conference on Next Generation Internet (NGI 2012), Blekinge Institute of Technology, Karlskrona, Sweden, June 25-27, 2012.
- First Workshop on Pricing and Incentive in Networks (W-PIN 2012), in conjunction with ACM SIGMETRICS/Performance 2012, London, England, 11 June 2012.
- 9th International Workshop on Economics of Grids, Clouds, Systems and Services (GECON'2012), Berlin, Germany, 27-28 November 2012.
- Track on Simulation Methods and Tools, Winter Simulation Conference (WSC'12), Berlin, Germany, December 9-12, 2012.

Bruno Sericola served in the Program Committee of the following conferences:

- ASMTA 2012, 19th International Conference on Analytical and Stochastic Modelling Techniques and Applications, Grenoble, France, 4–6 June 2012.
- ACCESS 2012, 3rd International Conference on Access Networks, Venice, Italy, 24-29 June 2012.
- NOTERE/CFIP 2012 : Colloque Francophone sur l'Ingénierie des Protocoles - Nouvelles technologies de la répartition, Anglet, France, 29–31 October 2012.

Adlen Ksentini served as TPC member for

- IEEE Global Communication Conference, GLOBECOM 2012 Wireless Network Symposium, December 2012, Anaheim, California, USA
- IEEE International Conference on Communication, ICC 2012 Wireless Network Symposium, June 2012, Ottawa, Canada
- IEEE Wireless Communication and Networking Conference, April 2012, Paris, France

César Viho served as TPC member for

- 3rd International Conference on the Internet of Things (IoT2012), Oct 2012, Wuxi, China.
- 11th African Conference on Research in Computer Science and Applied Mathematics, Oct 2012, Algiers, Algeria.
- TTCN-3 User Conference June 2012, Bangalore, India

Yassine Hadjadj-Aoul served as TPC member for

- IEEE Global Communication Conference, GLOBECOM 2012 Wireless Network Symposium, December 2012, Anaheim, California, USA
- IEEE International Conference on Communication, ICC 2012 Wireless Network Symposium, June 2012, Ottawa, Canada
- IEEE Wireless Communication and Networking Conference, April 2012, Paris, France

Gerardo Rubino served as TPC member of

- CLEI 2012, XXXVIII Conferencia Latinoamericana de Informática (Latin-American Informatics Conference), Medellín, Colombia, October 1–5, 2012.
- RESIM (9th International Workshop on Rare Event Simulation) 2012, Trondheim, Norway, June 25–27, 2012.

8.1.5. Managing research activities

- G. Rubino is a member of the Steering Committee of the international conference QEST (Quantitative Evaluation of SysTems).
- G. Rubino is a member of the Steering Committee of the International Workshop on Rare Event Simulation (RESIM).
- B. Tuffin is a member of the Steering Committee of the International Workshop on Rare Event Simulation (RESIM).
- G. Rubino has been appointed as the Inria representative at the Scientific Committee of the IFCAM (Indo-French Center for Applied Mathematics), a joint international unit between Indian Ministry of Science and Technology and several French partners including the CNRS, the École Polytechnique, the École normale supérieure, Inria, Nice Sophia Antipolis University and the University of Toulouse III - Paul Sabatier.
- Bruno Sericola is responsible for the Inria Rennes - Bretagne Atlantique budget.
- Bruno Sericola is a member of the Inria Evaluation Committee which role is to assess the calibre of research conducted at Inria and to guarantee the quality of its hiring and internal promotions.
- Bruno Sericola is the leader of the research group MAPI (Math Appli Pour l'Info) the goal of which is to improve the collaboration between computer scientists and mathematicians.

