IN PARTNERSHIP WITH:
Institut polytechnique de Grenoble

Université de Grenoble Alpes

Activity Report 2017

Project-Team CTRL-A

Control for safe Autonomic computing systems

IN COLLABORATION WITH: Laboratoire d'Informatique de Grenoble (LIG)

RESEARCH CENTER
Grenoble - Rhône-Alpes

THEME
Distributed Systems and middleware

Table of contents

Project-Team CTRL-A

Creation of the Team: 2014 January 01, updated into Project-Team: 2017 June 01

Keywords:

Computer Science and Digital Science:

A1.1.2. - Hardware accelerators (GPGPU, FPGA, etc.)
A1.1.4. - High performance computing
A1.1.6. - Cloud
A1.1.9. - Fault tolerant systems
A1.1.10. - Reconfigurable architectures
A1.3. - Distributed Systems
A1.4. - Ubiquitous Systems
A2.1.8. - Synchronous languages
A2.1.10. - Domain-specific languages
A2.2. - Compilation
A2.3.1. - Embedded systems
A2.5.1. - Software Architecture & Design
A2.5.2. - Component-based Design
A2.5.4. - Software Maintenance & Evolution
A2.6.2. - Middleware
A4.9. - Security supervision
A4.9.1. - Intrusion detection
A4.9.3. - Reaction to attacks
A6.4.2. - Stochastic control

Other Research Topics and Application Domains:

B4.5. - Energy consumption
B5.1. - Factory of the future
B6.1. - Software industry
B6.1.1. - Software engineering
B6.1.2. - Software evolution, maintenance
B6.4. - Internet of things
B6.5. - Information systems
B6.6. - Embedded systems
B8.1. - Smart building/home

1. Personnel

Research Scientist

Eric Rutten [Team leader, Inria, Researcher, HDR]

Faculty Members

Gwenaël Delaval [Université de Grenoble Alpes, Associate Professor]
Stéphane Mocanu [Institut polytechnique de Grenoble, Associate Professor]

Post-Doctoral Fellow
Soguy Mak Kare Gueye [Inria]

PhD Students
Adja Sylla [CEA]
Neïl Ayeb [CIFRE Orange labs, since dec. 2017]

Interns
Emmanuel Stahl [G-INP E3, intern, from Feb. until Jul. 2017]
Lenaïg Terrier [UGA, Masters2 intern, from Feb. until Jul. 2017]

Administrative Assistant
Maria Immaculada Presseguer [Inria]

External Collaborator
Bogdan Robu [Univ Grenoble Alpes]

2. Overall Objectives

2.1. Objective: control support for autonomic computing

CTRL-A is motivated by today's context where computing systems, large (data centers) or small (embedded), are more and more required to be adaptive to the dynamical fluctuations of their environments and workloads, evolutions of their computing infrastructures (shared, or subject to faults), or changes in application functionalities. Their administration, traditionally managed by human system administrators, needs to be automated in order to be efficient, safe and responsive. Autonomic Computing is the approach that emerged in the early 2000's in distributed systems to answer that challenge, in the form of self-administration control loops. They address objectives like self-configuration (e.g. in service-oriented systems), self-optimization (resource consumption management e.g., energy), self-healing (fault-tolerance, resilience), self-protection (security and privacy).

Therefore, there is a pressing and increasing demand for methods and tools to design controllers for self-adaptive computing systems, that ensure quality and safety of the behavior of the controlled system. The critical importance of the quality of control on performance and safety in automated systems, in computing as elsewhere, calls for a departure from traditional approaches relying on *ad hoc* techniques, often empirical, unsafe and application-specific solutions.

The main objective of the CTRL-A project-team is to develop a novel framework for model-based design of controllers in Autonomic Computing. We want to contribute generic Software Engineering methods and tools for developers to design appropriate controllers for their particular reconfigurable architectures, software or hardware, and integrate them at middleware level. We want to improve concrete usability of techniques from Control Theory, particularly Discrete Event Systems, by specialists of concrete systems (rather than formal models), and to provide tool support for our methods in the form of specification languages and compilers. We address policies for self-configuration, self-optimization (resource management, low power), self-healing (fault tolerance) and self-protection (security).

3. Research Program

3.1. Modeling and control techniques for autonomic computing

The main objective of CTRL-A translates into a number of scientific challenges, the most important of these are:

- (i) programming language support, on the two facets of model-oriented languages, based on automata [7], and of domain specific languages, following e.g., a component-based approach [6], [1] or related to rule-based or HMI languages ;

- (ii) design methods for reconfiguration controller design in computing systems, proposing generic systems architectures and models based on transition systems [3], [9], classical continuous control or controlled stochastic systems.

  We adopt a strategy of constant experimental identification of needs and validation of proposals, in application domains like middleware platforms for Cloud systems [8], [5], multi-core HPC architectures [10], Dynamic Partial Reconfiguration in FPGA-based hardware [2] and the IoT and smart environments [4].

