San José State University
Computer Science Department
CS259-03: Advanced Parallel Processing - Fall 2022

Course and Contact Information

Instructor:	Robert Chun
Office Location:	MH 413
Telephone:	(408) 924-5137
Email:	Robert.Chun@sjsu.edu
Office Hours:	MW 4:30pm-5:30pm (and by appointment, On-Line)
Class Days/Time:	MW 7:30pm - 8:45pm
Classroom:	On-line
Prerequisites:	CS146, Introductory Course in Architecture, also in Operating Systems

Faculty Web Page

Course materials such as presentation slides, notes, assignments, etc. can be found on my faculty web page at http://www.sjsu.edu/people/Robert.Chun/courses

Course Description

A 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 selected subset 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 and oral presentation on a topic selected by the student will be required. Because this course is on-line, the student will be expected to produce a video of their term project presentation.

Course Learning Outcomes (CLO)

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

Textbooks

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:
https://ebookcentral.proquest.com/lib/sjsu/detail.action?docID=3338748

[OPTIONAL]: Scientific Parallel Computing, Ridgway Scott and Terry Clark, 2005, Princeton University Press, ISBN 9780691119359

Web Resources: *See Informational Sheet: "Useful Web Pages for Parallel Processing Course"*

Course Requirements and Assignments

Assignments include two midterms, one final exam, a written and oral report, a set of projects (consisting of a combination of written problems and programming assignments), and active participation during student presentations, weighted as shown below. 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 (including the scheduled oral presentations) or exams are not accepted. All students must uphold academic honesty, especially for the required term paper, per university policy detailed at http://www.sjsu.edu/specialed/docs/current-forms/AcademicIntegrityPolicy.pdf

Final Examination

The final exam for the class will be held on Monday, December 12, 2022 at 7:45pm-10:00pm

Classroom Protocol

This class will be taught in an on-line fashion via Zoom Meetings and/or pre-recorded video lessons. There will be no on-campus meetings in person.

Students are expected to attend all classes (On-Line), including all student presentations (On-Line).

The majority of lectures and student presentations can be viewed Asynchronously as pre-recorded videos, meaning that students can view them at their own convenience anytime within the specified class schedule.

All Exams (Midterm1, Midterm2, and the Final Exam) will be Synchronous sessions, meaning that all students must take the exams on the same day and at the same time. Midterm1 is approximately the beginning of October; Midterm2 is approximately the end of October; and the Final Exam is on December 12, 2022.

Grading Information

Grading consists of two midterms, one final, a written and oral report, a set of projects (consisting of a combination of written problems and programming assignments), and active participation during student presentations, weighted as follows. After each assignment is weighted as listed below, the overall course grade will be determined via the accompanying table. All assignments (especially the oral presentation) are all required and all 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 the following official SJSU webpage:
http://www.sjsu.edu/specialed/docs/current-forms/AcademicIntegrityPolicy.pdf

15% Midterm Exam 1 (Approximately Scheduled around the beginning of October 2022)

15% Midterm Exam 2 (Approximately Scheduled around the end of October 2022)

30% Written Term Paper/Project & Oral Presentations
Written Reports Due Approximately around the middle of November 2022
Due date for Oral Presentation will be specified per student

30% Final Exam
Monday, December 12, 2022 at 7:45pm-10:00pm

10% Combined total of Three HW/Projects

A plus = 100 to 97.0 points
A = 96.9 to 93 points
A minus = 92.9 to 90.0 points
B plus = 89.9 to 87.0 points
B = 86.9 to 82.0 points
B minus = 81.9 to 80.0 points
C plus = 79.9 to 77.0 points
C = 76.9 to 72.0 points
C minus = 71.9 to 70.0 points
D plus = 69.9 to 67.0 points
D = 66.9 to 62.0 points
D minus = 61.9 to 60.0 points
F = 59.9 points or lower

