Inria, Evaluation of Theme Networks and Telecommunications

Project-team DistribCom

March 21-22, 2012

Project-team title: DistribCom: Distributed Models and Algorithms for the Management of Telecommunication Systems

Scientific leaders: Albert Benveniste and Claude Jard

Research center: Rennes Bretagne Atlantique

Common project-team with: CNRS, ENS Cachan Antenne de Bretagne, Université de Rennes I

1 Personnel

Personnel (March 2007)

	University	Inria	CNRS	ENS Cachan	**Total**
DR (1) / Professors		0.5		1	**1.5**
CR (2) / Assistant Professors		3	1	1	**5**
Permanent Engineers (3)					
Temporary Engineers (4)					
PhD Students	1	3		1	**5**
Post-Doc.		1			**1**
Total	**1**	**7.5**	**1**	**3**	**12.5**
External Collaborators					
Visitors (>1 month)		1			**1**

(1) "Senior Research Scientist (Directeur de Recherche)"
(2) "Junior Research Scientist (Chargé de Recherche)"
(3) "Civil servant (CNRS, Inria, ...)"
(4) "Associated with a contract (Ingénieur Expert or Ingénieur Associé)"

Personnel (March 21-22, 2012)

	University	Inria	CNRS	ENS Cachan	**Total**
DR / Professors		1.5		1	**2.5**
CR / Assistant Professor	1	2	0.15	1	**4.15**
Permanent Engineer					
Temporary Engineer					
PhD Students	1	4		2	**7**
Post-Doc.		3		1	**4**
Total	**2**	**10.5**	**0.15**	**5**	**17.65**
External Collaborators					
Visitors (>1 month)					

Changes in staff

DR / Professors CR / Assistant Professors	University	Inria	CNRS	ENS Cachan	total
Arrival	1	1		1	3
Leaving		1	1	1	3

Comments:

- Inria: 1 CR (S. Haar) has left, 1 CR (A. Legay) has joined and 1 CR has been promoted DR (E. Fabre)
- ENS Cachan: 1 MC has left (A. Bouillard) and 1 MC has been hired (F. Schwarzentruber)
- CNRS: 1 CR CNRS (B. Genest) has moved in Singapore, but remains active part-time in Distribcom
- Université de Rennes I: G. Aucher has been hired on a "chaire Inria-Université de Rennes I" and joined the group

Current composition of the project-team (March 21-22, 2012):

- Permanents:
  - Albert Benveniste, DR Inria (50% DistribCom, 50% S4)
  - Claude Jard, PR ENS Cachan
  - Eric Fabre, DR Inria
  - Loïc Hélouët, CR Inria
  - Blaise Genest, CR CNRS (15% DistribCom)
  - Axel Legay, CR Inria (see below)
  - Guillaume Aucher, MC Chaire Inria-Université de Rennes I (see below)
  - François Schwarzentruber, MC ENS Cachan (see below)
- Post-Docs:
  - Sean Sedwards, Postdoc Inria (A. Legay's group, see below)
  - Uli Fahrenberg, Postdoc Inria (A. Legay's group, see below)
  - Akshay Sundararaman, Postdoc ENS Cachan
- PhD students:
  - Ajay Kattepur, PhD student Cordis-Inria
  - Loïg Jézéquel, PhD student ENS Cachan
  - Rouwaida Abdallah, PhD student ENS Cachan
  - Cyrille Jégourel, PhD student Inria (A. Legay's group, see below)
  - Carole Hounkonnou, PhD student Inria
  - Aurore Junier, PhD student Inria
  - Valérie Murat, PhD student Université Rennes I (A. Legay's group, see below)

Current position of former project-team members (including PhD students during the period):

- Stefan Haar, DR Inria, head of Mexico team at Inria-Saclay, located with LSV ENS Cachan
- Blaise Genest, CR CNRS, IPAL Unité Mixte Internationale at Singapore (85%)
- Anne Bouillard, former MC Ens Cachan, now MC ENS Paris
- Deepak Bhatia, former Ingénieur Expert, ?
- Shaofa Yang, former Post-Doc, PR ShenZheng University
- Paolo Ballarini, former Post-Doc, MC (Ass. Prof.) Ecole Centrale de Paris
- Hélia Poullyau, former PhD student, IG Alcatel-Bell Labs at Villarceaux
- Sidney Rosario, now back to India; part time teaching at a local University and part time involved in natural farming
- Debmalya Biswas, former PhD student, now at Nokia, Switzerland.
- Bartosz Grabiec, former PhD student, IG Tours

Last Inria enlistments

- Guillaume Aucher, MC on a Inria-Université de Rennes I "chaire", see below
- Axel Legay, CR Inria hired in 2009 in team S4, joined DistribCom in 2011, see below.

Other comments: seed activities (please read carefully)

The strong structuring of Inria into Project-Teams (referred to as "teams" for short in the sequel) is at times a source of rigidity in the organization of research. We believe that it is the duty of established teams to compensate for this by hosting seed research activities, not necessarily aligned with the core research directions of the team. DistribCom has performed this at several occasions. We insist that we do not see these seed activities as part of the DistribCom portfolio and we take this fact into account for this activity report. Nevertheless, we must inform the evaluation committe of such hosting and we do it here.

- *Digital Communications*: during the previous evaluation term, we hosted for three years a small group of researchers from the area of digital communications. In particular, Aline Roumy and Jean-Jacques Fuchs subsequently joined the Temics team, where they are now active. By this way, the research in Temics could expand to cover the interaction of source video compression with MIMO radio techniques and network coding.
- *Non-classical logics*: in 2009, several researchers at Rennes promoted the idea that skills in logics should be developed, as a novel pillar for dealing with *interfaces* in several areas including systems design, services, security and privacy. For all these contexts, logics with special modalities could be useful in establishing the use of *policies* on firm bases. Guillaume Aucher was recuited in 2010 on an Inria-Université de Rennes I "chaire" and François Schwarzentruber was recruited in 2011 at ENS Cachan. DistribCom started a cooperation with the two of them regarding service interfaces and policy based fault management. These two researchers have, in addition, their own interests and research tracks, not shared with DistribCom.

- *Statistical Model Checking (SMC)*: SMC is a highly promising spinoff of model checking for systems too complex for being subject to a yes/no type of analysis. Probabilistic answers are then preferred. SMC makes deep use of concepts and techniques from statistical testing with scaling-up as an objective. Axel Legay wanted to launch this as an exploratory research track with some autonomy. The well developed skills in statistics available in DistribCom justifed the hosting, which occurred in 2011, with Axel Legay, Uli Fahrenberg, Sean Sedwards, Valérie Murat, and Cyrille Jégourel becoming hosted by DistribCom.

None of these activities is included in this report for evaluation. Some of them come with their own resources. We either discard them from our portfolio or point their specific status.

Accordingly, to facilitate the work of the evaluators, we list again the people that contributed to the research and results reported in detail in this document:

- Permanents:
  2008-2011: Albert Benveniste, DR Inria (50% DistribCom, 50% S4)
  2008-2011: Claude Jard, PR ENS Cachan
  2008-2011: Eric Fabre, DR Inria
  2008-2011: Loïc Hélouët, CR Inria
  2008: Blaise Genest, CR CNRS at IRISA; then 2009-2011 (15% DistribCom)
  2008-2009: Stefan Haar, DR Inria
  2008-2010: Anne Bouillard, former MC Ens Cachan

- Post-Docs :

  2006-2008: Shaofa Yang, former Post-Doc
  2009-2010: Paolo Ballarini, former Post-Doc
  2011: Akshay Sundararaman, Postdoc ENS Cachan

- PhD students:

  2008-2009: Hélia Poullyau, former PhD student
  2008-2009: Sidney Rosario, former PhD student
  2008-2009: Debmalya Biswas, former PhD student
  2008-2011 Bartosz Grabiec, former PhD student
  2009-2011: Ajay Kattepur, PhD student Inria
  2008-2011: Loïg Jézéquel, PhD student ENS Cachan
  2010-2011: Rouwaida Abdallah, PhD student ENS Cachan
  2009-2011: Carole Hounkonnou, PhD student Inria
  2010-2011: Aurore Junier, PhD student Inria

- Engineers:

  2010-2011: Deepak Bhatia, Ingénieur Expert

Also, we reproduce the table of current *contributive members* according to the above criteria:

Contributing members	University	Inria	CNRS	ENS Cachan	**Total**
DR / Professors		1.5		1	**2.5**
CR / Assistant Professor		1	0.15		**1.15**
Permanent Engineer					
Temporary Engineer					
PhD Students		3		2	**5**
Post-Doc.				1	**1**
Total		**5.5**	**0.15**	**4**	**9.65**
External Collaborators					
Visitors (>1 month)					

2 Work progress

2.1 Keywords

2.2 Context and overall goal of the project

The DistribCom team addresses models and algorithms for distributed management, with applications to telecommunication networks and services, Web services, and Business Processes. Today, most research on network and service management as well as Web Services focuses on issues of software architectures, management architectures, and related frameworks. However, these areas also involve (much less investigated) algorithmic problems such as fault diagnosis and alarm correlation, planification, and more generally QoS aware management. The DistribCom team develops the models, theories, and techniques, supporting such algorithms. Our algorithms are distributed and model-based. For obvious reasons of complexity, models cannot be built by hand, so we also investigate how to construct them.

2.3 Objectives for the evaluation period

As quoted from the 2007 activity summary, objectives planed for the previous evaluation period were:

1. *Fundamentals of distributed systems*: models for concurrent systems are needed to support distributed autonomic management. We study such models: how to compose them, how to analyze them (decidability), what is their complexity, what are the needed data structure upon which to develop distributed algorithms for various tasks. This includes the special topic of *self-modeling,* which consists in (quasi-)automatically constructing very large models. Plans were to extend our studies to more quantitative aspects such as time, cost, and probability.

2. *Distributed self-management algorithms*: algorithms for observing the system and performing alarm correlation and fault handling were studied during the previous evaluation period. Plans were to extend our studies to more quantitative tasks, e.g., involving optimization and negotiation.

3. *Composite Web services and their QoS*: in 2007 we proposed our very first framework of soft probabilistic contracts for the QoS aware management of composite services, for the restricted case of *latency.* Plans were to extend this to other dimensions of QoS.

4. *Business Processes and Web scale combined data/workflow management with Active XML documents*: Active XML Documents [1] were proposed by the data base community (Serge Abiteboul et al.), as a Web scale infrastructure for composite services. In 2007, we just started understanding this new area (new for us). Plans were to investigate its use for both composite services and workflows.

For this evaluation period, the above objectives have only slightly evolved. The last two ones have significantly converged, so we merged them. In addition, the increasing "seed role" of DistribCom calls for a brief description of our seed activities. In the following list, we only comment the differences with respect to initial plans.

1. *Fundamentals of distributed observation and supervision of concurrent systems.* The handling of "time" in concurrent models and distributed systems is known to be a difficult issue, due to non-determinism in communications between distant sites. A large effort has been indeed develoted to handling time in models of concurrency. Distributed optimization and planning is a central algorithmic task in distributed management under scarce resources. The development and study of concurrency models to support such activities involved significant efforts from our team. So far issues related to probability have been less investigated during this last period.

2. *Distributed self-management algorithms.* Distributed and autonomic diagnosis and alarm correlation remained an important topic for this period. The consideration of management activities related to maintenance has led to the development of studies on distributed planning. Recently, self-modeling became again a top priority topic, due to the study of real-size joint network and service diagnosis of IMS.

3. *Composite Web services, document based workflows, and QoS.* It took us a few years to discover that *monotonicity* is a central issue in QoS aware management of composite services. Monotonicity is the following property for an orchestration: a called service improving its QoS performance will only improve the overall performance of the orchestration. In contrast to QoS in networks, monotonicity may not hold in composite services, due to the tight interactions between control, data, and QoS. The research community of composite Web services seems mostly unaware of this difficulty. Monotonicity and its consequences for contract-based QoS aware management has been our main focus. Extensions to multi-dimensional QoS came as a byproduct of the above efforts. Our research on Active Documents evolved toward the broader concept of *document based workflows,* where we could abstract away (in part) from the details of pattern matching techniques related to XML. Finding the right notion of *interface* in this context has been our main focus.

4. *Seed activities.* Two of them emerged during the evaluation period. *They are not reported here.*

   The first one concerns *non-classical logics* (such as epistemic and deontic logics). Research on mathematical concepts for interfaces was undergoing in both DistribCom and our neighbours from S4 team (from embedded systems and software program), for systems and services. We came to the conclusion that logical approaches may be effective in providing firm bases for *policy based* management techniques. This led DistribCom to consistently support the creation of a small group on this topic, with the hiring of Guillaume Aucher and François Schwarzentruber, see Section 1. First efforts are ongoing to investigate the above topic.

[1] http://webdam.inria.fr/axml/index.axml.html

DistribCom was less proactive in hosting the second topic of *Statistical Model Checking*. It was only an opportunistic positioning to offer Axel Legay to host his group. This was, however, justified by common interests in probability and statistics, and discussions regarding these areas of interaction have started during our group meetings.

