Out-of-Order Issue

High Performance Substrate Research Group

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Terminology

Cache/Decode

↓ *ISSUE*

Reservation Stations

↓ *DISPATCH*

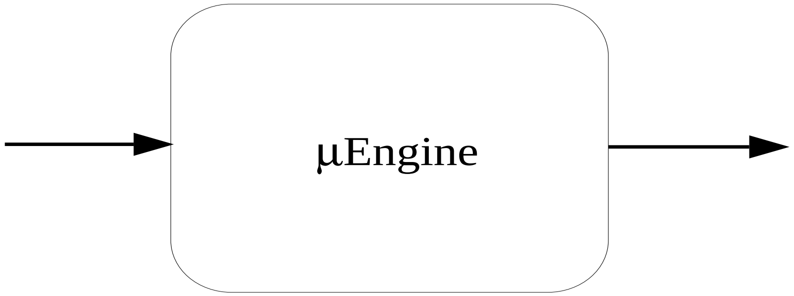
Functional Units

Outline

- Motivation
- Out-of-Order Issue
- Experiments
- Conclusions

Fundamental Principle

Flynn's Bottleneck

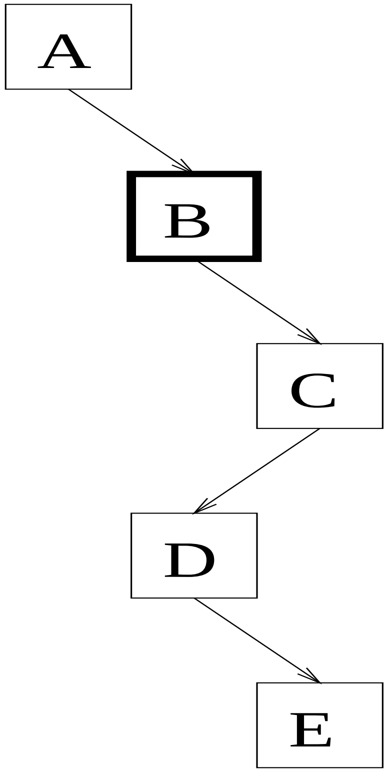


Can't get out more than you put in.

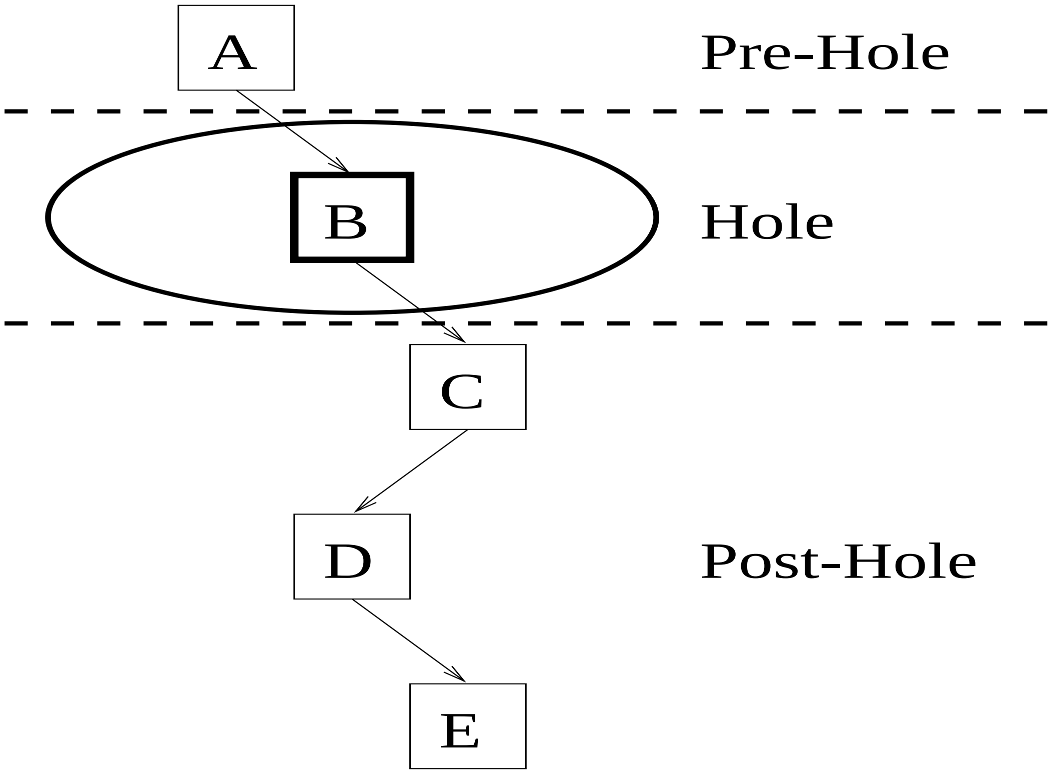
Maximizing Issue Bandwidth

- no issues thrown away (caused by mispredictions)
- no partial issues (caused by branches)
- no empty issues (caused by cache misses)

