Designing Domain-Specific Heterogeneous Manycores from Dataflow Programs

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Motivation

- Machine Learning
- Audio/Video Processing
- Wireless Communication
- Radar Signal Processing
- Heterogeneous structure

Solution

Manycore architectures with cores specialized on certain tasks through instruction extension.

- Efficient for certain domain
- Can perform general purpose processing

Results

- 4x performance increase with accelerator
- 3x performance increase with accelerator
- 10-15% increase in LUT and FF usage in FPGA
- No increase in FPGA resource usage
- No performance loss

Conclusions

- Specialized cores provide higher performance
- Automation facilitates design of architectures and consequently exploration of design space

Future work

- Support generation of different tile types
- Optimizations on code generation
- System integration
- Compilation framework development including mapping

SUMMARY OF THE DESIGN FLOW

- Developing the application in a language with support for parallelism
  - CAL actor language
- Analyzing the application to identify hot-spots via TURNUS framework
  - Number of operations, execution count etc.
- Generating hardware/software co-design via Cal2Many framework
  - C + Chisel
- Integrating the custom hardware to a general purpose core and create a tile
  - Rocket core with RoCC interface
- Connecting several tiles with a network-on-chip (Ongoing work)
  - 2D mesh NoC

Application Development

- CAL
- C
- Chisel
- Rocket Chip

Code Generation

- CAL2MANY
- Chisel
- RoCC Interface
- Rocket Chip Generator

System Integration

- NoC
- Mapping
- Configuration Parameters

Accelerator Integration

- CAL
- Chisel
- Interface

Program

- 4x performance increase with accelerator
- With automatic code generation

RISC-V core

- Interrupt
- Data
- Mem
- Busy
- Resp
- Cmd
- NoC
- 2D mesh

CAL code

- Generator
- Native Generator
- Tiles

Heterogeneous Manycore

- Domain Specific

Profiles

- Memory Tile
- Memory Accelerator Tile
- Code generation

Support generation of different tile types

- 4x performance increase with accelerator
- With automatic code generation


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