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Guest editorial: special issue of the Euromicro Conference on Real-Time Systems (ECRTS 2009)

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Embedded systems have an increasing influence in technology and in the society in general, with a growing number of application fields (industrial processes, transportation, telecommunications, multimedia, medical equipment), and expanding capabilities and complexity. Such computing systems, because they have to adapt the timing of their response to changes in their environment, feature real-time constraints; they have to provide results which are not only correct, but also delivered in time. Instead of average behavior as for standard computing, real-time systems have to allow for guarantees that the temporal requirements will be met. This poses important challenges to the real-time systems community to find appropriate methods to engineer safe and reliable embedded systems.

The Euromicro/European Conference on Real-Time Systems (ECRTS) has established itself as one of the top conferences in the world in the field of real-time computing. Its 21st edition was held in Dublin, Ireland in July 2009 and contained an excellent technical program contributing to advancing the state of the art in field of real-time systems.

The conference program committee selected four of the many excellent papers presented at the conference, and their authors were invited to submit extended versions of their ECRTS paper to this special issue. Each paper was extended to add significant extra material and the resulting papers were re-reviewed and subject to the usual editorial process. The result is a special issue that I hope will be of interest to the real-time community.

In recent years, multiprocessor architectures have become mainstream, and multicore processors are found in products ranging from small portable cell phones to

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large computer servers. For real-time systems to fully leverage the extra capacity offered by new multicore processors, new design techniques, scheduling approaches, real-time analysis methods and real-time operating systems have to be developed. The first two papers address some of these important issues.

The first paper: "Improved multiprocessor global schedulability analysis", presented by Sanjoy Baruah, Vincenzo Bonifaci, Alberto Marchetti-Spaccamela and Sebastian Stiller deals with the fundamental question of schedulability on multiprocessors when tasks can migrate between processors at run-time. They generalize a previous technique originally designed for the global Earliest Deadline First (EDF) scheduling such that it is applicable to any work-conserving scheduling algorithm.

In contrast to synchronization in uniprocessor systems, research work regarding real-time synchronization in multiprocessor systems has been somewhat limited, being mostly focused on mechanisms that ensure strict mutual exclusion. The second paper of the special issue: "Spin-based reader-writer synchronization for multiprocessor real-time systems" by Björn B. Brandenburg and James H. Anderson presents the first systematic study of reader-writer synchronization in multiprocessor real-time systems. Three lock algorithms are presented and demonstrated to be efficiently implementable on common hardware platforms. Formal bounds on worst-case blocking are derived for all considered lock types.

Primarily due to the emergence of embedded devices that rely on battery power, energy management has moved in the forefront of research in real-time systems. The third paper in this special issue, by Vinay Devadas, Fei Li and Hakan Aydin is titled "Competitive analysis of online real-time scheduling algorithms under hard energy constraint", and applies to systems that have to operate within a given and fixed energy budget (energy-constrained systems). The authors undertake the competitive analysis of the online real-time scheduling problem under a given hard energy constraint.

As technology now makes it possible to put embedded devices virtually everywhere, real-time communication between devices is gaining importance. The final paper in this special issue, co-authored by Praveen Jayachandran and Tarek Abdelzaher and titled "reduction-based schedulability analysis of distributed systems with cycles in the task graph" is about the end-to-end schedulability of tasks in distributed systems with cycles in the task communication graph. The proposed method, whose original version won the prize for best paper at the conference, contributes to easing the analysis by defining techniques to compose the timing response of specific nodes in distributed systems.

In summary, the contents of this special issue reflect the current research trends in real-time computing, which include scheduling and operating system support in distributed and multiprocessor systems and support for different mixed application requirements.