San José State University
Computer Science Department
CS259 - Advanced Parallel Processing - Summer 2022

➔*Special Procedures and Protocols for Remote-learning during COVID will be discussed on first day of class.*

Course and Contact Information

Instructor:	Robert Chun
Office Location:	MH 413 (And On-Line by Appointment)
Telephone:	(408) 924-5137
Email:	Robert.Chun@sjsu.edu
Office Hours:	MW 5:30pm-6:00pm & 8:00pm-8:30pm (And On-Line by appointment)
Class Days/Time:	MW 1800 - 2000
Classroom:	Hybrid – Combination of On-Campus and On-Line Meetings (See Calendar)
Prerequisites:	CS146, Introductory Course in Architecture, also in Operating Systems

Faculty Web Page

Course materials for CS 259 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. Active participation during student presentations will be required.

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
A Google Search on the following file name can sometimes find this source on-line as a PDF.
Multi-Core_Programming.pdf

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. 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 (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 Wednesday, August 3, 2022 at 1800-2000

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. Grading is based on a class curve. 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 Monday, June 27, 2022
15%	Midterm Exam 2 Wednesday, July 13, 2022
30%	Written Term Paper/Project & Oral Presentations July 18 for Written Term Paper; July 18, 20, 25, 27 for Oral (to be specified per student)
30%	Final Exam Wednesday, August 3, 2022 at 1800-2000
10%	Combined total of Three HW/Projects Project 1 Due on June 27; Project 2 Due on July 13; Project 3 Due August 3, 2022

Classroom Protocol

This class will be taught in a Hybrid fashion using a combination of on-line pre-recorded video lessons and in-class, on-campus meetings. See the calendar for the color-coded Meeting Pattern.

Students are expected to attend all classes in person when scheduled as such. The first day, all exams, and all student presentations are on-campus, in-classroom meetings. These meetings will not be broadcast on-line and will not be recorded. These meetings require in-classroom attendance by all students (Red Calendar Days)

The majority of lectures can be viewed Asynchronously as pre-recorded videos, meaning that students can view them at their own convenience anytime on-line before the corresponding exam (Yellow Calendar Days).

All Exams: Midterm1 on June 27, Midterm2 on July 13, and the Final Exam on August 3 will be on-campus. All Student Presentations scheduled for July 18, 20, 25, and 27 will also be on-campus, in-person meetings.

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/

CS259 Summer 2022 Tentative Course Schedule

Lecture	Topic

Introduction, Motivation and Broad Overview of Parallel Processing *(View between June 1 -June 8, 2022)*

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 *(View between June 8 - June 20, 2022)*

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	Monday, June 27, 2022 at 1800-1930

Software Challenges of Parallel Processing *(View between June 29 - July 6, 2022)*

11 - 12	Software Challenges of Parallel Processing: Deadlocks
13 - 14	Software Challenges of Parallel Processing: Race Conditions, Semaphores
MidTerm2	Wednesday, July 13, 2022 at 1800-1930

Advanced, Specialized Topics of Parallel Processing (Presented by Students) *(On-Campus July 18-27, 2022)*

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	Wednesday, August 3, 2022 at 1800-2000

Key Delivery Due Dates for Assignments:

Term Paper/Project Title & Abstract Due:	Wednesday, June 15, 2022
MidTerm1 & HW Project 1 Due:	Monday, June 27, 2022 at 1800-1930
MidTerm2 & HW Project 2 Due:	Wednesday, July 13, 2022 at 1800-1930
Term Paper/Project Due:	Monday, July 18, 2022
Student Presentations Due:	Between July 18 to July 27 (to be specified per student)
Selection of 5 Papers for Final Exam Due:	Monday, July 25, 2022
Final Exam & HW Project 3 Due:	Wednesday, August 3, 2022 at 1800-2000

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

CS 259 Summer 2022 Meeting Pattern

Monday	Tuesday	Wednesday	Thursday	Friday
		1 June **First Day of Class On-Campus MH 422**	**2**	**3**
6 **Video Lecture Day 2 & Day 3**	**7**	**8** **Video Lecture Day 4 & Day 5**	**9**	**10**
13 **Video Lecture Day 6**	**14**	**15** **Video Lecture Day 7 & Day 8**	**16**	**17**
20 **Video Lecture Day 9 & Day 10**	**21**	**22** **Review Session to Prepare for Midterm1 On-Campus MH 422**	**23**	**24**
27 **Midterm1 & HW1 Due On-Campus MH 422**	**28**	**29** **Video Lecture Deadlock (Part 1 & 2)**	**30**	**1** July
4 **July 4 Holiday**	**5**	**6** **Video Lecture Race Conditions (Part 1 & 2)**	**7**	**8**
11 **Review Session to Prepare for Midterm2 On-Campus MH 422**	**12**	**13** **Midterm2 & HW2 Due On-Campus MH 422**	**14**	**15**
18 **Term Papers Due Student Presentations On-Campus MH 422**	**19**	**20** **Student Presentations On-Campus MH 422**	**21**	**22**
25 **Student Presentations On-Campus MH 422**	**26**	**27** **Student Presentations On-Campus MH 422**	**28**	**29**
1 August **Closing Remarks & Review for Final Exam On-Campus MH 422**	**2**	**3** **Final Exam & HW3 Due On-Campus MH 422**		

(Green)	Holiday, No Class (No in-person meeting, and No on-line lecture)
(Yellow)	Asynchronous Video Lecture (View at your own convenience, on-line, remotely)
(Orange)	In-Class Meeting Recommended, but Optional. Not Broadcast, Not Recorded (Review session for exam)
(Red)	In-Class Meeting Required (All Exams and Student Presentations must be attended by all students)