

Course Syllabus

18-749: *Building Reliable Distributed Systems*
Fall 2018

Instructor: Priya Narasimhan
Office Location: CIC 410
Email Address: priya@cs.cmu.edu
Office Hours: An hour after each lecture (in the same classroom as the lecture)

Teaching Assistant: To be announced after the 1st week of classes
Email Address: Slack channel
Office Hours: To be announced after the 1st week of classes

Course Management Assistant: Michelle Mahouski
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Course Description:

The course provides an in-depth and hands-on overview of designing and developing reliable distributed systems, throughout a systems lifecycle, starting from fault-tolerant design and execution (replication, group communication, databases) to fault-recovery (fault-detection, logging, check-pointing, failure-diagnosis) for various classes of faults (crashes, communication errors, software upgrades). The course will cover real-world practices for reliability, supplemented by case studies of large-scale downtime incidents. The concepts will be taught in the context of contemporary cloud-computing platforms, and the course will include a hands-on project that involves the design, implementation and empirical evaluation of a reliable distributed cloud-based system. Students will be taught to write, review, and present a conference-style research paper by the end of the semester, with the goal of documenting the design, lessons learned and experimental results of their team project. Students can expect to learn about the reliability issues underlying cloud computing, the tools and best practices for implementing and evaluating reliability, and the strengths and weaknesses of current cloud-computing platforms from the perspective of reliability.

Number of Units: 12

Pre-requisites: Graduate standing or instructor permission.

Graduate Course Designation:

Graduate Course Area: Software Systems & Computer Networking

Class Schedule:

- **Lecture:**
Monday and Wednesday 4:30pm – 5:20pm BH A51
- **Recitation:**
Monday 5:30pm – 6:20pm BH A51

Required Textbook: *No Textbook!*

You will leave this course understanding (through first-hand experience) the skills, critical thinking and trade-offs in designing enterprise systems and fault tolerance.

Suggested Reading: Academic research papers will be provided from time to time, to supplement the class materials and discussions.

Other Supplemental Materials: White-papers and market surveys will be provided in class, and will be updated every year, based on the most recent case-studies and industry downtime incidents.

Brief List of Topics Covered:

- Fault model
- Fault detection
- Replication
- Consistency
- Checkpointing
- Recovery
- Nondeterminism
- Network partitioning
- Availability
- Reliability
- Downtime Incidents
- Industry Fault-Tolerance Standards
- Fault-Tolerance in Enterprise Systems
- Fault-Tolerance in Embedded Systems
- Case Studies from Industry (Incidents and Post-Mortem)

Course Slack:

The primary communication channel for the course will be through Slack. Students should sign up at https://join.slack.com/t/18749-fall2018-cmu/shared_invite/enQtNDI0NTQwMjExNjA3LTc3ZWQzMzZmZGIzYmUwMzdlMmEzOTc3YTM4ZTIzM2JmZTc1ZDMxMmMwZTNkZWQxZjgyYmI1M2I0ZjFiY2M0YzA

All grading information will be maintained on the Course Canvas site.

Course Wiki:

Students are encouraged to use the ECE wiki to provide feedback about the course at: <http://wiki.ece.cmu.edu/index.php>.

Grading Algorithm:

25%	Midterm exam (covers all the material taught until the mid-term)
25%	Final Exam (Covers all the material taught until the final)
35%	Project
15%	Research Paper

Late Policy:

- Last day to turn in everything is the last day of class.
- 10% of the specific category of grade per-day penalty (including Saturday and Sunday)

Projects:

- There will be a single project that applies all of the concepts taught in class
- In the first 2 weeks, you will finalize the course project and start the work on the project
- The goal is to build a reliable distributed system

Expectations:

You are expected to:

- Attend lectures
- Learn how to use the tools and to try things out for yourself
- Get the project done
- Get the research paper done

Learning material in this course requires participation:

- Questions are welcome and appreciated
- If you see something that is a problem, you need to tell us right away

Feedback:

- Talk to us if you have any concerns regarding anything related to the course.
- You can also provide anonymous feedback anytime

Getting Help:

"Showing up is 80% of life." (Woody Allen)

- We expect an "average" CMU student will put in 12 hours/week

If you see yourself exceed the number of hours greatly, then:

- You might need to brush up on some background knowledge
- You might be approaching the project in the wrong way

Tentative Course Calendar: Subject to change based on new topics and interest from students that arise during class sessions, or if any additional help is needed for the project.

