# Abstract

This Habilitation Thesis presents some of the most important results of my post doctoral research activity, which has been carried on since 2005 at the Department of Computer and Software Engineering, Politehnica University of Timisoara.

A synopsis of my overall scientific and professional achievements is presented in the first chapter. During over 17 years of academic and research activity, I have gained a rich expertise in the following fields of interest: *real-time and embedded hardware/software systems, digital measurement and instrumentation, digital signal processing and multimedia, wireless sensor networks, digital telecommunication systems, collaborative robotic environments, and energy-efficiency and power management mechanisms*.

In these fields, I *published over 89 scientific works*, out of which, 8 articles appeared in high ranked journals indexed by the Thomson ISI database with impact factors, 20 papers in ISI-indexed proceedings of international conferences, and 22 works are indexed in other international scientific databases. The ISI-indexed papers cumulate a *total impact factor of 11.978*. The published works are *cited by more than 62 papers* published by other authors, out of which 28 are ISI-indexed.

I have also been actively involved in *more than 40 research and development projects and programs*, as director (13), manager (7) or team member. As project/program director or manager, I have been in charge of executing a *total value of over 0.8 Mil. EUR*.

My professional activity has been recognized by the academic and scientific community through several awards, distinctions and prizes, such as the *Eminent Young Researcher of Timisoara Prize and Medal*, from the National Authority for Scientific Research (ANCS), Romania, the *Eminent Researcher Prize*, from the Orizonturi Universitare Association, Timisoara, and *a total of 8 prizes*, won at 11 editions of the International Computers Contest for Students, "Hard&Soft" Suceava, as coach or advisor of the teams of students.

In Chapter 2, some of my most relevant post doctoral contributions to the field of *real-time and embedded systems* are presented. The first part describes a *full framework for inter-task communication and synchronization* on the HARETICK hard real-time operating kernel. The proposed mechanisms, including the persistent data structures for hard real-time task output parameters and guarded buffers for hard- to soft- real-time data exchange, provide a highly predictable, feasible and efficient inter-task communication support. Another research focus in this area has been to increase the scheduling performance (acceptance ratio) and flexibility of real-time embedded platforms, while preserving maximum execution predictability. As a solution, we proposed and validated the *$H^2$RTS hybrid hard real-time scheduling mechanism*. It combines the high predictability of a non-preemptive cyclic scheduler with the efficiency of a modified version of the Earliest Deadline First algorithm.

Advances and results, obtained by our research team in the field of *intelligent sensor networks*, are described in Chapter 3. The *CORE-TX* (*Collaborative Robotic*

*Environments – The Timisoara Experiment*) platform has been designed and implemented at prototype level, for the study and development of real-time systems, distributed artificial perception applications, intelligent sensor networks and collaborative robotic environments. The *PARSECS* (*Predictable ARchitecture for Sensor Communication Systems*) data communication system has been specifically designed and implemented to sustain, at low costs and complexity, the predictable communication of multiprocessor or distributed hard real-time systems.

In the field of *collaborative robotic environments*, several important contributions of our research team are discussed in Chapter 4. *A collaborative robotic alignment algorithm* has been developed as the first stage of some more complex robotic location management procedures. Further on, the *MTDOA* (*Modified Time-Difference-of-Arrival*) inter-robot distance measurement technique has been introduced and tested, yielding a worst case accuracy of 7.3 cm for inter-robot distances of up to 300 cm. To increase the accuracy and the performance of inter-robot distance measurement, the *CTOF* (*Combined Time-of-Flight*) method has been designed and implemented. By applying the Kalman filter to repetitive CTOF distance measurements, an accuracy of 1 cm can be achieved for distances of 300 cm between robots and without the need of fixed landmarks. Based on the previous results, a *location management and robotic positioning methodology* has been developed. The methodology relies on the collaborative inter-robot alignment and CTOF distance measurement techniques and employs the triangulation and the trilateration methods to determine the coordinates of a robotic and/or sensing node within a collaborative environment.

Chapter 5 covers some of the main contributions to the field of *energy efficiency and power management techniques*. We designed and tested a *software execution framework for measuring and evaluating power consumption signatures*, along with a set of *power consumption benchmarks*, with direct applicability in the power profiling of mobile systems and their multi-threading applications. A novel *methodology for online State-of-Health battery assessment* has also been developed and implemented, along with a fully functional *hardware/software battery management system (BMS)*, for resource-constrained Ni-MH battery powered embedded devices. The paper with the most relevant results of this research is currently being cited by more than 12 scientific articles, published by other authors in major journals or conference proceedings in the field.

The thesis is concluded by a set of principles and concrete elements of my scientific and academic development plan, as well as by the references used in this material, sorted in several distinct categories.