

OptiMMA: Optimization of MP-SoC Middleware for event-driven dynamic Applications

Description:

Developing software for contemporary embedded systems, featuring heterogeneous multiprocessors, multiple power modes, complex memory hierarchies and advanced interconnects, is a daunting task. Mapping of emerging, dynamic software applications on complex MP-SoC will be achieved through the use of Middleware components which will be able to mediate between embedded software and the hardware platforms. State-of-the-art tools that help to map software tasks to hardware resources are limited because they do not take into account the interdependencies among processing, memory and communication constraints. Moreover, they also require the granularity of the right models at different abstractions and model transformations in the system synthesis to leverage between the complexity of middleware components and optimization of system cost (ex: energy consumption) while satisfying the real-time constraints of applications.

In the OptiMMA project, we have focused on all these aspects to reduce the final system cost (ex: energy consumption) while optimizing the middleware components which includes both the design-time and run-time phases. We start from the Process Network model of dynamic applications and model transformations will be applied for different abstractions of system optimizations like mapping exploration. In the design-time phase, the dynamism in the application is reflected in the appropriate number of scenarios using the System Scenario based Methodology. We have also applied the Task Concurrency Management methodology (TCM) design-time phase. There, for each identified system scenario, we efficiently explore the search space of all possible mappings and extract only the few Pareto-optimal mapping solutions. We propose middleware components for the run-time decisions; some are specific to applications (like the scenario detection logic to identify in which scenario the application is in) others are generic middleware components (like run-time resource managers for MPSoC resource processing elements, memories and interconnect). We propose various tools for the design-time phase activities to meet the time-to market demand and also run-time phase middleware components to leverage between the system cost savings and overheads in terms of performance and energy consumption.

In the context of the OptiMMA project, we demonstrate our software prototype of mapping the dynamic applications with our proposed models at different abstractions, model transformations, methodologies applied to explore the mapping solutions at design-time and MPSoC Middleware components at run-time. We demonstrate our work on 3D-WSS based Scalable Graphics game engine (graphics), H264 (multimedia), and Cavity Detector (medical imaging) applications test benches. We show our experimental gains on our high-level functional MPSoC virtual simulator developed in SystemC. Our middleware components experimental results have shown that we can either obtain up to 4x gains on performance or up to 70% energy reduction on the trade-off axes for the Scalable 3D graphics application, when compared to state-of-the art approaches.

Keywords: middleware, resource management, multiprocessor, MP-SoC, run-time, design-time, scheduling, computation, memories, and communication.