C4 Model-Based Design of Embedded Systems

Time: Tuesday, 14.09.2010
Location: Humboldt-Building, Lecture Room 129
Chairman: A. Zimmermann (D-Ilmenau)

1:30 p.m.	D. Macos, D. Meisen, S. von Klinski (DE-Berlin)

Implementation of a High Performance Embedded VM for the Java Language Integrating Optimization Aspects of Procedural and Functional Program Paradigms

Software portability is one of the main goals in the field of modern mobile devices. Compared to other possibilities such as (1) binary source-to-source compilers and (2) template based cross compiler chains, the realization of java embedded software is a more and more used technique to achieve high portability of embedded software. The main challenge of this technique is the implementation of high performance java virtual machines (JVM) for small devices with limited hardware capabilities. Besides the functional scope reduction (achieved through the use of configurations such as CDC, CLDC and their combinations) the most important factor is the performance implementation of the following VM aspects: (a) efficient VM data structures (b) efficient environment for the interpretation of the operational semantics of the VM and (c) efficient optimization set of the VM. We implemented a VM which requires 50k of memory and whose runtime performance is comparable with the performance of natively compiled programs with the GNU C-Compiler (GCC). We investigated the main compiler optimization techniques of procedural paradigms such as peephole optimizations, caching, loop optimizations, etc. as well as the main compiler optimizations for functional languages: indirection nodes, director strings, dependency analysis, memo functions etc. After the evaluation of performance and memory requirements of selected optimizations, we defined the main VM optimization set which resulted in a small high performance runtime environment fort he Java language. The new aspect in our approach is the adaption of specific techniques of the functional programming paradigm such as memo functions defined by John Hughes and indirection nodes used for optimizing SK combinator machines and their integration into an embedded VM. The result of our work is the possibility to realize very small java based embedded systems.

1:50 p.m.	K. Schulze (DE-Ilmenau)

Wiring of Avionic Systems
Avionic systems become more and more complex and are increasing rapidly. Flight assistant and entertainment systems need higher bandwidth. As a result, the information flow inside of an aircraft is growing. Consequently, one of the main issues is the wiring to connect the systems and the different aircraft zones with each other in an optimal way. Therefore, a method is required to keep the amount of cabling low and to get it more structured, lighter, cheaper and energy-efficient. Hence, to develop a method which implies to organise the cabling with optical fibre and copper is needed to find the optimum of network architecture and topologies. Accordingly the development of a new network architecture consisting of fibre optic associated with copper is a great step towards higher bandwidth and more ordered network architecture. To build up a network with optical components will decrease the weight of cabling instead of copper. The paper will present first solutions of a network model regarding optimal architecture, topologies and wiring methods. Hence, there are three different points to be observed. At first, the network redundancy has to be studied and examined in simulations. Secondly, criticality and assurance level has to be considered as well as effects of failure or breakdown of network parts. Finally, performance assessment regarding "Quality of Service" and the network load has to be considered during the work.

2:10 p.m.	D. Shorin, A. Zimmermann (DE-Ilmenau)

Model-based Development of Energy-efficient Automation Systems
We present an ongoing work towards a methodology for model-based engineering of energy-efficient automation systems. Energy consumption as an increasingly important decision criterion has to be included in the search for good architectural and design alternatives. As a result of the work, new models of energy-efficient automation systems have to be developed. The methodology will have to show its contribution and industrial value by demonstrating the possible improvement for a real system design. New projects of equipment for energy saving will be developed and appropriate software will be created. As another result, we expect new methods of industrial energy consumption estimation. The first task will be a description method for energy consumption that can be simulated to evaluate and later optimize this non-functional property. An important candidate is the new UML profile for Modelling and Analysis of Real-Time and Embedded systems (MARTE), which might have to be extended or adapted for our project. The system simulation will be carried out after a transformation into a Petri net or MLDesigner functional block model. A laboratory for testing and evaluating modelling and estimation quality of the work is being set up. A small lab plant will be realized based on the energy-controllable ATMEL microcontroller ATxmega128A1 and evaluation board. The first aim is to find the best possible control algorithm in terms of energy consumption minimum. The second aim is to examine the possibility of developing a microcontroller conception as a self-optimising system.

2:30 p.m.	F. Lohse (DE-Ilmenau)

Optimal Mapping of Functions to Architectures Using Model-Based Design
Today networked embedded systems are very complex. Factors like product lifetime, time to market, growing system requirements or additional constraints complicate system design. 60% of most critical system errors depends on formalization inaccuracy of secondary influence quantities like resource load, communication behavior, degree of networking, several functionalities, memory usage, execution time, type of architecture, topology, device count or energy consumption. An important criterion of system performance is the optimal usage of system components and resources. Thus a special problem is which functionality (sensor/actor system, calculation, data dump, storage, …) should be processed on which architecture (operating system, CPU, driver, controller unit, …). Keeping this factors in mind the resulting design space of system variants has to be searched for an optimal system configuration using appropriate algorithms. The problem is split into binpacking problem (optimal mapping of functions to architectures) and traveling salesman problem (best communication behavior). Therefore naturally-based heuristics are suitable. Primary source is the transformation of a given system specification into an executable model on abstract level of detail (virtual prototype), which enables simulation, analysis and estimation in early design steps. The following optimization via system variation results in a reconfigured system. Automated model scaling, which decides the level of detail a subsystem has, could accelerate simulation and optimization speed against conventional simulation and optimization techniques. To sum up the design methodology shows all steps from abstract system description via simulation to optimization and is validated with the help of theoretical and practical examples.

2:50 – 3:10 p.m. Coffee break

End of Lecture Session