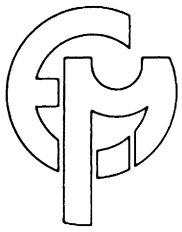
Embedded Software Design



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SPECIAL ISSUE ON DESIGN AND OPTIMIZATION FOR EMBEDDED AND REAL-TIME COMPUTING SYSTEMS AND APPLICATIONS

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Special issue: Design and Optimization for Embedded and Real-Time Computing Systems and Applications

Embedded software has become a necessity in almost every aspect of the daily lives of individuals and organizations, from self-contained applications to those embedded in various devices and services (mobile phones, vital sign sensors, medication dispensers, home appliances, engine ignition systems, etc). A large proportion of these systems are mission/life critical and performance sensitive. Therefore, it is important to design and optimize embedded and real-time computing systems and applications. This special issue aims to address some of these challenges by including the extended versions of the eight best papers selected from the 15th IEEE International Conference on Embedded and Real-Time Computing Systems and Applications (RTCSA 2009), held in Beijing, China.

The eight selected papers cover a variety of subjects in design and optimization for embedded and real-time computing systems and applications, and represent the state-of-the-art techniques in the field:

- In the first paper titled with "Platform Synthesis and Partitioning of Real-Time Tasks for Energy Efficiency", the authors study how to synthesize a heterogeneous multiprocessor platform or select processing units with the partitioning of real-time tasks so that the energy consumption is minimized. Given a set of processing unit types, characterized by the power consumption for maintaining activeness and executing jobs, this paper proposes an efficient and effective algorithm to allocate processing units with energy-efficient task partitioning. Experimental results show that the proposed algorithm is effective for energy consumption minimization.

- The second paper is titled with "Simultaneous Thermal and Timeliness Guarantees in Distributed Real-Time Embedded Systems". This paper proposes a coordinated control solution that can provide simultaneous thermal and timeliness guarantees for distributed real-time embedded systems running in unpredictable environments. The control solution has been implemented in a real system and the empirical results show that the solution provides dynamic thermal and timeliness guarantees simultaneously. The simulation results also demonstrate the efficacy of the control solution in large-scale real-time systems.

- In the third paper titled with "Supporting Component-based Failover Units in Middleware for Distributed Real-time and Embedded Systems", a technique called

CORFU (the COmponent Replication based on Failover Units component middleware) is proposed that can provide fail-stop behavior and fault correlation across groups of components treated as an atomic unit in distributed real-time systems. The authors empirically evaluate the client fail over and group shutdown capabilities of CORFU and compare/contrast it with existing object-oriented fault-tolerance methods. The results show that CORFU outperforms the existing techniques.

- In the fourth paper titled with “An Efficient Algorithm for Parametric WCET Calculation”, the authors present a new efficient algorithm that can obtain a safe parametric estimate of the WCET of a program. This algorithm is evaluated on a large set of benchmarks and compared to previous approaches of parametric WCET calculation. The evaluation shows that the new algorithm, to the cost of some imprecision, scales much better and can handle more realistic programs than the previous approach.

- In the fifth paper titled with “Branch Target Buffers: WCET Analysis Framework and Timing Predictability”, the authors propose a modular WCET analysis framework for branch target buffers (BTB), which allows for easy adaptability to different BTB. As an example, the authors investigate the Motorola PowerPC 56x family, which is used in automotive and avionic systems. On a set of avionic and compiler benchmarks, the results show that the proposed framework can improve the WCET bounds on average by 17% over no BTB analysis. Capitalizing on the modularity of the framework, the authors explore alternative hardware designs.

- The sixth paper is titled with “An Overview of Interrupt Accounting Techniques for Multiprocessor Real-Time Systems”. In this paper, the importance of accounting for interrupts in multiprocessor real-time schedulability analsysis is discussed and three interrupt accounting methods, namely quantum-centric, task-centric, and processor-centric accounting, are analyzed and contrasted. Additionally, two special cases, dedicated interrupt handling (i.e., all interrupts are processed by one processor) and timer multiplexing (i.e., all jobs are released by a single hardware timer) are considered and corresponding analysis is derived. All discussed approaches are evaluated in terms of schedulability based on interrupt costs previously measured on a Sun Niagara multicore processor. The results show that there is no single "best" accounting technique that is always preferable, but rather that the relative performance of each approach varies significantly based on task set composition, i.e., the number of tasks and the maximum utilization.
- In the seventh paper titled with “A Co-commitment based Secure Data Collection Scheme for Tiered Wireless Sensor Networks”, the authors propose a secure data

collection protocol called SDC to support time-based queries in tiered WSNs. With small overhead introduced to data communication, SDC protects both data confidentiality and data integrity. In particular it employs data co-commitment scheme such that it can detect the seriousness of data losing and estimate the value of lost data in the network.

- The eighth paper is titled "Energy Reduction for Scheduling a Set of Multiple Feasible Interval Jobs". In this paper, the authors explore the energy minimization problem for real-time systems in which jobs have more than one feasible interval. The static and dynamic energy management schemes are both investigated to minimize the energy consumption while preserving the system's feasibility. Simulation results show that all proposed schemes achieve significant improvements of energy efficiency while the system remains schedulable.

Finally, we would like to take this opportunity to thank the authors for their contributions to this special issue, thoughtful reviewers, and the RTCSA-2009 program committee for their excellent work in organizing the conference. In particular, we would like to thank the RTCSA-2009 steering chairs, Prof. Joseph K. Ng and Prof. Tei-Wei Kuo, and the Editor-in-Chief of Journal of System Architecture, Dr. Iain Bate, for their support.

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