CSCI 5673/ECEN 5673: Distributed Systems
Spring 2022

Instructor

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- Office Hours: Monday: 11:00 AM-12:00 Noon; Tuesday: 1:00-2:00 PM
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Lectures

- Tuesday, Thursday: 11 AM – 12:15 PM
- Online over Zoom
  https://cuboulder.zoom.us/j/97697526609
  Passcode: 606767
- In-person at ECCR 1B51
- **Note:** There won't be an in-person lecture in the first two weeks of classes as per CU directive. In-person lectures will start from the week of January 24.

Short Description

A distributed system is comprised of multiple computing devices interconnected with one another via a loosely-connected network. Almost all computing systems and applications today are distributed in nature for a variety of reasons, including resource sharing, fault tolerance, performance, security and geography. This course provides an in-depth coverage of the underlying principles and practices involved in the design, implementation and evaluation of a distributed system. The course will be divided into two parts. The first part will focus on the foundations of distributed system design, and the second part will focus on the current, state-of-the-art distributed systems technologies, including Internet-based services as well as distributed services built using small, mobile computing devices.

Prerequisite

- CSCI 5273 or a course in Computer Networks.

Reading Material

Selected papers from literature.

Class webpage

Please see *https://canvas.colorado.edu/*

Grading (*Weights assigned are tentative and subject to change during the semester*)

- Homework and programming assignments: 50%
- Course Project: 20%
- Exams and quizzes: 30%

- Homework assignments comprised of questions from lecture material and papers will be posted on Canvas every two or three weeks. You will typically have one week to submit the answers after an assignment has been posted.
- Course project will be a semester-long team project. Details will be provided in class.

POLICIES

Please see an accessible online version at
https://www.colorado.edu/academicaffairs/policies-customs-guidelines/required-syllabus-statements

CLASSROOM BEHAVIOR

Both students and faculty are responsible for maintaining an appropriate learning environment in all instructional settings, whether in person, remote or online. Those who fail to adhere to such behavioral standards may be subject to discipline. Professional courtesy and sensitivity are especially important with respect to individuals and topics dealing with race, color, national origin, sex, pregnancy, age, disability, creed, religion, sexual orientation, gender identity, gender expression, veteran status, political affiliation or political philosophy. For more information, see the policies on classroom behavior and the Student Conduct & Conflict Resolution policies.

REQUIREMENTS FOR COVID-19

As a matter of public health and safety, all members of the CU Boulder community and all visitors to campus must follow university, department and building requirements and all public health orders in place to reduce the risk of spreading infectious disease. Students who fail to adhere to these requirements will be asked to leave class, and students who do not leave class when asked or who refuse to comply with these requirements will be referred to Student Conduct and Conflict Resolution. For more information, see the policy

on classroom behavior and the Student Code of Conduct. If you require accommodation because a disability prevents you from fulfilling these safety measures, please follow the steps in the "Accommodation for Disabilities" statement on this syllabus.

CU Boulder currently requires masks in classrooms and laboratories regardless of vaccination status. This requirement is a precaution to supplement CU Boulder's COVID-19 vaccine requirement. Exemptions include individuals who cannot medically tolerate a face covering, as well as those who are hearing-impaired or otherwise disabled or who are communicating with someone who is hearing-impaired or otherwise disabled and where the ability to see the mouth is essential to communication. If you qualify for a mask-related accommodation, please follow the steps in the "Accommodation for Disabilities" statement on this syllabus. In addition, vaccinated instructional faculty who are engaged in an indoor instructional activity and are separated by at least 6 feet from the nearest person are exempt from wearing masks if they so choose. In this class, you may be reminded of the responsibility to complete the Buff Pass and given time during class to complete it.

If you feel ill and think you might have COVID-19, if you have tested positive for COVID-19, or if you are unvaccinated or partially vaccinated and have been in close contact with someone who has COVID-19, you should stay home and follow the further guidance of the Public Health Office (contacttracing@colorado.edu). If you are fully vaccinated and have been in close contact with someone who has COVID-19, you do not need to stay home; rather, you should self-monitor for symptoms and follow the further guidance of the Public Health Office (contacttracing@colorado.edu). Please alert the instructional faculty via email about any absences due to illness or quarantine. Note that you do not need to state the nature of your illness when alerting the faculty.

ACCOMMODATION FOR DISABILITIES

If you qualify for accommodations because of a disability, please submit your accommodation letter from Disability Services to your faculty member in a timely manner so that your needs can be addressed. Disability Services determines accommodations based on documented disabilities in the academic environment. Information on requesting accommodations is located on the Disability Services website. Contact Disability Services at 303-492-8671 or dsinfo@colorado.edu for further assistance. If you have a temporary medical condition, see Temporary Medical Conditions on the Disability Services website.