2.4 Objective Fundamentals of distributed systems : Executive summary

2.4.1 Personnel

Permanent researchers: Albert Benveniste, Eric Fabre, Loïc Hélouët, Claude Jard, Anne Bouillard, Blaise Genest, Stefan Haar

PhD: Thomas Gazagnaire, Bartosz Grabiec, Sidney Rosario, Rouwaida Abdallah, Loïg Jézéquel

2.4.2 Project-team positioning

Today, research on network and service management as well as Web Services mainly focuses on issues of software architecture and infrastructure deployment. These tasks, however, also requires *algorithms* for their realization. The DistribCom team develops algorithms for fault diagnosis, testing, network and service maintenance operations, service deployment, QoS evaluation and negotiation, etc. Our algorithms are model-based with strong mathematical bases. This objective collects fundamental studies regarding these models:

- Can such models capture the widely distributed nature of our systems? Can they combine the description of the function being performed together with more quantitative and QoS-related aspects, such as timing, cost, availability, probabilistic features, etc. Are these models amenable of distributed and decentralized management algorithms for observation, optimization, and reconfiguration?
- Can such models compose? This is the first requirement if we want to be able to construct models for real-size systems in a modular way.
- Can self-modeling be applied? How automatically can we generate models of real-size systems? How much manual effort remains? Building models is the main bottleneck in deploying model based algorithms.
- What can we compute about such models? This requires research on decidability of properties and complexity of algorithms.

Main scientific achievements are summarized next.

2.4.3 Scientific achievements

As this objective collects our theoretical activities, developments and results are numerous. We highlight what we see as our main theoretical contributions for this period and we complete this with a brief list ("à la Prévert") of all results.

Concurrency models of distributed systems: Regarding concurrency models of distributed systems, we made significant contributions to frameworks of *scenarios* by proposing *Causal Message Sequence Charts* (CMSC) [21, 22]. Scenario models are widely used in telecoms and business processes for specifying protocols, and more generally for describing interactions between components. Scenarios are part of UML notation zoo. Most scenario formalisms in practical use lack formal mathematical counterpart, thus resulting in engine-dependent executions. Formal mathematical studies are thus needed. By supporting loose synchronization to comply with targeted applications, scenario models suffer from undecidability issues. CMSC now appear as the most expressive class of scenario models for which major properties (e.g., reachability) are decidable. We are in particular able to solve the diagnosis problem for CMSCs [21]. CMSCs and corresponding algorithms are available as part of our SOFAT platform for MSCs, see Section 3.3.

Enriching concurrency models with quantitative aspects: Our second main body of results aims at enriching concurrency models with quantitative aspects: time, cost (for optimization), and probability. An enabler of this was our extensive effort during previous evaluation period in developing efficient data structures for manipulating distributed logs of events and data. This is now completed with *distributed unfoldings* for Petri nets and networks of automata, the construction of related *complete prefixes* [35], as well as *symbolic unfoldings* to support data in a symbolic, not enumerated, form [40].

Having these enablers handy, we were able to enhance net unfoldings with time [12], thus preparing for e.g., making use of timing information while performing distributed diagnosis.

We were also able to address a weak form of distributed optimal control, specifically *distributed planning.* This consists in organizing the actions of a collection of components in such a way to reach a global goal in an optimal manner. This is made difficult by the necessary cooperations between components. Nevertheless, we were able to propose a distributed solution based on a weighted automata calculus [17, 18], which is a first simple manner to take advantage of concurrency.

Uncertainties and non-determinism in the observation of distributed systems led to the consideration of *probabilistic concurrency models.* Probabilistic models of systems whose trajectories are partially, not totally ordered, were not known. We have proposed *Markov nets* [1, 2] as a randomization of Petri nets whose trajectories are seen as partially ordered sets of events—concurrent events are not ordered. Markov nets possess the Markov property and concurrent local processes are probabilistically independent. We have developed a law of large numbers for Markov nets and a local and global renewal theory, thus paving the way to a mathematically sound framework for distributed agents.

Self-modeling: All the techniques we develop are model based. How can we construct such models? For sure not by hand—the models we need for diagnosis are graphs of causally related events, services, functions, network and service elements, in amounts rising to tens or hundreds of thousands. Some of these nodes can even be dynamical (automata). It is not even thinkable to construct and store such models for use. Models must therefore be deployed *automatically* and *on demand*: this we call *self-modeling.* Self-modeling is not learning from data—data tell us a lot about mainstream behavior, not so much about rare events as we need it for diagnosis. By combining intelligence gathered from standards and crude topological information gathered from data-bases (MIBs, network discovery, etc.), self-modeling is made possible. It takes the following form: a few generic and composable model elements are designed offline, then, at runtime, several (possibly many) instances of these generic tiles are assembled to fit the topology of a given managed system. We already

used self-modeling for our work in network diagnosis during the previous evaluation period. We are revisiting and improving it again for our current effort on IMS end-to-end model based diagnosis, see Sections 2.5 and 4.

Miscellaneous: We have contributed to algorithmic aspects of the Network Calculus operators [10] and on composition of network elements in presence of cross-traffic [6, 7]). We have proposed (centralized and distributed) diagnosis solutions for Petri Nets [26], High-level MSCs [29, 21], rewriting-based models [3], and logic-based models [41]. On a different direction, more related to system deployment, we have studied how HMSCs can be deployed on a network of communicating automata while preserving behavioral properties [30] and how to schedule a distributed system [14] to achieve an overall goal. In [16], we have propose a model for sessions in web-based applications. This model is admittedly less powerful that BPEL, but keeps a reasonable expressive power while allowing for the verification of safety properties.

2.4.4 Competition and Collaborations

Our main competitor on diagnosis is the team of Stephane Lafortune at Ann Arbor, MI for diagnosis. Our originality is the explicit handling of concurrency in distributed systems (local time, local states). Regarding unfolding techniques, competitors are Victor Khomenko (Newcastle, UK, model checking problems) and Javier Esparza (Stuttgart, also model checking). Our originality is in the exploitation of factorization properties of unfoldings to study large systems by parts, and a positioning in diagnosis rather than model checking. Symbolic (and time) unfoldings are a new subject. Our main competitors are V. Khomenko (Newcastle, UK) and J. Lilius (Abo, FInland). Our application to supervision is unique to our knowledge. Concurrent probabilistic models have also been studied by Hagen Völzer (Lübeck), Glynn Winskel (Cambridge, UK, where our former student Samy Abbes was hosted), et Daniele Varacca (Liafa, Paris).

Major vehicles for publications on these subjects are the journals *IEEE Trans on Automatic Control, Theoretical Computer Science, Information and Computation* and the conferences FOSSACS, ICALP, STACS, and CONCUR.

We had strong collaborations with the MEXICO team in LSV (Stefan Haar, Thomas Chatain, Benedikt Bollig, Serge Haddad) [5, 29, 4, 3, 9, 11, 3, 12], and with researchers from IRCCYN in Nantes (Didier Lime, Franck Cassez, Olivier H. Roux) [40, 26]. We also had interactions with partners of the EU-STREP-DISC project (Serge Haddad, Alessandro Giua, Jan Komenda, Jan van Schuppen), where we obtained our results about distributed planning and distributed probabilistic diagnosis. Our results regarding probabilistic models were obtained with Samy Abbes, now at PPS, Paris VI [1, 2]. We also maintain active exchanges with partners of the DST associated team, namely P.S. Thiagarajan at the National University of Singapore [14, 22] and Madhavan Mukund at the Chennai Mathematical Institute [16]. We also had frequent interactions with members of the Vertecs and S4 teams at IRISA [16, 14, 13].

2.4.5 External support

1. ANR DOTS (2007-2011)
2. Inria associated teams CASDS (2005-2008) and DST (2009-2011)
3. EU-STREP-DISC (2008-2011)
4. ANR IMPRO (2011-2013)

5. EU-IP-UNIVERSELF (2011-2013)

2.4.6 Self assessment

This objective perfectly fits the skills of DistribCom: we all share a strong background in theoretical computer science and half of the team has in addition a good background in mathematics. Not surprinsingly, this is the objective in which we have our largest publication record. We are among the major players in discrete event systems diagnosis, with leadership on distributed algorithms. Our work on classes of concurrency models with regard to issues of decidability was performed in cooperation with top level international teams (Paris, Singapore, Chennai). Our work on probabilistic models is recognized as highly original but has not find its way to applications as we expected. Overall, we expect the effort to decrease on these topics.

Our more recent results on quantitative models (time, cost) and planning/optimization algorithms will need some more effort to get recognition at the same level. This is where we plan to push our efforts.

Our fundamental work on web-services and ochestrations led to several publications in reknowned conferences and journals, but we are not identified as leaders in this domain.

Finally, despite it will never be a source of massive publication, we see self-modeling as an essential topic. Our proposal of considering this in the framework of EU-IP-Univerself has attracted significant attention and interest.

2.5 Objective Distributed self-management algorithms : Executive summary

2.5.1 Personnel

Permanent researchers: Eric Fabre, Albert Benveniste, Claude Jard, Anne Bouillard

PhD: Carole Hounkonnou, Aurore Junier

2.5.2 Project-team positioning

DistribCom has long been working on network management, from the angle of failure diagnosis. The focus was essentially on core networks (MPLS or SONet), and the strong point of the team was its unique approach mixing formal methods to analyze concurrent systems, distributed model-based algorithms, coupled with a methodology to automatically build a model of the managed network. This approach contrasts with the mainstream techniques to address network diagnosis, that rely essentially on data mining. This set of results was fed by long lasting collaborations with Alcatel and France Telecom, supported by various contracts, and led to several demo prototypes.

At the last evaluation in 2007, this activity was mature, partly transfered, and it was not clear whether it would either decay in intensity or be revitalized by new collaborations. The second option happened at the end of 2008. DistribCom joined the starting common lab between Alcatel-Lucent and Inria and set up the joint team *High Manageability* (co-leaders Pierre Peloso and Eric Fabre) dedicated to the design of self-management methods. We have focused on several use-cases, putting aside part of our background on concurrent systems monitoring to focus on the relevance of distributed algorithms. This approach has been rather successful in terms of transfer (4 patents so far) and impact. The High Manageability group has been a key element in the definition of the EU IP UniverSelf (3 years, start in Sept. 2010) which has absorbed most of its manpower and topics. UniverSelf

gathers EU operators, vendors and academics and aims at defining guidelines and examples of self-managment methods through relevant use-cases. DistribCom's commitment is on the topics of self-modelling and self-diagnosis.

2.5.3 Scientific achievements

Autonomic management of photonic networks. This problem concerns the tuning of per-color optical amplification gains in the cross-connects of core networks. The successive amplifications met by a connection along its journey in the network has a non-linear influence on its reach (without electrical regeneration) and on its OSNR at egress. The tuning of these gains is made difficult by several other factors, in particular the limited power allowed in each fiber, and the limited tuning range of each amplifier, which introduces a coupling of all gains over the global performance of the network. Gains are currently adjusted by hand, once for all, which requires overdimensioning of equipment, and prevents adjusting the performance of the network to its actual load. We have proposed a distributed algorithm to maximizes the reach of all connections and equalize their quality. It takes the form of a local optimization procedure within each router, coupled with information exchanges between neighbouring routers. A byproduct of the method is that it supports hot restart, i.e., run-time reconfiguration of the network without interruption. A demonstration prototype has been designed and presented at several events (plenary address at the Bell Labs-Inria days in 2009, Alcatel-Lucent Open Days in 2009 and 2011). A preindustrial prototype then showed that this approach would save up to 50% of the regeneration equipment. Two joint Alcatel-Inria patents were taken about this work [19, 20], but publications are frozen.

Autonomic graceful shutdown and restart. This topic emerged as an avatar of our activities about minimal impact maintenance operations (where we suspected our investment in planning techniques could be recycled [25]). It corresponds to part of Carole's PhD work. OSPF routers now have a forwarding hardware separated from their other route computation functions. Routers can thus be left in the routing plane while they are rebooting or upgrading... as long as the network topology does not change, which could cause routing loops and black holes. In that case, the frozen router must be withdrawn from the routing plane, whence the burden of an OSPF convergence. We have proposed an algorithm that checks whether a frozen router is dangerous to the forwarding of packets, and in that case that compute a minimal set of temporary patches to correct the dangerous routes. These results are being patented.

Joint network and service active diagnosis in IMS. The diagnosis problem remains a central issue in network management, and, despite numerous contributions, no satisfactory approach has prevailed. We decided to resume research on this topic by focusing on two new aspects. The first one concerns the automatic model construction (self-modelling) which is central if one aims at large scale alarm correlations, taylored to a specific network instance. For simplicity, we have chosen to consider a network as a static system, and to focus on the modelling of large scale resource dependencies, capturing the physical, functional and service layers, as well as the core and acces networks. This model has two essential features that we try to capture: it is hierarchical, and generic, that is made of numerous instances of a limited number of patterns. The second novelty concerns the nature of the monitoring algorithms. We consider active diagnosis algorithms, that build a model of a limited part of the network to explain a given observed malfunction, and

progressively extend and refine it, collecting more observations and performing tests. This is still ongoing work, that corresponds to Carole's PhD.