- Adlen Ksentini is vice-chair of the Interest Group on QoE of the Technical Committee on Multimedia (IEEE Communication Society).
- César VIHO is responsible of the “Network, Telecommunication and Services” department of Irisa composed of 7 research teams. He is member of the Scientific advisory board (Conseil scientifique) of Irisa. He is now deputy-director of the MATISSE Doctoral school of Electronics, Computer Sciences and Mathematics. In the context of international relations of Irisa, he is responsible of relations with Africa area universities and research centers.
- Gerardo Rubino is a member of the Research Commission of TELECOM Bretagne (advisory board for the research activities of the institution).
- Gerardo Rubino is a member of the CSV (Selection and Validation Committee) of the “Images et Réseaux” (Images and networks) cluster in the French Brittany Region. The cluster includes most companies and academic institutions working in networking and in image-based applications in Western France.
- Gerardo Rubino is the Inria representative at the GIS SISCOM, an association composed of the four main academic institutions in Western France in the area of information and communication sciences: the European University of Brittany-UEB, the Institut TELECOM, the CNRS and Inria, to promote the excellence of the ICT research in Brittany.

8.2. Teaching - Supervision - Juries

8.2.1. Teaching

Licence L3: Introduction to networks, 20 hours, Istic/University of Rennes 1, France
 Master M1: Introduction to networks, 24 hours, Esir/University of Rennes 1, France
 Master M1: Wireless networking, 46 hours, Esir/University of Rennes 1, France
 Master M1: Networks and protocols, 24 hours, Istic/University of Rennes 1, France
 Master M1: Computer networks, 24 hours, Esir/University of Rennes 1, France
 Master M1: Algorithms and graphs, 48 hours, Esir/University of Rennes 1, France
 Master M1: Performance and dependability evaluation of computer systems, 54 hours, Istic/University of Rennes 1, France
 Master M1: Introduction to graph theory, 14 hours, Esir/University of Rennes 1, France
 Master M1: Introduction to networks, 20 hours, Esir/University of Rennes 1, France
 Master M1: Wireless Networks, 48 hours, Esir/University of Rennes 1, France
 Master M2: Multimedia transmission, 48 hours, Esir/University of Rennes 1, France
 Master M2: Introduction to C language, 12 hours, Istic/University of Rennes 1, France
 Master M2: Validation and tests, 6 hours, Istic/University of Rennes 1, France
 Master M2: Quality of service and multimedia, 6 hours, Istic/University of Rennes 1, France
 Master M2: Multimedia transmission, 18 hours, Istic/University of Rennes 1, France
 Master M2: Performance evaluation, 26 hours, Istic/University of Rennes 1, France
 Master M2: Network security, 14 hours, Istic/University of Rennes 1, France
 Master M2: Dependability analysis, 15 hours, Supelec, Rennes, France
 Master M2: Simulation, 5 hours, Telecom Bretagne, Rennes, France
 Master M2: Multimedia streaming over IP (MMR), 50 hours, Esir/University of Rennes 1, France
 Master M2: Multimedia services in IP networks (RSM), 29 hours, Esir/University of Rennes 1, France
 Master M2: Logistic and performance, 8 hours, Faculté de Sciences économiques/University of Rennes 1, France.

8.2.2. Supervision

PhDs

- Sebastián Basterrech, title: “Learning with Random Neural Networks and Reservoir Computing models”; advisor: G. Rubino; date: November 15, 2012.
- Tran Hoang-Hai, title: “Auctions for competitive network providers”; advisor: B. Tuffin; date: April 2012.

PhD in progress:

- Romaric Ludinard; title: “Data-aggregation for large-scale distributed networks”; PhD started in April 2011; advisors: B. Sericola from Inria/Dionysos and E. Anceaume from Inria/Cidre
- Damien Le Queré; Cifre Grant, Orange Labs; title: “Conception et étude des performances d’une solution auto-configurable pour les réseaux de transport du futur”; PhD started in January 2012; advisors: B. Sericola and A. Ksentini
- Samira Saggadi; title: “Rare event simulation with application to telecommunications”; PhD started in November 2008; advisor: Bruno Tuffin
- Pablo Sartor; title: “Diameter-constrained reliability: exact analysis and simulation techniques”; PhD started on October 2012; advisors: G. Rubino from Dionysos, P. Robledo from the university of the Republic, Uruguay (joint PhD between this university and the university of Rennes 1, France)
- Laura Aspirot; title: “Fluid limits in performance evaluation”; thesis started in 2010; advisors: Gerardo Rubino from Dionysos, and Ernesto Mordecki from the university of the Republic, Uruguay (PhD of the university of the Republic, Uruguay)
- Leslie Murray; title: “Monte Carlo methods for rare event analysis”; thesis started in 2009; advisors: Gerardo Rubino from Dionysos, and Pablo Robledo from the university of the Republic, Uruguay (PhD of the PEDECIBA, Uruguay)
- Leila Ghazzai; title: “Replication and caching strategies for adaptive video streaming in future information centric networks”; PhD started on October 2012; advisors: G. Rubino, Y. Hadjadj-Aoul
- Nanxing Chen; title: “On passive approach for interoperability testing”; PhD started on October 2009; advisor: C. Viho

