Course Title: Principles of Distributed Computing
Instructor: Mohsen Lesani (e-mail: lesani@cs.ucr.edu)
Class format: Lectures (3 hours per week)
Outside Research reading: 3 hours per week based on the covered topics in lectures
Course Requirement: Course Project and Report (based on outside research reading, 1 hour per week on average)
Grading: Letter grade based on the following:

a. Outside Research Reading and In-Class Discussion (10%)

Students are expected to participate in in-class discussions along with the Lecture, during which we introduce and discuss recent advances in distributed computing such as blockchains. Participating in the discussions, based on outside research reading will enhance students' understanding of course materials.

b. Midterm (45%)

One midterm will involve questions about the covered distributed algorithms, their specification and their proof of correctness.

c. Project (45%)

We will have a course project. Students will select from a list of research topics on distributed computing, perform independent literature survey, propose solutions, and conduct preliminary analysis. Depending on enrollment, we will either have projects for each individual student or students would encouraged to team up, with another student so that there is a maximum of two members. The project report will be a report in IEEE or ACM double-column conference format of 5 pages (not including references).

Prerequisite: CS 014 Introduction to Data Structures and Algorithms

Text book:
Introduction to Reliable and Secure Distributed Programming
Christian Cachin, Rachid Guerraoui, Luís Rodrigues
Second Edition, Springer, 2011, XIX, 320 pages, ISBN-13: 978-3-642-15259-7
DOI: doi:10.1007/978-3-642-15260-3
http://distributedprogramming.net/index.shtml

Course Overview:
Distribution is ubiquitous in modern computing systems. For example, today's telephone systems, banking systems, global information systems, and aircraft and nuclear power plant control systems all depend critically on distributed algorithms. Robust distributed algorithms should offer reliability and security despite process failures, network disconnections, or even malicious attacks on processes. This course will introduce fundamental distributed computing problems and provides a collection of applicable algorithms. It also presents formal specification and rigorous reasoning about distributed algorithms. The course follows a modular and layered approach to the implementation of distributed abstractions. It covers reliable broadcast, causal broadcast, total-order broadcast, distributed shared memory, consensus variants including blockchain consensus, atomic commit and terminating reliable broadcast, and replicated systems. The course considers processes that are subject to crashes and also malicious attacks by non-cooperating processes.
The course will use the textbook along with a number of current papers that focus on individual topics being discussed. Papers that we will use are likely to be continually updated for the course, up to the beginning of the quarter.

Course topics, schedule (each part approximately corresponds to one week):

Week 1:
- Components, Process Abstraction, Communication Abstraction, Time Abstraction
- Reading: Chapter 1 Sections 1.4, and Chapter 2 Sections 2.2, 2.4, 2.6 of the Textbook

Week 2:
- Reliable and Causal Broadcast
- Reading: Chapter 3 Sections 3.2, 3.3, 3.4, 3.9 of the Textbook

Week 3:
- Byzantine Broadcast
- Reading: Chapter 3 Sections 3.10, 3.11, 3.12 of the Textbook

Week 4:
- Shared Memory
- Reading: Chapter 3 Sections 4.2, 4.3, 4.4 of the Textbook

Week 5:
- Byzantine Shared Memory
- Reading: Chapter 3 Sections 4.6, 4.7, 4.8 of the Textbook

Week 6:
- Total order Broadcast
- Reading: Chapter 6 Section 6.1, 6.2 of the Textbook

Week 7:
- Consensus and State Machine Replication, Quorums
- Reading: Chapter 2 Section 2.7, and Chapter 5 Section 5.3 of the Textbook

Week 8:
- Byzantine Consensus
- Reading: Chapter 5 Section 5.6 of the Textbook

Week 9:
- Non-blocking Atomic Commit and Terminating Reliable Broadcast
- Reading: Chapter 6 Section 6.3, 6.6 of the Textbook

Week 10:
- Blockchain Consensus
- Bitcoin A Peer-to-Peer Electronic Cash System. Nakamoto. White paper. 2008.
- Atomic Cross-Chain Swaps. Maurice Herlihy. PODC 2018.

Final Exam Week: Project Presentations.