On-line detection of congestion and failure in networks using max-plus techniques. This is part of a larger objective that concerns the analysis of network stability or robustness to some changes in protocol parameters. This work has taken OSPF as a case study of protocols that need to regularly broadcast information. A first study has considered anomaly detection in such protocols, by examining the stability of the arrival rates of messages; fast and robust change detection schemes have been proposed (patent in preparation). A second study analyzes the effect of flooding in such protocols, in particular on the load of routers, for a given network topology. The objective is to find the adequate tuning of the protocol parameters that would not put the network at risk [8].

2.5.4 Competition and Collaborations

Network management problems are traditionally addressed by Artificial Intelligence techniques, and specifically by what one could call "blind methods" such as neural networks, self-organizing maps, case-based reasoning, expert systems, data-mining, etc. Our positioning in favor of model-based methods, combined with a background in formal methods for distributed systems and in distributed algorithms is still original.

The main collaborations on these topics took place within the *High Manageability* group (2008-2012) of the joint research laboratory of Alcatel-Lucent and Inria, dedicated to self-organizing networks. This group finances both Carole's and Aurore's PhD theses. We have tight contacts with them, including cross visits and several 1 or 2 weeks stay of our students in Villarceaux (Bell Labs France). The publication record is still low, however, due to a preference of our industrial partner for patent registration. The results on optical network management have not yet been disclosed; Alcatel still considers including such features in some equipment. Since Sept. 2010 where we joined the UniverSelf IP, we have revitalized our activities on model-based diagnosis by close contacts with Orange Labs.

2.5.5 External support

1. European Integrated Project *UniverSelf*: Sept. 2010 - Sept. 2013
2. *High Manageability* contract with Alcatel-Lucent: Dec. 2008 - Oct. 2012

2.5.6 Self assessment

Regarding the above topics, we have tight contacts with well identified industrial problems, and the group has a wide background of techniques to address them, ranging from different modelling formalisms for static or dynamic distributed systems (Petri nets, Bayesian networks, network calculus,...), as well as distributed monitoring algorithms (optimization, state estimation and diagnosis, planning,...). In network management one can notice a trend towards problems involving quantitative aspects, and still advocating distributed solutions. Many problems are also of closed-loop nature, which we have not much explored so far, but that we see as new opportunities.

The difficulties we may face have several aspects. One concerns the rapid evolution of telecommunication technologies, that are an obstacle to long term developments. For example, the diagnosis problem, at large, has been present for years in different forms, but little effort is made on the industrial side to really invest in its adequate resolution. Short term and off the shelf solutions are often preferred. We also rely much on our industrial

contacts to identify the most relevant problems, since none of us in the team has a network management research profile. Few of us invest in following these technologies, that are somehow aside of our main focus on formal methods.

2.6 Objective Composite Web services, document based workflows, and QoS

2.6.1 Personnel

Permanent researchers: Albert Benveniste, Claude Jard, Blaise Genest, Loïc Hélouët

PhDs: Sidney Rosario, Ajay Kattepur, Debmalya Biswas

Post-Docs: Shaofa Yang, Benoit Masson

2.6.2 Project-team positioning

When it was launched in 2004, DistribCom focused on telecommunication networks and services management—it is still contributing to these areas. However it came soon to us that our modeling and algorithmic techniques applied as well to wide area services deployed over the Web. In 2005 we started two research directions in this area: 1/ QoS aware management of composite Web services, and 2/ document based Web services and workflows.

Unlike in networks, routing in composite Web services can be data-dependent. Orchestration languages such as the industrial standard BPEL offer primitives for sequencing, parallel calls, merge of returns, and data-dependent if-then-else. This make the study of performance and QoS very different from that of networks. Composite Web services can be *non-monotonic* with respect to QoS or performance, in that a called service improving its performance may result in a degradation of end-to-end QoS of the composite service. Also, QoS has many dimensions (throughput, latency, availability, security, cost). Finally, due to numerous hidden effects in the infrastructure (communication media and servers), QoS is subject to significant uncertainties and is best captured by probabilistic frameworks. We have developed a framework of *probabilistic contracts* for multi-dimensional QoS in monotonic composite services, with associated end-to-end QoS evaluation/optimization and QoS contract monitoring. We have developed criteria ensuring monotonicity and techniques to handle the lack of it. This, as we believe, is a rich and original contribution to the QoS aware management of composite Web services—so far the issue of monotonicity has been mostly ignored by the community of Web services.

Web area services and workflows are now central in consumer and business services. They involve a mix of complex data and workflows in a balanced way. Still, these two aspects are handled today using separate technologies, namely data bases and business orchestration languages. We started in 2005 an exploratory cooperation with the team of Serge Abiteboul (a leader in the data base community) regarding *Active XML* documents, extension of XML which allows enriching documents with service calls. This cooperation lasted for six years and led to the autonomic infrastructures of *Guarded* AXML documents, *Distributed* GAML documents, and finally, to the concept of *document based workflow* (DbW), a declarative formalism for wide area distributed services and service interfaces blending semi-structured data and workflows in a unified framework.

Our current developments involve a proof of concecpt platform for DbW and its integration with the Orc language for orchestrations, a clean alternative to BPEL developed by the group of Jay Misra at the University of Texas at Austin.

2.6.3 Scientific achievements

QoS aware management of composite services: Quality of Service (QoS) is becoming increasingly important in a world of services. Services are offered with commitments regarding what they can do (the function) and how good they can do it (the QoS). Such commitments are exposed in the interface of the service as part of its Service Level Agreement (SLA).

In QoS aware management, it is implicitly assumed that, if a service taking part in an orchestration improves its performance, then so does as a consequence the orchestration itself. We proved in [9] that this assumption of *monotonicity* is not true in general, thus impairing most usages regarding SLA and QoS issues for the—non exceptional—cases where this assumption is violated. In the same reference, we gave necessary and sufficient conditions for monotonicity to hold, for the case of latency. Monotonicity for the case of general and multi-dimensional QoS, under both deterministic and probabilistic QoS frameworks for QoS, is submitted for publication. This body of results is under implementation on top of the Orc tool, jointly between our PhD former student and student Sidney Rosario and Ajay Kattepur, and John Thywissen, a researcher from the Orc team at UT Austin.

A number of lesser important side results have also been published: [33] studies the modeling of variability in QoS for services orchestrations; [34] proposes efficient methods for pairwise testing of services; [32] proposes efficient methods of optimizing decisions in web services compositions; [31] proposes using rare event simulation techniques for end-to-end QoS evaluation.

Web services and document based workflows: Our direct contribution to the topic of Active Documents consisted in: 1/ making the role and effect of distribution explicit in AXML, and 2/ proposing an abstract model of Active Documents able of specifying workflows [28]. This contribution was developed in several steps. In Distributed AXML [27] we defined *interfaces* for Active Documents and clarified the distinction between local and distant service execution. Reachability issues (will a service eventually return an answer?) were addressed in [37, 36], where conditions were given ensuring it. By abstracting away non-essential features of XML pattern matching, we simplified the above frameworks and proposed the model of *DocNets*. DocNets are dynamic Petri nets where places are typed and transitions are guarded by computable type transformations. DocNet modules compose well, and if their closure by type transformation is finite, reachability of the composition is decidable [37]. We believe DocNets are a valuable contribution and we aim at further developing them.

Jointly with the team of Anca Muscholl, we also studied the alternative formalism of *Tree Pattern Rewriting Systems* (TPRS), a flexible model of dynamic documents in which XML pattern matching is abstracted. TPRS systems generate infinite transition systems, where states are unranked and unordered trees. It is shown in [23] that reachability is decidable in TPRS. This has been extended in [24] to include URL specifications.

Within the context of the DST associated team, we have proposed a new paradigm of *Web services sessions*. The current trend, as in BPEL, is to associate a unique identifier to each session. Our formalism allows designing systems that use sessions without the obligation to provide identifiers. The formalism has the expressive power of reset Petri nets, for which coverability is decidable. This is sufficient to decide whether a set of agents can be in some bad configuration during the lifetime of a system. This joint work with Ph. Darondeau from the S4 Team, and with M. Mukund from the Chennai Mathematical Institute led to a publication in the ATVA conference [16].

In 2011, we have developed a *proof-of-concept platform* to test the DAXML architecture proposed in [27]. The prototype was developed by B. Masson during his post doc and by L. Hélouët. The platform is composed of four mini-dell machines running under Linux, and connected to Inria-Rennes' network. So far we have developed small applications, mainly distant database queries. We plan to design larger applications with the native AXML specification, but also to extend the prototype with new features, such as arithmetic operators to avoid the cumbersome task of encoding every manipulation as a sequence of rewritings. From a longer perspective, we will try to mix DAXML and Orc, as it will offer a nice blending of declarative and imperative styles of programming, for large applications.

2.6.4 Competition and Collaborations

The competition is widely spread and no obvious academic leadership emerges on Web services. The academic leader on business processes is the team of Wim van der Aalst. Major conferences include ICWS (the major large event on Web services) and BPM (on Business Processes); the topics are also addressed by many conferences in software engineering and some conferences in formal methods (WS-FM, Petri Nets, Concur). Some second rank journals are devoted to Web services (we do have publications there) but the most selective journal in the area are the *IEEE Transactions on Software Engineering*. On the other hand, the industrial sector of services orchestrations and business processes is strongly dominated by IBM and SAP. The data base community also addresses services orchestrations, with Richard Hull from Microsoft and Victor Vianu from San Diego being most visible. Serge Abiteboul has made his proposal of AXML documents visible in this community.

On the topic of QoS-aware management, we have an ongoing fruitful cooperation with the Orc team, headed by Jayadev Misra at the University of Texas at Austin, which has developed the Orc language to support orchestrations. The two teams cooperate since 2006 and have decided to join their efforts in launching the Inria associated team FOSSA.[2] Our research track on Active Documents was born from deep exchanges with Serge Abiteboul and benefited from sustained interactions with him and Anca Muscholl. Our long and tight cooperation with Singapore-Chennai teams within the framework of the Inria associated team DST resulted in the development on Web services sessions.

2.6.5 External support

1. ANR-DocFlow (analysis, monitoring, and optimization of Web documents and services), 2006-2009, jointly with the Gemo team of Serge Abiteboul at Inria-Saclay and the team of Anca Muscholl at CNRS-Labri, Bordeaux.

2. CREATE grant of Région Bretagne ActiveDoc (Active Documents), 2006-2010, involving DistribCom only.

3. Associated team DST, Distributed Supervision and Time, involving DistribCom and S4 teams at Inria-Rennes, the National University of Singapore, and two institutes in Chennai, the Chennai Mathematical Institute and the Institute for Mathematical Sciences, 2007-2011.

4. Associated team FOSSA, Formalizing Orchestration & Secure Services Analysis, involving DistribCom and the Orc team at the University of Texas at Austin, 2009-2012.

[2] http://www.irisa.fr/distribcom/FOSSA2010/index.htm

2.6.6 Self assessment

We have come up with a comprehensive theory of QoS aware management of service orchestrations, and more generally composite services. We believe our contract-based, monotonicty aware approach for dealing with QoS is deeply novel and important, and we have submitted a joint paper (with UT Austin) to the IEEE Transactions on Software Engineering, which is currently under revision. Our visibility in the Web services community is still medium, however. This is due in part to our different background—Web services community is dominated by either software engineers or people from AI. This is also due to a lack of software for dissemination—development of our framework on top of Orc is still ongoing.

Our work on Document Based services and workflows is also a right and important track, due to its relevance. So far we have been able to publish this work in our core community of formal methods (ATVA, Petri nets, WS-FM) and in the Web services community (ICWS) but we did not succeed in publishing in the data base community—in contrast to Serge Abiteboul on the same area. Again, we hope that the development of our proof-of-concept platform will help improving this situation.

Overall, we have heavily invested in an area that was totally new for us. We believe we now have valuable assets and we think it is now timely to create some bandwidth with relevant industrial sectors, particularly business processes.

3 Knowledge dissemination

3.1 Highlights

We have taken the liberty to add this section. The reason is that we do not see appropriate places in the current structure where we could develop this. We see a few important facts that, as we think, demonstrate the visibility of our team. We list them now:

- We see our involvement in the ALU-BellLabs/Inria common Lab as central to our team. Our joint research has resulted in two patents (optical networks) and two more patents under internal processing at BellLabs (autonomic management). Eric Fabre, from our team is heading the Action de Recherche (ADR) on High Manageability, which served as a seed for IP-Univerself. Albert Benveniste is scientific director of the Common Lab and operates it with Olivier Audouin from BellLabs, who is managing director.