Achieving the goals of CTRL-A requires multidisciplinarity and expertise from several domains. The expertise in Autonomic Computing and programming languages is covered internally by members of the Ctrl-A team. On the side of theoretical aspects of control, we have active external collaborations with researchers specialized in Control Theory, in the domain of Discrete Event Systems as well as in classical, continuous control. Additionally, an important requirement for our research to have impact is to have access to concrete, real-world computing systems requiring reconfiguration control. We target autonomic computing at different scales, in embedded systems or in cloud infrastructures, which are traditionally different domains. This is addressed by external collaborations, with experts in either hardware or software platforms, who are generally missing our competences on model-based control of reconfigurations.

4. Application Domains

4.1. Self-adaptive and reconfigurable computing systems in HPC and the IoT

We are attacking the problem of designing well-regulated and efficient self-adaptive computing systems by the development of novel strategies for systems management.

The kind of systems we typically target involve relatively coarse grained computation tasks (e.g. image processing or HPC tasks, components or services), assembled in workflows, application dependency graphs, or composites. At that level, there can be parallel and conditional branches, as well as choices that can be made between alternative branches, corresponding to different ways to perform that part of the application. Such tasks can be achieved following a choice of implementations or versions, such as in service oriented approaches. Each implementation has its own characteristics and requirements, e.g., w.r.t. resources consumed and QoS offered. The systems execution infrastructures present heterogeneity, with different computing processors, a variety of peripheral devices (e.g., I/O, video port, accelerators), and different means of communications. This hardware or middleware level also presents adaptation potential e.g., in varying quantities of resources or sleep and stand-by modes.

The kinds of control problems encountered in these adaptive systems concern the navigation in the configurations space defined by choice points at the levels of applications, tasks, and architecture. Upon events or conditions triggering reconfiguration and adaptation, the controller has to choose a next configuration where, on the one hand, all consistency constraints are satisfied w.r.t. dependencies and resources requirements. On the other hand, it has to apply a policy or strategy deciding between correct configurations which one to chose e.g. by optimizing one or more criteria, or by insuring reachability of some later configuration (goal or fallback). This targeted class of computing systems we consider is mid-sized, in the sense that the combinatorial complexity is large enough for manual solving to be impossible, while remaining within the range where supervisory control techniques are tractable. The pace of control is more sporadic, and slower than the instruction-level computation performance within the coarse-grained tasks.

The objectives of CTRL-A will be achieved and evaluated in both of our main application domains, thereby exhibiting their similarities from the point of view of reconfiguration control. A first application domain is High Performance Computing. In this area, we currently focus especially on the management of Dynamic Partial Reconfiguration in FPGA based hardware, at the level of middleware. Here the particular application we consider is, as in our ANR project HPeC starting end of 2015, video image flow processing for smart cameras implemented on DPR FPGASs themselves embedded in drones.

A second general application domain to confront our models is the Internet of Things (IoT), more specifically self-adaptive middleware platforms for Smart Environments, or Industry 4.0 related topics, like SCADA. We focus on providing coordination components and controllers of software components and services, or rule-based middleware platforms. The adaptation problems concern both the functional aspects of the applications in a smart building, and the middleware support deployment and reconfiguration issues. We are considering perspectives concerning self-protection and security.

5. New Software and Platforms

5.1. Heptagon

KEYWORDS: Compilers - Synchronous Language - Controller synthesis
FUNCTIONAL DESCRIPTION: Heptagon is an experimental language for the implementation of embedded real-time reactive systems. It is developed inside the Synchronics large-scale initiative, in collaboration with Inria Rhones-Alpes. It is essentially a subset of Lucid Synchrone, without type inference, type polymorphism and higher-order. It is thus a Lustre-like language extended with hierchical automata in a form very close to SCADE 6. The intention for making this new language and compiler is to develop new aggressive optimization techniques for sequential C code and compilation methods for generating parallel code for different platforms. This explains much of the simplifications we have made in order to ease the development of compilation techniques.

The current version of the compiler includes the following features: - Inclusion of discrete controller synthesis within the compilation: the language is equipped with a behavioral contract mechanisms, where assumptions can be described, as well as an "enforce" property part. The semantics of this latter is that the property should be enforced by controlling the behaviour of the node equipped with the contract. This property will be enforced by an automatically built controller, which will act on free controllable variables given by the programmer. This extension has been named BZR in previous works. - Expression and compilation of array values with modular memory optimization. The language allows the expression and operations on arrays (access, modification, iterators). With the use of location annotations, the programmer can avoid unnecessary array copies.

- Participants: Adrien Guatto, Brice Gelineau, Cédric Pasteur, Eric Rutten, Gwenaël Delaval, Léonard Gérard and Marc Pouzet
- Partners: UGA - ENS Paris - Inria - LIG
- Contact: Gwenaël Delaval
- URL: http://heptagon.gforge.inria.fr

6. New Results

6.1. Programming support for Autonomic Computing

6.1.1. Reactive languages

Participants: Gwenaël Delaval, Eric Rutten.

Our work in reactive programming for autonomic computing systems is focused on the specification and compilation of declarative control objectives, under the form of contracts, enforced upon classical mode automata as defined in synchronous languages. The compilation involves a phase of Discrete Controller Synthesis in order to obtain an imperative executable code. The programming language Heptagon / BZR (see Section Software and Platforms) integrates our research results [7].

