IN PARTNERSHIP WITH:
Institut polytechnique de Grenoble

Université de Grenoble Alpes

Activity Report 2019

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
A1.1.5. - Exascale
A1.1.9. - Fault tolerant systems
A1.1.10. - Reconfigurable architectures
A1.3. - Distributed Systems
A1.3.5. - Cloud
A1.4. - Ubiquitous Systems
A2.1.9. - 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
A2.6.4. - Ressource management
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. Team, Visitors, External Collaborators

Research Scientist

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

Faculty Members

Raphaël Bleuse [Univ Grenoble Alpes, Associate Professor, from Sep 2019]
Gwenaël Delaval [Univ Grenoble Alpes, Associate Professor]
Stéphane Mocanu [Institut polytechnique de Grenoble, Associate Professor]

Post-Doctoral Fellows

Quang Pham Tran Anh [Inria/Nokia, co-advised EPI Dyonisos, Rennes, until nov. 2019]
Hamza Sahli [Inria, co-advised EPI Stack, Nantes, from jan. 2019]

PhD Student

Neil Ayeb [Orange Labs, PhD Student]

Technical staff

Jan Pristas [Institut polytechnique de Grenoble, Engineer, from Feb 2019 until Jul 2019]

Interns and Apprentices

Abdul Hafeez Ali [Inria, from Feb 2019 until Jul 2019]
Ayan Hore [Inria, from Feb 2019 until Jul 2019]
Fabien Lefevre [Univ Grenoble Alpes, from Oct 2019]
Lucie Muller [Inria, until Jul 2019]
Gaetan Sorin [Univ Grenoble Alpes, from Oct 2019]
Mohsen Zargarani [Univ Grenoble Alpes, from Feb 2019 until Jul 2019]

Administrative Assistant

Maria Immaculada Presseguer [Inria, Administrative Assistant]

External Collaborators

Soguy Mak Kare Gueye [Atos, until Jul 2019]
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) [7], 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 [5], and of domain specific languages, following e.g., a component-based approach [4], [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], 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 [3], multi-core HPC architectures [10], Dynamic Partial Reconfiguration in FPGA-based hardware [2] and the IoT and smart environments [8].

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. Highlights of the Year

5.1. Highlights of the Year

The Ctrl-A team co-organised, in cooperation with the Gipsa-lab laboratory, the 40th International Summer School in Grenoble, with a special topic on Control of Computing Systems, on 9-13th of September 2019.

Invited speakers were international specialists of the field, from USA, Europe and France. Full information and programme are available : http://www.gipsa-lab.fr/summerschool/auto2019

6. New Software and Platforms

6.1. 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

7. New Results

7.1. Programming support for Autonomic Computing

7.1.1. Reactive languages

Participants: Gwenaël Delaval, Lucie Muller, 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, integrating the tool ReaX, in order to obtain an imperative executable code. The programming language Heptagon / BZR (see Section Software and Platforms) integrates our research results [5].

An ongoing topic is on abstraction methods for compilation using discrete controller synthesis (needed for example, in order to program the controllers for systems where the useful data for control can be of arbitrary types (integer, real, ...), or also for systems which are naturally distributed, and require a decentralized controller).

Recent work concerns compilation and diagnosis for discrete controller synthesis. The compilation involving a phase of controller synthesis can fail to find a solution, if the problem is overconstrained. The compiler does notify so to the programmer, but the latter would need a diagnosis in order to understand where and how to debug the program. Such diagnosis is made especially difficult by the declarative nature of the synthesis.

This was the object of the M1 TER internship of Lucie Muller [19].

7.1.2. Domain-specific languages

Participants: Gwenaël Delaval, Soguy Mak Kare Gueye, Eric Rutten.

Our work in Domain-specific languages (DSLs) is founded on our work in component-based programming for autonomic computing systems as examplified by e.g., FRACTAL. We consider 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 7.1.1 [4]. In recent work, we proposed an extension of a classical Software Architecture Description Languages (ADL) with Ctrl-F, DSL for the specification of dynamic reconfiguration behavior in a [1]. Based on this experience, we also proposed a DSL called Ctrl-DPR [6], allowing designers to easily generate Autonomic Managers for DPR FPGA systems (see Section 7.2.3).