DAY	DATE	DURATION	LECTURE CONTENT	PROJECT MILESTONE	RESEARCH-PAPER MILESTONE
Mon	27-Aug	90 mins	Week 1+2: Dependability Principles & Terminology		
Wed	29-Aug	50 mins	Week 1+2: Dependability Principles & Terminology	8/31: Submit project group and ideas	
Mon	3-Sep	-	No class; Labor Day (official holiday)		
Wed	5-Sep	50 mins	Week 1+2: Dependability Principles & Terminology	9/7: Submit detailed project idea	
Mon	10-Sep	90 mins	Week 3: Replication, Ordering, Consistency		
Wed	12-Sep	50 mins	Week 3: Replication, Ordering, Consistency	9/14: Submit detailed project plan	
Mon	17-Sep	90 mins	Week 4: Replication, Ordering and Consistency		
Wed	19-Sep	50 mins	Week 4: Replication, Ordering, Consistency		
Mon	24-Sep	90 mins	Week 5: Logging, Checkpointing and Recovery		
Wed	26-Sep	50 mins	Week 5: Logging, Checkpointing and Recovery		
Mon	1-Oct	90 mins	Week 6: Real-World Failure Incidents & Post-Mortem		
Wed	3-Oct	50 mins	Week 6: Real-World Failure Incidents & Post-Mortem		
Mon	8-Oct	90 mins	Week 7: Project Presentations In Class (1)	Demonstrate working prototype	Send draft of topics to Priya
Wed	10-Oct	50 mins	Week 7: Project Presentations In Class (2)	Demonstrate working prototype	
Mon	15-Oct	90 mins	Mid-Term Exam, 4.30-6pm		Pick a final topic
Wed	17-Oct	-	No class: Mid-term break		
Mon	22-Oct	90 mins	Week 9: Advanced Topics: Nondeterminism, Partitioning		
Wed	24-Oct	50 mins	Week 9: Advanced Topics: Nondeterminism, Partitioning		
Mon	29-Oct	90 mins	Week 10: Software Upgrades and Fault-Tolerance	Progress on working prototype	
Wed	31-Oct	50 mins	Week 10: Software Upgrades and Fault-Tolerance	Progress on working prototype	
Mon	5-Nov	90 mins	Week 11: Failure Diagnosis, Root-Cause Analysis		First draft of the paper
Wed	7-Nov	50 mins	Week 11: Failure Diagnosis, Root-Cause Analysis		
Mon	12-Nov	90 mins	Week 12: Project Presentations In Class (1)	Demonstrate near-complete prototype	
Wed	14-Nov	50 mins	Week 12: Project Presentations In Class (2)	Demonstrate near-complete prototype	
Mon	19-Nov	-	Thanksgiving; No class; holiday		
Wed	21-Nov	-	Thanksgiving; No class; holiday		
Mon	26-Nov	90 mins	Week 14: Fault-Tolerance in Embedded Systems		
Wed	28-Nov	50 mins	Week 14: Fault-Tolerance in Embedded Systems		
Mon	3-Dec	90 mins	Week 15: Final Exam, 4.30-6pm		
Wed	5-Dec	90 mins	Week 15: Interviews of Project Teams	Final demo of prototype	Final draft of the paper
Thur	6-Dec	90 mins	Week 15: Interviews of Project Teams	Final demo of prototype	
Fri	7-Dec	90 mins	Week 15: Interviews of Project Teams	Final demo of prototype	

ECE Academic Integrity Policy

(<http://www.ece.cmu.edu/programs-admissions/masters/academic-integrity.html>):

The Department of Electrical and Computer Engineering adheres to the academic integrity policies set forth by Carnegie Mellon University and by the College of Engineering. ECE students should review fully and carefully Carnegie Mellon University's policies regarding Cheating and Plagiarism; Undergraduate Academic Discipline; and Graduate Academic Discipline. ECE graduate student should further review the Penalties for Graduate Student Academic Integrity Violations in CIT outlined in the CIT Policy on Graduate Student Academic Integrity Violations. In addition to the above university and college-level policies, it is ECE's policy that an ECE graduate student may not drop a course in which a disciplinary action is assessed or pending without the course instructor's explicit approval. Further, an ECE course instructor may set his/her own course-specific academic integrity policies that do not conflict with university and college-level policies; course-specific policies should be made available to the students in writing in the first week of class.

This policy applies, in all respects, to this course.

CMU Academic Integrity Policy (<http://www.cmu.edu/academic-integrity/index.html>):

In the midst of self exploration, the high demands of a challenging academic environment can create situations where some students have difficulty exercising good judgment. Academic challenges can provide many opportunities for high standards to evolve if students actively reflect on these challenges and if the community supports discussions to aid in this process. It is the responsibility of the entire community to establish and maintain the integrity of our university.

This site is offered as a comprehensive and accessible resource compiling and organizing the multitude of information pertaining to academic integrity that is available from across the university. These pages include practical information concerning policies, protocols and best practices as well as articulations of the institutional values from which the policies and protocols grew. The Carnegie Mellon Code, while not formally an honor code, serves as the foundation of these values and frames the expectations of our community with regard to personal integrity.

This policy applies, in all respects, to this course.

The Carnegie Mellon Code

Students at Carnegie Mellon, because they are members of an academic community dedicated to the achievement of excellence, are expected to meet the highest standards of personal, ethical and moral conduct possible.

These standards require personal integrity, a commitment to honesty without compromise, as well as truth without equivocation and a willingness to place the good of the community above the good of the self. Obligations once undertaken must be met, commitments kept.

As members of the Carnegie Mellon community, individuals are expected to uphold the standards of the community in addition to holding others accountable for said standards. It is rare that the life of a student in an academic community can be so private that it will not affect the community as a whole or that the above standards do not apply.

