A Common Machine Language for Communication-Exposed Architectures

Bill Thies, Michal Karczmarek, Michael Gordon, David Maze and Saman Amarasinghe

MIT Laboratory for Computer Science

HPCA Work-in-Progress Session, February 2002
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Language Designers Have Been Ignoring Architects

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Back in The Good Old Days...

• Architecture: simple von-Neumann
• “Common Machine Language”: C
  - Abstracts away idiosyncratic differences
    • Instruction set
    • Cache configuration
  - Exposes common properties
    • Program counter
    • Monolithic memory
  - Efficient implementations on many machines
  - Portable: everyone uses it
Programming Language Evolution

Language Effectiveness

C++
Java

C
Programming Language Evolution
Languages Have Not Kept Up

- Two choices:
  - Develop cool architecture with complicated, ad-hoc language
  - Bend over backwards to support old languages like C/C++
Evidence: Superscalars

- Huge effort into improving performance of sequential instruction stream
- Complexity has grown unmanageable
- Even with 1 billion transistors on a chip, what more can be done?

- Pipelining
- Out-of-Order Execution
- Renaming
- Branch Prediction
- Prefetching
- Speculative Execution
- Value Prediction
A New Era of Architectures

• Facing new design parameters
  - Transistors are in excess
  - Wire delays will dominate

• “Communication-exposed” architectures
  - Explicitly parallel hardware
  - Compiler-controlled communication
  - e.g. RAW, Smart Memories, TRIPS, Imagine, the Grid Processor, Blue Gene
A New Common Machine Language

• Should expose shared properties:
  - Explicit parallelism (multiple program counters)
  - Regular communication patterns
  - Distributed memory banks
  - No global clock

• Should hide small differences:
  - Granularity of computation elements
  - Topology of network interconnect
  - Interface to memory units

→ C does not qualify!
The StreamIt Language

- A high-level language for communication-exposed architectures
- Computation is expressed as a hierarchical composition of independent filters
The StreamIt Language

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- Computation is expressed as a hierarchical composition of independent filters
- Features:
  - High-bandwidth channels
  - Low-bandwidth messaging
  - Re-initialization
The StreamIt Compiler

- We have a compiler for a uniprocessor
  - Performs comparably to C++ runtime system
The StreamIt Compiler

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• Working on a backend for RAW
  - Fission and fusion transformations
  - Many optimizations in progress
The StreamIt Compiler

• We have a compiler for a uniprocessor
  - Performs comparably to C++ runtime system
• Working on a backend for RAW
  - Fission and fusion transformations
  - Many optimizations in progress
• Goal: High-performance, portable language for communication-exposed architectures
For more information, see:

http://cag.lcs.mit.edu/streamit/

Thank you!