Recent work concerns exploring new possibilities offered by logics-numeric control. We target the problem of the safe control of reconfigurations in component-based software systems (see also Section 6.1.2 for the component-based aspects), where strategies of adaptation to variations in both their environment and internal resource demands need to be enforced. In this context, the computing system involves software components that are subject to control decisions. We approach this problem under the angle of Discrete Event Systems (DES), involving properties on events observed during the execution (e.g., requests of computing tasks, work overload), and a state space representing different configurations such as activity or assemblies of components. We consider in particular the potential of applying novel logico-numerical control techniques to extend the expressivity of control models and objectives, thereby extending the application of DES in component-based software systems. We elaborate methodological guidelines for the application of logico-numerical control based on a case-study, and validate the result experimentally.

This work is in cooperation with the Sumo team at Inria Rennes and University of Liverpool, and is published in the CCTA 2017 conference [15].

6.1.2. Component-based approaches

Participants: Gwenaël Delaval, Eric Rutten.

Our work in component-based programming for autonomic computing systems as examplified by e.g., FRACTAL, considers essentially the problem of specifying the control of components assembly reconfiguration, with an approach based on the integration within such a component-based framework of a reactive language as in Section 6.1.1 [6].

Dynamic reconfiguration is a key capability of Component-based Software Systems to achieve self-adaptation as it provides means to cope with environment changes at runtime. The space of configurations is defined by the possible assemblies of components, and navigating this space while achieving goals and maintaining structural properties is managed in an autonomic loop. The natural architectural structure of component-based systems calls for hierarchy and modularity in the design and implementation of composites and their managers, and requires support for coordinated multiple autonomic loops. [1] [12].

In recent work, we leverage the modularity capability to strengthen the Domain-Specific Language (DSL) Ctrl-F, targeted at the design of autonomic managers in component-based systems. Its original definition involved discrete control-theoretical management of reconfigurations, providing assurances on the automated behaviors. The objective of modularity is two-fold: from the design perspective, it allows designers to seamlessly decompose a complex system into smaller pieces of reusable architectural elements and adaptive behaviours. From the compilation point of view, we provide a systematical and generative approach to decompose control problems described in the architectural level while relying on mechanisms of modular Discrete Control Synthesis (DCS), which allows us to cope with the combinatorial complexity that is inherent to DCS problems. We show the applicability of our approach by applying it to the self-adaptive case study of the existing RUBiS/Brownout eBay-like web auction system.

This work is done in cooperation with Inria teams ASCOLA in Nantes and SPIRALS in Lille, and is published in the Journal of Systems and Software [12] and the SeAC 2017 - 2nd Workshop on Self-Aware Computing, a satellite of the ICAC'17 conference [14].

We are also considering integration at the DSL level of expressivity extensions, for which the compilation and controller synthesis is relying on the ReaX tool developed at Inria Rennes, in the Sumo team as mentioned in Section 6.1.1 [15].

6.1.3. Rule-based systems

Participants: Adja Sylla, Gwenaël Delaval, Eric Rutten.

This work concerns a high-level language for safe rule-based programming in the LINC transactional rule-based platform developed at CEA [17]. Rule based middlewares such as LINC enable high level programming of distributed adaptive systems behaviours. LINC also provides the systems with transactional guarantees and hence ensures their reliability at runtime. However, the set of rules may contain design errors (e.g. conflicts, violations of constraints) that can bring the system in unsafe safe or undesirables states, despite the guarantees provided by LINC. On the other hand, automata based languages such as Heptagon/BZR enable formal verification and especially synthesis of discrete controllers to deal with design errors. Our work studies these two languages and combines their execution mechanisms, from a technical perspective. We target applications to the domain of Internet of Things and more particularly smart building, office or home (see Section 6.2.2.1).

This work is in cooperation with CEA LETI/DACLE, it is the topic of the PhD of Adja Sylla at CEA, co-advised with M. Louvel [11], and aspects on Software Engineering and Software Architecture for Multiple Autonomic Loops are published in the ICCAC 2017 conference [18].

6.1.4. A Language for the Smart Home

Participant: Gwenaël Delaval.

This work is about the design of the CCBL programming language (Cascading Contexts Based Language), an end-user programming language dedicated to Smart Home. CCBL has been proposed to avoid the problems encountered by end-users programming with ECA (Event Conditions Actions), which is the dominant approach in the field. This language has been evaluated by means of a user-based experiment where 21 adults (11 experimented programmers and 10 non-programmers) have been asked to express four increasingly complex behaviors using both CCBL and ECA. It has been shown that significantly less errors were made using CCBL than using ECA. From this experiment, some categorization and explanation of the errors made when using ECA have been proposed, with explanations about why users avoid these errors when programming with CCBL. Finally, error reporting for CCBL have been explored by identifying two specific errors and by developing a solution based on Heptagon and ReaX to detect them in CCBL programs.

This work is done in cooperation with the IIHM team of LIG (Alexandre Demeure), in the framework of a LIG « projet émergence » and was the topic of the MSc internship of Lénaïg Terrier [22].

6.2. Design methods for reconfiguration controller design in computing systems

We apply the results of the previous axes of the team's activity to a range of infrastructures of different natures, but sharing a transversal problem of reconfiguration control design. From this very diversity of validations and experiences, we draw a synthesis of the whole approach, towards a general view of Feedback Control as MAPE-K loop in Autonomic Computing [20] [19].

