CS544 - Computer Networks: Theory, Applications and Programming
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Syllabus

Couse Objectives

The goal of this class is to examine computer networks in detail using the model that powers most networks these days including the Internet (TCP/IP and OSI). We use these models to break down the complexity of computer networking to examine each layer with respect to its duties and responsibilities. We'll also analyze networking protocols and understand how they are successfully analyzed, designed, and implemented. We'll use the Internet to illustrate the theory and operation of each layer. The student will be graded on how well they understand the theory of computer networks through the course readings and assignments, with the underlying measure of success being able to perform protocol analysis, design, and implementation.

Student Expectations / Prerequisites

This is a hands-on computer science graduate class. As such student must be comfortable working with a systems programming language such as C for the programming component of this course. Other programming languages will be considered upon request. The student should also have access and plan to use a Linux environment to complete required coursework. Acceptable options are MacOS, a VM on a Windows Machine, the Linux Subsystem for Windows, or using Tux – CCI's Linux cluster. There are also ways to virtualize into a Linux environment using docker containers. One good example is ".devcontainers" in MS Code. I can do a one-off tutorial on how to configure your machine to support development on Tux or in a container using a modern IDE installed on your computer.

Office Hours

I conduct office hours both in person and virtual. My office hours for the term, both in-person and virtual over zoom will be posted on Blackboard under the Instructor Information tab.

Discord

I do not like using emails to manage classes, its not designed for that. Blackboard announcements are also a drag. As such, we have a class Discord that is my preferred venue for communicating with the class. You can DM me over Discord or better yet, use the channels that are open to the entire class to ask questions. If you have a question, share with the class, somebody else also likely has that question.

Textbook

None required, but I suggest that you get a textbook to help you though the concepts if you are completely new to networking. If you are going to invest in purchase or renting a textbook, the first one in green is the one I recommend.

- Computer Networking: A Top-Down Approach Featuring the Internet, by James F. Kurose and Keith W. Ross; Addison Wesley, 2017 (7th or 8th edition).
- Computer Networks: A Top-Down Approach, 1st edition, by Behrouz A Forouzan and Firouz Mosharraf (McGraw Hill), Copyright 2012. ISBN 978-0-07-352326-2 https://www.mheducation.com/highered/product/M0073523267.html
- https://www.pearsonhighered.com/program/Kurose-Computer-Networking-A-Top-DownApproach-7th-Edition/PGM1101673.html. ISBN-13: 978-0-13-359414-0.
- Additional readings are from Design and Validation of Computer Protocols [in syllabus as Spinroot], by Gerard J. Holzmann (Prentice Hall), Copyright 1991. ISBN 0-13-539925-4. Available online at http://spinroot.com/gerard/popd.html

Free/OpenSource Materials:

- Computer Networks: A Systems Approach - https://book.systemsapproach.org/
- Computer Networks, Principals, Protocols & Practice - https://github.com/cnp3/ebook/releases/download/draft-3rd/CNP3-2021.pdf
- Beej's Guide to Network Programming Using Internet Sockets - https://beej.us/guide/bgnet/

Course Deliverables

This course will include a multi-part course project, and various targeted summaries of relevant content (papers, videos, etc) that are assigned throughout the term.

The course project will be broken down into 3 distinct phases.

- **Protocol Specification** – you will investigate a real protocol and provide an analysis of that protocol against defined criteria.
- **Protocol Design** – you will design an application-level protocol and create a specification for it
- **Protocol Implementation** – you will implement the protocol you designed in the second part of the project

Rough Schedule

The following is a rough schedule for this course, by week:

1. Introduction to Computer Network Concepts
2. How Do Networks Really Work; Socket Review; Application Layer; Protocol Analysis
3. Application Layer – HTTP/Web Networking Deep Dive (HTTP/1, HTTP/2, HTTP/3); Web APIs, Content Delivery Networks
4. Transport Layer – Transport Layer Objectives - UDP & TCP
5. Transport Layer – TCP Deep Dive – Sequence Numbers, Windowing, QoS, Congestion Control
6. Network Layer and Services (Routing Objectives, IP and Neighbor Discovery, Router/Switch Architectures)

7. Network Layer – Routing Protocols (Distance vs Link State; OSPF, EIGRP, BGP)
8. Data Link Layer – Physical Layer; Overview of Software Defined Networks and Cloud Networking
9. Network Routing Lab
10. Overflow week if we are running behind or a special topic to be announced.

