2018-00703 - Autonomic management of cluster resources with a control-based approach [PhD campaign]

Level of qualifications required: Graduate degree or equivalent
Function: PhD Position

About the research centre or Inria department
Grenoble Rhône-Alpes Research Center groups together a few less than 800 people in 35 research teams and 9 research support departments.

Staff is localized on 5 campuses in Grenoble and Lyon, in close collaboration with labs, research and higher education institutions in Grenoble and Lyon, but also with the economic players in these areas.

Present in the fields of software, high-performance computing, Internet of things, image and data, but also simulation in oceanography and biology, it participates at the best level of international scientific achievements and collaborations in both Europe and the rest of the world.

Context
The thesis will be carried out in the Inria Ctrl-A team (responsible: Eric Rutten). This team is a common team between Lig (Laboratoire d'Informatique de Grenoble) and Inria, and is located at Minatec in Grenoble.
It will be co-advised by Olivier Richard in the Datamove team of the same lab, specialized in High Performance Computing.
It will be made in cooperation with Bogdan Robu at Gipsa-lab for Control Theory aspects.

The PhD target will be the CiGri grid management system developed in the Datamove team. The CiGri production environment is currently deployed onto CIMENT, part of the Gridac unit and one of the most powerful HPC tier-2 centers in France, located at Grenoble. It is a joint center from the Community Université Grenoble Alpes and more than 30 research laboratories from CEA, INRIA and CNRS.

http://team.inria.fr/ctrl-a/members/eric-rutten

Key words:
High-Performance Computing, Autonomic Computing, resource management, grid computing, feedback computing

Assignment
HPC systems are facing more and more variability in their behavior (related to e.g., performance and power consumption) and because they are less predictable their administration requires runtime management. This can be done by monitoring the information in the systems, analyzing this data in order to activate appropriate system-level or application-level feedback mechanisms (e.g., informing schedulers, down-clocking CPUs).

Such feedback mechanisms rely on extensive monitoring and analysis, and involve decisions and their execution. Such feedback loops, in the domain of Computer Science, are the object of Autonomic Computing [1], which emerged mainly from distributed and Cloud systems. One approach in designing feedback loops is naturally Control Theory, which is extremely widespread in all domains of engineering, but only quite recently and scarcely applied to regulation in computing systems [2]. It can bring to the systems designers methodologies to design and implement feedback loops with well-mastered and guaranteed behavior (for example mathematical proofs of stability, convergence, disturbance rejection) in order to obtain automated management with goals of optimization of resources or avoidance of crashes and overloads.

Main activities
The research work will consist in designing and implementing feedback loops for the runtime management of resources, targeting the particular computation platform CiGri [3], a lightweight, scalable, and fault tolerant grid system which exploits the unused resources of a set of computing clusters. It interacts with the computing clusters through the Ressource Job Management System OAR [4], a batch...
scheduler software, developed in the Datamove team.

Help from Control engineering scientists form INRIA and Gipsa-lab Grenoble will be provided for the conception of the control algorithms.

The design of the feedback loops will build upon previous work in cooperation between the two teams and Gipsa-lab, and follow our methodology:

- analysis of the system, identification of its behavior and dynamics. Formulation of the problems to be tackled by taking into account the needs of CIGRI developers and users; this phase involves defining the software architecture to integrate the control into the platform, as well as possibly instrumenting new sensors and/or actuators.

- design of a feedback controller which will need to maximize the utilisation of the CIGRI platform (cluster) utilisation while avoiding overload, taking into account the non-linear behavior of the platform and interactions with the OAR schedulers, the storage and communication systems. We will start from simple regulation algorithms (with static threshold and of PID type), which maximize only the number of jobs to be sent to the cluster, and go toward more complex control algorithms which can adapt to the system complex behavior or be robust to the natural variability of the system. Moreover, a multi objective control which takes into account multiple objectives and dynamic constraints could also be employed. We will also explore having multiple loops and coordinating them using a more discrete control approach.

- implementation and experimental results in simulation and on Grid 5000 (French research cluster); comparing the new control scheme with the existing solution.

According to this sequence of steps, more characteristics of the platform will be considered, e.g., other problems of overload, for example concerning storage architecture. Special consideration will be given to the co-existence of multiple control loops, and their coordination.

Controllers will be designed exploring the application of advanced control techniques, alternative objectives and control schemes will be explored, e.g., adaptive and discrete control. Implementations and experimental validation will be performed on the platform.

References


Skills

The applicant should have good knowledge in at least some of the following: distributed systems, high performance computing, control theory, modelling and design of controllers.

Benefits package

- Subsidised catering service
- Partially-reimbursed public transport
- Social security
- Paid leave
- Flexible working hours
- Sports facilities

Remuneration