Multicriterial Optimizations in Embedded and Real-Time Systems

Scientific Report for STSM, COST Action IC1202*

Nicolas Roeser
Institute of Embedded Systems/Real-Time Systems
Ulm University
89069 Ulm, Germany

nicolas.roeser@uni-ulm.de

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1 Overview

Real-time systems that are also embedded systems usually have more than one optimization target. In order for tasks to reach their deadlines, the WCET of tasks can be optimized on source code or binary code level. Further optimizations try to reduce the size of generated binaries or the energy consumption of the system. While current compilers typically target a single objective, it is desirable to define more than one optimization goal, which requires the combination of existing algorithms and development of new approaches.

An energy model is one of the key components of a compiler which optimizes for a low energy consumption. Among other ideas, an approach for such a model and future joint work on it have been discussed during the STSM.

Time and place

From 2014-09-06 until 2014-09-14, Professor Heiko Falk's research group from the Institute of Embedded Systems/Real-Time Systems (ES) at Ulm University visited National University of Singapore (NUS) for a Short-Term Scientific Mission.

Host was Professor Abhik Roychoudhury[1] at the School of Computing at NUS. His group carries out research in the areas of embedded software, automated testing, and WCET and energy analysis.

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[1] abhik@comp.nus.edu.sg

2 Progress of the STSM

The STSM started with an overview given on 2014-09-08 by the NUS and ES teams about their recent research and future plans, including short-term goals and ideas to be detailed later.

Ideas for research topics in cooperation between the two groups were initiated on 2014-09-09, and specified in more detail until the end of the visit. Among other topics, creation of an energy model which supports compilers or other tools in the software development process was planned.

In the wrap-up meeting on 2014-09-12, expected future publications as the result of the joint research were discussed and the teams subsumed their ideas and work carried out during the research week.

3 Results of scientific exchange

Discussions have lead to a plan for an energy model which allows flexible application across different embedded systems, and which can be used in development environments and help optimizing compilers to reduce the energy footprint of a system.

Development of this model utilizes previous research by the NUS group[1] that identified the biggest consumers of energy in a system, and builds on a work using power states presented at EuroSys'11[3]. The power levels at which components operate are crucial for the total energy consumption of the system. Classes of processor instructions used in embedded software, accesses to installed memory or other peripheral devices also contribute to the needed power, but to a lesser amount. A compiler is able to put consumers of energy at their power levels together, and calculate the energy consumed by a given program running on a given hardware.

It is expected that rules in the energy model will make it adaptable for different systems, or specialized components or ones which might in future appear in various embedded devices.

4 Work and research plan

The outcome of the STSM results in the following plan for progressing further.

The WCET-aware C Compiler WCC[2], the research compiler used and developed at ES, does not yet support multi-criteria or energy optimization. After the optimization algorithm described in [4] has been integrated, it can use the energy model discussed during the STSM in Singapore, which shall be added to the compiler as well, for multi-criteria optimization.

Further steps for the research teams are measurements of power consumption on different levels and over a wide range of input programs and data to be analyzed, which shall sufficiently increase the detail level in the energy model.

In future, it is planned to enhance the energy model with even more detailed knowledge about the system being compiled. Worthwhile insights for multi-task scenarios may also be gained by looking into how input to the energy model can possibly help schedulability.

5 Future collaboration

The NUS and ES teams will to share their respective tools which have already been developed during previous research, in order to allow merging them with their existing software or future new developments.

6 Publications

Implementation of the energy model, as described above, is expected to result in a concerted publication, and further progress will warrant additional publications in this area by members of the NUS and ES groups together.

7 Acknowledgements

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