6.2.1. High-Performance Computing

Participants: Soguy Mak Kare Gueye, Gwenaël Delaval, Stéphane Mocanu, Bogdan Robu, Eric Rutten.

6.2.1.1. Towards a Control-Theory based approach for cluster overload avoidance

This work is addressing the problem of automated resource management in an HPC infrastructure, using techniques from Control Theory to design a controller that maximizes cluster utilization while avoiding overload. We put in place a mechanism for feedback (Proportional Integral, PI) to system software, through a maximum number of jobs to be sent to the cluster, in response to system information about the current number jobs processed.

This work is done in cooperation with the Datamove team of Inria/LIG, and Gipsa-lab. It was the topic of the internship of Emmanuel Stahl for the Grenoble INP ENSE[3] engineering school, [21].

6.2.1.2. Reconfiguration control in DPR FPGA

6.2.1.2.1. DPR FPGA and discrete control for reconfiguration

Implementing self-adaptive embedded systems, such as UAV drones, involves an offline provisioning of the several implementations of the embedded functionalities with different characteristics in resource usage and performance in order for the system to dynamically adapt itself under uncertainties. FPGA-based architectures offer for support for high flexibility with dynamic partial reconfiguration (DPR) features. We propose an autonomic control architecture for self-adaptive and self-reconfigurable FPGA-based embedded systems.

The control architecture is structured in three layers: a mission manager, a reconfiguration manager and a scheduling manager. In this work we focus on the design of the reconfiguration manager. We propose a design approach using automata-based discrete control. It involves reactive programming that provides formal semantics, and discrete controller synthesis from declarative objectives.

This work is in the framework of the ANR project HPeC (see Section 8.2.1), and is published in the AHS 2017 conference [16].

6.2.1.2.2. Mission management and stochastic control

In the Mission Management workpackage of the ANR project HPeC, a concurrent control methodology is constructed for the optimal mission planning of a U.A.V. in stochastic environnement. The control approach is based on parallel ressource sharing Partially Observable Markov Decision Processes modeling of the mission. The parallel POMDP are reduced to discrete Markov Decision Models using Bayesian Networks evidence for state identification. The control synthesis is an iterative two step procedure : first MDP are solved for the optimisation of a finite horizon cost problem ; then the possible ressource conflicts between parallel actions are solved either by a priority policy or by a QoS degradation of actions, e.g., like using a lower resolution version of the image processing task if the ressource availability is critical.

6.2.2. IoT

Participants: Neïl Ayeb, Adja Sylla, Gwenaël Delaval, Stéphane Mocanu, Eric Rutten.

6.2.2.1. Control of smart buildings

A smart environment is equipped with numerous devices (i.e., sensors, actuators) that are possibly distributed over different locations (e.g., rooms of a smart building). These devices are automatically controlled to achieve different objectives related, for instance, to comfort, security and energy savings. Controlling smart environment devices is not an easy task. This is due to: the heterogeneity of devices, the inconsistencies that can result from communication errors or devices failure, and the conflicting decisions including those caused by environment dependencies.

Our work proposes a design framework for the reliable and environment aware management of smart environment devices. The framework is based on the combination of the rule based middleware LINC and the automata based language Heptagon/BZR (H/BZR). It consists of: an abstraction layer for the heterogeneity of devices, a transactional execution mechanism to avoid inconsistencies and a controller that, based on a generic model of the environment, makes appropriate decisions and avoids conflicts. A case study with concrete devices, in the field of building automation, is presented to illustrate the framework.

This work is in the framework of the cooperation with CEA (see Section 7.1), and is published in the Springer Journal of Internet Services and Applications, with recognized editors from the Middleware community [13]

6.2.2.2. Device management

The research topic is targeting an adaptative and decentralized management for the IoT. It will contribute design methods for processes in virtualized gateways in order to enhance IoT infrastructures.

More precisely, it concerns Device Management in the case of large numbers of connected sensors and actuators, as can be found in Smart Home and Building, Smart Electricity grids, and industrial frameworks as in Industry 4.0.

In contrast with a centralized management of such large sets of devices, for the autonomic management of their adaptations, upgrades and other commands, the objective its to target a distributed management, enabling local decisions, by proposing an appropriate middleware framework. These local adjustments will be processed using context data. The context is a synchronized (i.e., always up-to-date with reality) description of concepts and relations. Technically, the context data information are extracted from multiple sources such as IT environment, user environment and physical environment.

This work is in the framework of the Inria/Orange labs joint laboratory (see Section 7.2.1), and supported by the CIFRE PhD thesis grant of Neïl Ayeb, starting dec. 2017.

6.2.2.3. Security in SCADA industrial systems

We focus mainly on vulnerability search, automatic attack vectors synthesis and intrusion detection. Model checking techniques are used for vulnerability search and automatic attack vectors construction. Intrusion detection is mainly based on process-oriented detection with a technical approach from run-time monitoring. The LTL formalism is used to express safety properties which are mined on an attack-free dataset. The resulting monitors are used for fast intrusion detections.

A demonstrator of attack/defense scenarion in SCADA systems will be built on the existing G-ICS lab (hosted by ENSE3/Grenoble-INP).