CS259 Fall 2022 Tentative Course Schedule

Lecture	Topic
Introduction, Motivation and Broad Overview of Parallel Processing	
1 - 4	Introduction, Motivation and Broad Overview of Parallel Processing with an emphasis on the Micro- and Macro-Hardware Evolutionary Trends leading to Parallelism and the Software Challenges of Parallelism including Concurrent vs. Parallel Execution Models, and Amdahl's Law
Hardware Parallel Processing	
5 - 6	Hardware Pipelining and Instruction-Level Parallelism (ILP)
7	Multi-Function Parallelism in Hardware
8	Data dependency analysis and control hazard analysis including RAW, WAR, WAW, Branch Prediction, and VLIW Architectures
9	Memory Interleaving (Parallelism in Memory Subsystems)
10	Memory Matrix Demo & Hyper-Threading
MidTerm1	Tentatively around the beginning of October 2022
Software Challenges of Parallel Processing	
11 - 12	Software Challenges of Parallel Processing: Deadlocks
13 - 14	Software Challenges of Parallel Processing: Race Conditions, Semaphores
MidTerm2	Tentatively around the end of October 2022
Advanced, Specialized Topics of Parallel Processing (Selected and Presented by Students)	
15 - 18	Varied Topics including Parallel Programming Paradigms such as Unix Process Forking, PVM, POSIX Threads, Thread Pools, Applications of Parallelism, MPI, OpenMP, CUDA, OpenCL, Hadoop Map-Reduce, GPGPU Computing, Toolsets for Parallel Program Software Development and Debugging, Models of Parallelism such as Shared Memory vs. Message Passing, Specific Parallel Programming Languages, Algorithms & Tools.
Final Exam	Monday, December 12, 2022 at 7:45pm - 10:00pm

University Policies

Per University Policy S16-9, university-wide policy information relevant to all courses, such as academic integrity, accommodations, etc. will be available on Office of Graduate and Undergraduate Programs' Syllabus Information web page at http://www.sjsu.edu/gup/syllabusinfo/

General University Policies

DISABILITIES:

If you need course adaptations or accommodations because of a disability, or if you need special arrangements in case the building must be evacuated, please inform the instructor as soon as possible. Presidential Directive 97-03 requires that students with disabilities register with DRC to establish a record of their disability.

ACADEMIC INTEGRITY:

Academic integrity is essential to the mission of San José State University. As such, students are expected to perform their own work (except when collaboration is expressly permitted by the course instructor) without the use of any outside resources. Students are not permitted to use old tests or quizzes when preparing for exams, nor may they consult with students who have already taken the exam. When practiced, academic integrity ensures that all students are fairly graded.

We all share the obligation to maintain an environment which practices academic integrity. Violations to the Academic Integrity Policy undermine the educational process and will not be tolerated. It also demonstrates a lack of respect for oneself, fellow students and the course instructor, and can ruin the university's reputation and the value of the degrees it offers. Violators of the Academic Integrity Policy will be subject to failing this course and being reported to the Office of Judicial Affairs for disciplinary action which could result in suspension or expulsion from San José State University.

CHEATING:

At SJSU, cheating is the act of obtaining or attempting to obtain credit for academic work through the use of any dishonest, deceptive, or fraudulent means. Cheating at SJSU includes but is not limited to:

Copying in part or in whole, from another's test or other evaluation instrument; Submitting work previously graded in another course unless this has been approved by the course instructor or by departmental policy. Submitting work simultaneously presented in two courses, unless this has been approved by both course instructors or by departmental policy. Altering or interfering with grading or grading instructions; Sitting for an examination by a surrogate, or as a surrogate; any other act committed by a student in the course of his or her academic work which defrauds or misrepresents, including aiding or abetting in any of the actions defined above.

PLAGIARISM:

At SJSU plagiarism is the act of representing the work of another as one's own (without giving appropriate credit) regardless of how that work was obtained, and submitting it to fulfill academic requirements. Plagiarism at SJSU includes but is not limited to:

The act of incorporating the ideas, words, sentences, paragraphs, or parts thereof, or the specific substances of another's work, without giving appropriate credit, and representing the product as one's own work; and representing another's artistic/scholarly works such as musical compositions, computer programs, photographs, painting, drawing, sculptures, or similar works as one's own.

Additional Information:

http://www.cs.sjsu.edu/greensheetinfo/index.html