HIERARCHICAL PLANNING AND CONTROL IN MODEL-BASED DESIGN OF SYSTEMS AND CIRCUITS

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ABSTRACT

The design space of integrated circuits and systems are becoming increasingly intricate and difficult to manage day by day. The model-based design paradigm is a natural consequence of the rising complexity of such engineering systems. Model-based system design demands efficient construction of models at different levels of abstraction combined with systematic methodologies to apply the model in designing and verifying the system. In this thesis, we primarily focus on developing formal model-assisted systematic approaches for the design and implementation of integrated systems. The present line of research touches upon intricate problems, arising in the domains of circuits and control systems.

The first problem addressed in course of this thesis is a control design problem for the energy-aware operation of the Heating Ventilation and Air Conditioning (HVAC) system. We propose an energy-aware building resource allocation and economic model predictive control (MPC) framework for HVAC system design and control. Our approach comprises a two-step hierarchical technique where we first minimize the running time of individual zone-based HVAC air supplies suitably allocating building resources (thermal zones) to the usage demands for zones. Next, we formulate a finite receding horizon control problem for trading off energy consumption against thermal comfort during HVAC operations.

The second problem in this research concerns the implementation issues of MPC systems, in continuation of the previous line of work, in the context of resource-constrained real-time control settings. We propose a systematic approach for computational platform-specific linear MPC implementation that guarantees control inputs within pre-define delay and maintains satisfactory control performance during real-time control of large scale plant. The plant model is analyzed systematically to formulate the optimization problem, measure the computation time for solving the problem and provide required optimization parameters for implementing the MPC system on a dedicated computing platform.

The last work in this research attempts at solving a combinatorially intensive design problem in the circuits domain. It deals with the issue of automated test program generation for finding alternative bug scenarios that are useful for verifying the robustness of bug fixes in microprocessor design. The proposed methodology provides a high-level abstraction for representing micro-architectural events, a formalized characterization of the bug scenario and usage of AI planner for finding alternative bug scenarios.

Both the works on control design and test plan generation are applicable in different domains but exhibit a common solution theme. In both cases, we leverage hierarchical modelling. The control problem is addressed with a demand allocation phase, followed by supervisory MPC and then the lower level control design. The test generation problem is addressed with high-level planning followed by concrete test program generation. For all the problems investigated in this research, we develop model-based tool-flows with manageable run times.

Keywords: *Cross-computing tools and techniques, Model-based design, Energy-aware HVAC control, Platform-aware MPC, Automated planning and test generation.*