- Our team actively participates to the CominLabs *Laboratoire d'Excellence*[3]—Labex. Labex are an important chapter of the program *Investissements d'avenir* of the French government. CominLabs is, so far, the only Labex selected that has software as its core area. Albert Benveniste is Scientific Director of CominLabs and Dominique Massaloux, Telecom Bretagne, is Operational Director. CominLabs gathers labs from Bretagne and Nantes in areas ranging from electronics to software in telecommunications and the Web; it has been granted of a 10-year annual funding, with a starting amount of 1.4M Euros for 2011. A major project of CominLabs is its information system and social network CominWeb/CominTogether, which is within the research activities of the team.

- Claude Jard is Director of the Research at ENS-Cachan Bretagne (Collège de recherche Hubert Curien).

[3] http://www.cominlabs.ueb.eu/

- Albert Benveniste has been granted with the 2008 Grand Prix France Telecom of the French Academy of Sciences. He has been elected in 2011 to the French Academy of Technologies. He is member of the Scientific Councils of France Telecom and Safran Group (the latter relates to his research activity in S4 team on embedded systems).
- We are or have been involved in ANR grants that were or are best ranked (DOTS, programme "blanc" Impro).

3.2 Publications

	year 1	year 2	year 3	year 4
PhD Thesis	1	2	-	1
H.D.R (*)	1	-	-	-
Journal	8	2	2	2
Conference proceedings (**)	14	13	17	7
Book chapter	1	1		2
Book (written)	-	-	-	-
Book (edited)	1	1		
Patent				2 (+2)
General audience papers				
Technical report	4	4	-	3
Deliverable	2	1	-	1

(*) HDR Habilitation à diriger des Recherches
(**) Conference with a program committee

Indicate the major journals in the field and, for each, indicate the number of papers coauthored by members of the project-team that have been accepted during the evaluation period.

1. Theoretical Computer Science: 2 ([1, 22])
2. Information Processing letters: 0
3. Fundamenta informaticae: 1 ([35])
4. Information and Computation: 1 ([14])
5. IEEE Transactions on Software Engineering: 0
6. IEEE Transactions on Automatic Control: 0

Indicate the major conferences in the field and, for each, indicate the number of papers coauthored by members of the project-team that have been accepted during the evaluation period.

1. FOSSACS: 2 ([13, 2])
2. ICALP: 0
3. STACS: 0
4. CONCUR: 2 ([15, 3])
5. TACAS: 0

6. ASE: 0
7. ICSE: 0
8. FASE: 0
9. Petri nets: ([9, 11])
10. IEEE-CDC: ([17])
11. ICWS: 3 ([39, 33, 28])

3.3 Software

SOFAT toolbox for scenario models: The SOFAT toolbox is a scenario manipulation toolbox. Its aim is to implement all known formal manipulations on scenarios. Among practical applications of the toolbox, we have implemented model checking algorithms (that can be used to check is a scenario specification is correct) and scenario based diagnosis. The SOFAT toolbox is permanently updated to integrate new algorithms. It is freely available from Distribcom's website[4]. SOFAT has also been used as a demonstrator for all our proposals in standardization committees at ITU. This involvement in standardization was also the occasion for numerous contacts with MSC users (France Telecom, Nokia, Motorola), but also with CASE tool designers at IBM. Up to now, 4 successive versions of SOFAT have been released. In the 2007-2010 period SOFAT has been extended with model checking and diagnosis functionnalities, and an automatic code synthesis for web-based architectures is under implementation.

There are several scenario-based university tools (MSCAN in Marseille, but up to now, SOFAT is the most complete scenario toolbox. Furthermore, many of them do not comply with the standard semantics of Message Sequence Charts, hence limiting their usefulness as specification/verification tool. Our most serious competitors were the UBET tool, developped at Bell-Labs, but this tool does not seem to be maintained anymore, and the Play-in/Play-out engine, developped by D. Harel's team (with a different semantics). Many UML case tools allow to model finite scenarios, but high-level scenarios are usualy not considered, hence limiting the practical use of such models to use cases documentation. We have tried to transfer our tool via a small company called Pragmadev, but this transfer failed. SOFAT was used as a specification design tool during a project with France Telecom from 2004 to 2006, but othewise remains an academic tool. The download page is frequently visited but mainly by university members.

A new REST-based service platform for documents and orchestrations: building on top of our experience with Serge Abiteboul's AXML platform,[5] we started in 2011 the development of a REST based proof-of-concept platform for document based services and workflows. This ongoing effort will benefit from a Carnot post-doc grant that our team won.

3.4 Valorization and technology transfert

Our main transfer activities take place within the joint research team High Manageability (common lab ALU BellLabs - Inria). A first transfer concerns the use of distributed

[4] `http://www.irisa.fr/distribcom/Prototypes/SOFAT/index.html`
[5] `http://webdam.inria.fr/axml`

algorithms to optimally tune photonic networks (two common patents). A deeper evaluation of the first prototype was performed on Alcatel's side to estimate the potential gains of this approach, and it resulted positive. This work has assessed the relevance of distributed algorithms to manage large networks, and has reinforced the motivation for a use-case based exploration of the self-management concept. This approach was later adopted to structure the UniverSelf IP. Two other transfers are in progress (patents being registered). One concerns the graceful shutdown and restard of OSPF networks, the other one the early detection of changes in the behavior of protocols based on broadcast.

3.5 Teaching

Because of its composition, Distribcom has forged ties with the computer science department of the ENS Cachan in Rennes.

C. Jard is a full-time professor at the ENS Cachan and teaches mainly at the undergrade and Master levels, in Computer Science and Telecom, and in Maths (2 courses per year: Formal Languages, Algorithmics, Networks). He supervises the third year of the cursus (the research master's degree). He is also in charge of the competitive examination for the entry of new students in computer science in the French ENS schools.

A. Bouillard (until Sept. 2010) was a full-time assistant professor at the ENS Cachan in Rennes. She teached Formal Languages and Algorithmics, especially in the preparation of the "aggrégation".

E. Fabre taught "information theory and coding" at the ENS Cachan Bretagne in the computer science and telecommunications Master program (15h/y). He also taught "numerical and combinatorial optimization," (12h/y) and "distributed algorithms and systems" (9h/y) in the computer science Master program at the University of Rennes 1.

L. Hélouët taught algorithmic techniques (8 h/y) to students of ENS Cachan in Rennes who are preparing the aggregation. He was also Involved in the ISN project, which aims at giving an introduction to computer science and programming to teacher in undergraduate classes.

A. Benveniste does not teach.

Teaching activities of G. Aucher and F. Schwartzentruber are not reported here.

3.6 General Audience Actions

Eric Fabre gave a plenary address at the first joint INRIA-Bell Labs workshop on the "Fundamentals of Communications and Networks," Murray Hill, June 1-2, 2009. Together with Pierre Peloso (Alcatel-Lucent), he presented a demo of the DOBLIN software prototype (Distributed Optimal Balancing of LIght in photonic Networks) during the Alcatel-Lucent Bell Labs Open Days, June 1-5, 2009, and Sept. 29, 2011.

3.7 Visibility

Major elements of our visibility are found in the special section 3.1 collecting *highlights*. Other elements are listed next.

Albert Benveniste: Until 2009, A.B. was associated editor at large (AEAL) for the journal *IEEE Transactions on Automatic Control*. Until 2011, he was member of the Steering Committee of the *International Journal of Discrete Event Systems and its Applications* (JDEDS). He is member of the Strategic Advisory Council of the Institute for Systems Research, Univ. of Maryland, College Park, USA. He is president of the Scientific Committee of the *Joint Bell Labs INRIA Laboratory*. He is member of the Scientific Council of France Telecom and of Safran group (relevant to his participation to S4 team). He is Scientific Director of the *CominLabs* excellence center (Labex). In 2011, he has been elected to the French Academy of Technologies.

Eric Fabre: E.F. was Associate Editor for the *IEEE Transactions on Automatic Control* from 2008 to 2011. His term at the Evaluation Commission of INRIA ended in 2008. He served in several committees for the hiring of young researchers (INRIA 2008 and 2010, ENS Cachan 2007 and 2008, University of Rennes 1 in 2011). He was PC member of DX'08 and ACSD'10, and in the PhD committee of Jingxian Zu in 2011 (Bordeaux University). In 2011, E.F. was appointed as academic expert for submissions to the CIR national program (support of research activities in private companies).

Blaise Genest: B.Genest is an elected member of the Comité National de la Rercherche Scientifique, sections 07 (computer science) and 43 (bioinformatics), for 2008-2012. He was PC member of ICE 2008.

Loic Hélouët: L. Hélouët has been member of the program committee of SAM, SDL conferences, and of the DOTS workshop, affiliated to CONCUR. In 2013, He will be Co-organizer (with H. Marchand, Vertecs team) of MSR'2013 (Modélisation des Systèmes Réactifs) in Rennes. He was member of the PhD jury of C. Meuters (Bruxelles), G. Benattar (Nantes), and M. S. Alvim (Ecole Polytechnique). He was chosen as expert for the evaluation of a collaboration proposal by the CFQCU (Conseil franco-québécois de coopération universitaire) in 2011.

He was the coordinator for two associated teams, namely CASDS (2007-2009) and DST (2009-2011) between Rennes, the National University of Singapore, INRIA Rennes, National University of Singapore, the Chennai Mathematical Institute and the Institute for Mathematical sciences in Chennai. He was invited in 2011 to contribute to the LIA "Informel" between CNRS and several institutes in Chennai. He was co-rapporteur at ITU for the question 17 on MSC language from 2006 to 2011. He contributed to the correction of the current version of Z.120 (standard document on Message Sequence Charts published by the International Telecommunication Union), and published an appendix on formal use of MSCs for this standard. He contributed to GROLO, a working group on the evaluation of softwares at INRIA (2008), and from 2009 to 2010, he was a member of the working group for international relations in the scientific orientation council of INRIA (COST-DRI). This group is responsible for the evaluation of applications to international programs (STIC Tunisie, AYAME Japan, ERCIM Post-docs) and to INRIA's associated team program.

Claude Jard: In the period, C. Jard has been member of the Program Committees of the following international conferences: ICAPTN, ROGICS, FORTE, NOTERE, MOVEP, FORMATS, A-MOST, Concur/Wdots. He is also member of the editorial board of the *Annales des Télécommunications* and the steering committee of MSR series of conferences. C. Jard supervises a CNRS national transverse program on formal approaches for embedded systems (AFSEC).

C. Jard is the director of the research of the Brittany extension of the ENS Cachan (director of the pluridisciplinary institute called the Hubert Curien Research College). Until 2009, he was member of the board of directors of the ENS Cachan. He is member of the scientific council of the European University of Brittany and member of the executive board of the CominLabs. He is expert of the AERES, the national evaluation agency and expert for the French ministry of research. He has also served as an expert in several programs of the french ANR and for scientific programs in Canada. He was recently nominated to the National Council of Universities (CNU).

In the period, C. Jard was president of the PhD jurys of T. Turpin, S. Sen, F. Bonnet, N. Le Scouarnec (Rennes 1), J. Haillot (Vannes), V. Gripon (Telecom Bretagne), L. Paulevé (Ecole Centrale Nantes), S. Brault (Rennes 2), and of the habilitation jury of P. Niebert (Marseille) and A. Gotlieb (Rennes 1). He was reviewer of the PhD thesis of T.Q. Tran (Bordeaux), L.-M. Traonouez (Nantes), A. Degorre (Grenoble), N. Snzajder (ENS Cachan) and of the habilitation of S. Graf (Grenoble).

4 External Funding

Indicate the budget allocated to your project-team in keuros. TBR

(k euros)	year1 (2008)	year2 (2009)	year3 (2010)	year4 (2011)
National initiatives				
RNRT Politess	0	-	-	-
ANR Docflow	56	56	19	-
ANR Dots	27	27	27	27
CREATE ActiveDoc	50	63	63	41
ANR Impro	-	-	-	30
ANR Pegase	-	-	0	0
European projects				
EU-FP7 STREP DISC	-	67	67	67
EU-FP7 IP UniverSelf	-	-	-	90
Associated teams				
CASDS	12	-	-	-
PHC FAST	5	5	-	-
DST	-	19	15	10
FOSSA	-	-	-	15
Industrial contracts				
High Manageability	8	0	33	82
Scholarships				
PhD ENS Cachan	-	1 (4pm)	2 (16pm)	2 (24pm)
PhD MENRT	2 (20pm)	1 (6pm)	-	-
Post Doc*	-	-	-	-
AI+	1 (9pm)	-	-	-
ODL#	-	-	-	-
Total	158	237	224	362

† Inria Cooperative Research Initiatives
‡ Large-scale Initiative Actions

∗ other than those supported by one of the above projects
+ junior engineer supported by Inria
# engineer supported by Inria

National initiatives

RNRT POLITESS (Sept. 2005 - Sept. 2008). In cooperation with GET, Vasco team of INPG/IMAG, INRIA team Vertecs, France Telecom R& D Caen, Leirios Technologies, SAP Research, Silicomp-AQL, DCS team of VERIMAG. The objective was the study of metholodologies ensuring the conformance between high-level security policies, their deployment, their test and their monitoring. Only Loïc Hélouët participates, budget handled by the Vertecs team.

