Scientific Report

First name / Family name	Isil Oz
Nationality	Turkey
Name of the *Host Organisation*	SICS Swedish ICT AB
First Name / family name of the *Scientific Coordinator*	Mats Brorsson
Period of the fellowship	01/11/2013 to 31/10/2014

I – SCIENTIFIC ACTIVITY DURING YOUR FELLOWSHIP

I worked under the supervision of Prof. Mats Brorsson in Computer Systems Laboratory at SICS. My work was part of European research project called PaPP (Portable and Predictable Performance on Heterogeneous Embedded Manycores). My research was related to performance modeling and prediction of task-based parallel programs. We worked with students and researchers from KTH closely to get performance prediction results, and achieved to have preliminary results for some project use-case programs.

We proposed a performance model in order to obtain performance predictions for task-based programs represented by task graphs. We built a two-level hierarchical model in order to represent the task-based application execution and implemented a simulation tool to simulate scheduling events of a task-based program. This tool can generate performance results by considering task-level instructions, and we have plans to extend it to be able to include memory behavior of the applications.

We also worked on regression-based techniques to predict parallel program performance. We already submitted a journal paper, which presents a prediction method among scheduling decisions, we are planning to apply the similar methodology for the prediction among hardware platforms and various programs.

We also worked on task scheduling strategies to get performance optimizations as another aim of the project. We proposed and applied a static tasks scheduling algorithm to workloads represented by task graphs. There are plans for conducting the optimizations for programs to guide runtime system.

II – PUBLICATION(S) DURING YOUR FELLOWSHIP

- *Noodle: A Heuristic Algorithm for Task Scheduling in MPSoC Architectures*, Muhammad Khurram Bhatti, Isil Oz, Konstantin Popov, Ananya Muddukrishna, and Mats Brorsson, Euromicro Conference on Digital System Design (DSD), Verona, Italy, 2014.

Abstract: Multiprocessor system-on-chip (MPSoC) based architectures promise higher performance for computationally intensive applications. Since programs for parallel systems consist of tasks executed simultaneously, task scheduling be- comes crucial for the performance of these applications. Given dependence constraints between tasks, their arbitrary sizes, and bounded resources available for execution, optimal task scheduling is considered as an NP-hard problem. Therefore, proposed scheduling algorithms are based on heuristics. This paper presents a novel heuristic algorithm, called the Noodle heuristic. Noodle differs from the existing list scheduling techniques in the way it assigns task priorities. The priority mechanism of Noodle maintains a proportionate fairness among all ready tasks belonging to all paths within a task graph. We conduct an extensive experimental evaluation for task graphs taken from Standard Task Graph (STG) to present the efficiency of Noodle. Our experimental results demonstrate that Noodle produces schedules that are within a maximum of 12% (in worst-case) of the optimal schedule for 2, 4, and 8 core systems. For unbounded computing resource, Noodle always produces an optimal schedule. We also compare Noodle with existing scheduling heuristics and perform comparative analysis of its performance.

- *Performance Prediction of Task-Based Programs*, Isil Oz, Ananya Muddukrishna Muhammad Khurram Bhatti, Konstantin Popov, and Mats Brorsson, Poster presentation, International Summer School on Advanced Computer Architecture and Compilation for High-Performance and Embedded Systems, Fiuggi, Italy, 2014.

Abstract: Dynamic runtime behavior and contention on shared resources make it harder to predict the execution time of task-based programs on multicore systems. Modeling the program performance is difficult due to impact of several application-specific and architecture-dependent factors. In this work, we develop a modeling technique based on task graph simulation analysis that provides detailed performance prediction for task-based programs with task scheduling policies, and communication and resource contention.

- *Proportionately Fair Task Scheduling for Parallel Computing Systems*, Muhammad Khurram Bhatti, Isil Oz, Konstantin Popov, and Mats Brorsson. Submitted to Journal of Systems Architecture, Under review.

Abstract: Parallel computing systems promise higher performance for computationally intensive applications. Since programs for parallel systems consist of tasks executed simultaneously, task scheduling becomes crucial for the performance of these applications. Given dependence constraints between tasks, their arbitrary sizes, and bounded resources available for execution, optimal task scheduling is considered as an NP-hard problem. Therefore, proposed scheduling algorithms are based on heuristics. This paper presents a novel list scheduling heuristic, called the Noodle heuristic. Noodle is a simple yet effective scheduling heuristic that differs from the existing list scheduling techniques in the way it assigns task priorities. The priority mechanism of Noodle maintains a proportionate fairness among all ready tasks belonging to all paths within a task graph. We conduct an extensive experimental evaluation of Noodle heuristic with task graphs taken from Standard Task Graph (STG). Our experimental study includes results for task graphs comprising of 50, 100, and 300 tasks per graph and execution scenarios with 2, 4, 8, and 16 core systems. We report results for average Schedule Length Ratio (SLR) obtained by producing variations in Communication to Computation cost Ratio (CCR). We also analyse results for different degree of parallelism and number of edges in the task graphs. Our results demonstrate that Noodle produces schedules that are within a maximum of 12% (in worst-case) of the optimal schedule for 2, 4, and 8 core systems. We also compare Noodle with existing scheduling heuristics and perform comparative analysis of its performance. Noodle outperforms existing heuristics for average SLR values.

- *Regression-Based Prediction for Task-Based Program Performance,* Isil Oz, Muhammad Khurram Bhatti, Konstantin Popov, and Mats Brorsson. Submitted to Real-Time Systems Journal, Under review.

Abstract: Dynamic runtime behavior and contention on shared resources make it harder to predict the execution time of task-based programs on multicore systems. In order to get the highest performance and provide real-time guarantees, it is required to identify which runtime configuration is needed and how processor resources must be shared among tasks. Exploring design space for all possible scheduling and runtime options, especially for large input data, becomes infeasible and requires statistical modeling. Regression-based modeling determines the effects of multiple variables on a response variable, and makes predictions based on statistical analysis. In this work, we propose a regression-based modeling approach to predict task-based program performance for different scheduling parameters with variable input data size. We execute a set of task-based programs by varying runtime parameters, and conduct a systematic measurement for influencing factors on execution time. Our approach uses executions with different configurations for a set of input data, and derives different regression models to predict execution time for larger input data. Our results show that regression models provide accurate predictions for validation inputs with mean error rate as low as 6.3%, and 14% in average among four task-based programs.

III – ATTENDED SEMINARS, WORKHOPS, CONFERENCES

- ITEA & ARTEMIS Co-summit, Stockholm, Sweden, 4-5 December 2013.
- International Conference on High-Performance and Embedded Architectures and Compilers (HIPEAC), Vienna, Austria, 20-22 January 2014.
- SICS Open House, Stockholm, Sweden, March 27, 2014.
- CSL Conference, Stockholm, Sweden, 17-18 June, 2014.
- International Summer School on Advanced Computer Architecture and Compilation for High-Performance and Embedded Systems (HIPEAC ACACES), Fiuggi, Italy, 13-19 July 2014.
- SICS Software Week, Multicore Day, Stockholm, Sweden, October 8, 2014.

IV – RESEARCH EXCHANGE PROGRAMME (REP)

- REP 1:

INRIA Paris, France, hosted by Prof. Albert Cohen, March 30-April 4 2014.
Presentation related to research activities, discussions with students and researchers.

- REP 2:

UPC Barcelona, Spain, hosted by Associate Prof. Marisa Gil, September 14-20, 2014.
Presentation related to research activities, discussions about future collaborations with researchers.