CIS 501
Introduction to Computer Architecture

Class Project

Slides originally developed by Amir Roth with contributions by Milo Martin at University of Pennsylvania with sources that included University of Wisconsin slides by Mark Hill, Guri Sohi, Jim Smith, and David Wood.

Mini-Research Course Project

- What?
  - Investigate a research idea in a paper mentioned in class (default)
  - Examine modest extension to paper (more ambitious)
  - Your own idea (great!)
- Who?
  - You and three other students (groups of four)
- When?
  - Proposal: Thursday, Nov 18
  - Final report: Monday, Dec 13 @ noon (first day of reading days)
- Tools?
  - Simulation of instruction traces
- How much?
  - 15% of your final grade

Proposal and Final Report

- Proposal (~500 words)
  - Names of group members & **brief** description of idea
    - What you plan to measure and how
  - The more information, the more feedback I can provide!
- Final report (~4000 words)
  - Brief description of idea
  - Brief description of your implementation
  - Description of your experimental configuration
  - Presentation **and analysis** of results
  - Brief overview of related work/prior work
  - Like a mini conference paper (you've read some)
- Group contribution report
  - Your **individual** evaluation of contribution of all group members
  - Submitted via blackboard

Finding Ideas

- Research ideas described in class
  - E.g., grid processor, advanced branch prediction, prefetching, etc.
- Ideas found in recent research papers
  - ACM digital library: http://www.acm.org/dl
  - Recent MICRO conferences: http://www.microarch.org/
  - Others: http://www.cs.wisc.edu/~arch/www/conferences.html
- At most two groups may work on exact same idea
  - First-come, first-served
  - E-mail us (cis501@cis) with a general topic as soon as you know it
- Or come talk to me

Ideas: Branch Prediction Algorithms

- Implement new branch predictor
  - Compare new predictor to existing predictors
  - Examples:
    - Agree [Sprangle+, ISCA'97]
    - YAGS [Eden+, MICRO'98]
    - Perceptron [Jimenez, HPCA'01]
    - Piecewise Linear Branch Prediction [Jimenez, ISCA '05]
    - GEometric History-Length predictor [Seznec, ISCA'05]
- **2nd Branch Prediction Championship (2006)**
  - Examples of state-of-the-art predictors
  - http://cava.cs.utsa.edu/camino/cbp2/
  - Also includes tracing infrastructure for evaluating ideas
    - Or can use our instruction traces

Ideas: Prefetching

- Implement prefetching algorithm
  - Instructions or data
  - Examples (a bit out of date)
    - Call-graph prefetching for insns [Annavaram+, HPCA'01]
    - Dependence-based prefetching for pointers [Roth+, ASPLOS'98]
    - Context-based prefetching for pointers [Cooksey+, ASPLOS'02]
    - Dead-block prefetching [Lai+, ISCA'01]
    - In-memory prefetching [Solihin, ISCA'02]
- **Data Prefetching Championship (2009)**
  - Examples of state-of-the-art prefetchers
  - http://www.jilp.org/dpc/
  - Also includes tracing infrastructure for evaluating ideas
    - Or can use our instruction traces

Ideas: Processor Microarchitecture

- Study the effects of real constraints on potential of ILP
  - Critical path modeling [Fields+, ISCA'01]
  - Limits of ILP [Wall, ASPLOS'91, Lam+, ISCA'02]
- Front end
  - High-throughput instruction fetch
  - Trace cache
- Back end
  - Clustering/steering [Farkas+, MICRO'97, Baniasadi+, MICRO'00]
    - Criticality Analysis of Clustering in Superscalar… [MICRO' 05]
  - Memory dependence prediction (Store sets++)
  - Scalable instruction windows (Cyclone scheduler, Matrix scheduler)
  - Runahead execution

Evaluation Methods and Infrastructure

- Instruction traces (default)
  - But, should provide results for multiple benchmarks
  - We will provided some traces for additional benchmarks
- "Functional" simulation
  - Miss rates and mis-prediction rates
  - Okay for design space exploration and initial results
- "Timing" simulation
  - Can calculate full execution time
  - Pipeline model with integrated cache and branch predictor
  - Simulate the timing interactions (was a prefetch far enough in advance? how does out-of-order execution impact the idea?)
- Depending on topic, I expect at least some "timing" results