What is computer architecture?

- Design of instruction set architecture (ISA) and hardware organization of computer.
- Layered view of computer systems

Role of computer architecture:
- To make design trade-offs across the HW/SW interface to meet functional, performance, power and cost requirements
Class goal

• Study of architectures that enable parallel computing through:
  – Instruction-Level Parallelism (ILP)
  – Thread-Level Parallelism (TLP)
  – Task-Level and Request-Level Parallelism (RLP)

• With objectives and constraints:
  – Performance
  – Design area ($$$)
  – Power consumption
Topics

1. Introduction and quantitative analysis
2. Review of classical concepts
3. Superscalar core design
4. Multicores, GPUs and fusion processors
5. Coherent memory hierarchy design
6. Cluster computing
1. Introduction and quantitative analysis

- Trends in computer architecture
- Quantifying performance
- Quantifying power consumption
- Role of simulators in computer architecture research
2. Quick review of classical concepts (required background for EN2910A)

- Instruction set architecture (ISA)
- Classical 5-stage pipeline
- Cache memory design
- Virtual memory
- DRAM
3. Superscalar core design (1/2)

- Static superscalar processors
- Dynamic out-of-order superscalar processors
- Hazards (structural, data, and control)
- Exceptions

[Shen & Lipasti]
3. Superscalar core design (2/2)

- Tomasulo’s algorithm
- Branch prediction
- Speculative execution
- VLIW processors
- Vector processors
4. Multicores, GPUs and fusion processors

- Thread-level parallelism

- Multi-core processors and multi-processor systems

- General Purpose Graphical Processing Units (GPGPU)

- Fusion (CPU+GPU) processors
5. Coherent memory design

• Shared cache organizations

• Memory coherency

• Bus-based shared memory:
  – Snoopy cache protocols (e.g., MSI, MESI)

• Scalable shared memory
  – Directory cache protocols
6. Cluster computing

- Cluster parallel programming models
- Network topologies and routing algorithms.
- Supercomputing organization
- Warehouse-scale datacenter organization
Class organization

• Grade distribution:
  – 25% midterm
  – 25% final
  – 25% HWs
  – 25% Projects

• Books:
  – *Modern Processor Design* by Shen and Lipasti
  – *Parallel Computer Organization and Design* by Debot, Annavaram and Stenstrom
  – *Computer Architecture: A Quantitative Approach* by Hennessy and Patterson
  – *The datacenter as a computer* by Barroso and Holzle

• Class website:
  – [http://scale.engin.brown.edu/classes/EN2910AF15](http://scale.engin.brown.edu/classes/EN2910AF15)