Ongoing work involves a generalization from our past experiences in software components, DPR FPGA, as well as IoT [8], and Cyberphysical Systems. As we observed a similarity in objects and structures (e.g., tasks, implementation versions, resources, and upper-level application layer), we are considering a more general DSL, which could be specialized towards such different target domains, and where the compilation towards reactive models could be studied and improved, especially considering the features of Section 7.1.1. This direction will also lead us to study the definition of software architecture patterns for multiple loops Autonomic Managers, particularly hierarchical, with lower layers autonomy alleviating management burden from the upper layers as in Section 7.2.

7.2. Design methods for reconfiguration controller design in computing systems

We apply the results of the previous axes of the team's activity, as well as other control techniques, 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 [7], [9].

7.2.1. Self-adaptative distributed systems

Participants: Quang Pham Tran Anh, Eric Rutten, Hamza Sahli.

Complex Autonomic Computing Systems, as found typically in distributed systems, must involve multiple management loops, addressing different subproblems of the general management, and using different modeling, decision and control approaches (discrete [3], continuous, stochastic, machine-learning based, ...) They are generally addressing deployment and allocation of computations on resources w.r.t. QoS, load, faults, ... but following different, complementary approaches. The similarities and recurring patterns are considered as in Section 7.1.2 . Their execution needs to be distributed w.r.t. different characteristics such as latency (as in Fog and Edge Computing) or load. We are studying Software Architectures to address the design of such complex systems.

7.2.1.1. Self-adaptation of micro-services in Fog/Edge and Cloud computing

Fog systems are a recent trend of distributed computing having vastly ubiquitous architectures and distinct requirements making their design difficult and complex. Fog computing is based on leveraging both resource-scarce computing nodes around the Edge to perform latency and delay sensitive tasks and Cloud servers for the more intensive computation.

In this work, we present a formal model defining spatial and structural aspects of Fog-based systems using Bigraphical Reactive Systems, a fully graphical process algebraic formalism. The model is extended with reaction rules to represent the dynamic behavior of Fog systems in terms of self-adaptation. The notion of bigraph patterns is used in conjunction with boolean and temporal operators to encode spatio-temporal properties inherent to Fog systems and applications. The feasibility of the modelling approach is demonstrated via a motivating case study and various self-adaptation scenarios.

This work is done in cooperation with the Inria team Stack in Nantes, and published in the FOCLASA workshop, co-located with the SFEM conference [13].

7.2.1.2. Autonomic management in Software Defined Networks

In the framework of our cooperation with Nokia Bell-labs (See Section 8.1.2), and the Dyonisos team at Inria Rennes, we are considering the management of Software Defined Networks (SDN), involving Data-Centers and accelerators.

The main approach AI / Machine Learning approaches, developed in Rennes. An ongoing topic is to consider that these reinforcement learning based approaches involve questions of trust, and we are beginning to consider their composition with controllers based e.g. on Control Theory, in order to maintain guarantees on the behaviors of the managed system.

7.2.2. High-Performance Grid Computing

Cloud and HPC (High-Performance Computing) systems have increasingly become more varying in their behavior, in particular in aspects such as performance and power consumption, and the fact that they are becoming less predictable demands more runtime management [10].

7.2.2.1. A Control-Theory based approach to minimize cluster underuse

Participants: Abdul Hafeez Ali, Raphaël Bleuse, Bogdan Robu, Eric Rutten.

One such problem is found in the context of CiGri, a simple, lightweight, scalable and fault tolerant grid system which exploits the unused resources of a set of computing clusters. In this work, we consider autonomic administration in HPC systems for scientific workflows management through a control theoretical approach. We propose a model described by parameters related to the key aspects of the infrastructure thus achieving a deterministic dynamical representation that covers the diverse and time-varying behaviors of the real computing system. We propose a model-predictive control loop to achieve two different objectives: maximize cluster utilization by best-effort jobs and control the file server's load in the presence of external disturbances. The accuracy of the prediction relies on a parameter estimation scheme based on the EKF (Extended Kalman Filter) to adjust the predictive-model to the real system, making the approach adaptive to parametric variations in the infrastructure. The closed loop strategy shows performance improvement and consequently a reduction in the total computation time. The problem is addressed in a general way, to allow the implementation on similar HPC platforms, as well as scalability to different infrastructures.