This work is in the framework of the ANR project Sacade on cybersecurity of industrial systems (see Section 8.2.2),

7. Bilateral Contracts and Grants with Industry

7.1. Bilateral Contracts with Industry

Our cooperation with CEA (an EPIC, industrial and commercial public institution) concerns the LETI/LIST DACLE laboratory at Grenoble Minatec; it is bilateral, currently involving the CEA PhD grant of Adja Sylla, to work with F. Pacull and M. Louvel on high-level programming on top of a rule-based middleware (See Sections 6.1.3 and 6.2.2.1).

7.2. Bilateral Grants with Industry

7.2.1. Orange

We have a cooperation with Orange labs, around a CIFRE PhD grant, on the topic of autonomic device management (see Section 6.2.2.2). This activity is part of the Inria/Orange joint laboratory.

7.2.2. Nokia / Bell labs

We are starting a research action with Nokia / Bell labs, around a PhD, co-advised with project-team Dyonisos at Inria Rennes, on the topic of the integration of FPGA-based accelerators in network nodes, and their reconfiguration management in coordination with higher level Software Defined Networks management. This activity is part of the Inria/ Nokia / Bell labs joint laboratory.

8. Partnerships and Cooperations

8.1. Regional Initiatives

8.1.1. HPES action-team of the Labex Persyval-lab

The Labex Persyval-lab is a large regional initiative, supported by ANR, where we are contributing through the project *Equipe-action HPES*.

This project (2013-17) groups members from Inria, LIG, Gipsa-lab, TIMA and Gipsa-lab, around the topic of High-Performance Computing benefitting from technologies originally developed for Embedded Systems : https://persyval-lab.org/en/sites/hpes. Ctrl-A is directly involved in the co-advising of the PhD of Naweiluo Zhou, with J.F. Méhaut (Corse team of Inria/LIG), on the topic of autonomic management of software transactional memory mechanisms : https://persyval-lab.org/en/research/phd/autonomic-thread-parallelism-and-mapping-control-software-transactional-memory.

In 2017 we organized a workshop on Autonomic Computing and Control in Grenoble, supported by HPES (https://team.inria.fr/ctrl-a/members/eric-rutten/autoctrl/).

8.1.2. EcoSesa Cross-Disciplinary Project of the Idex

The Eco-SESA project, “Eco-district: Safe, Efficient, Sustainable and Accessible energy”, aims to produce knowledge, concepts, tools and methods to rethink the planning, management and governance of urban energy systems and the design of their components. Ctrl-A contributes to the research front 4 : Architectures for integration of renewable on-the-spot generation. A Post-doctoral position shared with G2Elab research lab will be funded.

8.2. National Initiatives

8.2.1. ANR HPeC

HPeC is an ANR project on Self-Adaptive, Energy Efficient High Performance Embedded Computing, with a UAV case study (http://hpec.fr/). The Coordinator is Lab-STICC / MOCS (Lorient / Brest), and the duration: 42 month from october 2015. Others Partners are: UBO, U. Clermont-Ferrand, InPixal.

In Ctrl-A, it is funding a post-doc position, hired in Grenoble and co-advised with Lorient : Soguy Gueye. A PhD based in Brest, Chabha Hireche, is co-advised by Stéphane Mocanu.

8.2.2. ANR Sacade

The ANR ASTRID Sacade project is funded by DGA. Stéphane Mocanu is in charge of several workpackages including a demonstrator. An expert engineer position is funded for the implementation of attack/defense scenarios in SCADA.

8.2.3. Informal National Partners

We have contacts with colleagues in France, in addition to the cooperation mentioned before, and with whom we are submitting collaboration projects, co-organizing events and workshops, etc. They feature : Avalon Inria team in Lyon (Ch. Perez, L. Lefevre, E. Caron), LIP6 (J. Malenfant), Scales Inria team in Sophia-Antipolis (L. Henrio), LIRRM in Montpellier (A. Gamatié, K. Godary, D. Simon), IRISA/Inria Rennes (J. Buisson, J.L. Pazat, ...), Telecom Paris-Tech (A. Diaconescu, E. Najm), LAAS (Thierry Monteil), LURPA ENS Cachan (J.M. Faure, J.J. Lesage).

8.2.4. Informal National Industrial Partners

We have ongoing discussions with several industrial actors in our application domains, some of them in the framework of cooperation contracts, other more informal: Eolas/Business decision (G. Dulac, I. Saffiedine), ST Microelectronics (V. Bertin), Schneider Electric (C. El-Kaed, P. Nappey, M. Pitel), Orange labs (J. Pulou, T. Coupaye, G. Privat, Anne Roch).

8.3. International Initiatives

8.3.1. Inria International Labs

We participate in the jLESC, Joint Laboratory for Extreme Scale Computing, with partners Inria, the University of Illinois, Argonne National Laboratory, Barcelona Supercomputing Center, Jülich Supercomputing Centre and RIKEN AICS.

We participated to the 7th Workshop of the JLESC at Urbana-Champain in July 2017.

We started a cooperation with Argonne National Labs, on Improving the performance and energy efficiency of HPC applications using autonomic computing techniques.

