

# Embedded Hardware Desing

## *Microprocessors and Microsystems*

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*L. Jozwiak*; Faculty of Electrical Engineering, Technische Universiteit Eindhoven, Postbus 513, 5600 MB, Eindhoven, Netherlands. E-mail: L.Jozwiak@tue.nl

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## Editorial

### Special issue on: “Heterogeneous architectures for Cyber-physical systems (HACPS)”



Cyber-physical Systems (CPS), implemented in a broad range of applications ranging from critical systems like automotive to smartphones, are expected to cope with an increasing demand of functional and temporal constraints of the applications, with the corresponding growth in processing capabilities, claiming for high-performance computing and low power consumption.

Recent trends in the design of CPS propose heterogeneous systems as efficient processors to improve performance and power/energy/thermalefficiency. Different heterogeneity design choices have been explored ranging from hybrid CPU/GPU architectures that deal with parallel performance, to Systems-on-Chip (SoCs) with specialized hardware accelerators, to systems with different core types implementing distinct Instruction-Set Architectures (ISA) as single-ISA heterogeneous multi-cores with different core types, or multi-ISA heterogeneous multi-cores in which different core types implement different ISAs.

To take advantage of the heterogeneous architectures, important challenges are to be studied related to new programming models and compilers, hardware/software interface, run-time support, efficient load balancing and scheduling policies, with a resulting substantial performance improvement. Likewise, the system designer must trade off between different design parameters such as performance, timing, reliability, code portability and programmability and power consumption, which is a major concern in current architecture designs. This special issue is a collection of a number of outstanding papers describing the latest developments and trends on heterogeneous architectures for cyber-physical systems.

Recent trends in the design of cyber-physical systems (CPS) are moving towards heterogeneous multi-core architectures with cloud support. The paper [55] proposes an energy-aware scheme for virtual machine placement in a cloud-supported CPS with Network-on-Chip (NoC) architecture. Authors formulate the energy-aware on-chip virtual machine placement problem as an optimization problem, and design a heuristic scheme based on ant-colony optimization. They address the problems of slow convergence speed and easily falling into stagnation in ant-colony algorithm by employing pheromone diffusion model that makes the proposed scheme more efficient. Simulation results show that the proposed scheme achieves much higher energy efficiency compared with previous schemes with different network sizes and traffic models.

Cloud computing and cyber-physical system (CPS) are definitely basic elements in real industrial fields. The work presented in paper [40] proposes a security scheme, which provides light-weight secure CPS information transmission and device control scheme in integration of CPS and cloud computing. In this scheme, a

lightweight security scheme can multicast event information to users who have heterogeneous device information access authorities based on oneM2M standards, and also be able to manage the control devices. The performance analysis of the proposed scheme confirms its security and efficiency.

The developments of wearable devices such as Body Sensor Networks (BSNs) have greatly improved the capability of tele-health industry. Large amount of data are collected from every local BSN and transferred to distributed storage systems for further processing. Hybrid memories are widely adopted in reducing the latency and energy cost on multi-core systems. Most of the current works are about static data allocation, which cannot achieve better data placement. In the paper [371], the authors propose on-line data allocation for hybrid memories on embedded tele-health systems. Considering the difference between profiled data access and actual data access, the proposed algorithms and heuristics use a feedback mechanism to improve the accuracy of data allocation. Experimental results demonstrate that, compared to greedy approaches, the proposed algorithms achieve 20–40% performance improvement based on different benchmarks.

The authors of paper [60] propose the design of real-time applications with security, safety, timing, and energy requirements on distributed heterogeneous architectures. Cryptographic services are deployed to satisfy security requirements on confidentiality of messages, task replication is used to enhance system reliability, and dynamic voltage and frequency scaling is applied for energy efficiency of tasks. The research focuses on determining the appropriate security measures for messages, the voltage and frequency levels for tasks, and the schedule tables such that: the security and reliability requirements are satisfied, the application is schedulable, and the energy consumption is minimized. Tabu Search based metaheuristic is used to solve this problem. Extensive experiments and a real-life application are conducted to evaluate the proposed techniques.

Flash is becoming a vital storage medium with the rapid development of mobile devices as well as the ever-increasing need of cloud storage. The paper [68] proposes a workload-aware flash translation layer for TLC/SLC dual-mode flash memory, to improve performance and lifespan of the system. SLC mode has lower-latency with smaller capacity, while TLC mode has longer-latency with larger capacity. The proposed techniques have been designed to distinguish workloads and allocate data judiciously. Experimental results show that the proposed techniques can effectively improve the performance and lifespan of the TLC/SLC dual-mode flash memories.

Virtual machine is becoming a key technology enabler in the ever-increasing cloud computing paradigm. The paper [48] considers virtual machine placement problem, and proposes an affinity aware resource scheduling framework which can improve performance of the existing methods. The experimental results demonstrate the significance of the introduced affinity model and the effectiveness of the proposed method.

Memory wall is often the bottleneck in scalability. The paper [50] explores the scalability of memory controllers and ranks in scalable memory systems, and achieves larger memory bandwidth. Furthermore, by reducing the number of miss status holding registers, memory bandwidth levels are reduced and rank energy-per-bit levels are increased. Experimental results show that with the proposed techniques, memory bandwidth levels are reduced by about 64% and rank energy-per-bit levels are increased of about 36% for different patterns. Smart environments are heterogeneous architectures with a broad range of heterogeneous electronic devices that permit to record information about the behavior of people interacting with the environment. In the paper [56] the authors propose, by using feature selection methods, the adaption of the extended belief rule-based inference methodology (RIMER+) to handle data binary sensors. Likewise they propose its use as the suitable classifier for activity recognition that keeps the accuracy of results even in situations where an essential sensor fails. A case study of a smart environment dataset for activity recognition with 14 sensors is presented. Two sensor optimizations are obtained with two feature selection methods in which the adaptation of RIMER+ provides an encouraged performance against the most popular classifiers in terms of robustness.

Finally, we would like to thank all the authors and reviewers for their contributions. Likewise, we would like to express our gratitude to Dr. Lech Jozwiak, Editor-in-Chief, for his valuable help in arranging this special issue.

Houcine Hassan\*  
*Universitat Politècnica de València, Spain*  
 Laurence T. Yang  
*St. Francis Xavier University, Canada*  
 Jason Xue  
*City University of Hong Kong, Hong Kong*  
 Eugenio Villar  
*Universidad de Cantabria, Spain*

\*Corresponding author.

E-mail address: [husein@disca.upv.es](mailto:husein@disca.upv.es) (H. Hassan)

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