Digital Sobriety: modeling & control of software

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Context

This internship investigates an emerging application of control theory: Digital Systems [1]. The "plant" to be controlled is a software—or an application—running on a hardware infrastructure. The focus is made on datacenters, and specially High Performance Computing, for the significant roles it plays in ICT footprint. Controlling software offers many novel and interesting opportunities compared to classical control usecases. Multiple sensors and actuators can simply be created and implemented via a few lines of code. Experimenting is easy, even for non-experts, and largely reproducible.

The general goal of the internship is to reduce the energy consumption of High Performance Computing (HPC) applications, while preserving their performance. Control theory techniques are used, relying on existing performance sensors (e.g. operations per second), and energy actuators (e.g. power capping of the processors). Previous works have shown the feasibility of such control, using a PI controller. Limitations remain in the non-linearity of the system, the availability of the sensors, as well as in the system variations depending on the hardware [2].

Expected work

The internship will consist in studying a new modeling and/or a control, aiming at overcoming previous limitations.

In particular, the student may work on one or more of the following aspects:

- modeling using discrete-time state space,
- taking into account the variability and uncertainties of the system in the modeling, e.g. with a parameter varying formulation,
- design of an estimator for non-measured states,
- design of a state feedback controller.

Experimental evaluation will be performed using an already existing platform [3]. There are opportunities to pursue this internship with a PhD.

Required skills

A good knowledge of linear control theory is required. **No** prior knowledge of computer science is needed, experimentations will be assisted by HPC experts.

Location

The project will be carried out in the Spirals team, at Inria Lille.

Contact and application

For additional information and to apply, please send an e-mail to Sophie Cerf and Lionel Seinturier (in English or French).

References

1. Filieri, A., Maggio, M., Angelopoulos, K., d'Ippolito, N., Gerostathopoulos, I., Hempel, A. B., ... & Vogel, T. (2015, May). Software engineering meets control theory. *In 2015 IEEE/ACM 10th International Symposium on Software Engineering for Adaptive and Self-Managing Systems* (pp. 71-82). IEEE. [PDF]

2. Ismail Hawila, Sophie Cerf, Raphaël Bleuse, Swann Perarnau, Eric Rutten. Adaptive Power Control for Sober High-Performance Computing. *CCTA 2022 - 6th IEEE Conference on Control Technology and Applications*, Aug 2022, Trieste, Italy. pp.1-8 [PDF]

3. Sophie Cerf, Raphaël Bleuse, Valentin Reis, Swann Perarnau and Eric Rutten. Artifact and instructions to generate experimental results for the Euro-Par 2021 paper: "Sustaining Performance While Reducing Energy Consumption: A Control Theory Approach" *Euro-Par Artifacts 2021* [Website]