This work is done in cooperation with the Datamove team of Inria/LIG, and Gipsa-lab. Some results were published in the CCTA conference [14]. It was the topic of the Master's thesis of Abdul Hafeez Ali [16].

7.2.2.2. Combining Scheduling and Autonomic Computing for Parallel Computing Resource Management

Participants: Raphaël Bleuse, Eric Rutten.

This research topic aims at studying the relationships between scheduling and autonomic computing techniques to manage resources for parallel computing platforms. The performance of such platforms has greatly improved (149 petaflops as of November 2019 [20]) at the cost of a greater complexity: the platforms now contain several millions of computing units. While these computation units are diverse, one has to consider other constraints such as the amount of free memory, the available bandwidth, or the energetic envelope. The variety of resources to manage builds complexity up on its own. For example, the performance of the platforms depends on the sequencing of the operations, the structure (or lack thereof) of the processed data, or the combination of application running simultaneously.

Scheduling techniques offer great tools to study/guaranty performances of the platforms, but they often rely on complex modeling of the platforms. They furthermore face scaling difficulties to match the complexity of new platforms. Autonomic computing manages the platform during runtime (on-line) in order to respond to the variability. This approach is structured around the concept of feedback loops.

The scheduling community has studied techniques relying on autonomic notions, but it has failed to link the notions up. We are starting to address this topic.

7.2.3. High-Performance Embedded Computing

Participants: Soguy Mak Kare Gueye, Stéphane Mocanu, Eric Rutten.

This topics build upon our experience in reconfiguration control in DPR FPGA [2].

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. 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. This work is in the framework of the ANR project HPeC (see Section 9.2.1).

7.2.3.1. DPR FPGA and discrete control for reconfiguration

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.

Ongoing work concerns experimental validation, where upon the availability of hardware implementations of vision, detection and tracking tasks, a demonstrator is being built integrating our controller.

7.2.3.2. 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.

This work was performed in the framework of the PhD of Chabha Hireche, defended in nov. 2019 [17].

7.2.4. IoT and Cyberphysical Systems

Participants: Neil Ayeb, Ayan Hore, Fabien Lefevre, Stéphane Mocanu, Jan Pristas, Eric Rutten, Gaetan Sorin, Mohsen Zargarani.

7.2.4.1. 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 (DM) 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.

Device Management is currently industrially deployed for LAN devices, phones and workstation management. Internet of Things (IoT) devices are massive, dynamic, heterogeneous, and inter-operable. Existing solutions are not suitable for IoT management. This work in an industrial environment addresses these limitations with a novel autonomic and distributed approach for the DM.

This work is in the framework of the Inria/Orange labs joint laboratory (see Section 8.1.1), and supported by the CIFRE PhD thesis grant of Neïl Ayeb, starting dec. 2017. It was awarded a best paper distinction at the Doctoral Symposium of ICAC 2019 [12].

7.2.4.2. Security in SCADA industrial systems

We focus mainly on vulnerability search, automatic attack vectors synthesis and intrusion detection [11]. 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 scenario in SCADA systems has been 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 9.2.2).

One of important results is the realization of a Hardware-in-the-loop SCADA Cyberange based on a electronic interface card that allows to interface real-world PLC with a software simulation [21]. The entire system is available in open-source including the electronic card fabrication files (http://gics-hil.gforge.inria.fr/). Interfacing system allow connection with various commercial simulation software but also with “home made” simulators [15]. The work is also supported by Grenoble Alpes Cybersecurity Institute (see Section 9.1.1) and Pulse program of IRT NANOELEC.

