San José State University
Computer Science Department
CS259, Advanced Parallel Processing, Section 1, Spring 2016

Course and Contact Information

Instructor: Robert Chun

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Office Hours: MW 4:30pm-5:30pm

Class Days/Time: MW 1800 - 1915

Classroom: MH222

Prerequisites: CS159

Course Description

An advanced hardware architecture and software development class focused on multi-threaded, parallel processing algorithms and techniques. A detailed study of high-performance parallel processing hardware architectures ranging from on-chip Instruction-Level Parallelism to multi-core microprocessor chips to large distributed supercomputing systems including Clusters, Grids, and Clouds. Discussion and hands-on exercises in a broad range of various parallel programming paradigms and languages such as Pthreads, MPI, OpenMP, Map-Reduce Hadoop, CUDA and OpenCL. The class will focus on the fundamental concepts associated with the design and analysis of parallel processing systems. Special emphasis will be placed on avoiding the unique non-deterministic software defects that can arise in parallel processing systems including race conditions and deadlocks. A term project on a topic selected by the student will be required.

Learning Outcomes

Upon successful completion of this course, students will be able to:

- Understand the Technical and Business motivation and need for current state-of-the-art computing systems to incorporate Parallel Processing into the Hardware and Software Subsystems.
- Explain the Micro-Hardware Architectural Evolutionary Trends leading to on-chip Instruction-Level Parallelism, and Pipelining, SuperScalar, Multi-Function Unit Parallel Processing.
- Understand the Macro-Hardware Architectural Evolutionary Trends leading to Parallel Processing including Flynn's Taxonomy and the recent progression in high-performance supercomputing architectures from Clusters to Grids and to Clouds.
- Explain data dependency analysis & hazards, and Amdahl's Law, which limits the amount of practical speedup and scalability that can be achieved with Parallel Processing.

- Perform Design and Analysis Techniques for Parallel Processing Systems including the identification of data vs. task partitioning in algorithms and applications.
- Understand the Different Models for implementing parallelism in Computing Systems such as shared memory and message passing.
- Explain the software challenges associated with Parallel Processing including the difference between concurrent vs. parallel execution models, deadlocks and race conditions.
- Understand a sample of current parallel programming paradigms and languages and be able to write parallel programs using them.

Required Texts/Readings

Textbook

Multi-Core Programming, Shameem Akhter and Jason Roberts, 2006, Intel Press, ISBN 0-9764832-4-6

Using OpenMP, Barbara Chapman, 2008, MIT Press, ISBN 978-0-262-53302-7. Students can access this entire textbook for free via the SJSU Library at: http://catalog.sjlibrary.org/record=b4222384

Scientific Parallel Computing, Ridgway Scott and Terry Clark, 2005, Princeton University Press, ISBN 9780691119359

Course Requirements and Assignments

SJSU classes are designed such that in order to be successful, it is expected that students will spend a minimum of forty-five hours for each unit of credit (normally three hours per unit per week), including preparing for class, participating in course activities, completing assignments, and so on. More details about student workload can be found in University Policy S12-3 at http://www.sjsu.edu/senate/docs/S12-3.pdf.

Assignments include two midterms, one final, a written and oral report, and a set of projects (consisting of a combination of written problems and programming assignments) weighted as follows. Grading is based on a class curve. All assignments (especially the oral presentation) must be completed by the student on the due date specified to receive credit for the class. Late assignments or exams are not accepted. All students must uphold academic honesty, especially for the required term paper, per university policy detailed at http://www2.sjsu.edu/senate/f88-10.htm

NOTE that University policy F69-24 at http://www.sjsu.edu/senate/docs/F69-24.pdf states that "Students should attend all meetings of their classes, not only because they are responsible for material discussed therein, but because active participation is frequently essential to insure maximum benefit for all members of the class. Attendance per se shall not be used as a criterion for grading."

Grading Policy

Grading consists of two midterms, one final, a written and oral report, and a set of projects (consisting of a combination of written problems and programming assignments) weighted as follows. Grading is based on a class curve. All assignments (especially the oral presentation) must be completed by the student on the due date specified to receive credit for the class. Late assignments or exams are not accepted. All students must uphold academic honesty, especially for the required term paper, per university policy detailed at http://www2.sjsu.edu/senate/f88-10.htm

15% Midterm Exam 1
Week 6 (Approximate)

15% Midterm Exam 2
Week 12 (Approximate)

30% Term Paper/Project & Presentations
Weeks 13-15

30% Final Exam
5/23/16 17:15-19:30

10% Combined total of Three HW/Projects
Due as announced in class

Note that "All students have the right, within a reasonable time, to know their academic scores, to review their grade-dependent work, and to be provided with explanations for the determination of their course grades." See University Policy F13-1 at http://www.sjsu.edu/senate/docs/F13-1.pdf for more details.

