Resource constrained embedded systems for performance critical applications

Harald Schrom and Rolf Ernst
Institut für Datentechnik
TU Braunschweig
{schrom | ernst}@ida.ing.tu-bs.de

SPONSORED BY THE
Federal Ministry of Education and Research

Abstract*— *We present an analysis approach for a system wide timing analysis for embedded systems in the domain of building management in combination with a demonstrator with small microcontrollers.

I. Introduction

The project adresses the domain of "Smart Buildings". Buildings will feature intelligent behavior by means of decentralized networked electronic components. This will improve user convenience and introduce new functionality while improving more flexibility. At the same time energy consumption can be reduced and maintainability is increased. At the beginning a short introduction into the research project is given followed by a section pointing out the project objectives. The next section introduces the general approach to resource constrained embedded systems, which is the base for the project and presented during the session. The last sections apply to the sponsoring and the future vision.

II. Research project

The research project "Embedded Systems mit kleinen Recheneinheiten und zuverlässigem Zeitverhalten" (EkReit; Resource constrained embedded systems for performance critical applications) examines the timing behavior of domain specific small-scale devices. The correct timing of the distributed real-time components and their interaction shall be guaranteed and will set the foundation for self-optimizing and self-configuring building management systems (BMS).

In cooperation with the automotive high-tech start-up Symtavision and the company iQST spatially distributed embedded systems consisting of a large number of small processing devices will be analyzed w.r.t. their timing behavior. Based on the commercial tool SymTA/S (Symbolic Timing Analysis for Systems) the timing of entire building management systems will be analyzed to allow certification of system properties.

The real-time requirements as well as effective processing demands of the targeted domain of building management systems lie in the intermediate range of the capabilities of existing embedded applications (see Figure 1). The use of embedded systems in the emerging domain of building management systems will enable entirely new opportunities.

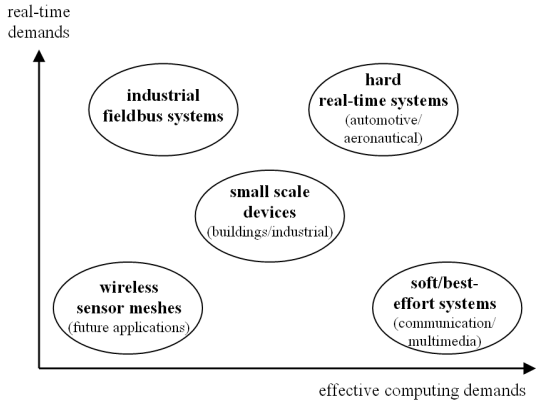

Figure 1. Domain positioning

III. Objectives

The EkReit project has different main objectives that are listed in the following. The first issue is the timing analysis of small-scale processing devices that cannot run a conventional real-time operating system because of limited system resources. Therefore existing devices are analysed in terms of timing behaviour and scheduling. The analysis should lead to an improved system schedule and a verification of the timing behaviour. The second issue is the adaption of the existing timing analysis approach, provided by the tool SymTA/S by Symtavision, to the domain specific characteristics of Building Management Systems. Thereby this automotive tool can be used in this domain. The third issue concerns the integration of best-effort and hard real-time systems. It should be possible to adjust the quality of a service, for example the sample rate, the resolution or the processing depth of algorithms, to match the application requirements with regard to the system resources. Furthermore a demonstrator consisting of improved Building Management devices is going to be constructed. This enables measurements of the real behaviour and a comparison to the analysis results. As a final result, the coupling of the tools for timing analysis and the Building Management System is to be performed, which enables the use of the timing analysis software in the building domain directly. The intended workflow of this tool coupling is shown in Figure 2.

IV. Resource constrained embedded system

We want to integrate all aspects of Building Management purposes into a single embedded system. The critical design constraints for a distributed system are the power consumption, the costs and and an easy to install structure. We want to develop a resource constrained embedded system with respect to the special demands of this domain. Therefore, our system consists of small-scale devices allowing that a large number of these devices can be be networked and powered by a single bus-line. This is important for an easy planning and installation of the electronic infrastructure, which is essential for a multi-purpose system that will be installed in any kind of building independent of the size and usage.

