ECEN 5005 (003) / CSCI 7000 (005) Syllabus

Special Topic: Advanced Network Systems

Semester: Fall 2022

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Office Hours: by appointment

Lectures:

Tu / Th 2:00pm – 3:15pm ECEE 1B32

Description:

Provides an advanced study of network architecture, across the end hosts, the network elements, and the people and systems that manage the network. The course provides the foundation for modern network systems, beyond the basic understanding of the OSI layers, and into the system which make networks work.

Prerequisites:

There are no hard pre-reqs for the class. Ideally, a student will have taken a network systems class (e.g., CSCI 4273/5273 & ECEN 5023 (Network Systems)), but we will spend the first few classes on fundamentals and in the past, students have been able to overcome this gap in background. Also, students should be comfortable in Linux and programming.

Class structure:

The classes will be lecture based and in person, and consist of a mix of reading and reviewing research paper, learning modern tools and systems, and performing independent research of the student's choosing.

Grading will be as follows:
Semester Project – 45%
Assignments – 20%
Reading and analyzing research papers – 25%
Class Participation – 15%

Project:

Students will be expected to work on a semester-long project of their choosing to build up skills in performing research in network systems. The expectation is they can motivate the work and demonstrate at least one finding toward a larger goal. That is, it is not expected to be publication ready in terms of completeness or novelty, but simply that they can identify a problem, build a prototype, and perform preliminary evaluation. This has multiple components: a proposal, an end of semester presentation, a final write-up, and a review of another student's writeup. Note: past iterations of this class have resulted in several successful publications.

Assignments:

Programming assignments will be assigned to build on the concepts discussed in class and gain exposure to some of the tools and infrastructures used in network systems research. Students will learn how to set up and use a research computing infrastructure, understanding modern network management and how to emulate large networks, understand how to build a data plane, and how to generate and measure traffic.

Readings:

Much of the technical details for advanced network systems is contained in academic publications, rather than textbooks. As such, students are expected to read the material, and to nurture critical thinking, students will be asked to provide a review of each paper they read. Papers will include both seminal papers in the space, as well as recent papers at conferences such as SIGCOMM, NSDI, and NDSS.

Class Participation:

The class is meant to not only convey the findings of research papers, but to also include discussions of it to see many view points and to discuss the topic within the context of other papers we will be reading. Students will be encouraged to discuss the topic during class, and each student will have an opportunity to practice presentation skills by presenting the paper and leading the discussion for at least one paper.

Description and Content

As this is a special topics course, the material will be adapted based on advances in research and student interests. However, from past offerings of the course, example topics are provided below.

Main topic 1: Network Environments

Sub-topic 1.1: Cloud / Data center – data centers are the primary environment for where applications are hosted, and is the backbone of "the cloud". The network architecture of data centers is critical in the scale and requirements. Specific topics include topologies to support huge scale, protocols to perform in the face of more demanding applications, end-host network design, and architectures to support isolation among multiple workloads.

Sub-topic 1.2: Internet – the Internet is the core network which connects everything together (connecting the mobile systems to the data centers). The Internet is unique in that it has many administrative domains, a challenge with legacy deployments, and has a global scale. Specific topics include measurement (to provide an understanding of a highly complex structure), and clean slate architecture designs (e.g., naming) to match more modern use (as opposed to the use cases from decades ago).

Sub-topic 1.3: Mobile / Wireless – mobile and wireless systems form the primary means of communication for a large (and growing) number of end systems, from smart phones to sensors. Covered in this sub-topic includes specific topics such as cellular, Wi-Fi, IoT and Edge architectures, ad-hoc / mesh networks, sensing and localization.

Main topic 2: Cross-cutting

Sub-topic 2.1 Operating System / architecture support for networking – the systems to process network traffic, including operating system and hardware modifications, is an advanced topic which takes a deeper look at the data plane of networks. Specific topics include programmable network interface cards (NICs), kernel processing (eBPF) and bypass techniques (e.g., DPDK), and structuring of how the network processing applications are built.

Sub-topic 2.2 Network Management – the management plane of networks is often not covered in networked systems courses, yet is needed to make networks operate (along with the data plane and control plane, which are covered). This topic covers the systems and processes used to manage networks, and includes topics such as software-defined networking, network virtualization, and container networking (e.g., Kubernetes CNI).

Sub-topic 2.3 Security and Privacy – going beyond management, to also include policy and views from malicious standpoints, security and privacy is a critical concern in network infrastructures as they become more integral to our life. Specific topics include anonymous routing, intrusion detection, botnets, and understanding the economies behind network attacks.

At the end of this course, students will be able to:

- Understand state of the art in Networked Systems
- Be able to read and critically evaluate research papers in networked systems
- Be prepared to publish in academic conferences in networked systems