Out-of-order Processing and Memory Operations

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(slides adapted in part from prior 6.823 offerings)
Previously: Complex Pipelines

- Scoreboarding
- Variable-latency execution units
- Out-of-order (OoO) processing
  - OoO Issue, OoO completion, in-order retiring (commit)
  - Register renaming
Out-of-Order (OoO) Summary

- OoO Processor: Restricted “data-flow” machine
  - Dynamically builds the data-flow graph

- Tolerates long latency operations by executing independent instructions in parallel

- The dynamically constructed data-flow graph is limited to the instruction window
OoO memory operations

• Can the ROB (Issue Queue) track memory dependences?
• Must respect all dependences:
  • WAW, WAR
    • buffer store in store queue until commit
  • RAW
    • If store executed before load:
      • Store-to-load forwarding (from store queue/buffer)
    • If load executed before store, need to disambiguate. Three solutions:
      • Load queue search when store executes
      • Re-execute the load at commit-time
      • Stall the load
When to bring data into the cache?

• Reads
• Writes?
  • Write allocate vs. no-write allocate
• Prefetching
• Advantages and disadvantages of bringing more data into the cache?
Branch Prediction

Control Flow Dependences. How to handle them?
• Stall: Delay until we know the next PC
• Speculate: Guess next value
• Do something else: Multi-threading

Why is branch prediction crucial for out-of-order and superscalar processors?
Branch predictor (BHT) entries:

- 1-bit (bimodal) predictor
- 2-bit predictor
  - Counter
  - Other options?
- More bits?
  - Perceptrons
How to index into the BHT?

• Some bits from PC
• Two-level predictor uses recent branch outcomes to compute index
  • Global history register
  • Local history table
• Combination of the above
  • Gshare uses XOR of bits from PC and global history
Tournament Predictors

LHist

GHist

Chooser

Prediction
Reminders

• Lab 2 due at 11:59pm Eastern Daylight Time (UTC+4)
• Review session for Quiz 2
  • 6pm on Tuesday
  • Using the same Zoom URL as recitation