In this cost sensitive area it is important to use small-scale devices in combination with an easy infrastructure and a bus-line integrated powering. Thereby the entire complexity of the devices can be minimised, not only the microcontroller part. Additionally the fault-prone power supply can be made high quality, high efficient and high

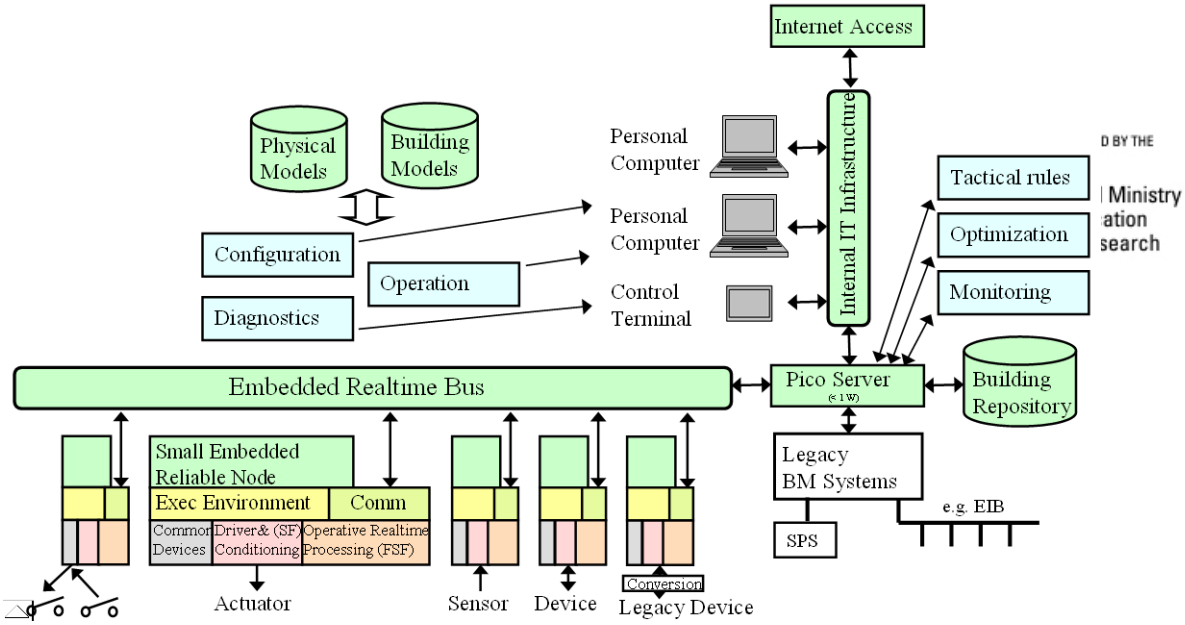

Figure 3. Building Operating System

reliable because there is only one device. However, this poses in high demands to the bus-line. A fault tolerant and optionally redundant network design is going to provide the required availability. The wired infrastructure is the base for a high reliable, available and flexible system. The large number of small-scale devices enables a system design with distributed intelligence and local data processing.

Due to the small-scale and the widespread bus-line it is mandatory to guarantee the performance, depart from the topological view. The timing and scheduling for every small-scale device has to be verified as well as the usage of the bus-line and the system wide overall timing and buffering. This symbolic timing analysis in combination with the above mentioned electronic approach guarantees the overall system performance and enables the construction of a system that is highly reliable.

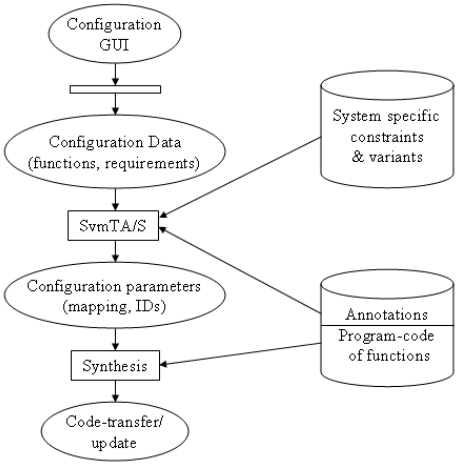

Figure 2. Workflow tool coupling

V. Demonstration

The demonstration presented is a part of a Building Management System with small microcontrollers. This example consists of a couple of devices with connected visualization software and a first impression to the timing analysis software. Some parameterized functions are shown. This first demonstration will be the base for the main demonstrator that is currently being developed.

VI. Sponsoring

The EkReit Project is sponsored by the Federal Ministry of Education an Research (BmBF) since 2010 including a consortium of the technical university of Braunschweig and the two companies Symtavision and iQST. The development of the examined system is sponsored by the German Federal Foundation for Environment (DBU) and by the European Regional Development Fund (EFRE / ERDF).

It is intended to expand the activities in the embedded systems area and therefore to establish further cooperations.

VII. Future Vision

The long-term objective is to establish an integrating embedded real-time system in the area of Building Management that is suitable for every class and scale of buildings. It is the vision of a ”Building Operating System” as shown in Figure 3 that is spread as a net of components all over the building and can operate a building as a complex technical device to provide convenience to the occupants. This includes alternation and adaption of optimising strategies as well as safe updates on suitable real-time and, at the same time, small scale bus nodes.

Our combination of real-time verification and small scale devices will be an important part on the way to a Building Operating System.