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Proposal for an Open Invited Track on **Control for Computing Systems**

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Abstract

Computing systems, large (data centers in the Cloud) or small (embedded architectures), have a growing need to be dynamically flexible and reconfigurable w.r.t. their environments and workloads, and to be automated with control loops in order to be efficient, safe and responsive. Whereas computing for control is well-established domain, the converse *control for computing systems* is a novel approach, explored only in the recent years. The aim of this open invited track is to propose a multi-disciplinary gathering around computing systems as a new application area for Control Theory, with challenges in modeling of these unfamiliar systems, and identification of the relevant control techniques for problems where automation has not been introduced yet.

IFAC Technical Committee : this track targets computing systems as an application domain of various approaches to control design, therefore a relevant Technical Committee is : 2.1: Control Design

1 Detailed description

Recently in Computer Science, the notion of reconfigurable or autonomic computing systems has been introduced and defined as computing systems that can reconfigure themselves through feedback loops. Motivations for dynamic adaptivity are important issues like resource management e.g., energy, computation, memory, communication bandwidth, integrated circuit surface, time. Reconfigurations can also support the management of aspects in quality of service e.g., levels of precision in computing, of urgency of treatment, graceful degradation ; and also in dependability and fault tolerance, e.g., controlling migrations in response to loss of a processor. Adaptation concerns systems ranging from hardware to operating systems to services and applications, and in size from tiny embedded systems to large-scale data-centers, from multi-core processors to the Cloud. Their complexity is growing, in scale (software of hardware), but also in interactions between different aspects of reconfiguration. Furthermore, these computing systems are increasingly complex and autonomous: their management cannot anymore rely on human system administrators. The correct design and implementation of automated control of the reconfigurations and their tuning is recognized as a key issue for the effectiveness of these reconfigurable computing systems.

Therefore, there is a need for well-founded methods, models and techniques for the design of controllers which can give guarantees on the behavior of the controlled computing systems. For the decision and control of the dynamical reconfiguration and adaptation of these computing systems, they have to be considered as an object of control. Currently, the design of the adaptation controllers is largely done in an

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ad-hoc programmatic fashion, but there is a growing interest in using Control Theory for their design, in order to provide designers with a support to master the complexity of designs, and with guarantees w.r.t. their correctness or optimality. Such feedback loops can be designed using continuous control techniques when they concern quantitative aspects. Another significant approach addresses synchronization and coordination problems using discrete control techniques. Computing systems constitute a novel application domain for Control Theory, different from its classical targets in physical systems, with specificities in the nature of entities to be controlled (CPUs, memory, communication, software components, tasks and services, migrations), the nature of dynamical runtime variations and perturbations (requests flows, value-dependent behaviors, supply, fault-tolerance, ...), or functionalities to be fulfilled.

The needs for control for computing systems can be found in a variety of domains within computing : data-center management for Cloud computing, where automating resource management has strong motivations in energy saving and quality of service (QoS) ; High Performance Computing (HPC) also has goals in resources and performances, with infrastructures classically less open, hence more controlled ; Dynamically Partially Reconfigurable (DPR) architectures, at a smaller system scale for example based on Field Programmable Gate Arrays (FPGA), where the rate at which reconfiguration decisions are made requires automated control.

Whereas computing for control is well-established domain, the converse *control for computing systems* is a novel approach, explored only in the recent years. The purpose of this open invited track is to group contributions about the control of adaptive and reconfigurable computing systems, especially involving models and algorithms related to Control Theory. On the one hand it will introduce this interesting new application domain, with very wide and lively potential, and differences from traditional applications of Control Theory. On the other hand, it will bring together researchers working in this area, up to now quite separately for the lack of an established community.

2 Internet links to related material

We have experience in organizing sessions and workshop on this topic of control for computing, examples are as follows :

- Cloud Control Workshops series :
  `http://cloudresearch.org/workshops/9th/`
- special sessions on discrete control for adaptive and reconfigurable computing systems
  at WODES'14 : `http://wodes2014.lurpa.ens-cachan.fr/`
  at DCDS'15 : `http://www.gdl.cinvestav.mx/dcds2015/submission.html`

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