Abstract

With the rapid proliferation of multicore processors and multiprocessor platforms, embedded application design has undergone a paradigm shift. The primary synthesis step of hardware-software co-design has been overshadowed by multiprocessor task-scheduling. In the subsequent verification step, this change in design philosophy requires researchers to address several new *functional and performance* verification problems and readdress some known verification problems in new settings. In this dissertation, we address three problems pertaining to functional and performance verification of multiprocessor embedded applications:

Functional Verification: In this work we propose a method for verifying the correctness of the task-scheduling step. For this, we prove the consistency of the output (scheduled application) with the input (native un-partitioned application) of the scheduling step. We propose a notion of consistency between the scheduled and native models and provide an algorithm to solve this problem efficiently.

Timing Verification: We propose an efficient graph-based static-timing-analysis method to check several real-time properties, which are currently verified by computationally expensive timed model checking. The proposed method is oblivious of concurrency in the model and hence significantly more scalable than timed model checking. We also use the proposed method in various frameworks to verify several timed protocols like the FDDI and Fischer protocols.

Thermal Analysis: We propose a model checking inspired method for analyzing chip heating behavior of multicore applications. This method improves the coverage of chip-thermal analysis by checking all executions arising due to decision branches and variations in task execution delays. We formulate the thermal analysis problem as a hybrid automata reachability analysis problem. Issues in formulating and solving this problem are addressed by a gamut of techniques from machine learning to counterexample-guided abstraction-refinement.

This work broadens the scope of formal methods applied to the multiprocessor embedded application design-flow, by enhancing scalability of formal verification and exploring applications to extra-functional (performance) domains like chip-thermal analysis. Enhanced scalability is achieved by developing new algorithms which take advantage of properties of embedded applications and the emergent design-flow. At the same time, investigation of formal methods for analyzing some performance metrics resonates with the emergence of several important performance centric quality criteria. We believe that the proposed methods reflect the emerging trends of developing verification methods which are closely entwined with the design-flow and address several performance assurance problems.

Keywords: Verification, Multiprocessor, Task-scheduling, Timing, Thermal