Educational Case Studies with an Open Source Embedded Real-Time Java Processor

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Educational Platform: JOP

- History: Met Martin as he finished his Ph.D. He is now with DTU
- A Java processor developed on a FPGA (ie. using VHDL) by Martin Schoeberl
- Analyzable with respect to real-time properties
- Tools exist for creating worst case execution time analysis of Java code
- It is GNU GPL
- [www.jopdesign.com](http://www.jopdesign.com) and Yahoo group
JOP in Industry

• JOP was used for a distributed application for a railway
• Masts were equipped with a JOP board which lifted and lowered the electrical cords in a synchronized fashion
• Is was also used for single path railway control
JOP at a Non-technical University

• 20 boards at Dept. of Informatics, Copenhagen Business School
• Used for bachelor, master, and thesis level classes
• Soldering at a business school is interesting
Bachelor Class

- Distributed Systems, 40 students
- Lab exercises with UDP
- Done to give students a broader understanding of the fact that embedded systems exist even at a business school
Master Level Class

- Distributed Data Mining
- Give the students the chance to implement something intelligent in Java
- Feel the restrictions that apply to embedded systems: fixed point math and limited stack size
- Happy for red LED...
Master Level Class

- Very Small Information Systems
- 450 Hours
- Martin Schoeberl, Rasmus Pedersen, and censor with EE background
- Intelligent humidity, activity heat control, barcode analyzer, speaker verification, stock data analysis
- Lesson: Need EE person
Master Level Theses

• Bluetooth connected to JOP via serial line, and communicating via OBEX
• Word recognition

• JOP is well-documented and stable, which makes this possible, and it is in Java
At a Technical University

• Martin Schoeberl used JOP for several project at the Technical University of Vienna
• Interesting point: The interaction between students last longer than one semester
• Many projects...
Specialized Course

• *Java Virtual Machine in Hardware*

• Students learn the inner workings of the hardware/software tradeoffs

• They see the whole way from processor design to system design (Java virtual machine), up to application programming
Example projects from Specialized Course

- Long bytecodes
- Integer division (moving critical parts into HW)
- Comparison of a JIT capable JVM on a different architecture with JOP + scientific paper
- Alternative implementation of priority cealing emulation
- Implementation of Scoped Memory (Safety Critical Java)
- Robot control with Xbee communication for control
- Further examples are: `tableswitch/lookupswitch`, WCET with UPPAAL, JOP UI in VHDL, NFS over UDP
- Learning: Students picked a place in the design stack or covered several layers of HW/SW design in their projects
Bachelor Projects

- Lego robot controller PCB
- Joptimizer: A tool to optimize bytecodes (normally a JIT task)
Master and Ph.D. Level Projects

• picoJava ported FPGA (also served as preparation for Ph.D. Work)
• Extension of worst case execution time analysis tool (the student continued this work from a master level class)
• Current work: Hardware transactional memory for chip-multiprocessor
• EU funded Ph.D. work chip-multiprocessor
Discussion/Conclusion

- JOP is well-suited for university teaching because it is more than an embedded system
- Network capabilities makes it possible to cover more classes
- Real-time properties are motivating (good stories can be told)
- Limitation/possibility: The limited stack is something that has to be mastered
- It is motivating for lectures/researchers engaged in similar research because there are many papers on JOP and it is an active community that supports it