PREFERRED STUDENT NAMES AND PRONOUNS

CU Boulder recognizes that students' legal information doesn't always align with how they identify. Students may update their preferred names and pronouns via the student portal; those preferred names and pronouns are listed on instructors' class rosters. In the absence of such updates, the name that appears on the class roster is the student's legal name.

HONOR CODE

All students enrolled in a University of Colorado Boulder course are responsible for knowing and adhering to the Honor Code academic integrity policy. Violations of the Honor Code may include, but are not limited to: plagiarism, cheating, fabrication, lying, bribery, threat, unauthorized access to academic materials, clicker fraud, submitting the same or similar work in more than one course without permission from all course instructors involved, and aiding academic dishonesty. All incidents of academic misconduct will be reported to the Honor Code (honor@colorado.edu; 303-492-5550). Students found responsible for violating the academic integrity policy will be subject to nonacademic sanctions from the Honor Code as well as academic sanctions from the faculty member. Additional information regarding the Honor Code academic integrity policy can be found on the Honor Code website.

SEXUAL MISCONDUCT, DISCRIMINATION, HARASSMENT AND/OR RELATED RETALIATION

CU Boulder is committed to fostering an inclusive and welcoming learning, working, and living environment. The university will not tolerate acts of sexual misconduct (harassment, exploitation, and assault), intimate partner violence (dating or domestic violence), stalking, or protected-class discrimination or harassment by or against members of our community. Individuals who believe they have been subject to misconduct or retaliatory actions for reporting a concern should contact the Office of Institutional Equity and Compliance (OIEC) at 303-492-2127 or email cureport@colorado.edu. Information about university policies, reporting options, and the support resources can be found on the OIEC website.

Please know that faculty and graduate instructors have a responsibility to inform OIEC when they are made aware of incidents of sexual misconduct, dating and domestic violence, stalking, discrimination, harassment and/or related retaliation, to ensure that individuals impacted receive information about their rights, support resources, and reporting options. To learn more about reporting and support options for a variety of concerns, visit Don't Ignore It.

RELIGIOUS HOLIDAYS

Campus policy regarding religious observances requires that faculty make every effort to deal reasonably and fairly with all students who, because of religious obligations, have conflicts with scheduled exams, assignments or required attendance. In this class, please notify the instructional faculty of any anticipated conflicts due to religious obligations as early in the semester as possible (at least two weeks before) so that there is adequate time to make necessary arrangements.

See the campus policy regarding religious observances for full details.

Class Attendance

You are expected to attend all lectures and stay up-to-date with the material posted on the class webpage. If you miss a lecture, you are responsible for finding out the material covered in that lecture. If you miss an exam or a quiz, a grade of zero will be assigned, unless the you explicitly receive a permission from the instructor. The instructor will grant permissions for only valid reasons.

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Course Content

- Introduction
- Interprocess Communication
  - Review of TCP/IP
  - Remote Procedure Calls (RPC)
      Local procedure calls – a review
      Stub functions, parameter passing, server binding, Data representation
      RPC: When things go wrong
      IDL, RPC compilers
  - RPC Case Studies
      Sun RPC, DCE RPC
      DCOM, CORBA, JAVA RMI
      SOAP/.NET webservices
      XML RPC
      gRPC
- Event Ordering
  - Happened before relation
  - Logical clocks
  - Vector clocks
- Clock Synchronization
  - Clock drift and clock skew
  - NTP and SNTP
- Consensus
  - Synchrony and failure models
  - Byzantine Generals problems
  - Consensus under different failure/synchrony models
  - Impossibility of consensus in asynchronous systems – FLP result
- Message Ordering
  - Group Communications – atomic broadcast protocols, group membership protocols
  - Gossip
  - FIFO, Causal and Total orders
  - Replicated state machines
  - Group communication systems from 80's and 90's
  - Raft, Paxos
- CAP Theorem
- Virtual Machines and Cloud Computing
  - Full virtualization vs para-virtualization
  - SaaS, IaaS and Paas
- Google File System
- Map Reduce and Hadoop

- Pregel, Spark, Storm
- Chubby, BigTable, ZooKeeper and ZAB
- Peer to Peer Systems
  - Napster, Gnutella, KaZaA, Skype
  - Bit Torrent, Darknet
  - Distributed Hash Tables: CAN, Chord, Kademlia, Pastry, Tapestry
- Large Scale Distributed Storage
  - Dynamo
  - Cassandra
  - Facebook's Haystack
- Current Research Topics