CS4223 Multi-core Architectures

From ILP to TLP

National University of Singapore
2023 – 2024 School Year, Semester 1 (August 2023 – December 2023)
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Office hours by request

Overview

This Multi-core Architectures class is an undergraduate-level class that focuses on foundational topics that include both advanced single-core and multi-core systems. The goal of this class is to guide students on these fundamental topics, build up knowledge in these topics with project-based assignments, and to expose research-paper based source materials to begin a journey into architecture research. This course will take you through a number of topics, from modern CPU architectures to accelerators, and will ask you to work with tools to build up a level of expertise for new topics and software.

Goals

- Understanding foundational topics in advanced single-core and multi-core parallelism
- Implement key designs and initiate the research process
    - Understand simulation, sampling, and investigation of system parameters
    - Go in-depth with coherence with a high-level simulator implementation
- Develop computer architecture paper reading skills and better understand research papers
    - Review source material and provide an analysis of the paper structure
    - Be able to summarize key research results, better understand yourself as a paper reader, and to actively choose your reading type depending on the purpose

Class Meetings

Mondays, 14:00-16:00, In person (COM4-SR3132) and potentially online via Zoom

Class Topics

- ILP exploitation via superscalar and VLIW, caches
- DLP exploitation via vector processors
- TLP exploitation via multi-core
    - Cache Coherence
    - Memory Consistency
    - Synchronization
- Power/Energy issues
- GPUs and AI Accelerators

Grading Criteria

- Project / Assignments (50%)
  - Project 1 – ILP Identification (20%)
  - Project 2 – Build-your-own Simulator: Cache Coherence (30%)
- In-class Tests (45%)
  - A number of short (<=1 hour) in-class tests to reinforce learned knowledge. All tests can contain material since the beginning of class.
- Participation and preparation for class (5%)
  - Participation (5%)

Important deadlines and test dates (subject to updates)

- Programming Assignments
  - Assignment 1 due by end-of-day on Friday, September 22nd
  - Assignment 2 due by end-of-day on Friday, November 11th
- Tests
  - Test 1 – ILP on Monday, August 28th
  - Test 2 – Caches on Monday, September 4th
  - Test 3 – Coherence on Monday, October 2nd
  - Test 4 – TLP/Synch on Monday, October 9th
  - Test 5 – Consistency on Monday, October 30st
  - Test 6 – DLP on Monday, November 6th
- Tutorials
  - ILP – September 4th
  - Caches – September 11th
  - Coherence – September 12th
  - Synchronization – September 26th
  - Consistency – October 3rd
  - DLP – October 17th

						August
Wk	Topic	Mon	Tues	Wed	Thurs	Fri
1	Introduction	14	15	16	17	18
2	ILP 1	21	22	23	24	25
3	ILP 2	28 Tutorial: ILP	29	30	31	1
						September
4	Caches	4 Test: ILP Tutorial: Caches	5	6	7	8 Programming Assignment 1
5	TLP, Multicore	11 Test: Caches	12	13	14	15
6	Cache Coherence	18 Tutorial: Coh.	19	20	21	22

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7	Synchronization	2 Tutorial: Synch.	3	4	5	6
						October
8	Consistency	9 Test: Coherence Tutorial: Consist.	10	11	12	13
9	DLP	16 Test: TLP/Synch.	17	18	19	20
10	DLP 2	23 Tutorial: DLP	24	25	26	27
11		30	31	1	2	3
						November
12	GPUs	6 Test: Consist.	7	8	9	10 NUS Holiday
13	ML/DNN Accelerators	13 Test: DLP	14	15	16	17 Programming Assignment 2