8.2.3. Juries

- B. Tuffin was a member of the Jury of HDR of Sandrine Vaton, from Telecom Bretagne; title: “Mesure et Analyse du Trafic de Réseaux : Théorie et Pratiques”; date: July 13, 2012.
- B. Tuffin was a member of the jury of PhD of Bahar Kaynar, from Vrije University, The Netherlands; title: “Rare Event Simulation Techniques for Stochastic Design Problems in Markovian Settings”; date: January 2012.
- B. Tuffin was a member of the jury of PhD of Lorenzo Maggi, from Eurecom, France; title: “Cooperative games for Markov decision processes with applications to telecommunications”; date: October 2012.
- B. Tuffin was a member of the jury of PhD (rapporteur) of Pablo Gabriel Romero Rodriguez from Universidad de la República, Montevideo, Uruguay; title: “Mathematical Analysis of Scheduling Policies in Peer-to-Peer Video Streaming Networks”; date: November 2012.
- G. Rubino was a member of the Jury of HDR of Sandrine Vaton, from Telecom Bretagne; title: “Mesure et Analyse du Trafic de Réseaux : Théorie et Pratiques”; date: July 13, 2012.
- G. Rubino was the President of the Jury of PhD of Oscar Olvera Irigoyen, from Telecom Bretagne; title: “Hybrid Home Networks Links Quality Supervision”; date: December 20, 2012.

- C. Viho was the President of the Jury of HDR of Frederic Weis, from University of Rennes 1; title: “Exploiting system approaches in wireless networks”; date: June 6, 2012.
- C. Viho was the President of the Jury of HDR of Laurent Toutain, from Telecom Bretagne; title: “Towards a polymorphic Internet”; date: December 17, 2012.
- C. Viho was the President of the Jury of PhD of Tran Hoang Hai, from the University of Rennes 1; title: “Auctions for competitive Network providers”; date: April 2, 2012.
- C. Viho was a member/reviewer of the Jury of PhD of Ubaid Abbassi, from University of Bordeaux I; title: “Quality-Aware Live and on-Demand Video Streaming in P2P Networks”; date: April 25, 2012.
- C. Viho was the President of the Jury of PhD of Ahmed Ayadi, from Telecom Bretagne; title: “Energy-efficient reliable transport protocols for IP-based low power wireless networks”; date: June 25, 2012.
- C. Viho was a member/reviewer of the Jury of PhD of Jean-Michel Combes, from Telecom Sud Paris; title: “Utilisation d’identifiants cryptographiques pour la sécurisation IPv6”; date: September 28, 2012.
- C. Viho was the President of the Jury of PhD of Heverson Ribeiro, from the University of Rennes 1; title: “Exploiting Rateless Coding in Structured Overlays to Achieve Persistent Storage”; date: October 12, 2012.
- C. Viho was the President of the Jury of PhD of German Castignani, from Telecom Bretagne; title: “Exploiting network diversity”; date: November 7, 2012.
- C. Viho was the President of the Jury of PhD of Sebastian Basterrech, from University of Rennes 1; title: “Learning with Random Neural Networks and Reservoir Computing Models”; date: November 15, 2012.
- C. Viho was a member of the Jury of PhD of Kheira Bekara, from Telecom Sud Paris; title: “Protection des données personnelles côté utilisateur dans le E-commerce”; date: December 18, 2012.

