San José State University
Computer Science Department
CS159 – Introduction to Parallel Processing – Spring 2024

Course and Contact Information

Instructor:	Robert Chun
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Office Hours:	MW 4:30pm-5:30pm (and by appointment, On-Line)
Class Days/Time:	MW 1:30pm - 2:45pm
Classroom:	MH 222
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 P-threads, 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, Super-Scalar, 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

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

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, weighted as shown below. Grading is based on the numerical information 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

Classroom Protocol

Students are expected to attend all classes, including (and especially) all student presentations.

As noted above, in-class participation is a graded component of this course.

There may be unannounced in-classroom quizzes or assignments administered, and if missed by the student, will be recorded as a zero for grading purposes. No make-ups will be allowed.

Final Examination

The final exam for the class will be held on Thursday, May 16, 2024 from 12:15pm - 2:30pm

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, weighted as follows. Grading for the course is based on the numerical information below. All assignments (especially the oral presentation) are all required and all must be completed by the student on the due date specified in order to successfully complete this course. Late assignments or exams will not be 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 Week 6

15% Midterm Exam 2
Approximately Week 9

30% Written Term Paper/Project & Oral Presentations
Approximately Week 10 - Due date for Oral Presentation to be specified per student

20% Final Exam
Thursday, May 16, 2024 from 12:15pm - 2:30pm

10% Combined total of Three HW/Projects
Each project will be due on or before each of the three exams.

10% Student Participation (via unannounced in-classroom quizzes and/or assignments)
Students who do not participate on the day(s) when these items are administered will not earn credit for that item. No make-ups will be allowed.

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

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/

CS159 Spring 2024 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	Approximately Week 6
Software Challenges of Parallel Processing	
11 - 12	Software Challenges of Parallel Processing: Deadlocks
13 - 14	Software Challenges of Parallel Processing: Race Conditions, Semaphores
MidTerm2	Approximately Week 9
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	Thursday, May 16, 2024 from 12:15pm - 2:30pm

Approximate and Tentative Due Dates for Assignments:

Term Paper/Project Title & Abstract Due:	Wednesday, February 14, 2024
MidTerm1 & HW Project 1 Due:	Approximately Week 6
MidTerm2 & HW Project 2 Due:	Approximately Week 9
Student Presentation (or Videos) Due:	Approximately Week 10 (to be specified per student)
Term Paper/Project Due:	Approximately Week 11
Final Exam & HW Project 3 Due:	Thursday, May 16, 2024 from 12:15pm - 2:30pm

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