ANR Docflow (Jan. 2007 - Apr. 2010). In association with INRIA team GEMO, and the LABRI/Bordeaux. The aim of Docflow was to model, analyze and monitor real life composite web services. It builds on the understanding between the Database community (data centric views) and the Discrete Event community (control centric), brought by the past ARC ASAX meetings. The objective was to understand how to model and monitor workflows based on active documents.

ANR Dots (Jan. 2007 - Dec. 2011). In cooperation with LSV/ENS Cachan, LABRI/Bordeaux, LAMSADE/Paris Dauphine and IRCCyN/Nantes. The project focused on open systems (that is interacting with other undefined systems) which were distributed and required timing information, in order to analyze concrete systems without abstracting one of these aspects. Distribcom was in charge of the interaction of distributed systems with timing aspect (as timed Petri nets) or openness (as distributed controllers and distributed games).

CREATE ActiveDoc (Feb. 2007 - Aug. 2011). Funded by Region Bretagne, and supporting the ANR Docflow. It extends the latter to the study of quantitative aspects of Web Services, in particular related to the notion of Quality of Service. The composability of QoS contracts has been examined, and the important notion of probabilistic contracts has been raised.

ANR Pegase (Oct. 2009 - Oct. 2012). Partners are ENS Lyon, the Mescal team of INRIA Rhône-Alpes, Thalès, ONERA and RT@W. The aim of Pegase is to develop the theory of Network Calculus and study the applicability to embedded networks (SpaceWire, AFDX). Only Anne Bouillard participates, budget driven by the Mescal team.

ANR Impro (Mar. 2011 - Feb. 2014). Partners are IRCCyN (Nantes), LIP6 (Paris), LSV (Cachan), LIAFA (Paris) and LIF (Marseille). The coordinator is Didier Lime from IRCCyN. It mainly adresses implementability of scenarios and Time Petri Nets, focusing on concurrency aspects.

Laboratoire d'Excellence CominLabs (June 2012-June 2022).[6] To foster research and innovation at highest international level, the french government has launched the program "Investissements d'Avenir". As part of the former, the program "Excellence Centers (Labex)" is assigned 1 billion Euros in capital, for a 10 years period. The CominLabs are an initiative selected as part of the "Labex" program by the French ministry of research and education. It has been assigned 40 Million Euros in capital,

[6] http://www.cominlabs.ueb.eu/

resulting in an effective annual funding of 1.4 Million Euros for a 10 year period. The CominLabs has been the only Labex selected in the area of software sciences. The CominLabs[7] federate the best teams from Bretagne and Nantes regions in the broad area of telecommunications, from electronic devices to wide area distributed applications "over the top". The scope of CominLabs covers research, education, and innovation. While being hosted by academic institutions, the CominLabs build on a strong industrial ecosystem made of large companies and competitive SMEs. Albert Benveniste is Directeur Scientifique of CominLabs. No specific funding is alloted to DistribCom, so this contract is not listed in the table.

European projects

EU STREP DISC (Sept. 2008 - Dec. 2011). Distributed Supervisory Control of Large and Complex Plants. The main collaborations of DistribCom were with LSV/ENS Cachan, the University of Cagliari (Italy), the CWI (Amsterdam, NL), Ghent University (Belgium), the Czech Academy of Sciences (Czech Republic). Distribcom contributed with distributed optimal planning methods, and with the devopment of distributed probabilistic observers and diagnosers.

EU IP UniverSelf (Sept. 2010 - Sept. 2013). UniverSelf is led by ALU-Bell Labs, in particular the people involved in our joint team HiMa. It gathers 18 of the most significant teams in Europe dealing with autonomic networking. Its objective is to bring to maturity some selected autonomic functions, covering configuration, optimization, diagnosis, healing, control, security, etc. The work is organized around an evolving set of use-cases, and will aim at designing a universal management framework for autonomic functions. DistribCom is involved in a use-cases related to self-diagnosis and self-healing for networks and services.

Associated teams and other international projects

CASDS (2006-2008). Associated team with the National University of Singapore. Control, Analysis and Synthesis of Distributed Systems. The main research theme was the control and diagnosis of distributed communicating systems. Two application areas were targeted: real-time embedded systems and telecommunications systems and services. Although very different in nature, both areas make fundamental use of models of concurrency. Several types of formal models are considered: scenarios, languages, communicating automata and Petri-nets.

PHC FAST (Jan. 2008 - Dec. 2009). Collaboration with the NICTA, Canberra, in association with INRIA's S4 team, and funded by the French Ministry of Foreign Affairs. For the DistribCom part, the aim was to design modular planning algorithms, taking advantage of formalisms capturing concurrency. This has started our activities in optimal planning.

DST (2009-2011). Distributed systems, Supervision and Time. This is follow-up of the associated team CASDS, still with the National University of Singapore, and an extra partner, the Institute for Mathematical Sciences in Chennai. It also involved members of the S4 INRIA team. The main research theme was the study of supervision and time issues in distributed systems, with the help of concurrency models. Main contributions on the distributed control of concurrent systems and the problem

[7] http://www.cominlabs.ueb.eu/

of synthesizing small controllers, quantitative aspects of timed distributed systems, and qualitative verification of timed constrained concurrent models.

FOSSA (2010-2011). Formalizing Orchestration & Secure Services Analysis. Associated Team INRIA-University of Texas at Austin. The Orc team, led by Jayadev Misra at UT Austin, has developed the Orc language to support orchestrations of Web Services, in view of automating the composition of business processes and workflows. DistribCom is developing a theory to model, analyse and monitor the QoS aspects of such composite services expressed in Orc.

Industrial contracts

ALU-BellLabs / Inria Common Lab (since January 2007). This common lab is a follow-up of the successive framework agreements set since 1997 to structure joint research programs between the two partners. It gathers teams from both sides. The research is organized into Actions de Recherche (ADR). Three of them have been launched for the first period 2007-2011: Self-Organizing Networks, Semantic Networking, and High Manageability. The common lab is jointly headed by Olivier Audouin (ALU-BellLabs, managing director) and Albert Benveniste (Inria, scientific director). The total amount spent by ALU for the 4-year period is 2.5 MEuros.

High Manageability (HiMa) (June 2008 - Oct. 2012). Research Action (ADR) hosted by the common research laboratory of Alcatel-Lucent-Bell Labs and INRIA. HiMa is lead by Pierre Peloso (ALU-BellLabs) and Eric Fabre (DistribCom-Inria). It also involves the Madynes team (INRIA Nancy), and 5 persons of the Packet Transport Infrastructure group on Bell Labs side. The aim was to desing distributed approaches to address a selection of self-management problems, in particular the optimal tuning of photonic networks, and the organization of maintenance operations with minimal service disruption. Most of the activity of this group is now hosted by the UniverSelf project. This contract funded 2 PhDs on DistribCom's side.

5 Objectives for the next four years

Due to time bounds for the existence of a team, major joint restructuring of several teams is expected to occur this year 2012. This restructuring will involve DistribCom together with several of its neighbours in the areas of software and embedded systems.

DistribCom has consistently insisted focusing on the telecommunications and services sector, which motivated its positioning within the *networking* program. However, the gap between the core skills of teams in this program and the skills of DistribCom made evaluation consistently uneasy. Therefore, it is already agreed that the researchers of DistribCom will move to another program, while keeping the telecom sector in their focus.

Since the new geometry of the concerned group of teams is yet to be determined, we are not presenting here the research plans of the future team. Instead, we collect here a brief description of the individual research plans for each permanent researcher of DistribCom. These plans are organized according to alphabetic order.

Guillaume Aucher: Guillaume plans to develop further his theoretical work on (dynamic) epistemic logic and in particular its application to fault localization in IMS network. The algorithmic part of the theory will be developped much further in order to prepare the practical implementation of the theory under the form of a prototype. In that respect, he hopes to work with Eric Fabre (and François Schwarzentruber)

even more closely on this topic. Second, he plans to invest more of his research time on one of the "seed" activity, that is the use of logic at the level of interfaces in order to specify policies. A third research track concerns the formalization of legal texts in logical terms (there is a starting collaboration with the Cour de Cassation on one of their projects). The ultimate goal of this third research track is to provide lawyers with software tools to assist them. Although these last two research tracks seem quite different in terms of application, the theoretical work needed to address them is rather similar. Therefore, it is likely that they overlap and interact at some point.

Albert Benveniste: Albert must retire in 2014 at latest—he plans to apply for an emeritus, though. Consequently, he is not running for staying as a head of a team. He is not taking part in the discussions for restructuring the area. Still he has his own research agenda. Regarding the topics developed in DistribCom, he plans to maintain his research track on QoS of composite services and Document Based workflows (jointly with Loïc Hélouët and Claude Jard). Effort will be targeted toward getting a good contact with an industrial of the sector (IBM-Ilog?) to transfer results and ideas. Also, Albert is convinced of the importance of the self-modeling paradigm; he will remin involved in that topic, jointly with Eric Fabre. Albert will maintain for at least 3 more years his scientific direction of the Labex CominLabs. He will be personally involved in the CominWeb/CominTogether project of innovative governance for this cooperative project. The objective is to run the Labex as a professional Social Network using an innovative Web based platform. The background in services acquired within DistribCom will be an important asset in doing this research. In parallel, Albert will continue his participation in the Scientific Councils of FT and Safran. Related to his other part time scientific activity, Albert plans to write a book on Synchronous Programming and Embedded Systems development, jointly with some colleagues.

Eric Fabre: E.F. plans to further explore the potential of formal methods to design innovative *network management* solutions. This application domain is urgently demanding new solutions and paradigms to manage increasingly complex systems that are already beyond human capabilities. We believe that self-management is a strong trend that will broaden its scope to most aspects of network monitoring, ranging from observational tasks (intelligent dashboards, diagnosis, verification) to closed-loop aspects (optimization, healing, control, balancing, planning, reconfiguration,...). And it is likely that blind methods based on learning techniques will not scale up with sufficient accuracy. To support these objectives, it is planned to reinforce the core background of this activity along two main research directions.

Concurrency in models is important, yet it must be enhanced with quantitative aspects such as *costs, probabilities*, and *time*. Progresses are needed towards a better understanding of *distributed knowledge*, and how communications modify it. Tools like information theory and epistemic logics seem good tracks to follow. The background in distributed algorithms must be reinforced. The team has a unique positioning in this field, and we believe that the management of large systems will strongly rely on distributed approaches. The efforts will concern the extension of the existing skills from diagnosis and planning towards *closed loop* aspects (distributed optimal control). A key issue is to model and understand the effect of communications in the control of concurrent systems. An opening to game theory seems necessary to capture multi-objective problems, open systems, or independently managed domains. Finally, we must understand how to design algorithms that adapt on

the fly to systems that are instrinsically hierarchical (so they can be considered at different degrees of abstraction), and that dynamically change their structure.

A last track concerns the *self-modeling* approach. We are convinced that model-based approaches can provide more powerful management methods, tailored to a given network instance. To make this feasible, we need techniques to instantiate on the fly the small part of the (possibly huge) model that is necessary and sufficient to a given task. We need to reinforce this approach.

Blaise Genest: Blaise Genest plans to return to Rennes in 2013. He will pursue its recent effort in the study of decidability and complexity for distributed and quantitative models, with two main focus. The first focus is the study of *timed distributed* models. Obtaining (reasonably fast) algorithms in the presence of both time and concurrency is challenging, as time messes up with Partial Orders, which forbids to apply partial order reductions directly as done with untimed systems. The second focus is the study of *distributed stochastic* systems. On the one hand, randomization is necessary to specify some important behaviors. It also allows to implement systems which cannot be deterministically implemented otherwise. On the other hand, it asks for more involved algorithms, that can hardly scale up. One way to cope with large systems will thus be to design new approximate algorithms with monitored error bounds. This will be particularly useful for analyzing biological systems, which Blaise Genest is studying during his stay in Singapore. At last, he will use the expertise aquired in the scope of ANR project DocFlow for the topic of security for web services, jointly with several members of DistribCom.

Loïc Hélouët: Loic proposes to extend and reinforce his research on Web services and active documents. Recent work has established the building blocks for further work. A QoS framework for Web services and orchestration has been proposed by DistribCom [38]. The team has gained experience in declarative frameworks and data driven workflows, starting first from Active XML [27, 36], subsequently extended to the distributed models [37]. In this line of research, focus has been on document-based systems, that is systems composed of communicating machines that maintain and update semi-structured data (via rewriting rules). Loic started the development of an experimentation platform for Web-Services and plans to further invest on it. Plans for the next 5 years include the study of *declarative and distributed composite service frameworks*. In particular, one of the objectives is to study the formal properties and practical applications of models based on the concepts of *communicating rewriting systems*. Loic is interested in *verification* (safety properties or security issues for instance), *composition* and *implementation* of such systems. The intuition is that this kind of rule-based declarative model is well adapted to describe workflows and business processes with quantitative aspects of Web-Services (Data), and could even be extended with probabilistic behaviors. It is planed to develop a framework of *contracts* for such document based workflows, encompassing both the function to be implemented by the service and its QoS aspects.