Classroom Protocol

Students are expected to attend all classes.

University Policies

General Expectations, Rights and Responsibilities of the Student

As members of the academic community, students accept both the rights and responsibilities incumbent upon all members of the institution. Students are encouraged to familiarize themselves with SJSU's policies and practices pertaining to the procedures to follow if and when questions or concerns about a class arises. See University Policy S90–5 at http://www.sjsu.edu/senate/docs/S90-5.pdf. More detailed information on a variety of related topics is available in the SJSU catalog, at http://info.sjsu.edu/web-dbgen/narr/catalog/rec-12234.12506.html. In general, it is recommended that students begin by seeking clarification or discussing concerns with their instructor. If such conversation is not possible, or if it does not serve to address the issue, it is recommended that the student contact the Department Chair as a next step.

Dropping and Adding

Students are responsible for understanding the policies and procedures about add/drop, grade forgiveness, etc. Refer to the current semester's Catalog Policies section at http://info.sjsu.edu/static/catalog/policies.html. Add/drop deadlines can be found on the current academic year calendars document on the Academic Calendars webpage at http://www.sjsu.edu/provost/services/academic_calendars/. The Late Drop Policy is available at http://www.sjsu.edu/aars/policies/latedrops/policy/**.** Students should be aware of the current deadlines and penalties for dropping classes.

Information about the latest changes and news is available at the Advising Hub at http://www.sjsu.edu/advising/.

Consent for Recording of Class and Public Sharing of Instructor Material

University Policy S12-7, http://www.sjsu.edu/senate/docs/S12-7.pdf, requires students to obtain instructor's permission to record the course and the following items to be included in the syllabus:

- "Common courtesy and professional behavior dictate that you notify someone when you are recording him/her. You must obtain the instructor's permission to make audio or video recordings in this class. Such permission allows the recordings to be used for your private, study purposes only. The recordings are the intellectual property of the instructor; you have not been given any rights to reproduce or distribute the material."
    - It is suggested that the greensheet include the instructor's process for granting permission, whether in writing or orally and whether for the whole semester or on a class by class basis.
    - In classes where active participation of students or guests may be on the recording, permission of those students or guests should be obtained as well.
- "Course material developed by the instructor is the intellectual property of the instructor and cannot be shared publicly without his/her approval. You may not publicly share or upload instructor generated material for this course such as exam questions, lecture notes, or homework solutions without instructor consent."

Academic integrity

Your commitment, as a student, to learning is evidenced by your enrollment at San Jose State University. The University Academic Integrity Policy S07-2 at http://www.sjsu.edu/senate/docs/S07-2.pdf requires you to be honest in all your academic course work. Faculty members are required to report all infractions to the office of Student Conduct and Ethical Development. The Student Conduct and Ethical Development website is available at http://www.sjsu.edu/studentconduct/.

Campus Policy in Compliance with the American Disabilities Act

If you need course adaptations or accommodations because of a disability, or if you need to make special arrangements in case the building must be evacuated, please make an appointment with me as soon as possible, or see me during office hours. Presidential Directive 97-03 at http://www.sjsu.edu/president/docs/directives/PD_1997-03.pdf requires that students with disabilities requesting accommodations must register with the Accessible Education Center (AEC) at http://www.sjsu.edu/aec to establish a record of their disability.

CS259 / Advanced Parallel Processing, Spring 2016, Course Schedule

List the agenda for the semester including when and where the final exam will be held. Indicate the schedule is subject to change with fair notice and how the notice will be made available.

Tentative Course Schedule

Lecture	Topic
1 - 3	Introduction, Motivation and Overview of Parallel Processing with an emphasis on the Micro- and Macro-Hardware Evolutionary Trends leading to Parallelism and the Software Challenges of Parallelism
4 - 6	Hardware Pipelining and Instruction-Level Parallelism (ILP)
7 - 8	Multi-Function Parallelism in Hardware
9	Data dependency analysis and control hazard analysis including RAW, WAR, WAW, and Branch Prediction
10	Limitations of Hardware-based, Software-transparent ILP
11 - 17	Software Challenges of Parallel Processing including Concurrent vs. Parallel Execution Models, Amdahl's Law, Deadlocks, Race Conditions, Semaphores
18	Models of Parallelism such as Shared Memory, Message Passing
19 - 21	Parallel Programming Paradigms including Unix Process Forking, PVM, MPI, OpenMP, CUDA, OpenCL, Hadoop Map-Reduce, GPGPU Computing, Toolsets for Parallel Program Software Development and Debugging.
Final Exam	5/23/16 17:15-19:30

Workload

Success in this course is based on the expectation that students will spend, at least 6 hours per week for working on the homework, team works, and the programming assignments.