Multi-Level Parallelization in Polyhedral Model for Heterogeneous Platforms with GPU Accelerators

Ana Balevic, Bart Kienhuis, Ed Deprettere
Leiden Institute for Advanced Computer Science
University of Leiden, The Netherlands
balevic@liacs.nl

Multi-Level Program Modeling
A novel intermediate model for multi-level program representation and manipulation in the polyhedral framework: Hierarchical Polyhedral Reduced Graph (HiPRDG)

HiPRDG is a connected, acyclic graph spanning several layers. A HiPRDG consists of a set of nodes and a set of edges. A HiPRDG is annotated with a fully-fledged polyhedral model (PRDG).

Zooming into a statement within a HiPRDG node leads to the child node of HiPRDG that contains the statement’s polyhedral model.

Usage Scenarios/Applications of the HiPRDG Model
- Compiler-assisted parallelization targeting heterogeneous multi-level platforms – HiPRDG enables derivation of multi-level parallel programs featuring task, data, and pipeline parallelism
- Modular hybrid parallelization – enables per-node application of the best-suited transforms and code generation tools
- Model-based granularity tuning – by adjusting encapsulation boundaries in the model itself

Multi-Level Parallelization Case Study
- M-JPEG Encoder can be easily transformed into a PPN to exploit task parallelism on the host.
- Using the HiPRDG, we generate a multi-level parallel M-JPEG code that uses asynchronous offloading of the computationally intensive DCT onto GPU.

The resulting multi-level program features task, data, and pipeline parallelism. With the MLP, we observed 4x performance improvement over the reference task-parallel code.

Conclusions
Introduction of the support for hierarchy and encapsulation in the polyhedral framework opens doors for research on automatic generation of multi-level parallel programs that can efficiently exploit the parallelism abundant on heterogeneous platforms.