ECE/CS 757: Advanced Computer Architecture II

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Midterm 1 Review

- Introductory material
- Cores, multithreading, multicore
- Multiprocessor software
- Memory systems & coherence
- Consistency

Introduction

- Thread-level parallelism

- Multiprocessor Systems

- Cache Coherence Basics
  - Snoopy
  - Scalable

- Flynn Taxonomy (SISD/SIMD/MIMD)

- UMA vs. NUMA

Introduction - Readings

- Skim Smith beta ch 1
- Gem5
- Sutter&Larus
- 21st Century white paper

Cores (Review of 752)

- ✓ Iron law
- ✓ Beyond pipelining
- ✓ Superscalar challenges
  - ✓ Instruction flow
  - ✓ Register data flow
  - ✓ Memory Dataflow
- ✓ Modern memory interface
- • What was not covered
  - – Virtual memory
  - – Power
  - – Many implementation/design details

Multithreading

- Historical Multi-threaded Cores
  - 6600, HEP
- In-Order Multi-threaded Cores
- Out-of-Order Multi-threaded Cores
  - Resource Sharing
  - Thread Scheduling
- Case Studies
  - Intel Pentium 4

Multicore Summary

- Objective:
  - resource sharing

- Design Issues
  - Where to connect
  - Shared vs private caches
  - Coherence
    - L1, L2 protocols, policies
  - Interconnect
    - Bus, crossbar, ring, mesh

- Case studies

Cores/Multithreading/Multicore - Readings

- Skim Smith ch. 3
- Olukuton CMP
- Kumar Heterogeneous CMP

MP Software

- Important Multiprocessor Interfaces
  - API
  - ABI
  - ISA
- Programming Models
- Major Abstractions
  - Processes & threads
  - Communication
  - Synchronization
- Shared Memory
  - API description
  - Implementation at ABI, ISA levels
  - ISA support
- Message Passing (cursory coverage only)
  - API description
  - Implementation at ABI, ISA levels
  - ISA support

MP Software - Readings

- Skim Smith Ch. 2
- Scott synthesis lecture
- Hillis & Steele

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Memory Systems & Cache Coherence

- DRAM & memory controllers
- Memory hierarchy review
- Coherence States
- Snoopy bus-based Invalidate Protocols
- Invalidate protocol optimizations
- Update Protocols (brief)
- Directory protocols
- Implementation issues

Coherence Readings

- Skim Smith Ch. 4
- Synthesis lecture on coherence & consistency
- Conway et al. (Opteron)

Consistency Models

- **UNDERSTANDING CONSISTENCY MODELS**
  - Atomicity
  - Program Ordering
  - Visibility/Causality
- **POPULAR CONSISTENCY MODELS**
  - Sequential Consistency
  - IBM/370
  - Processor Consistency
  - SPARC TSO/PSO/RMO
  - Weak Ordering
  - PowerPC Weak Consistency
- **VISIBILITY**
- **MEMORY REFERENCE REORDERING**
- **IMPLEMENTATION ISSUES**

Consistency - Readings

- Synthesis lecture on coherence & consistency
- Hill: position paper on simple models

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- Cores and multithreading
- Multicore
- Coherence
- Consistency