A Tool Environment for the Development of Embedded Systems

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1 Comparision between Project Plan and Results

We have been following the project plan. The original plan for 1999 and 2000 was to to develop a code-geneartor for the UPPAAL tool. It turned out that we had to study the problem of schedulability analysis for event-driven systems in order to generate executable code satisfying timing constrtaints specified in the design phase and issues on software architectures. In 1999 and 2000, the main scientific outputs of the project include:

- One Licentiate Thesis (September 15, 2000 is booked for Lic Defense): A Formal Approach to the Analysis of Software Architectures for Real-Time Systems. Anders Wall.
- 2 conference papers and 1 technical report. One has been published in RTSCA'99, one of the main international conferences on real time systems.

2 A list of Publications

- A Formal Approach to the Analysis of Software Architectures for Real-Time Systems. Anders Wall, sf Licentiate Thesis, MRTC, Mälardalen University and Department of Computer Systems, IT, Uppsala University, 2000.
- Time Automata as Task Models for Event-Driven Systems. C. Norstrm, A. Wall , and W. Yi. In proceedings of the 6th International Conference on Real-Time Computing Systems and Applications, Hong Kong, December 1999.
- Verifying Temporal Constraints on Data in Multi-Rate Transactions using Timed Automata. A. Wall, K. Sandstrm, J. Mki-Turja, C. Norstrm, and W. Yi. Submitted to Real-Time Systems Symposium, Florida, USA, 2000.

- Software Architectures for Real-Time Systems. Anders Wall, Technical Report MRTC 00/20 ISSN 1404-3041, Mlardalen Real-Time Research Centre, Mlardalen University, May 2000

3 Research Directions

One important problem in code generation for embedded real-time systems is "schedulability analysis" that is to check whether program codes generated can be executed or not within given deadlines. The traditional approach to schedulability analysis is often based on scheduling theory and a task model, which has been very successful for time-driven systems, but less successful for event-driven systems.

As the first result of this project, we have shown that the schedulability problem for the extended model can be transformed to a reachability problem for timed automata and thus it is decidable (The result is reported in a technical report and submitted to an international conference). This result allows us to apply model-checking tools for timed automata to schedulability analysis for event-driven systems. In addition, based on the same model of a system, we may use the tools to verify other properties (e.g. safety and functionality) of the system. This unifies schedulability analysis and formal verification in one framework. The next step is to study the problem of transforming such extended models into executable programs. Our vision is to develop an integrated tool environment for the development of embedded real-time systems supporting each step of the development process, from design, simulation, verification, runnable code generation, to test generation.

4 Industrial Collaboration

I have to mention that to get a Licentiate degree, the student must have 30 points in course study, which requires 75% of full time of a year. Anders Wall (the Ph.D. student) is working 80% on the project In 1999, Anders was mainly working on courses studies and theoretical research, which are very important for the continuation of the project and his licentiate degree.

The industrial partner of this project is Mecel AB. Mecel's role in the project has been mainly in evaluating the UPPAAL tool in industrial applications. The company is using UPPAAL to verify a locking system for modern cars, developed by SAAB. The feedback on verification tools from Mecel has been invaluable to our study on schedulability analysis.