Preface: Critical and real-time cyber-physical systems

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Raimundo da Silva Barreto has a degree in Data Processing in 1991 from the Federal University of Amazonas (UFAM), received his Master's in Computer Science from the Federal University of Minas Gerais in 1997 and PhD in Computer Science from the Federal University of Pernambuco in 2005. He did his postdoctorate at the University of Southampton, UK in 2011. He is currently an Associate Professor at the Federal University of Amazonas (UFAM). He has experience in the basic software area, acting on the following topics: real-time systems, embedded systems, software synthesis and fault tolerance.

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Critical and real-time embedded systems integrate the modelling, design and analysis of hardware, software and communication systems that are deeply integrated with physical processes and with strict time and other requirements. Those systems have special features that turn them into a different system from regular computer systems, i.e.:

1 they are *closely integrated* with physical systems

2 software is normally embedded in hardware with *limited resources*

3 the system is *distributed and in large-scale*

4 they must be *adaptable and reconfigurable*

5 they must be *dependable, secure and reliable*.

Some critical embedded systems have even more strict constraints of resources and reliability. For example, systems used in operating rooms for surgeries assisted by robots, the controlling of electric power grid (smart grids), and unmanned vehicles. The developments of such systems that attend these features, mainly the fact of being in *large-scale* and the necessity of *adaptability* and *reliability*, are the main subject of this special issue.

Being reliable and fault tolerant is another feature common to critical and real-time systems that could be listed as another challenge of the area. A system is considered to be fault tolerant if it does not fail despite the presence of faults. The most common way to have a fault tolerant system is by adding redundancy that can be achieved at hardware, software and network levels.

Based on this topic, we present this special issue to discuss and present the state-of-the-art concerning practices and tools for the development of adaptable and reliable systems ready to be embedded into critical and real-time systems. The papers were selected from among the best papers published in the Brazilian Symposium on Computer Systems Engineering (SBESC) in 2014 and 2015, and presented here in extended versions. The SBESC is an initiative of the Brazilian research community originally associated with three events, the Operating Systems Workshop (WSO), Embedded Systems Workshop (WSE) and Real-Time Systems Workshop (WTR), acknowledging the strong synergy between these three areas, and also motivated by the fact that the design of computing systems is an increasingly multidisciplinary task.

The first paper is 'Optimising QoS in adaptive real-time systems with energy constraint varying CPU frequency', which presents the optimisation of QoS for adaptive real-time systems varying CPU frequency to achieve better energy consumption. The work 'Design and implementation of a 6LoWPAN gateway for wireless sensor networks integration with the internet of things' evaluates the mechanisms of header compression and fragmentation of IPv6 datagrams proposed in the 6LoWPAN standard through experiments using a gateway prototype and IEEE 802.15.4 nodes. The paper 'A minimally intrusive method for analysing the timing of RTEMS core characteristics' presents a new approach for analysing the timing of the real-time executive for multiprocessor systems (RTEMS) core characteristics, with experiments carried out taking a satellite on-board computer case study implemented in a FPGA. The paper 'Model-based safety analysis of software product lines' presents a model-based approach to support the generation of safety analysis assets for multiple safety-critical software product lines products.

Other important aspects of real-time and critical systems are the time predictability and performance, which are the focus of the paper 'Priority L2 cache design for time predictability', which presents a priority L2 cache that allows both the instruction and data streams to share the aggregate L2 cache space while preventing them from mutually replacing each other at runtime. About performance, the work 'From RUN to QPS: new trends for optimal real-time multiprocessor scheduling' describes and analyses two algorithms used for scheduling of processors in real-time systems: RUN and QPS. Also, in 'Performance evaluation of CMSIS-RTOS: benchmarks and comparison' presents a comparative performance evaluation of a RTOS standard recently defined by ARM, called CMSIS-RTOS, which was created to improve portability among microcontroller applications. Testing critical autonomous systems is another challenge, discussed in the work 'Combination and mutation strategies to support test data generation in the context of autonomous vehicles', which presents a model and a software tool to support structural testing in the context of autonomous vehicles. Last, but not least, the work 'Hybrid real-time operating systems: deployment of critical FreeRTOS features on FPGA' presents a hybrid RTOS implementation, where a RTOS scheduler and mutexes handling sub-system are implemented and synthesised in FPGA.

Considering the high quality of the presented papers, we are sure that this special issue will be a great contribution to the scientific community. We also would like to acknowledge the excellent work of all anonymous referees, who have performed crucial work, together with the program committee and all involved with SBESC.