EE/CSCI 451
Parallel and Distributed Computation
Fall 2019

Units: 4.0

Term—Day—Time: Fall Tue, Thu 3:30 – 4:50pm
Lab/Lecture: Fri 3:30 – 4:50pm

Notes:

1. Students interested in taking CSCI 452 should enroll in EE/CSCI 451.

Location: ceng.usc.edu/~prasanna/teaching/fall2019/ee451

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Office Hours: TBD
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Teaching Assistant: TBD

Course Description

Application developers' perspective of architectural principles underlying modern processors. Parallel models of computation: PRAM, network, LOG P. Introduction to parallel programming techniques: software performance optimization strategies, and application mapping to multi-core, GPU and cloud platforms. Parallelization examples drawn from high performance computing, signal and image processing, networking, machine learning and data science.

Learning Objectives

- Understand the key architectural concepts of multicore platforms for parallel programming
- Develop simple parallel algorithms to solve computational problems
- Implement key algorithms on multi core and many core platforms
- Understand and determine the computational complexity of simple parallel algorithms
- Write parallel programs using message passing and shared memory paradigms
- Select an appropriate basic data structure (e.g. arrays) and access methods (e.g., pointers) to optimize performance
- Understand communication and coordination issues in parallel computing
- Understand basic principles of Cloud computing and Data Science processing

Prerequisite(s): EE 355 or CSCI 201
Co-Requisite(s): None
Concurrent Enrollment: None
Recommended Preparation: High level programming

Course Notes
Lecture slides will be made available in advance of the lectures.

Technological Proficiency and Hardware/Software Required
Desktop or notebook for accessing the computing resources at USC HPC and remote Cloud.

Required Readings and Supplementary Materials
Introduction to Parallel Computing, 2nd Ed.
Grama, Karypis, Kumar, Gupta
Addison-Wesley
USC Bookstore.

Description and Assessment of Assignments

There will be approximately ten home works and five programming home works. The course will also include a parallel programming project.

Grading Breakdown

Assignment	% of Grade
Class participation	5
Homework	10
Programming HW	10
Course project	10
Midterm 1 exam	20
Midterm 2 exam	20
Final exam	25
TOTAL	100

Assignment Submission Policy

Home works to be submitted in class or in a designated collection box. Programming home works to be submitted online.

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Tentative Course Schedule: A Weekly Breakdown for Lectures

	Topics/Daily Activities	Readings and Homework	Deliverable/ Due Dates
Week 1	Course overview (Aug 27) Parallel computing architectures (Aug 29)	Chapters 2.1, 2.2	
Week 2	Parallel computing architectures (Sep 3) Interconnection networks (Sep 5)	Chapters 2.2, 2.3 Homework 1 out	
Week 3	Network model of parallel computation (Sep 10) Analytical modeling of parallel systems (Sep 12)	Chapters 2.4.3-2.4.5	Homework 1 due
Week 4	Analytical modeling of parallel systems (Sep 17) Parallel algorithm design (Sep 19)	Chapters 2.5, 2.6, 2.7 Homework 2 out	
Week 5	Parallel algorithm design (Sep 24 and 26)	Chapters 3.1-3.3 Homework 3 out	Homework 2 due
Week 6	Parallel algorithm design (Oct 1) Shared address space programming: OpenMP (Oct 3)	Homework 4 out	Homework 3 due
Week 7	Shared address space programming: OpenMP (Oct 10)		Midterm 1 (Oct 11) 2 hrs. Homework 4 due
Week 8	PRAM (Oct 15)	Homework 5 out	Fall break
Week 9	PRAM (Oct 22) Message passing programming model (Oct 24)	Chapter 4 Homework 6 out	Homework 5 due
Week 10	Communication primitives (Oct 29 and 31)	Homework 7 out	Homework 6 due
Week 11	Data parallel programming and execution model of (GP) GPU (Nov 7)		Midterm 2 (Nov 8) 2 hrs. Homework 7 due
Week 12	Data parallel programming, execution model of (GP) GPU (Nov 12) Parallel sorting (Nov 14)	Chapters 8 and 9 Homework 8 out	
Week 13	Parallel dense algebra (Nov 19) Graph algorithms (Nov 21)	Chapters 10 and 13 Homework 9 out	Homework 8 due
Week 14	Fast Fourier transform (Nov 26)	Homework 10 out	Homework 9 due Thanksgiving
Week 15	Cloud and Data Science (Dec 5) MapReduce (Dec 7)		Homework 10 due
FINAL			As announced by university

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Tentative Course Schedule: A Weekly Breakdown for Lab

	Topics/Daily Activities	Readings and Homework	Deliverable/ Due Dates
Week 1	Account setup and Lab overview (Aug 30)		
Week 2	Pthreads (Sep 6)	Programming HW 1 out	
Week 3	Data Science Basics (Sep 13)		Programming HW 1 due
Week 4	OpenMP (Sep 20)	Programming HW 2 out	
Week 5	Course project discussion (Sep 27)		Programming HW 2 due
Week 6	MPI (Oct 4)	Programming HW 3 out	
Week 7	MPI (Oct 8) (class swapped)		Programming HW 3 due
Week 8	Fall Break		Course project proposals due
Week 9	CUDA (Oct 25)	Programming HW 4 out	
Week 10	CUDA (Nov 1)		Programming HW 4 due
Week 11	Spark (Nov 5) (class swapped)	Programming HW 5 out	
Week 12	Data Science Applications (Nov 15)		Programming HW 5 due
Week 13	Course project presentation (Nov 22)		
Week 14	Thanksgiving		
Week 15	Course project presentation (Dec 6)		Course project due

Note: The above are tentative outlines for Lectures and Lab sessions. Based on the number of students enrolled and the student interest, I expect to make some changes including schedule for the midterm exams, some project materials to be covered in the lecture or in

the lab session, and schedule for various topics to be covered in the lecture and lab sessions.

Statement on Academic Conduct and Support Systems

Academic Conduct

Plagiarism – presenting someone else's ideas as your own, either verbatim or recast in your own words – is a serious academic offense with serious consequences. Please familiarize yourself with the discussion of plagiarism in *SCampus* in Part B, Section 11, "Behavior Violating University Standards" https://policy.usc.edu/student/scampus/part-b. Other forms of academic dishonesty are equally unacceptable. See additional information in *SCampus* and university policies on scientific misconduct, http://policy.usc.edu/scientific-misconduct.

Discrimination, sexual assault, intimate partner violence, stalking, and harassment are prohibited by the university. You are encouraged to report all incidents to the *Office of Equity and Diversity/Title IX Office* http://equity.usc.edu and/or to the *Department of Public Safety* http://dps.usc.edu. This is important for the health and safety of the whole USC community. Faculty and staff must report any information regarding an incident to the Title IX Coordinator who will provide outreach and information to the affected party. The sexual assault resource center webpage http://sarc.usc.edu fully describes reporting options. Relationship and Sexual Violence Services https://engemannshc.usc.edu/rsvp provides 24/7 confidential support.

Support Systems

A number of USC's schools provide support for students who need help with scholarly writing. Check with your advisor or program staff to find out more. Students whose primary language is not English should check with the *American Language Institute* http://ali.usc.edu, which sponsors courses and workshops specifically for international graduate students. *The Office of Disability Services and Programs* http://dsp.usc.edu provides certification for students with disabilities and helps arrange the relevant accommodations. If an officially declared emergency makes travel to campus infeasible, *USC Emergency Information* http://emergency.usc.edu will provide safety and other updates, including ways in which instruction will be continued by means of Blackboard, teleconferencing, and other technology.