8.3.2. Inria International Partners

8.3.2.1. Informal International Partners

We have ongoing relations with international colleagues in the emerging community on our topic of control for computing e.g., in Sweden at Lund (K.E. Arzen, M. Maggio) and Linnaeus Universities (D. Weyns, N. Khakpour), in the Netherlands at CWI/leiden University (F. Arbab), in China at Heifei University (Xin An), in Italy at University Milano (C. Ghezzi, A. Leva), in the USA at Ann Arbor University (S. Lafortune) and UMass (P. Shenoy, E. Cecchet).

9. Dissemination

9.1. Promoting Scientific Activities

9.1.1. Scientific Events Organisation

9.1.1.1. Member of the Organizing Committees

Stéphane Mocanu is OC member of RESSI 2017 national meeting (https://ressi2017.sciencesconf.org/).

9.1.2. Scientific Events Selection

9.1.2.1. Member of the Conference Program Committees

Eric Rutten is PC member for :

- international conferences
  - ICAC 2017 (14th IEEE International Conference on Autonomic Computing), Columbus, Ohio, USA on July 17-21, 2017 (http://icac2017.ece.ohio-state.edu/)
  - ICCAC 2017 (2017 IEEE International Conference on Cloud and Autonomic Computing), The University of Arizona, Tucson, AZ, USA, September 18-22, 2017 (http://www.autonomic-conference.org/iccac-2017/)
  - FACS 2017, 14th International Conference on Formal Aspects of Component Software, 10-13 October 2016, in Braga, Portugal (http://facs2017.di.uminho.pt/)
  - 14th Workshop on Discrete Event Systems, WODES'18, Sorrento Coast, Italy, May 30 - June 1, 2018. (http://wodes2018.unisa.it/)
  - ICAC 2018 (15th IEEE International Conference on Autonomic Computing), Sept 3-7, 2018, Trento, Italy (http://autonomic-conference.org)

    (this conference is the merging of the previous ICAC and ICCAC conferences above)
  - 2nd IEEE Conference on Control Technology and Applications, CCTA 18, Copenhagen, Denmark, August 21-24, 2018 (http://ccta2018.ieeecss.org/)
- national conferences
  - workshop Architectures Logicielles et Matérielles pour la Robotique Autonome, les Systèmes Cyber-Physiques et les Systèmes Auto-Adaptables SHARC2017, LAAS Toulouse, 29 et 30 juin 2017, (https://sharc2017.sciencesconf.org)
  - 11ème colloque francophone sur la Modélisation des Systèmes Réactifs (MSR'17), 15-17 novembre 2017, Marseille (France) (http://www.lsis.org/msr2017/)

9.1.2.2. Reviewer

Stéphane Mocanu and Soguy Gueye are reviewers for ICAC 2017 (14th IEEE International Conference on Autonomic Computing), Columbus, Ohio, USA on July 17-21, 2017 (http://icac2017.ece.ohio-state.edu/).

Stéphane Mocanu is reviewer for 11ème colloque francophone sur la Modélisation des Systèmes Réactifs (MSR'17), 15-17 novembre 2017, Marseille (France) (http://www.lsis.org/msr2017/).

Gwenaël Delaval is reviewers for FACS 2017, 14th International Conference on Formal Aspects of Component Software, 10-13 October 2016, in Braga, Portugal (http://facs2017.di.uminho.pt/)

9.1.3. Journal

9.1.3.1. Reviewer - Reviewing Activities

Eric Rutten is invited editor of

- journal on Distributed Computing (Springer)
- Science of Computer Programming
- IEEE TSC Transactions on Services Computing
- IEEE TSE Transactions on Software Engineering
- ACM Transactions on Autonomous and Adaptive Systems
- IEEE Transactions on Industrial Informatics

Stéphane Mocanu is invited editor of journal of Discrete Events Dynamical Systems.

9.1.4. Invited Talks

Gwenaël Delaval was invited to give a talk at journées du LIP "Langage, Sémantique et Compilation", june 2017 (with E. Rutten).

Eric Rutten was invited to give a talk at :

- FETCH 2017, Ecole d'Hiver francophone sur la technologie de conception des systèmes embarqués hétérogènes, 9-11 janvier 2017, Mont Tremblant, Canada http://fetch-conference.org
- séminaire de l'équipe ASCOLA, IMT Nantes, 2 mai 2017
- FETCH 2018, Ecole d'Hiver francophone sur la technologie de conception des systèmes embarqués hétérogènes, 24-26 Janvier 2018, Saint Malo http://fetch-conference.org

9.1.5. Leadership within the Scientific Community

Eric Rutten is co-chair of the Technical Committee on Discrete Event Systems (DESTC), a part of the IEEE Control Systems Society (CSS) Technical Activities Board (http://discrete-event-systems.ieeecss.org/tc-discrete/home) ; and member of the IFAC Technical Committee 1.3 on Discrete Event and Hybrid Systems, for the 2017-2020 triennum (http://tc.ifac-control.org/1/3).

9.1.6. Research Administration

Eric Rutten is member of the LIG laboratory council, and in charge of scientific relations between Inria Grenoble Rhône-Alpes and CEA Tech.