8.3. Popularization

- G. Rubino makes regular presentations to high school students about the research work in general, and specific technical topics in particular. Titles of 2012:
 - “Utilisation du hasard pour résoudre des problèmes déterministes”
 - “Internet comme problème de recherche”
 - “Grands défis en mathématiques : la conjecture de Riemann”
 - “Grands défis en mathématiques : la conjecture $P \neq NP$ ”

8.4. Standardization activities

Participants: Anthony Baire, Arulnambi Nandagoban, César Viho.

The Dionysos team continues to dedicate a significant effort towards standardization and certification in the telecommunications area. We participate in several working groups of the main telecommunication standardization institutes like the IETF (Internet Engineering Task Force), ETSI (European Telecommunication Standardization Institute), etc. We are also active in the main mailing-lists treating new generation networks and protocols. Several proposals of drafts and contributions to the definition of standards and RFCs (Request For Comments) have been published. This year our contributions focus today mainly on IPv6 and related protocols such as 6LowPAN and CoAP.

8.4.1. IPv6 Ready Logo Program

Participants: Anthony Baire, César Viho.

Dionysos team has also a major role in the world-wide certification process for IPv6 products launched by the IPv6 Forum, the “IPv6 Ready Logo Program”. For details, see <http://www.ipv6ready.org>. This project aims to provide the means needed to test existing IPv6 products to be deployed in the market. Dionysos contributes to the technical part of this Program by defining the certification process itself, specifying required tests, and developing some of the interoperability tests needed. This work is done together with the IPv6 Forum, the ETSI in Europe, the WIDE-project in Japan and the TTA (Telecommunications Technology Association) in Korea.

In 2010 we started a collaboration with the IPSO alliance in order to address the usage of IPv6 on smart objects based on the IEEE 802.15.4 link layer (for instance, sensor networks). These network have special constraints (limited power, packet loss, ...) and new protocols are designed at IETF (6LoWPAN, RPL) to allow using IPv6 with these constraints. We are on the way to provide a certification program for 6LoWPAN.

9. Bibliography

Major publications by the team in recent years

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- [2] S. BARBIN, L. TANGUY, C. VIHO. *Towards a formal framework for interoperability testing*, in "21st IFIP WG 6.1 International Conference on Formal Techniques for Networked and Distributed Systems", Cheju Island, Korea, M. KIM, B. CHIN, S. KANG, D. LEE (editors), August 2001, p. 53–68.
- [3] N. BOUABDALLAH, A.-L. BEYLOT, E. DOTARO, G. PUJOLLE. *Resolving the Fairness Issues in Bus-Based Optical Access Networks*, in "IEEE Journal on Selected Areas in Communications", 2005, vol. 23, n^o 8, p. 1444–1457.
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Publications of the year

Doctoral Dissertations and Habilitation Theses

- [11] S. BASTERRECH. *Learning with Random Neural Networks and Reservoir Computing models*, Université de Rennes 1, November 2012.
- [12] T. HOANG-HAI. *Auctions for competitive network providers*, Université de Rennes 1, April 2012.

Articles in International Peer-Reviewed Journals

- [13] E. ANCEAUME, F. CASTELLA, B. SERICOLA. *Analysis of a large number of Markov chains competing for transitions*, in "International Journal of Systems Science", July 2012, p. 1–9, published online [DOI : 10.1080/00207721.2012.704090], <http://hal.inria.fr/hal-00736916>.
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- [32] G. RUBINO. *Quality of Monte Carlo rare event analyzers*, in "CIMPA School - New trends in Mathematical Statistics", Punta del Este, Uruguay, 2012, <http://hal.inria.fr/hal-00771633>.

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- [33] A. AMOKRANE, A. KSENTINI, Y. HADJADJ-AOUL. *Congestion Control for Machine Type Communications*, in "IEEE International Conference on Communication (ICC)", Ottawa, Canada, IEEE, June 2012, <http://hal.inria.fr/hal-00756983>.

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