

PhD subject in Multiprocessor System Design & Modelling

Machine learning methods for early performance prediction of data-flow oriented applications on multiprocessor platforms

Laboratory: IETR (Nantes Université, France) and CSE (IIT Madras, India)

Keywords: Multiprocessor systems, Performance prediction, Machine learning methods.

Supervisors: Sébastien Le Nours (Nantes Université), Madhu Mutyam (IIT Madras), Sébastien Pillement (Nantes Université)

Description of the project

With the development of the Internet of things as a support of many application domains, multiprocessor platforms are increasingly adopted to support efficient computing at the edge of the networks. Such platforms allow simultaneous execution of multiple applications including artificial intelligence algorithms to process the large amount of captured data. These platforms are built with multiple hardware resources (processor cores, hardware accelerators, communication buses or networks, shared memories) which are optimized for performance rather than predictability. As a consequence, shared resources can significantly influence the performance of simultaneously running applications. Early performance prediction of such systems represent thus an important challenge to guarantee that timing and energy constraints are fully met under possible working scenarios.

Traditional performance prediction approaches, based on simulation or formal models, consider the description of the workload caused by applications on the platform and the behaviour of shared resources. However, the commonly used approaches are limited in delivering fast and accurate performance predictions for multiprocessor platforms with complex arbitration policies of shared resources and with multiple running applications. In this context, **this PhD subject aims to investigate the definition of machine learning methods to favour the performance prediction of multiprocessor systems** with different levels of complexity in supported shared resources. Such methods have already been considered especially for single core platforms [1] but their adoption for multiprocessor systems with complex shared resources remains a challenging task [2].

This project requires skills in the domains of hardware/software architectures for embedded systems and methods for data science and machine learning. The research methodology will especially consider a measurement-based approach to train the considered machine learning algorithms. This will rely on an FPGA-based experimental platform developed in Nantes Université which allows accurate timing and power measurement for multiprocessor systems and control of the level of complexity in shared resources [3][4]. We expect to evaluate the efficiency of different training and inference approaches (such as linear regression models) according to the usage and complexity of shared resources (especially, cache memories). A comparison of the developed approach with traditional methods and real measured data will be considered to quantify the benefits of the work.

[1] Zheng *et al.*, “LACross: Learning-Based Analytical Cross-Platform Performance and Power Prediction”. *Int J Parallel Prog* 45, 1488–1514 (2017).

[2] Saeed *et al.*, “Learning based Memory Interference Prediction for Co-running Applications on Multi-Cores”, *2021 ACM/IEEE 3rd Workshop on Machine Learning for CAD (MLCAD)*, 2021, pp. 1-6.

[3] Stemmer *et al.*, “A Measurement-Based Message-Level Timing Prediction Approach for Data-Dependent SDFGs on Tile-Based Heterogeneous MPSoCs”. *Appl. Sci.* 2021, *11*, 6649.

[4] Vu H.-D. *et al.*, “A Fast Yet Accurate Message-level Communication Bus Model for Timing Prediction of SDFGs on MPSoC”. *2021 26th Asia and South Pacific Design Automation Conference (ASP-DAC)*, 2021, pp. 17-22.

Environment of the project

This PhD thesis is co-organized between Nantes Université (France) and Indian Institute of Technology Madras (India). The selected student will spend half of its PhD in Nantes, France, and half in Madras, India. The host research organizations are the Institute of Electronics and Digital Technologies (IETR) and the Department of Computer Science and Engineering (CSE). The two research groups involved in this project have long expertise in the domain of embedded system design and modelling. The selected student will also be associated to other activities of the research groups: group meetings, seminars, social events.

Candidate profile

This PhD project is for a Master student (or 5th year student in engineering) with specialty in computer and electrical engineering. The required skills are:

- Programming parallel software,
- Basics on machine learning methods,
- Processor system architecture,
- Good communication skills,
- Writing and reading in English.

Please send an email to the supervisors with your CV and a motivational letter. Ideally, the project should start in October 2022 and candidate can contact us as soon as possible.

Contacts

Sébastien Le Nours
Nantes Université, IETR
sebastien.le-nours@univ-nantes.fr

Madhu Mutyam
Dept of CSE, IIT Madras
madhu@cse.iitm.ac.in

Sébastien Pillement
Nantes Université, IETR
sebastien.pillement@univ-nantes.fr