9.2. Teaching - Supervision - Juries

9.2.1. Teaching

Licence : G. Delaval, Algorithmics and imperative programming, 18h class, 18h lab, L2, Université Grenoble Alpes

Licence : G. Delaval, Basis of software development : modularity, tests, 15h class, 15h lab, L2, Université Grenoble Alpes

Master : G. Delaval, Programming languages and compiler design, 33h, M1, Université Grenoble Alpes

Master : S. Mocanu, Computer Networks and Cybersecurity, 16h class, 34h lab, M1, Grenoble-INP/ENSE3

Master : S. Mocanu, Industriel Computer Networks, 8h class, 8h lab, niveau (M1, M2), M2, Grenoble-INP/ENSE3

Master : S. Mocanu, Reliability, 10h class, 8h lab, M2, Grenoble-INP/ENSE3

9.2.2. Supervision

- PhD : Maëlle Kabir-Querrec; Cybersécurité des systèmes de contrôle pour les smart-grids ; 28 juin 2017 ; U. Grenoble Alpes ; co-advised by S. Mocanu with J-M Thiriet (Gipsa-lab).
- PhD : Adja Ndeye SYLLA ; Support intergiciel pour la conception et le déploiement adaptatifs fiables, application aux bâtiments intelligents ; U. Grenoble Alpes ; 18 dec. 2017 ; co-advised by Eric Rutten with M. Louvel (CEA). [11]
- PhD in progress : Neïl Ayeb ; Vers un management des objets de l'IoT de´centralise´ et adaptable ; dec. 2017 ; co-advised by Eric Rutten with S. Bolle, T. Coupaye (Orange labs).
- PhD in progress : Chabha Hireche ; Etude et implémentation d'une approche probabiliste de contrôle de mission de drone autonome ; oct. 2015 ; co-advised by S. Mocanu with Catherine Dezan (U. Bretagne Occidentale), and Jean-Philippe Diguet (U. Bretagne Sud).

- PhD in progress : Ahmed Altaher ; Mise en oeuvre d'un cadre de sureté de fonctionnement pour les systèmes de contrôle industriel : application à des systèmes de distribution d'énergie électrique (smart grids) ; april 2013 ; co-advised by S. Mocanu with J-M Thiriet (Gipsa-lab).
- Oualid Koucham ; Détection d'intrusions dans les systèmes de contrôle industriels ; oct 2015 ; co-advised by S. Mocanu with J-M Thiriet (Gipsa-lab).

9.2.3. Juries

Eric Rutten was member of the jury for the PhD of Sabbir Hasan Rochi, 3 may 2017, IMT Atlantique campus Nantes, ASCOLA team at Inria Rennes Bretagne Atlantique, dir. Jean-Louis Pazat and Thomas Ledoux.

10. Bibliography

Major publications by the team in recent years

[1] F. Alvares De Oliveira Jr., E. Rutten, L. Seinturier. *Using Feature Models for Distributed Deployment in Extended Smart Home Architecture*, in "9th European Conference on Software Architecture (ECSA)", Dubrovnick, Croatia, LNCS, Danny weyns and Raffaela Mirandola and Ivica Crnkovic, September 2015, vol. 9278, pp. 285-293, https://hal.inria.fr/hal-01160612

[2] X. An, E. Rutten, J.-P. Diguet, A. Gamatié. *Model-based design of correct controllers for dynamically reconfigurable architectures*, in "ACM Transactions on Embedded Computing Systems (TECS)", February 2016, vol. 15, n° 3, https://hal.inria.fr/hal-01272077

[3] N. Berthier, É. Rutten, N. De Palma, S. M.-K. Gueye. *Designing Autonomic Management Systems by using Reactive Control Techniques*, in "IEEE Transactions on Software Engineering", July 2016, vol. 42, n° 7, 18 p. , https://hal.inria.fr/hal-01242853

[4] J. Cano, G. Delaval, E. Rutten. *Coordination of ECA rules by verification and control*, in "16th International Conference on Coordination Models and Languages", Berlin, Germany, June 2014, 16 p. , https://hal.archives-ouvertes.fr/hal-01006186

[5] G. Delaval, S. M.-K. Gueye, E. Rutten, N. De Palma. *Modular Coordination of Multiple Autonomic Managers*, in "17th International ACM Sigsoft Symposium on Component-Based Software Engineering (CBSE 2014)", Lille, France, June 2014, 291 p. [*DOI :* 10.1145/2602458.2602465], https://hal.archives-ouvertes.fr/hal-01006106

[6] G. Delaval, E. Rutten. *Reactive model-based control of reconfiguration in the Fractal component-based model*, in "Proceedings of the 13th International Symposium on Component Based Software Engineering (CBSE), Prague, Czech Republic, 23-25 June", 2010, pp. 93–112, best paper award, http://dx.doi.org/10.1007/978-3-642-13238-4_6

[7] G. Delaval, E. Rutten, H. Marchand. *Integrating Discrete Controller Synthesis in a Reactive Programming Language Compiler*, in "journal of Discrete Event Dynamic System, jDEDS, special issue on Modeling of Reactive Systems", 2013, vol. 23, n° 4, pp. 385-418, http://dx.doi.org/10.1007/s10626-013-0163-5

[8] S. M.-K. Gueye, N. De Palma, É. Rutten, A. Tchana, N. Berthier. *Coordinating self-sizing and self-repair managers for multi-tier systems*, in "Future Generation Computer Systems", June 2014, vol. 35, pp. 14 - 26 [*DOI :* 10.1016/j.future.2013.12.037], https://hal.inria.fr/hal-00949556

