Thesis Proposal

Scheduling of real-time heterogeneous multiprocessor platforms

Funding : 3 year funding (Bourse de thèse institutionelle de 3 ans de l'ISAE-ENSMA)
Place : Laboratoire d'Automatique et d'Informatique pour les Systèmes (LIAS), Poitiers
Start date : September 2025
Supervision : Pascal RICHARD and Antoine BERTOUT (Real-time team)
(The supervisor whose name is underlined is the referent supervisor, contact : antoine.bertout@univ-poitiers.fr)

Context

Many time-sensitive applications require significant processing capacities. For nearly two decades, the only way to increase processing performance has been through the use of multiple processor cores. Multiprocessor scheduling problems are much more complicated than their uniprocessor counterparts. The case in which processors are identical is well understood and optimal schedulers are known [1]. But in practice Multiprocessor Systems On Chips (MPSoCs) embedded in real-time systems are made of increasingly specialised computing units (CPUs, GPUs, NPU's, etc.). This heterogeneity offers a better use of the resources (processing units, power consumption, etc.) but systems may be harder to predict. Critical real-time systems must provide logical but also timing guarantees. Limited knowledge exists regarding the validation of timing constraints on these heterogeneous platforms.

The temporal characteristics of such applications require special treatment by the operating system via its scheduler. The scheduling algorithm must enable efficient resource management (e.g., multi-core processors, memory) while ensuring that the applications' timing constraints are met at run-time.

The PhD thesis objective is to study the real-time task scheduling for heterogeneous multiprocessor platforms.

Description of the subject

Goal The thesis aims to propose one or more real-time scheduling algorithms for heterogeneous multiprocessor platforms. Real-time tasks are released periodically, with a defined interval between two successive releases, and must be completed before their deadlines. For multiprocessor platforms, it is well-established that full task migration and dynamic priority assignment are necessary to design an optimal scheduler—that is, an algorithm capable of producing a feasible schedule if one exists.

Every scheduler must perform two fundamental stages: (i) allocating tasks to processors and (ii) dispatching tasks on each processor to ensure that deadlines are met and to avoid intra-task parallelism (i.e., a task is never executed on more than one processor at any point of time). Depending on the task model, optimal algorithms may either treat allocation and run-time dispatching as separate stages or combine them. The distinction between these approaches remains unclear, posing challenges in designing optimal algorithms or effective heuristics. Exploring these dependencies between these two stages in existing algorithms and classical system models will serve as the starting point for the thesis, aiming to classify existing solutions and highlight open problems.

Validation The developed solutions must be formally validated and compared with seminal schedulers. Simulations will focus on evaluating the scheduler's performance, such as the supported workload or the number of context switches (preemptions and migrations), which significantly impact the practical applicability of the results. The recruited researcher should be proficient in Python development. Additionally, the project emphasizes the practical evaluation of the solutions, including the implementation of scheduling algorithms on an existing testbed in our laboratory.

Required expertise

The candidate should hold a master's degree in computer science or an engineering degree, with knowledge of computer systems, mathematics, and software development. A good command of written and spoken English is required, and proficiency in French is appreciated.

Documents to be provided

- CV
- Covering letter
- Master's (or equivalent) grades and rankings
- Last internship report
- Any other document deemed necessary by the applicant to enrich the application

References

[1] R. I. Davis et A. Burns, « A survey of hard real-time scheduling for multiprocessor systems », ACM Comput. Surv., t. 43, n° 4, oct. 2011, ISSN : 0360-0300. DOI : 10.1145/1978802.1978814. adresse : https://doi.org/10.1145/1978802.1978814.

[2] A. Bertout, J. Goossens, E. Grolleau, R. Jamil et X. Poczekajlo, « Workload assignment for global real-time scheduling on unrelated clustered platforms », Real-Time Systems, p. 1-32, 2021.

[3] S. K. Baruah, « Feasibility Analysis of Preemptive Real-Time Systems upon Heterogeneous Multiprocessor Platforms », in Real-Time Systems Symposium, IEEE, 2004, p. 37-46.

[4] E. Massa, G. Lima, B. Andersson et V. Petrucci, « Heterogeneous Quasi-Partitioned Scheduling », in 2021 IEEE Real-Time Systems Symposium (RTSS), 2021, p. 266-278. DOI : 10.1109/RTSS52674.2021.00033.

[5] A. Bertout, J. Goossens, E. Grolleau et X. Poczekajlo, « Template schedule construction for global real-time scheduling on unrelated multiprocessor platforms », in 2020 Design, Automation & Test in Europe Conference & Exhibition (DATE), IEEE, 2020, p. 216-221.