

## EXECUTIVE SUMMARY

**PROJECT NAME:** G7-09: Virtualizing FPGA Resources for HPRCs

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### PROJECT DESCRIPTION

The execution of parallel applications on HPRCs mainly follows the Single-Program Multiple-Data (SPMD) model, which is largely the case in traditional High-Performance Computers (HPCs). In addition, the prevailing usage of FPGAs in such systems has been as co-processors. The overall system resources, however, are often underutilized because of the asymmetric distribution of the reconfigurable processors relative to the conventional processors. This asymmetry is often a challenge for using the SPMD programming model on these systems. In this project, we propose a resource virtualization solution based on Partial Run-Time Reconfiguration (PRTR). This technique will allow sharing the reconfigurable processors among the underutilized processors. Therefore, the goals of this project are maximizing resource utilization in HPRC systems and taking advantage of advances in multicore technology and trends by extending hardware virtualization for multitasking on multicore processors and FPGAs

### EXPERIMENTAL PLAN

The proposed virtualization solution is planned to be developed in stages, through a significant extension of the analytical and experimental framework developed earlier for carrying out PRTR on HPRCs (See project G7-08). The planned stages are as follows:

- (a) *Multitasking and multi-user support:* A direct extension of the previous work from G7-08 will be carried out, in order to manage different applications, from single as well as multiple users. The developed experimental framework from G7-08 will be extended and practically demonstrated.
- (b) *Multicore processing with multicore devices:* This part of the study will consider efficient utilization of FPGA resources when multi-core processors are used. The analysis will be carried out for different cases, by varying the number of cores per processor, number of FPGAs, granularity of tasks, FPGA partitioning granularity, etc. Multiplexing of reconfigurable resources in space and time will be addressed, and a detailed analytical framework will be developed. This will be followed by the development of a virtual manager as a proof-of-concept.
- (c) *Non-partially reconfigurable devices:* FPGAs from many vendors, such as Altera, are not partially reconfigurable. The developed analytical framework will be adapted for the case when only a full reconfiguration is allowed. In addition to increasing the applicability of the analysis, the study on non-partially reconfigurable devices will prepare the ground for future extension to heterogeneous computing resources.

### HOW THIS PROJECT IS DIFFERENT

Research on virtualization of reconfigurable resources is in its infancy; the proposed analytical framework would therefore enable systematic development and evaluation of virtualization solutions. The developed proof-of-concept may be used by others as a model or starting point for a full-fledged virtualization solution. The proposed solution will also position us to extend it for heterogeneous compute resources, which has the potential of far reaching impact.

### POTENTIAL MEMBER COMPANY BENEFITS

Asymmetry between the available processor and FPGA resources is a normal trend in modern HPRCs, and it is expected to increase further. Member organizations will be able to leverage the developed technology from this project, for efficiently managing reconfigurable resources in the presence of this asymmetry. In addition, commodity microprocessors are increasingly adopting a large number of cores on-chip; the proposed framework will allow CHREC members to exploit the performance potential of multi/many core processors to the fullest extent.

### EXPECTED DELIVERABLES

The primary deliverable from this project will be a virtualization framework, which can be adapted and used for any HPRC system. Deliverables include a theoretical framework for analyzing the performance and choosing a solution for maximum performance; a run-time virtual resource manager would also be delivered as a proof-of-concept. During the course of the project, mid-term and final reports will document the research methods adopted, the progress of the project, as well as analyses and results obtained from the study. It is also expected that a couple of papers will be published in journals and conferences.

### PROJECT BUDGET

3 CHREC Memberships