Ongoing work concerns the complementary topic of analysis and identification of reaction mechanisms for self-protection in cybersecurity, where, beyond classical defense mechanisms that detect intrusions and attacks or assess the kind of danger that is caused by them, we explore models and control techniques for the automated reaction to attacks, in order to use detection information to take the appropriate defense and repair actions. A first approach was developed in the M2R internship by Ayan Hore [18]

8. Bilateral Contracts and Grants with Industry

8.1. Bilateral Grants with Industry

8.1.1. Orange

We have a cooperation with Orange labs, around a CIFRE PhD grant, on the topic of autonomic device management (see Section 7.2.4.1). This activity is part of the Inria/Orange joint laboratory.

8.1.2. Nokia / Bell labs

We have a research action with Nokia / Bell labs, around a post-doctorate, co-advised with project-team Dyonisos at Inria Rennes, on the topic of the Autonomic management in Software Defined Networks. This activity is part of the Inria/ Nokia / Bell labs joint laboratory.

9. Partnerships and Cooperations

9.1. Regional Initiatives

9.1.1. Grenoble Alpes Cybersecurity Institute Cross-Disciplinary Project of the Idex

The Grenoble Alpes Cybersecurity Institute aims at undertaking ground-breaking interdisciplinary research in order to address cybersecurity and privacy challenges. Our main technical focus is on low-cost secure elements, critical infrastructures, vulnerability analysis and validation of large systems, including practical resilience across the industry and the society.

In Ctrl-A, it is currently funding two “alternance” student positions and a PhD position might be provided in September 2020 and supervised by Stephane Mocanu.

9.2. National Initiatives

9.2.1. 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 has been funding a post-doc position, hired in Grenoble and co-advised with Lorient : Soguy Gueye. The work will be continued with a post-doc hired in Lorient : Erwan Moreac. A PhD based in Brest, Chabha Hireche, is co-advised by Stéphane Mocanu.

9.2.2. 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.

9.2.3. IRT Nanoelec Pulse program

The Pulse program aims the development for SCADA cybersecurity demonstrators. It has funded a Master grant in 2019 and two master grants in 2020. A PhD position was also approved for September 2020 and it will be co-supervised by Stéphane Mocanu

9.2.4. 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).

9.2.5. 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).

9.3. European Initiatives

9.3.1. FP7 & H2020 Projects

Program: ECSEL

Project acronym: CPS4EU

Project title: Cyber Physical Systems for Europe

Duration: july 2019 - june 2022

Coordinator: VALEO

Other partners: 38 participants

Abstract: CPS4EU proposes to address technical issues and organizational issues in an integrated way. Hence, CPS4EU promotes a high level of sharing, so that an operational ecosystem, with adequate skills and expertise all along the value chain can enable, at the end of the project, the European industry to lead strategic markets based on CPS technologies.

In this project, the Ctrl-A team is involved in WP4 and WP9 mainly, on topics of Software Architectures for Self-Adaptive systems in CPS, and our main industrial collaboration is with RTE.

9.4. International Initiatives

9.4.1. 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 9th Workshop of the JLESC at Knoxville, TE, USA, in April 2019, and visited ANL in Chicago.

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

https://jlesc.github.io/projects/energy_autonomic/

We are also exploring possibilities on the topic of integrating FPGAs in HPC grids, with a participation in a workshop at FPT 18.

https://collab.cels.anl.gov/display/HPCFPGA/HPC-FPGA

9.4.2. Inria International Partners

9.4.2.1. 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), Mälardalen (A. Papadopoulos) and Linnaeus Universities (D. Weyns, N. Khakpour), in the Netherlands at CWI/leiden University (F. Arbab), in the U.K. at Liverpool U. (N. Berthier), 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).