Out-of-Order Issue



The Dataflow Graph Hole



Experiments

- Benchmarks: SPECint95 + Non-SPEC
- Machine Model: Augmented RDF Model

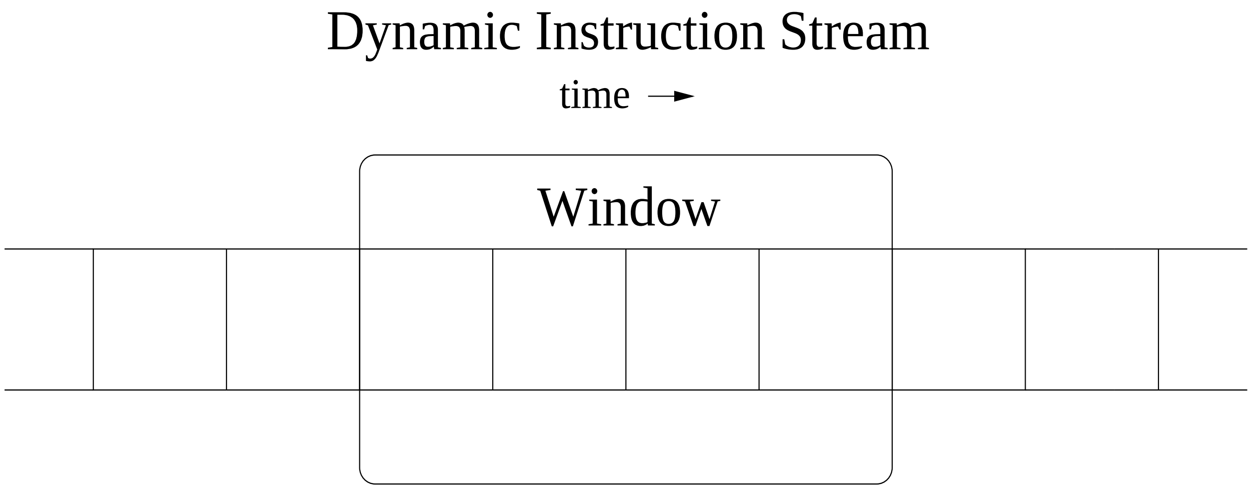
Additional (Non-SPEC) Benchmarks

- chess - GNU Chess
- groff - GNU groff document formatting system
- gs - Aladdin Ghostscript interpreter
- pgp - Pretty Good Privacy encryption system
- plot - gnuplot plotting program
- python - Python programming language interpreter
- ss - SimpleScalar superscalar processor simulator
- tex - Web2c port of the $\TeX$ document formatting system

Augmented RDF Model

- real dcache: 16k bytes, direct mapped, 64 byte lines,
  10 cycle miss penalty
- real icache: 16k bytes, direct mapped, 64 byte lines,
  10 cycle miss penalty
- real branch predictor: 16 bit gshare, 64 entry RAS,
  last-time scheme for indirect jump targets

RDF Paradigm [Butler et al. '91]



- window size
- issue rate
- instruction class latencies

RDF Parameters

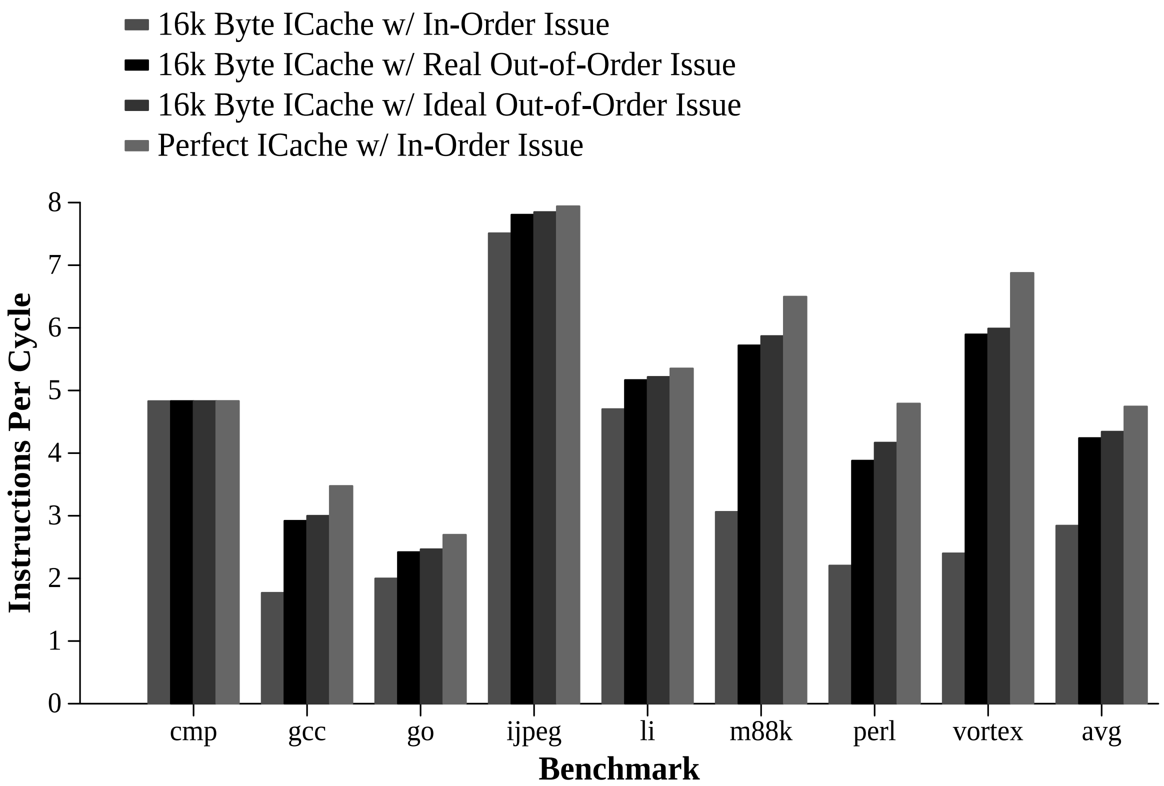
- window size: 256 instructions
- issue rate: 16 instructions / cycle
- instruction class latencies:

Instructions	Execution Latency (cycles)
FP div	16
other FP	4
INT mul	8
load	2 (minimum)
all others	1

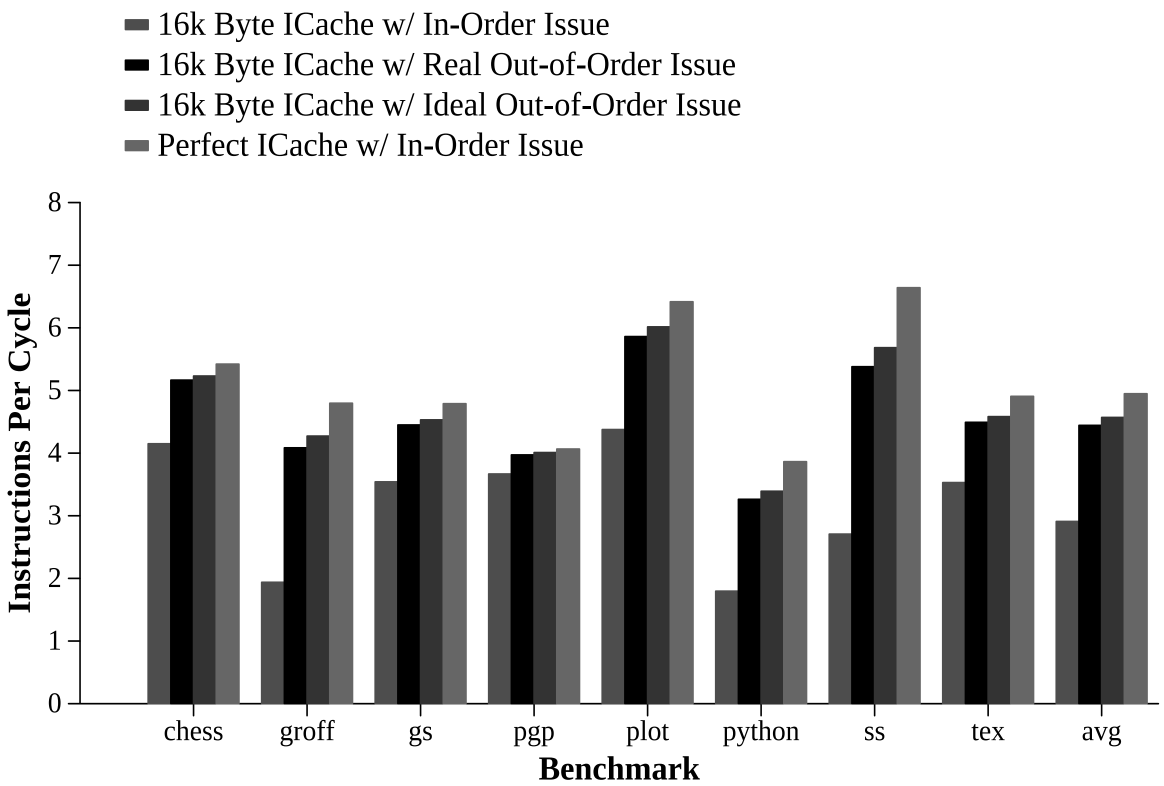
The Experiments

- 16k Byte ICache w/ In-Order Issue
- 16k Byte ICache w/ Real Out-of-Order Issue
- 16k Byte ICache w/ Ideal Out-of-Order Issue
- Perfect ICache w/ In-Order Issue

Results (SPECint95)



Results (Non-SPEC)



Conclusions

- Real OOO Issue: + 51%
- Ideal OOO Issue: + 55%

For more, see our MICRO-30 paper on the HPS Web Page:

http://www.eecs.umich.edu/HPS/