Regarding implementation, Loic plans to develop communicating rewriting systems through experimentations. He will sustain the development of the DistribCom web-service platform. The main idea is to design solutions based on communicating virtual machines. Each machine locally interprets a formal model and communicates with the other machines. This solution has several advantages. First of all, each site runs the same virtual machine, with different model. Once the virtual machine is proved correct with respect to a formalized semantics, the formal model an its

implementation exhibit the same behaviors (except when the communication support fails). This should open the way for **verified running web applications**.

Claude Jard: Claude is heavily involved in the management/supervision of research at the ENS Cachan and in its development in Rennes. His research activity is about one third of his working time. He currently focuses on issues of modeling time and concurrency. Privileged applications are in the area of large telecommunications systems. His interest in Internet and Web services will be maintained and cultivated. These aspects will remain present in the future of the Distribcom team and in the CominLabs environment.

Axel Legay: Axel is a young researcher. who is currently developing his own research track in the area of embedded systems development. He is a recognized specialist of quantitative model checking. He is currently developing the important and timely topic of statistical model checking to address large software systems. He plans to join the reasearchers of current Triskell team on software engineering for the launching of a new team.

François Schwarzentruber: François focuses on automatic reasoning in modal logics both on the theoretical and practical point of view. He will concentrate on two applications:

1) Fault localization in networks (collaboration with Eric Fabre, Guillaume Aucher and Bastien Maubert). The logical approach consists in using a high-level language to describe the problem and to solve it with a generic solver. Dynamic Epistemic Logic is a framework devoted to represent epistemic situations and their changes and we claim that it can be applied to fault localization. François will investigate the decidability and complexity results of variants of DEL.

2) Formalization of legal texts (collaboration with Guillaume Aucher, Leon Van Der Torre - university of Luxembourg, Cour de Cassation, etc.). The objective is to develop a software to assist lawyers. The logical framework needs to capture obligations, knowledge, actions etc. and their interactions. Deontic logic, Dynamic epistemic logic and logic of agency as STIT may be one key points of this logical framework. François will provide complexity results and a prover of a fragment STIT (collaboration with Heinrich Wansing and Caroline Semmling - Ruhr-Universität Bochum).

6 Bibliography of the project-team

We have chosen the following policy regarding this bibliography: publications by the "core members" of DistribCom (the four permanent members belonging to the team for the entire evaluation period) are all included; publications of all PhD and post-doc students are all included; from Blaise Genest we have selected only a small subset of his publications, corresponding to the three research objectives developed in this report. Regarding researchers who joined the group only recently and may not be aligned with the core objectives reported here, their publications are collected in a separate section.

6.1 Books and Monographs

References

[1] Debmalya Biswas and Il-Gong Kim. *Active XML Transactions, chapter of Service and Business Computing Solutions with XML: Applications for Quality Management and Best Processes*. IGI Global, 2008.

[2] Franck Cassez and Claude Jard. *The 6th International Conference on Formal Modelling and Analysis of Timed Systems, FORMATS 2008*. Springer-Verlag, LNCS 5215, 2008.

[3] Eric Fabre. *Distributed Control of Large Plants; Chapter 5, Observers and automata*. Springer, Editors Carla Seatzu, Manuel Silva and Jan H. van Schuppen, 2012. To appear.

[4] Stefan Haar and Eric Fabre. *Distributed Control of Large Plants; Chapter 13, Diagnosis with Petri nets unfoldings*. Springer, Editors Carla Seatzu, Manuel Silva and Jan H. van Schuppen, 2012. To appear.

[5] Claude Jard and Olivier-H. Roux, editors. *Communicating Embedded Systems – Software and Design*. ISTE Publishing / John Wiley, October 2009. ISBN:978-1-8482-1143-8.

[6] Claude Jard and Olivier-Henri Roux. *Systèmes embarqués communicants : Approches formelles*. Hermès, Traité IC2, 2008.

6.2 Doctoral dissertations and "Habilitation" theses

References

[1] Debmalya Biswas. *Visibility in Hierarchical Systems*. PhD thesis, Université de Rennes 1, 2009.

[2] Thomas Gazagnaire. *Scenario Languages: Using Partial Orders to Model, Verify and Supervize Distributed and Concurrent Systems*. PhD thesis, Université de Rennes 1, 2008.

[3] Bartosz Grabiec. *Distributed system supervision using timed constrained unfoldings*. PhD thesis, ENS Cachan, 2011.

[4] Stefan Haar. Law and partial order; nonsequential behaviour and probability in asynchronous systems, 2008. Habilitation thesis.

[5] Sidney Rosario. *Quality of Service issues in compositions of Web services*. PhD thesis, Université de Rennes 1, 2009.

6.3 Articles in referred journals and book chapters

References

[1] Samy Abbes and Albert Benveniste. True-concurrency probabilistic models: Markov nets and a law of large numbers. *Theoretical Computer Science*, 390(2-3):129–170, 2008.

[2] Dragan Bosnacki, Edith Elkind, Blaise Genest, and Doron Peled. On commutativity based edge lean search. *Special issue of BISFAI 2007, Annals of Mathematic and Artificial Intelligence (AMAI)*, in press, 2009.

[3] Anne Bouillard and Bruno Gaujal. Backward coupling in bounded free-choice nets under markovian and non-markovian assumptions. *Journal of Discrete Event Dynamic Systems (JDEDS)*, 18(4):473–498, 2008.

[4] Anne Bouillard, Bruno Gaujal, Sébastien Lagrange, and Eric Thierry. Optimal routing for end-to-end guarantees using network calculus. *Performance Evaluation*, 65(11-12):883–906, 2008.

[5] Anne Bouillard and Eric Thierry. An algorithmic toolbox for network calculus. *Journal of Discrete Event Dynamic Systems (JDEDS)*, 18(1):3–49, 2008.

[6] Philippe Darondeau, Blaise Genest, P. S. Thiagarajan, and Shaofa Yang. Quasi-static scheduling of communicating tasks. *Information and Computation*, 208(10):1154–1168, 2010.

[7] Edith Elkind, Blaise Genest, Doron Peled, and Paola Spoletini. Quantifying the discord: Order discrepancies in message sequence charts (special issue of atva'07). *International Journal of Foundations of Computer Sciecnce (IJFCS)*, 21(2):211–233, 2010.

[8] Thomas Gazagnaire, Blaise Genest, Loïc Hélouët, P.S. Thiagarajan, and Shaofa Yang. Causal message sequence charts. *Theoretical Computer Science (TCS)*, 410(41):4094–4110, 2009.

[9] Blaise Genest and Anca Muscholl. Pattern matching and membership for hierarchical message sequence charts. *Theory of Computing Systems (TOCS)*, 42(4):536–567, 2008.

[10] Samir Ghamri-Doudane, Eric Fabre, and Laurent Ciavaglia. Constraint-based distributed planning as enabler for self-management. *Bell Labs Technical Journal, special issue on Self-Organizing, Self-Optimizing Networks*, 15(3):193–198, 2010.

[11] Agnes Madalinski and Eric Fabre. Modular Construction of Finite and Complete Prefixes of Petri Net Unfoldings. *Fundamenta Informaticae*, (95), 2009.

[12] Helia Pouyllau and Stefan Haar. Distributed busacker-gowen algorithm for end-to-end qos pipe negotiation in x-domain networks. *Annals of Telecommunications*, pages –, October 2008. DOI 10.1007/s12243-008-0055-0.

[13] Sidney Rosario, Albert Benveniste, Stefan Haar, and Claude Jard. Probabilistic qos and soft contracts for transaction-based web services orchestrations. *IEEE T. Services Computing*, 1(4):187–200, 2008.

[14] Sidney Rosario, Albert Benveniste, and Claude Jard. Flexible probabilistic qos management of orchestrations. *Int. J. Web Service Res.*, 7(2):21–42, 2010.

[15] Shaofa Yang, Loïc Hélouët, and Thomas Gazagnaire. Logic-based diagnosis for distributed systems. *Perspectives in Concurrency – Festschrift for P.S. Thiagarajan'*, 2008.

6.4 Publications in Conferences and Workshops

References

[1] Samy Abbes and Albert Benveniste. Concurrency, Sigma-Algebras, and Probabilistic Fairness. In *FOSSACS*, pages 380–394, 2009.

[2] Rouwaida Abdallah and Claude Jard. An experiment in automatic generation of protocols from HMSCs. In *Notere*, May 2011.

[3] Paolo Baldan, Thomas Chatain, Stefan Haar, and Barbara König. Unfolding-based diagnosis of systems with an evolving topology. In *CONCUR 2008*, pages 203–217, 2008.

[4] Albert Benveniste. Composing web services in an open world: Issues of quality of service. In *FORMATS*, page 14, 2008.

[5] Debmalya Biswas. Active XML replication and recovery. In *2nd IEEE International Conference on Complex, Intelligent and Software Intensive Systems (CISIS-2008)*, pages 263–269, Barcelona, Spain, March 2008.

[6] Debmalya Biswas, Thomas Gazagnaire, and Blaise Genest. Small logs for transactional services. In *11th IEEE High Assurance Systems Engineering Symposium (HASE'08)*, Nanjing, China, December 2008.

[7] Debmalya Biswas and Blaise Genest. Minimal observability for transactional hierarchical services. In *20th International Conference on Software Engineering and Knowledge Engineering (SEKE'08)*, volume ISBN 1-891706-22-5, pages 531–536, San Francisco, USA, July 2008.

[8] Debmalya Biswas, Ashwin Jiwane, and Blaise Genest. Atomicity for XML databases. In *Sixth International XML Database Symposium (XSym)*, volume LNCS 5679, pages 160–167, 2009.

[9] Debmalya Biswas and Krishnamurthy Vidyasankar. A highly flexible data structure for multi-level visibility of p2p communities. In *9th International Conference on Distributed Computing and Networking (ICDCN 2008)*, volume LNCS 4904, pages 363–374, Kolkata, India, January 2008.

[10] Gregor Bochmann, Stefan Haar, Claude Jard, and Guy-Vincent Jourdan. Testing systems specified as partial order input/output automata. In *Testcom/Fates 08, 20th IFIP International Conference on Testing of Communicating Systems and 8th International Workshop on Formal Approaches to Testing of Software*, volume LNCS 5047, pages 169–183, Tokyo, june 2008.

[11] Benedikt Bollig and Loïc Hélouët. Realizability of dynamic MSC languages. In *CSR*, volume 6072 of *Lecture Notes in Computer Science*, pages 48–59. Springer, 2010.

[12] Anne Bouillard, Bertrand Cottenceau, Bruno Gaujal, Laurent Hardouin, Sébastien Lagrange, Mehdi Lhommeau, and Eric Thierry. Coinc library: a toolbox for the network calculus. In *Fourth International Conference on Performance Evaluation Methodologies and Tools (ValueTools)*. ICST, 2009.

[13] Anne Bouillard, Stefan Haar, and Sidney Rosario. Critical paths in the partial order unfolding of a stochastic petri net. In Joël Ouaknine and Frits W. Vaandrager, editors, *FORMATS*, volume 5813 of *Lecture Notes in Computer Science*. Springer, 2009.

[14] Anne Bouillard, Laurent Jouhet, and Eric Thierry. Computation of a (min,+) multi-dimensional convolution for end-to-end performance analysis. In *3rd international conference on Performance Evaluation Methodologies and Tools (ValueTools 2008)*, Athens, Greece, October 2008.

[15] Anne Bouillard, Laurent Jouhet, and Eric Thierry. Comparison of different classes of service curves in network calculus. In *International Workshop on Discrete Event Systems (WODES 2010)*, 2010.

[16] Anne Bouillard, Laurent Jouhet, and Eric Thierry. Tight performance bounds in the worst-case analysis of feed-forward networks. In *IEEE Conference on Computer Communications (INFOCOM 2010)*, 2010.

[17] Anne Bouillard and Aurore Junier. Worst-case delay bounds with fixed priorities using network calculus. In *Proc. of Valuetools'2011*, 2011.

[18] Anne Bouillard, Linh T.X. Phan, and Samarjit Chakraborty. Lightweight modeling of complex state dependencies in stream-processing systems. In *15th IEEE Real-Time and Embedded Technology and Applications Symposium (RTAS)*, 2009.

[19] Anne Bouillard, Sidney Rosario, Albert Benveniste, and Stefan Haar. Monotonicity in service orchestrations. In *Petri Nets*, volume 5606 of *Lecture Notes in Computer Science*, pages 263–282. Springer, 2009.

[20] Marc Boyer, Laurent Jouhet, and Anne Bouillard. Notations pour le calcul réseau. In *Modélisation des systèmes réactifs (MSR)*. JESA, 2009.

[21] Thomas Chatain and Eric Fabre. Factorization properties of symbolic unfoldings of colored petri nets. In *Petri Nets*, pages 165–184, 2010.

[22] Thomas Chatain and Claude Jard. Concurrent symbolic semantics of safe petri nets and application to time petri nets. In *IEEE 10th annual international conference on New Technologies of Distributed Systems (NOTERE 2010)*, volume IEEE, pages 9–16, 2010.