Expected Learning

By the end of this course the student should be expected to have a solid grasp on:

- An in-depth understanding of computer networks and computer networking models,
- To show through theory and example how computer networks operate,
- To understand the complexities and various issues that networking protocols must address,
- To understand the security implication and requirements of network protocols,
- To understand how networking protocols must evolve to meet the increasing traffic and security demands of modern networks

Tools (get these installed in your OS)

1. "Unix" command line tools, e.g., netstat, arp, traceroute, ifconfig, etc
2. Wireshark
3. C Programming environment (I use VSCode with gcc on my machine)

Programming Expectations

This course will not require you to use a systems programming language in your project implementation, but you should be comfortable understanding systems programming code in C. I will likely be doing demonstrations as well highlighting common programing languages used in constructing network applications such as Go and Rust. Where appropriate, I will provide you with scaffolded code to get you started with programming deliverables.

Also, there are many libraries out there that can be found to implement assignments in just a few lines of code. You are encouraged to use these libraries as a foundation when appropriate, but not as a substitute for your own implementation. There is more information about this in the project implementation assignment.

Assignments, Due Date and your Late Day Bank

This course will have assignments that will be spread out over the course (due approx. every 2-3 weeks).

Given my previous experience teaching graduate classes, students tend to have different levels of readiness, especially with background in programming. I will adjust deadlines for the whole class as necessary, based on my observation of student effort and questions being asked over Discord, and attending office hours (mine or the TAs). One off deadline extensions are not

possible, but I do realize that things come up from time to time. If you go into grade center, you will notice that you have a bank of 5 late days to use over the term. Late submissions will be accepted without penalty by deducting from your late day bank. Once you exhaust your bank, late assignments will take a 50% penalty on day 1, and will not be accepted on day 2+. Assignments are typically due at the end of the week (midnight on Friday).

Note that the late day bank is to accommodate students "when things come up" for whatever reason. This includes full-time work deadlines, sickness, unexpected travel, and so on. They should be considered as "insurance", because once they are gone, they are gone. You do not require any permission to submit assignments late – they will be accepted without penalty, without any reason for lateness so long as late days exist in your bank.

Expectations of Timely Communication for Hardships
If, for whatever reason, you find yourself struggling with keeping up with course deliverables, it is important that you let me know right away, including your plan to get back on track. I am here to help you and am willing to be as flexible as possible. However, my flexibility becomes very limited if you come to me weeks after one or more assignment deadlines have been missed with a hardship story.

Grading Breakdown
60% project – 30% each for parts 1 and 2; 40% for the final part.
40% other homework, videos, papers, etc.

Grades
A+ (98-100); A (93-97); A- (90-92)
B+ (87-89); B (83-86); B- (80-82)
C+ (77-79); C (73-76); C- (70-72)
D (60-69)
F (< 60)

University Policies:
This course follows university, college, and department policies, including but not limited to:

- Academic Integrity, Plagiarism, Dishonesty and Cheating Policy: http://www.drexel.edu/provost/policies/academic_dishonesty.asp
- Student Life Honesty Policy from Judicial Affairs: http://www.drexel.edu/provost/policies/academic-integrity
- Students with Disability Statement: http://drexel.edu/oed/disabilityResources/students/
- Course Add/Drop Policy: http://www.drexel.edu/provost/policies/course-add-drop
- Course Withdrawal Policy: http://drexel.edu/provost/policies/course-withdrawal
- Department Academic Integrity Policy: http://drexel.edu/cci/resources/current-students/undergraduate/policies/cs-academic-integrity/

- Drexel Student Learning Priorities: http://drexel.edu/provost/assessment/outcomes/dslp/
- Office of Disability Resources: http://www.drexel.edu/ods/student_reg.html

Students requesting accommodations due to a disability at Drexel University need to request a current Accommodations Verification Letter (AVL) in the ClockWork database before accommodations can be made. These requests are received by Disability Resources (DR), who then issues the AVL to the appropriate contacts. For additional information, visit the DR website at drexel.edu/oed/disabilityResources/overview/, or contact DR for more information by phone at 215.895.1401, or by email at disability@drexel.edu.

Couse Change Policy

The instructor may, at their discretion, change any part of the course during the term, including assignments, grade breakdowns, due-dates, and the schedule. Such changes will be communicated to students via the course web site Announcements page. This page should be checked regularly and frequently for such changes and announcements. Other announcements, although rare, may include class cancellations and other urgent announcements will be communicated via the course discord channel.