USC Viterbi School of Engineering
Ming Hsieh Department of Electrical Engineering

Course Announcement

MW 2-320, SPRING 2016

EE/CS 451: PARALLEL AND DISTRIBUTED COMPUTATION

The course will focus on broad principles of parallel and distributed computation. The Lab associated with the course will illustrate the principles through parallel programming examples.

INSTRUCTOR: VIKTOR K. PRASANNA

Prerequisite: (EE 357 or EE 352) or consent of the instructor.

Text: Introduction to Parallel Computing, Second edition, Grama, Karypis, Kumar, Gupta, Addison-Wesley.

Course Grade: based on home works, parallel programming assignments, midterm(s), and final.

Course Outline:

1. **Introduction (1):** Architectural advances**,** technology perspectives, motivating examples**,** challenges.
2. **Architectural Principles for Application Developers (2): 1.** Pipelined processor organization: data and control hazards, ILP, out of order execution, multithreading. **2.** Memory systems: DRAM organization, cache organization. Impact on software performance, locality, multithreading. **3.** Interconnection networks: static, dynamic networks.
3. **Analytical Models for Parallel Systems (4): 1.** Architecture performance metrics: CPI, MIPS, SpecMark. Software performance benchmarks: Peak performance, sustained performance, LinPack, Bandwidth benchmarks. **2.** Limits on achievable performance, Amdhal's Law, Gustafson's Law, Scaled speed-up, scalability definitions, work optimality, Iso efficiency function, Order notation. **3.** Communication costs in parallel machines: start-up cost, throughput, latency. Routing mechanisms: packet routing, cut through, virtual channels. Modeling message passing and shared address space machines. Data layouts and graph embeddings. **4.** Multi-core, many-core architectures.
4. **PRAM and Data Parallel Algorithms (4): 1.** PRAM model of computation, Brent's theorem, various models, illustrative examples. **2.** Max, Scan operations. **3.** Recursive doubling, graph algorithms. **4.** Sorting. **5.** Performance analysis, scalability. **6.** FFT.
5. **Basic Communication Primitives (4): 1.** Broadcast and all to all, communication costs on various topologies. **2.** Personalized communication. **3.** Reduce, prefix sum and scatter and gather**. 4** Graph embeddings.
6. **Message Passing Programming Model (2): 1.** Message passing abstraction, send receive primitives, blocking and non blocking commands, collective operations. **2.** Illustrative examples: Canon's algorithm, overlapping computation and communication, Odd even merge sort.
7. **Shared Address Space Programming Models (2): 1.** Pthreads**,** OpenMP. **2.** Illustrative examples.
8. **Data Parallel Programming Abstraction of GPUs (2): 1.** GPU architecture, SIMT execution model, CUDA programming model. **2.** Illustrative examples and application mapping, optimizations, OpenCL.
9. **Parallel Dense Algebra (2): 1.** Matrix vector, matrix matrix computations. **2.** Solution to linear systems.
10. **Parallel Search and Sorting (2): 1.** Parallel search, illustrative example applications, throughput optimization. **2.** Multi-dimensional search, decision tree and decomposition. **3.** Sorting techniques, bitonic sort, row-column sort. **4.** Mapping onto parallel architectures.
11. **Cloud, Big Data and Map Reduce (2): 1.** Cloud as a computing platform, Large data sets and organization. **2.** Map Reduce as a parallel programming model, Hadoop. **3.** Frameworks for graph analytics. **4.** Illustrative examples.

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