[23] Philippe Darondeau, Blaise Genest, and Loïc Hélouët. Products of message sequence charts. In *11th International Conference on Foundations of Software Science And Computation Structures (FOSSACS'08)*, volume LNCS 4962, pages 459–474, Budapest, Hungary, April 2008.

[24] Philippe Darondeau, Blaise Genest, P.S. Thiagarajan, and Shaofa Yang. Quasi-static scheduling of communicating tasks. In *19th International Conference on Concurrency Theory (CONCUR'08)*, volume LNCS 5201, pages 310–324, Toronto, Canada, August 2008.

[25] Philippe Darondeau, Loïc Hélouët, and Madhavan Mukund. Assembling sessions. In *ATVA*, volume 6996 of *Lecture Notes in Computer Science*, pages 259–274. Springer, 2011.

[26] Eric Fabre and Loïg Jezequel. Distributed optimal planning: an approach by weighted automata calculus. In *IEEE Conference on Decision and Control (CDC)*, 2009.

[27] Eric Fabre and Loïg Jezequel. On the construction of probabilistic diagnosers. In *Workshop on Discrete Event Systems, WODES'2010*, 2010.

[28] Eric Fabre, Loïg Jezequel, Patrik Haslum, and Sylvie Thiébaux. Cost-optimal factored planning: Promises and pitfalls. In *Proceedings of the 29th International Conference on Automated Planning and Scheduling, ICAPS 2010*, pages 65–72, Toronto, Ontario, Canada, May 12-16 2010.

[29] Eric Fabre, Pierre Peloso, and Pascal Pecci. Method and equipment for adjusting power amplification. In *EU patent EP 09290408*, July 2008.

[30] Eric Fabre, Pierre Peloso, and Pascal Pecci. Method and equipment for adjusting power amplification in an optical network. In *EU patent EP 09290409*, July 2008.

[31] Blaise Genest, Anca Muscholl, Olivier Serre, and Marc Zeitoun. Tree pattern rewrite systems. In *6th International Symposium on Automated Technology for Verification and Analysis (ATVA'08)*, Seoul, Korea, October 2008.

[32] Blaise Genest, Anca Muscholl, and Zhilin Wu. Verifying Recursive Active Documents with Positive Data Tree Rewriting. In Kamal Lodaya and Meena Mahajan, editors, *IARCS Annual Conference on Foundations of Software Technology and Theoretical Computer Science (FSTTCS 2010)*, volume 8 of *Leibniz International Proceedings in Informatics (LIPIcs)*, pages 469–480, Dagstuhl, Germany, 2010. Schloss Dagstuhl–Leibniz-Zentrum fuer Informatik.

[33] Bartosz Grabiec and Claude Jard. Unfolding of networks of automata and their application in supervision. In *9th annual international conference on New Technologies of Distributed Systems (NOTERE)*, july 2009.

[34] Bartosz Grabiec, Claude Jard, and Axel Legay. Unfolding petri nets under partial observation. In *International Workshop on Distributed Open Timed Systems, satellite of CONCUR 2010*, volume Paris 7, pages 16–23, 2010.

[35] Bartosz Grabiec, Louis-Marie Traonouez, Claude Jard, Didier Lime, and Olivier H. Roux. Diagnosis using unfoldings of parametric time petri nets. In *FORMATS*, volume 6246 of *Lecture Notes in Computer Science*, pages 137–151. Springer, 2010.

[36] Loïc Hélouët and Albert Benveniste. Document based modeling of web services choreographies using active XML. In *ICWS*, pages 291–298. IEEE Computer Society, 2010.

[37] Loïc Hélouët, Benedikt Bollig, and Stefan Haar. Diagnosis with dynamic MSC languages. In *DOTS'2010, satellite workshop of CONCUR 2010*, 2010.

[38] Loïc Hélouët and Aline Roumy. Covert channel detection using information theory. In *Secco 2010,8th International Workshop on Security Issues in Concurrency*, 2010. to appear as ENTCS.

[39] Loïc Hélouët and Aline Roumy. On the differences between covert channels and interference. In *GIPSY'2010 : 1st Workshop on Games, Logic and Security*, 2010.

[40] Claude Jard. Runs of distributed systems and partial orders. In *ROGICS'2008, 1st International Conference on Relations, Orders and Graphs: Interaction with Computer Science*, Mahdia, Tunisia, may 2008.

[41] Claude Jard. Teaching distributed algorithms using spin. In *Formal Methods in Computer Science Education, ETAPS 2008*, pages –, Budapest, Hungary, march 2008.

[42] Loïg Jezequel and Eric Fabre. Networks of automata with read arcs: a tool for distributed planning. In *IFAC World Congress*, Sept. 2011.

[43] Ajay Kattepur. Importance sampling of probabilistic contracts in web services. In *9th International Conference on Service-Oriented Computing (ICSOC)*, pages 557–565. Springer, 2011.

[44] Ajay Kattepur, Albert Benveniste, and Claude Jard. Optimizing decisions in web services orchestrations. In *9th International Conference on Service-Oriented Computing (ICSOC)*, pages 77–91. Springer, 2011.

[45] Ajay Kattepur, Sagar Sen, Benoit Baudry, Albert Benveniste, and Claude Jard. Variability modeling and qos analysis of web services orchestrations. In *ICWS*, pages 99–106. IEEE Computer Society, 2010.

[46] Ajay Kattepur, Sagar Sen, Benoit Baudry, Albert Benveniste, and Claude Jard. Pairwise testing of dynamic composite services. In *6th international symposium on Software engineering for adaptive and self-managing systems (SEAMS)*, SEAMS '11, pages 138–147, New York, NY, USA, 2011. ACM.

[47] Florian Kerschbaum, Debmalya Biswas, Daniel Dahlmeier, and Axel Schropfer. An Experimental Study on the Practical Importance of Communication Complexity for Secure Multi-Party Computation Protocols. In *24th Annual ACM Symposium on Applied Computing (SAC 2009)*, Hawaii, USA, March 2009.

[48] Florian Kerschbaum, Daniel Dahlmeier, Axel Schröpfer, and Debmalya Biswas. On the practical importance of communication complexity for secure multi-party computation protocols. In *Proceedings of the 2009 ACM Symposium on Applied Computing (SAC), Honolulu, Hawaii, USA, March 9-12, 2009*, pages 2008–2015, 2009.

[49] Agnes Madalinski and Eric Fabre. Modular construction of finite and complete prefixes of petri net unfoldings. In *ACSD'08, Applications of Concurrency to System Design*, Xian, China, July 2008.

[50] Benoît Masson, Loïc Hélouët, and Albert Benveniste. Compatibility of data-centric web services. In *WS-FM, 8th International Workshop on Web Services and Formal Methods*, Lecture Notes in Computer Science. Springer, 2012. to appear.

[51] Vojtech Rehák, Petr Slovák, Jan Strejcek, and Loïc Hélouët. Decidable race condition and open coregions in HMSC. *ECEASST*, 29, 2010.

[52] Sidney Rosario, Albert Benveniste, and Claude Jard. Monitoring probabilistic slas in web service orchestrations. In *IFIP/IEEE Intern. Symposium on Integrated Network Management, Mini-conference*. IEEE, june 2009.

[53] Sidney Rosario, Albert Benveniste, and Claude Jard. Probabilistic qos management of transaction based web services orchestrations. In *IEEE 7th International Conference on Web Services (ICWS 2009)*. IEEE, july 2009.

[54] Louis-Marie Traonouez, Bartosz Grabiec, Claude Jard, Didier Lime, and Olivier H. Roux. Symbolic unfolding of parametric stopwatch petri nets. In *ATVA*, volume 6252 of *Lecture Notes in Computer Science*, pages 291–305. Springer, 2010.

6.5 Internal Reports

References

[1] S. Akshay, Blaise Genest, Loïc Hélouët, and Shaofa Yang. Regular set of representatives for time-constrained MSC graphs. Rapport de recherche RR-7823, INRIA, November 2011.

[2] Anne Bouillard, Stefan Haar, and Sidney Rosario. Critical paths in the partial order unfolding of a stochastic petri net. Technical Report 7003, INRIA, 2009.

[3] Anne Bouillard, Laurent Jouhet, and Eric Thierry. Tight performance bounds in the worst-case analysis of feed-forward networks. Technical Report 7012, INRIA, 2009.

[4] Anne Bouillard, Sidney Rosario, Albert Benveniste, and Stefan Haar. Monotonicity in service orchestrations. INRIA Research Report RR-6528, INRIA, 2008.

[5] Loïc Hélouët. Appendix 1 to z.120: Applications of messages sequence charts. Technical report, ITU-T, 2008.

[6] Loïc Hélouët. *SOFAT V3 : User Manual*, August 2008.

[7] Loïc Hélouët and Albert Benveniste. Distributed active XML and service interfaces. Research report 7082, INRIA, 2009.

[8] Loïc Hélouët, Thomas Gazagnaire, and Hervé Marchand. Anomaly detection with diagnosis technique. Technical report, Projet Politess, 2008.

[9] Loïc Hélouët, Hervé Marchand, and Thierry Jéron. Testing covert channels. Technical report, Projet Politess, 2008.

[10] Loïc Hélouët and Aline Roumy. Canaux cachés et théorie de l'information. Research report, dots deliverable 2.4.b, Projet ANR DOTS, 2009.

[11] Claude Jard, Rouwaida Abdallah, and Loïc Hélouët. Realistic Implementation of Message Sequence Charts. Rapport de recherche RR-7597, INRIA, April 2011.

[12] Agnes Madalinski and Eric Fabre. Modular construction of finite and complete prefixes of petri net unfoldings. Technical Report 6412, IRISA, jan. 2008.

[13] Benoît Masson, Loïc Hélouët, and Albert Benveniste. Compatibility between DAXML Schemas. Rapport de recherche RR-7559, INRIA, March 2011.

[14] Vojtech Rehák, Petr Slovák, Jan Strejček, and Loïc Hélouët. Decidable Race Condition for HMSC. Technical Report FIMU-RS-2009-10, Faculty of Informatics, Masaryk Univ., 2009.

6.6 Publications by recent members of the team (arrived in 2011)—not included in the summary tables

References

[1] Guillaume Aucher. DEL-sequents for progression. *Journal of Applied Non-Classical Logics*, 21(3–4), 2011.

[2] Guillaume Aucher. DEL-sequents for regression and epistemic planning. *Journal of Applied Non-Classical Logics*, 2011. to appear.

[3] Guillaume Aucher. *Dialogue, Rationality, Formalism.*, chapter Principles for knowledge, belief and conditional belief. Logic, Epistemology and the Unity of Science. Springer, 2011. to appear.

[4] Guillaume Aucher, Steve Barker, Guido Boella, Valerio Genovese, and Leendert van der Torre. Dynamics in delegation and revocation schemes: A logical approach. In Yingjiu Li, editor, *Data and Applications Security and Privacy XXV*, pages 90–105, 2011.

[5] Guillaume Aucher, Catherine Barreau-Saliou, Guido Boella, Annie Blandin-Obernesser, Sébastien Gambs, Guillaume Piolle, and Leendert van der Torre. The Coprelobri project : the logical approach to privacy. In *2e Atelier Protection de la Vie Privée (APVP 2011)*, Sorèze, France, June 2011. 6 pages.

[6] Guillaume Aucher, Guido Boella, and Leendert van der Torre. A dynamic logic for privacy compliance. *Journal of artificial intelligence and law*, 19(2–3), 2011.

[7] Guillaume Aucher, Bastien Maubert, and François Schwarzentruber. Tableau method and NEXPTIME-completeness of DEL-sequents. In *Proceedings of Methods for Modalities (M4M 2011)*, ENTCS, 2011.

[8] Sebastian S. Bauer, Uli Fahrenberg, Line Juhl, Kim G. Larsen, Axel Legay, and Claus R. Thrane. Quantitative refinement for weighted modal transition systems. In *MFCS*, pages 60–71, 2011.

[9] Sebastian S. Bauer, Philip Mayer, and Axel Legay. Mio workbench: A tool for compositional design with modal input/output interfaces. In *ATVA*, pages 418–421, 2011.

[10] Saddek Bensalem, Lavindra de Silva, Andreas Griesmayer, Félix Ingrand, Axel Legay, and Rongjie Yan. A formal approach for incremental construction with an application to autonomous robotic systems. In *Software Composition*, pages 116–132, 2011.

[11] Saddek Bensalem, Andreas Griesmayer, Axel Legay, Thanh-Hung Nguyen, Joseph Sifakis, and Rongjie Yan. D-finder 2: Towards efficient correctness of incremental design. In *NASA Formal Methods*, pages 453–458, 2011.

[12] Laura Bozzelli, Axel Legay, and Sophie Pinchinat. Hardness of preorder checking for basic formalisms. *Theor. Comput. Sci.*, 412(49):6795–6808, 2011.