10. Dissemination

10.1. Promoting Scientific Activities

10.1.1. Scientific Events: Organisation

10.1.1.1. General Chair, Scientific Chair

Eric Rutten is co-chairing, with Bogdan Robu (Gipsa-lab), the program of the 40th Summer School of Automatic Control, Grenoble, September 2019, on the special topic of Control for Computing Systems.

http://www.gipsa-lab.fr/summerschool/auto2019

10.1.2. Scientific Events: Selection

10.1.2.1. Chair of Conference Program Committees

Eric Rutten is co-chairing, with Françoise Baude, Antonio Fileri, and Nicola Capodieci, the 5th International Workshop on Autonomic High Performance Computing (AHPC 2019), http://hpcs2019.cisedu.info/2-conference/workshops/workshop09-ahpc

as part of The 17th International Conference on High Performance Computing & Simulation (HPCS 2019), July 15 – 19, 2019 Dublin, Ireland, http://hpcs2019.cisedu.info/

10.1.2.2. Member of the Conference Program Committees

Eric Rutten is PC member for :

- international conferences
  - ICAC 2019 (16th IEEE International Conference on Autonomic Computing), Umeøa, Sweden, June 16-20, 2 019 (http://icac2019.cs.umu.se)
  - 17th High Performance Computing & Simulation Conference (HPCS 2019). July 15 – 19, 2019 Dublin, Ireland (http://hpcs2019.cisedu.info/)
  - 15th Workshop on Discrete Event Systems, WODES'20, Rio de Janeiro, May, 13th-15th, 2020. (https://wodes2020.eventos.ufrj.br)
  - CPS&IoT'2020 - the 8th International Conference on Cyber-Physical Systems and Internet-of-Things, Budva, Montenegro, June 8-11, 2020 (http://embeddedcomputing.me/en/cps-iot-2020)
  - (Associate Editor) 4th IEEE Conference on Control Technology and Applications, CCTA 2020, Montreal, August, 2020 (http://ccta2020.ieeecss.org/)
  - 7th International Conference on Control, Decision and Information Technologies, CoDIT'20, June 29 - July 02, 2020, Prague, Czech Republic (https://codit2020.com/)
  - MSR 19, Modélisation des Systèmes Réactifs 2019 LARIS Université d'Angers, France, du 13 au 15 novembre 2019 (http://msr2019.laris.univ-angers.fr/)

10.1.3. Journal

10.1.3.1. Reviewer - Reviewing Activities

Eric Rutten is reviewer for

- Science of Computer Programming
- journal of Discrete Event Dynamic System (jDEDS)

10.1.4. Invited Talks

Eric Rutten was invited to give a talk at :

- Workshop on Integrating HPC and FPGAs, December 11, 2018 in Okinawa, Japan ; co-held with the International Workshop on FPGA for HPC (IWFH), the Joint Laboratory on Extreme Scale Computing (JLESC), and the Field-Programmable Technology (FPT'18).

  http://www.fpt18.sakura.ne.jp/workshop.html

  https://collab.cels.anl.gov/display/HPCFPGA/HPC-FPGA
- FETCH 2019, Ecole d'Hiver francophone sur la technologie de conception des systèmes embarqués hétérogènes, Louvain-la-Neuve, Belgique, 28-30 janvier 2019 http://fetch-conference.org
- Languages, Compilation, and Semantics LIP Seminar, 10th Edition, Lyon, 2019, March 21

  http://perso.ens-lyon.fr/christian.perez/journeelangages
- 15th Cloud Control Workshop, Sandhamn, Sweden June 11–13, 2019

  http://cloudresearch.org/workshops/15th/

10.1.5. 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).

10.1.6. Scientific Expertise

Eric Rutten was reviewer for the ANR : *Appel à projets Générique* 2019, PRCI international

10.1.7. 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.

10.2. Teaching - Supervision - Juries

10.2.1. Teaching

Licence : R. Bleuse, C language, 12h lab, L2, Univ. Grenoble Alpes

Licence : R. Bleuse, methodology of software development, 30h, L2, Univ. 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

Master : S. Mocanu, Intrusion Detection and Defense in Depth labs, niveau M2, Grenoble-ENSE3/ENSIMAG

10.2.2. Supervision

- HdR : Stéphane Mocanu ; Cyberdéfense des infrastructures critiques ; COMMUNAUTÉ UNIVERSITÉ GRENOBLE ALPES ; January 2019.
- PhD : Chabha Hireche ; Etude et implémentation d'une approche probabiliste de contrôle de mission de drone autonome ; Université de Bretagne Occidentale ; nov. 2019 ; co-advised by S. Mocanu with Catherine Dezan (U. Bretagne Occidentale), and Jean-Philippe Diguet (U. Bretagne Sud).
- PhD in progress : Neïl Ayeb ; Vers un management des objets de l'IoT décentralisé et adaptable ; dec. 2017 ; co-advised by Eric Rutten with S. Bolle, T. Coupaye (Orange labs).

