Feedback Driven Annotation and Refactoring of Parallel Programs

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This thesis combines programmer knowledge and feedback to improve modeling and optimization of software. The research is motivated by two observations. First, there is a great need for automatic analysis of software for embedded systems - to expose and model parallelism inherent in programs. Second, some program properties are beyond reach of such analysis for theoretical and practical reasons - but can be described by programmers. Three aspects are explored. The first is annotation of the source code. Two annotations are introduced. These allow more accurate modeling of parallelism and communication in embedded programs. Runtime checks are developed to ensure that annotations correctly describe observable program behavior. The performance impact of runtime checking is evaluated on several benchmark kernels and is negligible in all cases. The second aspect is compilation feedback. Annotations are not effective unless programmers are told how and when they are beneficial. A prototype compilation feedback system was developed in collaboration with IBM Haifa Research Labs. It reports issues that prevent further analysis to the programmer. Performance evaluation shows that three programs perform significantly faster - up to 12.5x - after modification directed by the compilation feedback system. The last aspect is refinement of compilation feedback. Out of numerous issues reported, few are important to solve. Different compilers and compilation flags are used to estimate whether an issue can be resolved or not. On average, 43% of the issues reported can be categorized as potentially resolvable (27%) or unresolvable (15%).

General information
State: Published
Organisations: Embedded Systems Engineering, Department of Informatics and Mathematical Modeling
Contributors: Larsen, P., Karlsson, S., Madsen, J.
Number of pages: 163
Publication date: 2011

Publication information
Place of publication: Kgs. Lyngby, Denmark
Publisher: Technical University of Denmark (DTU)
Original language: English
(IMM-PHD-2011; No. 251).
Electronic versions:
phd251_pl.pdf
Source: orbit
Source-ID: 282035
Research output: Research › Ph.D. thesis – Annual report year: 2011