CS 704 Version 4 (2020–21)

Advanced Computer Architecture

Dr. Muhammad Al-Hashimi

Credits 3

Prerequisite None

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This is a graduate course on designs, organizations, and methods related to building computers, combining a historical perspective of evolving technologies with a modern take on the current state of the art. Students gain unique original insights into major aspects of modern computers by reading relevant articles including seminal works in the field. They develop and demonstrate an understanding of architectural principles through discussions and short presentations. I present some background material as needed. An optional small programming project further explores the GPU as a modern fine-grained massively parallel architecture.

Topics

- ✎ **Evolving Power** Moore's law, Flynn's taxonomy, Amdahl's law, seminal machines and architectures from CDC6600 to the Tianhe.
- ✎ **Instruction Set Design** The road to modern power-efficient RISC.
- ✎ **Instruction Level Parallelism** Pipelined processors, processor performance equation, multiple issue, superscaler, speculative and out-of-order execution, emerging security concerns.
- ✎ **Parallel Computers** The dataflow computer, multithreading, SIMD, multiprocessing, multicores, and modern fine-grained parallelism.
- ✎ **Cache Memory** Reference locality and memory hierarchies, direct-mapped, associative and multilevel strategies, performance and design tradeoffs, coherence in parallel systems.
- ✎ **High Performance Computing** Bell's eleven rules of supercomputer design, modern supercomputing and high-performance applications.
- ✎ **Looking Ahead** Exascale and quantum computers: implications and challenges.

Assessment Weekly presentations, group discussions, and short essays assess reading quality and grasp of course material.

50%	Weekly class presentations
30%	Semester work portfolio
20%	Final presentation

Resources Check announcement topics in course group for reading schedules and material.

References

1. Mark D. Hill (Editor) et. al., *Readings in Computer Architecture*, Morgan Kaufmann Series in Computer Architecture and Design 2000. ISBN: 0201361183
2. Daniel Siewiorek and Philip Koopman, *The Architecture of Supercomputers: Titan, a Case Study*, Academic Press 1991.
3. David B. Kirk and Wen-mei W. Hwu, *Programming Massively Parallel Processors, A Hands-on Approach*, 3rd ed., Morgan Kaufmann 2016. ISBN: 978-0128119860
4. David A. Bader (Editor), *Petascale Computing: Algorithms and Applications*, Chapman & Hall/CRC 2008. ISBN: 978-1584889090
5. Jeffrey S. Vetter (Editor), *Contemporary High Performance Computing: From Petascale toward Exascale* , Chapman & Hall/CRC 2013. ISBN: 978-1466568358
6. W. Wayt Gibbs, *The Law of More*, from Understanding Supercomputing (Science Made Accessible Series), Sandy Fritz (Editor) 2002.
7. Chris Mack, *The Multiple Lives of Moore's Law*, IEEE Spectrum April 2015.
8. Olin Sibert, Phillip Porras, and Robert Lindell, *Intel 80x86 Processor Architecture: Pitfalls for Secure Systems*, Proceedings 1995 IEEE Symposium on Security and Privacy.
9. Daniel A. Reed and Jack Dongarra, *Exascale Computing and Big Data*, Communications of the ACM, July 2015.
10. Oreste Villa et. al., *Scaling the Power Wall: A Path to Exascale*, SC14 (New Orleans) 2014.
11. Eleanor Hutterer, *Not Magic. . . Quantum*, 1663, July 2016.
12. D-Wave 2000Q Technology Overview, 2018.
13. M. Veldhorst, H. G. J. Eenink, C. H. Yang and A. S. Dzurak, *Silicon CMOS architecture for a spin-based quantum computer*, Nature Communications, December 2017.
14. Patterson and Hennessy, *Computer Organization and Design*, Morgan-Kaufmann, 5th or revised 4th editions. ISBN: 978-0124077263 or 978-0123747501

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