The discovery, advancement and communication of knowledge are not possible without a commitment to these standards. Creativity cannot exist without acknowledgment of the creativity of others. New knowledge cannot be developed without credit for prior knowledge. Without the ability to trust that these principles will be observed, an academic community cannot exist.

The commitment of its faculty, staff and students to these standards contributes to the high respect in which the Carnegie Mellon degree is held. Students must not destroy that respect by their failure to meet these standards. Students who cannot meet them should voluntarily withdraw from the university.

This policy applies, in all respects, to this course.

Carnegie Mellon University's Policy on Cheating

(<http://www.cmu.edu/academic-integrity/cheating/index.html>) states the following:

According to the University Policy on Academic Integrity, cheating "occurs when a student avails her/himself of an unfair or disallowed advantage which includes but is not limited to:

- Theft of or unauthorized access to an exam, answer key or other graded work from previous course offerings.
- Use of an alternate, stand-in or proxy during an examination.
- Copying from the examination or work of another person or source.
- Submission or use of falsified data.
- Using false statements to obtain additional time or other accommodation.
- Falsification of academic credentials."

This policy applies, in all respects, to this course.

Carnegie Mellon University's Policy on Plagiarism

(<http://www.cmu.edu/academic-integrity/plagiarism/index.html>) states the following:

According to the University Policy on Academic Integrity, plagiarism "is defined as the use of work or concepts contributed by other individuals without proper attribution or citation. Unique ideas or materials taken from another source for either written or oral use must be fully acknowledged in academic work to be graded. Examples of sources expected to be referenced include but are not limited to:

- Text, either written or spoken, quoted directly or paraphrased.
- Graphic elements.
- Passages of music, existing either as sound or as notation.
- Mathematical proofs.
- Scientific data.
- Concepts or material derived from the work, published or unpublished, of another person."

This policy applies, in all respects, to this course.

Carnegie Mellon University's Policy on Unauthorized Assistance

(<http://www.cmu.edu/academic-integrity/collaboration/index.html>) states the following:

According to the University Policy on Academic Integrity, unauthorized assistance "refers to the use of sources of support that have not been specifically authorized in this policy statement or by the course instructor(s) in the completion of academic work to be graded. Such sources of support may include but are not limited to advice or help

provided by another individual, published or unpublished written sources, and electronic sources. Examples of unauthorized assistance include but are not limited to:

- Collaboration on any assignment beyond the standards authorized by this policy statement and the course instructor(s).
- Submission of work completed or edited in whole or in part by another person.
- Supplying or communicating unauthorized information or materials, including graded work and answer keys from previous course offerings, in any way to another student.
- Use of unauthorized information or materials, including graded work and answer keys from previous course offerings.
- Use of unauthorized devices.
- Submission for credit of previously completed graded work in a second course without first obtaining permission from the instructor(s) of the second course. In the case of concurrent courses, permission to submit the same work for credit in two courses must be obtained from the instructors of both courses."

This policy applies, in all respects, to this course.

Carnegie Mellon University's Policy on Research Misconduct

(<http://www.cmu.edu/academic-integrity/research/index.html>) states the following:

According to the University Policy For Handling Alleged Misconduct In Research, "Carnegie Mellon University is responsible for the integrity of research conducted at the university. As a community of scholars, in which truth and integrity are fundamental, the university must establish procedures for the investigation of allegations of misconduct of research with due care to protect the rights of those accused, those making the allegations, and the university. Furthermore, federal regulations require the university to have explicit procedures for addressing incidents in which there are allegations of misconduct in research."

The policy goes on to note that "misconduct means:

- fabrication, falsification, plagiarism, or other serious deviation from accepted practices in proposing, carrying out, or reporting results from research;
- material failure to comply with Federal requirements for the protection of researchers, human subjects, or the public or for ensuring the welfare of laboratory animals; or
- failure to meet other material legal requirements governing research."

"To be deemed misconduct for the purposes of this policy, a 'material failure to comply with Federal requirements' or a 'failure to meet other material legal requirements' must be intentional or grossly negligent."

To become familiar with the expectations around the responsible conduct of research, please review the guidelines for Research Ethics published by the Office of Research Integrity and Compliance.

This policy applies, in all respects, to this course.

Take care of yourself. Do your best to maintain a healthy lifestyle this semester by eating well, exercising, avoiding drugs and alcohol, getting enough sleep and taking some time to relax. This will help you achieve your goals and cope with stress.

All of us benefit from support during times of struggle. You are not alone. There are many helpful resources available on campus and an important part of the college experience is learning how to ask for help. Asking for support sooner rather than later is often helpful.

If you or anyone you know experiences any academic stress, difficult life events, or feelings like anxiety or depression, we strongly encourage you to seek support. Counseling and Psychological Services (CaPS) is here to help: call 412-268-2922 and visit their website at <http://www.cmu.edu/counseling/>. Consider reaching out to a friend, faculty or family member you trust for help getting connected to the support that can help.

If you have questions about this or your coursework, please let me know.