[13] Benoît Caillaud, Benoît Delahaye, Kim G. Larsen, Axel Legay, Mikkel L. Pedersen, and Andrzej Wasowski. Constraint markov chains. *Theor. Comput. Sci.*, 412(34):4373–4404, 2011.

[14] Andreas Classen, Patrick Heymans, Pierre-Yves Schobbens, and Axel Legay. Symbolic model checking of software product lines. In *ICSE*, pages 321–330, 2011.

[15] Alexandre David, Kim G. Larsen, Axel Legay, Marius Mikucionis, Danny Bøgsted Poulsen, Jonas van Vliet, and Zheng Wang. Statistical model checking for networks of priced timed automata. In *FORMATS*, pages 80–96, 2011.

[16] Alexandre David, Kim G. Larsen, Axel Legay, Marius Mikucionis, Danny Bøgsted Poulsen, Jonas van Vliet, and Zheng Wang. Stochastic semantics and statistical model checking for networks of priced timed automata. *CoRR*, 2011.

[17] Alexandre David, Kim G. Larsen, Axel Legay, Marius Mikucionis, and Zheng Wang. Time for statistical model checking of real-time systems. In *CAV*, pages 349–355, 2011.

[18] Benoît Delahaye, Benoît Caillaud, and Axel Legay. Probabilistic contracts: a compositional reasoning methodology for the design of systems with stochastic and/or non-deterministic aspects. *Formal Methods in System Design*, 38(1):1–32, 2011.

[19] Benoît Delahaye, Joost-Pieter Katoen, Kim G. Larsen, Axel Legay, Mikkel L. Pedersen, Falak Sher, and Andrzej Wasowski. Abstract probabilistic automata. In *VMCAI*, volume 6538 of *Lecture Notes in Computer Science*, pages 324–339. Springer, 2011.

[20] Benoît Delahaye, Kim G. Larsen, Axel Legay, Mikkel L. Pedersen, and Andrzej Wasowski. Apac: A tool for reasoning about abstract probabilistic automata. In *QEST*, pages 151–152, 2011.

[21] Benoît Delahaye, Kim G. Larsen, Axel Legay, Mikkel L. Pedersen, and Andrzej Wasowski. Decision problems for interval markov chains. In *LATA*, pages 274–285, 2011.

[22] Uli Fahrenberg, Axel Legay, and Claus Thrane. The quantitative linear-time–branching-time spectrum. In *FSTTCS*, LIPIcs. Schloss Dagstuhl - Leibniz-Zentrum fuer Informatik, 2011.

[23] Uli Fahrenberg, Axel Legay, and Andrzej Wasowski. Vision paper: Make a difference! (semantically). In *Model Driven Engineering Languages and Systems, 14th International Conference, MODELS 2011, Wellington, New Zealand, October 16-21, 2011. Proceedings*, pages 490–500, 2011.

[24] Uli Fahrenberg, Claus Thrane, and Kim G. Larsen. Distances for weighted transition systems: Games and properties. In *QAPL*, volume 57, pages 134–147, 2011.

[25] Kim G. Larsen, Axel Legay, Louis-Marie Traonouez, and Andrzej Wasowski. Robust specification of real time components. In *FORMATS*, pages 129–144, 2011.

[26] James Jerson Ortiz, Axel Legay, and Pierre-Yves Schobbens. Distributed event clock automata - extended abstract. In *CIAA*, pages 250–263, 2011.

[27] Jean-Baptiste Raclet, Eric Badouel, Albert Benveniste, Benoît Caillaud, Axel Legay, and Roberto Passerone. A modal interface theory for component-based design. *Fundamenta Informatica*, 108(1-2):119–149, 2011.

7 Articles cited in this document

References

[1] Samy Abbes and Albert Benveniste. True-concurrency probabilistic models: Markov nets and a law of large numbers. *Theoretical Computer Science*, 390(2-3):129–170, 2008.

[2] Samy Abbes and Albert Benveniste. Concurrency, Sigma-Algebras, and Probabilistic Fairness. In *FOSSACS*, pages 380–394, 2009.

[3] Paolo Baldan, Thomas Chatain, Stefan Haar, and Barbara König. Unfolding-based diagnosis of systems with an evolving topology. In *CONCUR 2008*, pages 203–217, 2008.

[4] Gregor Bochmann, Stefan Haar, Claude Jard, and Guy-Vincent Jourdan. Testing systems specified as partial order input/output automata. In *Testcom/Fates 08, 20th IFIP International Conference on Testing of Communicating Systems and 8th International Workshop on Formal Approaches to Testing of Software*, volume LNCS 5047, pages 169–183, Tokyo, june 2008.

[5] Benedikt Bollig and Loïc Hélouët. Realizability of dynamic MSC languages. In *CSR*, volume 6072 of *Lecture Notes in Computer Science*, pages 48–59. Springer, 2010.

[6] Anne Bouillard, Bruno Gaujal, Sébastien Lagrange, and Eric Thierry. Optimal routing for end-to-end guarantees using network calculus. *Performance Evaluation*, 65(11-12):883–906, 2008.

[7] Anne Bouillard, Laurent Jouhet, and Eric Thierry. Computation of a (min,+) multi-dimensional convolution for end-to-end performance analysis. In *3rd international conference on Performance Evaluation Methodologies and Tools (ValueTools 2008)*, Athens, Greece, October 2008.

[8] Anne Bouillard and Aurore Junier. Worst-case delay bounds with fixed priorities using network calculus. In *Proc. of Valuetools'2011*, 2011.

[9] Anne Bouillard, Sidney Rosario, Albert Benveniste, and Stefan Haar. Monotonicity in service orchestrations. In *Petri Nets*, volume 5606 of *Lecture Notes in Computer Science*, pages 263–282. Springer, 2009.

[10] Anne Bouillard and Eric Thierry. An algorithmic toolbox for network calculus. *Journal of Discrete Event Dynamic Systems (JDEDS)*, 18(1):3–49, 2008.

[11] Thomas Chatain and Eric Fabre. Factorization properties of symbolic unfoldings of colored petri nets. In *Petri Nets*, pages 165–184, 2010.

[12] Thomas Chatain and Claude Jard. Concurrent symbolic semantics of safe petri nets and application to time petri nets. In *IEEE 10th annual international conference on New Technologies of Distributed Systems (NOTERE 2010)*, volume IEEE, pages 9–16, 2010.

[13] Philippe Darondeau, Blaise Genest, and Loïc Hélouët. Products of message sequence charts. In *11th International Conference on Foundations of Software Science And Computation Structures (FOSSACS'08)*, volume LNCS 4962, pages 459–474, Budapest, Hungary, April 2008.

[14] Philippe Darondeau, Blaise Genest, P. S. Thiagarajan, and Shaofa Yang. Quasi-static scheduling of communicating tasks. *Information and Computation*, 208(10):1154–1168, 2010.

[15] Philippe Darondeau, Blaise Genest, P.S. Thiagarajan, and Shaofa Yang. Quasi-static scheduling of communicating tasks. In *19th International Conference on Concurrency Theory (CONCUR'08)*, volume LNCS 5201, pages 310–324, Toronto, Canada, August 2008.

[16] Philippe Darondeau, Loïc Hélouët, and Madhavan Mukund. Assembling sessions. In *ATVA*, volume 6996 of *Lecture Notes in Computer Science*, pages 259–274. Springer, 2011.

[17] Eric Fabre and Loïg Jezequel. Distributed optimal planning: an approach by weighted automata calculus. In *IEEE Conference on Decision and Control (CDC)*, 2009.

[18] Eric Fabre, Loïg Jezequel, Patrik Haslum, and Sylvie Thiébaux. Cost-optimal factored planning: Promises and pitfalls. In *Proceedings of the 29th International Conference on Automated Planning and Scheduling, ICAPS 2010*, pages 65–72, Toronto, Ontario, Canada, May 12-16 2010.

[19] Eric Fabre, Pierre Peloso, and Pascal Pecci. Method and equipment for adjusting power amplification. In *EU patent EP 09290408*, July 2008.

[20] Eric Fabre, Pierre Peloso, and Pascal Pecci. Method and equipment for adjusting power amplification in an optical network. In *EU patent EP 09290409*, July 2008.

[21] Thomas Gazagnaire. *Scenario Languages: Using Partial Orders to Model, Verify and Supervize Distributed and Concurrent Systems.* PhD thesis, Université de Rennes 1, 2008.

[22] Thomas Gazagnaire, Blaise Genest, Loïc Hélouët, P.S. Thiagarajan, and Shaofa Yang. Causal message sequence charts. *Theoretical Computer Science (TCS)*, 410(41):4094–4110, 2009.

[23] Blaise Genest, Anca Muscholl, Olivier Serre, and Marc Zeitoun. Tree pattern rewrite systems. In *6th International Symposium on Automated Technology for Verification and Analysis (ATVA'08)*, Seoul, Korea, October 2008.

[24] Blaise Genest, Anca Muscholl, and Zhilin Wu. Verifying Recursive Active Documents with Positive Data Tree Rewriting. In Kamal Lodaya and Meena Mahajan, editors, *IARCS Annual Conference on Foundations of Software Technology and Theoretical Computer Science (FSTTCS 2010)*, volume 8 of *Leibniz International Proceedings in Informatics (LIPIcs)*, pages 469–480, Dagstuhl, Germany, 2010. Schloss Dagstuhl–Leibniz-Zentrum fuer Informatik.

[25] Samir Ghamri-Doudane, Eric Fabre, and Laurent Ciavaglia. Constraint-based distributed planning as enabler for self-management. *Bell Labs Technical Journal, special issue on Self-Organizing, Self-Optimizing Networks*, 15(3):193–198, 2010.

[26] Bartosz Grabiec, Louis-Marie Traonouez, Claude Jard, Didier Lime, and Olivier H. Roux. Diagnosis using unfoldings of parametric time petri nets. In *FORMATS*, volume 6246 of *Lecture Notes in Computer Science*, pages 137–151. Springer, 2010.

[27] Loïc Hélouët and Albert Benveniste. Distributed active XML and service interfaces. Research report 7082, INRIA, 2009.

[28] Loïc Hélouët and Albert Benveniste. Document based modeling of web services choreographies using active XML. In *ICWS*, pages 291–298. IEEE Computer Society, 2010.

[29] Loïc Hélouët, Benedikt Bollig, and Stefan Haar. Diagnosis with dynamic MSC languages. In *DOTS'2010, satellite workshop of CONCUR 2010*, 2010.

[30] Claude Jard, Rouwaida Abdallah, and Loïc Hélouët. Realistic Implementation of Message Sequence Charts. Rapport de recherche RR-7597, INRIA, April 2011.

[31] Ajay Kattepur. Importance sampling of probabilistic contracts in web services. In *9th International Conference on Service-Oriented Computing (ICSOC)*, pages 557–565. Springer, 2011.

[32] Ajay Kattepur, Albert Benveniste, and Claude Jard. Optimizing decisions in web services orchestrations. In *9th International Conference on Service-Oriented Computing (ICSOC)*, pages 77–91. Springer, 2011.

[33] Ajay Kattepur, Sagar Sen, Benoit Baudry, Albert Benveniste, and Claude Jard. Variability modeling and qos analysis of web services orchestrations. In *ICWS*, pages 99–106. IEEE Computer Society, 2010.

[34] Ajay Kattepur, Sagar Sen, Benoit Baudry, Albert Benveniste, and Claude Jard. Pairwise testing of dynamic composite services. In *6th international symposium on Software engineering for adaptive and self-managing systems (SEAMS)*, SEAMS '11, pages 138–147, New York, NY, USA, 2011. ACM.

[35] Agnes Madalinski and Eric Fabre. Modular Construction of Finite and Complete Prefixes of Petri Net Unfoldings. *Fundamenta Informaticae*, (95), 2009.

[36] Benoît Masson, Loïc Hélouët, and Albert Benveniste. Compatibility between DAXML Schemas. Rapport de recherche RR-7559, INRIA, March 2011.

[37] Benoît Masson, Loïc Hélouët, and Albert Benveniste. Compatibility of data-centric web services. In *WS-FM, 8th International Workshop on Web Services and Formal Methods*, Lecture Notes in Computer Science. Springer, 2012. to appear.

[38] Sidney Rosario. *Quality of Service issues in compositions of Web services*. PhD thesis, Université de Rennes 1, 2009.

[39] Sidney Rosario, Albert Benveniste, and Claude Jard. Probabilistic qos management of transaction based web services orchestrations. In *IEEE 7th International Conference on Web Services (ICWS 2009)*. IEEE, july 2009.

[40] Louis-Marie Traonouez, Bartosz Grabiec, Claude Jard, Didier Lime, and Olivier H. Roux. Symbolic unfolding of parametric stopwatch petri nets. In *ATVA*, volume 6252 of *Lecture Notes in Computer Science*, pages 291–305. Springer, 2010.

[41] Shaofa Yang, Loïc Hélouët, and Thomas Gazagnaire. Logic-based diagnosis for distributed systems. *Perspectives in Concurrency – Festschrift for P.S. Thiagarajan'*, 2008.