10.2.3. Juries

Stéphane Mocanu was member of the jury of the PhD defense of Chabha Hireche, Université de Bretagne Occidentale, nov. 2019 (examinator).

Eric Rutten was member of the following juries :

- habilitation (HdR) defense, Stéphane Mocanu, UNIVERSITÉ GRENOBLE ALPES, 16 jan. 2019 (examinator)
- PhD defense of Anis Mezni, INSA Lyon, 13 may 2019 (reviewer)
- PhD defense of Mete Özbaltan, U. Liverpool, 10 dec 2019 (reviewer)
- PhD of Romolo Marotta, Uni. Roma Sapienza, dec 2019 (reviewer)

10.3. Popularization

10.3.1. Interventions

- National events:

  During the 2019 edition of Fête de la Science, Raphaël Bleuse co-hosted with Clément Mommessin (DataMove team) six one-hour popularization sessions. These sessions introduce the concept of infinity, and detail key milestones towards its construction in the modern mathematics for high-school students.

11. Bibliography

Major publications by the team in recent years

[1] 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

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[3] N. BERTHIER, E. 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^{o} 7, 18 p. , https://hal.inria.fr/hal-01242853

[4] 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

[5] 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^o 4, pp. 385-418, http://dx.doi.org/10.1007/s10626-013-0163-5

[6] S. M.-K. GUEYE, G. DELAVAL, E. RUTTEN, D. HELLER, J.-P. DIGUET. *A Domain-specific Language for Autonomic Managers in FPGA Reconfigurable Architectures*, in "ICAC 2018 - 15th IEEE International Conference on Autonomic Computing", Trento, Italy, IEEE, September 2018, pp. 1-10, https://hal.archives-ouvertes.fr/hal-01868675

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[9] E. RUTTEN, N. MARCHAND, D. SIMON. *Feedback Control as MAPE-K loop in Autonomic Computing*, in "Software Engineering for Self-Adaptive Systems III. Assurances.", Lecture Notes in Computer Science, Springer, January 2018, vol. 9640, pp. 349-373 [*DOI :* 10.1007/978-3-319-74183-3_12], https://hal.inria.fr/hal-01285014

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Doctoral Dissertations and Habilitation Theses

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International Conferences with Proceedings

[12] N. AYEB, E. RUTTEN, S. BOLLE, T. COUPAYE, M. DOUET. *Towards an Autonomic and Distributed Device Management for the Internet of Things*, in "FAS*W 2019 - IEEE 4th International Workshops on Foundations and Applications of Self* Systems", Umea, Sweden, 16th IEEE International Conference on Autonomic Computing (ICAC), IEEE, June 2019, pp. 246-248, Best paper award at the Doctoral Symposium of ICAC 2019 [*DOI :* 10.1109/FAS-W.2019.00065], https://hal.archives-ouvertes.fr/hal-02295409

[13] H. SAHLI, T. LEDOUX, E. RUTTEN. *Modeling Self-Adaptive Fog Systems Using Bigraphs*, in "FOCLASA 2019 - 17th International Workshop on coordination and Self-Adaptativeness of Sotware applications", Oslo, Norway, September 2019, pp. 1-16, https://hal.inria.fr/hal-02271394

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[15] S. MOCANU, M. PUYS, P.-H. THEVENON. *An Open-Source Hardware-In-The-Loop Virtualization System for Cybersecurity Studies of SCADA Systems*, in "C&esar 2019 - Virtualization and Cybersecurity", Rennes, France, November 2019, pp. 1-16, https://hal.archives-ouvertes.fr/hal-02371133

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[21] M. ZARGARANI. *Hardware in the loop simulation of physical processes: a Tennessee-Eastman-like chemical process*, Masters Thesis, M2R MISCIT, Université Grenoble Alpes, France, 2019