[9] N. KHAKPOUR, F. ARBAB, E. RUTTEN. *Supervisory Controller Synthesis for Safe Software Adaptation*, in "12th IFAC - IEEE International Workshop on Discrete Event Systems, WODES '14", Paris, France, May 2014, https://hal.inria.fr/hal-01091155

[10] N. ZHOU, G. DELAVAL, B. ROBU, E. RUTTEN, J.-F. MÉHAUT. *Autonomic Parallelism and Thread Mapping Control on Software Transactional Memory*, in "13th IEEE International Conference on Autonomic Computing (ICAC 2016)", Würzburg, Germany, July 2016, https://hal.archives-ouvertes.fr/hal-01309681

Publications of the year

Doctoral Dissertations and Habilitation Theses

[11] A. NDEYE SYLLA. *Middleware Support for Adaptive, Reliable Conception and Deployment, Application to Building Automation*, Université Grenoble - Alpes, December 2017, https://hal.archives-ouvertes.fr/tel-01671747

Articles in International Peer-Reviewed Journals

[12] F. ALVARES, E. RUTTEN, L. SEINTURIER. *A Domain-specific Language for The Control of Self-adaptive Component-based Architecture*, in "Journal of Systems and Software", January 2017, https://hal.archives-ouvertes.fr/hal-01450517

[13] A. NDEYE SYLLA, M. LOUVEL, É. RUTTEN. *Design Framework for Reliable and Environment Aware Management of Smart Environment Devices*, in "Journal of Internet Services and Applications", November 2017, https://hal.archives-ouvertes.fr/hal-01650737

International Conferences with Proceedings

[14] F. ALVARES, G. DELAVAL, E. RUTTEN, L. SEINTURIER. *Language Support for Modular Autonomic Managers in Reconfigurable Software Components*, in "SeAC 2017 - 2nd Workshop on Self-Aware Computing @ ICAC'17", Colombus, United States, July 2017, pp. 271 - 278 [*DOI :* 10.1109/ICAC.2017.48], https://hal.inria.fr/hal-01575353

[15] N. BERTHIER, F. ALVARES, H. MARCHAND, G. DELAVAL, E. RUTTEN. *Logico-numerical Control for Software Components Reconfiguration*, in "CCTA 2017 - IEEE Conference on Control Technology and Applications", Mauna Lani, HI, United States, IEEE, August 2017, pp. 1599 - 1606 [*DOI :* 10.1109/CCTA.2017.8062685], https://hal.inria.fr/hal-01644754

[16] S. M.-K. GUEYE, E. RUTTEN, J.-P. DIGUET. *Autonomic Management of Missions and Reconfigurations in FPGA-based Embedded System*, in "The 2017 NASA/ESA Conference on Adaptive Hardware and Systems", Pasadena, California, United States, July 2017, 8 p. , The 2017 NASA/ESA Conference on Adaptive Hardware and Systems (AHS 2017) will be held July 24 – 27, 2017 at California Institute of Technology in Pasadena, CA, USA., https://hal.inria.fr/hal-01582518

[17] M. LOUVEL, F. PACULL, E. RUTTEN, A. N. SYLLA. *Development Tools for Rule-Based Coordination Programming in LINC*, in "19th International Conference on Coordination Languages and Models (COORDINATION)", Neuchâtel, Switzerland, J.-M. JACQUET, M. MASSINK (editors), Coordination Models and Languages, Springer International Publishing, June 2017, vol. LNCS-10319, pp. 78-96, Part 2: Languages and Tools [*DOI :* 10.1007/978-3-319-59746-1_5], https://hal-cea.archives-ouvertes.fr/cea-01531019

[18] A. N. SYLLA, M. LOUVEL, E. RUTTEN, G. DELAVAL. *Design Framework for Reliable Multiple Autonomic Loops in Smart Environments*, in "2017 IEEE International Conference on Cloud and Autonomic Computing (ICCAC)", Tucson, AZ, United States, September 2017, https://hal-cea.archives-ouvertes.fr/cea-01570026

Scientific Books (or Scientific Book chapters)

[19] M. LITOIU, M. SHAW, G. TAMURA, N. M. VILLEGAS, H. MÜLLER, H. GIESE, R. ROUVOY, E. RUTTEN. *What Can Control Theory Teach Us About Assurances in Self-Adaptive Software Systems?*, in "Software Engineering for Self-Adaptive Systems 3: Assurances", R. DE LEMOS, D. GARLAN, C. GHEZZI, H. GIESE (editors), LNCS, Springer, May 2017, vol. 9640, https://hal.inria.fr/hal-01281063

References in notes

[20] E. RUTTEN, N. MARCHAND, D. SIMON. *Feedback Control as MAPE-K loop in Autonomic Computing*, in "Software Engineering for Self-Adaptive Systems", Lecture Notes in Computer Science, Springer, April 2016, https://hal.inria.fr/hal-01285014

[21] E. STAHL. *Techniques de contrôle pour la gestion autonomique des plateformes de calcul*, Grenoble INP, ENSE 3 , France, 2017

[22] L. TERRIER. *A Language for the Smart Home* , UFRIM 2 AG, Université Grenoble Alpes, France, 2017