

# CSC 591/791-023, ECE 592-087

## Advanced Computer Networks for Distributed Computing Systems Cloud, Edge and P2P

**Instructor(s):** Dr. Ruozhou Yu (ryu5@ncsu.edu)

**Description and Objective:**

This course explores the design and implementation principles of advanced computer networks that support modern distributed computing systems. In particular, the course will emphasize on recent networking techniques developed and used for **cloud computing**, **edge computing**, and **peer-to-peer systems**, which have enabled high-performance and reliable applications such as MapReduce, search engines, stream analysis, mobile AR/VR, etc. For different topics, this class features both state-of-the-art networking solutions proposed and used in the industry such as Google Data Centers and Amazon Web Services, and the latest research and development from the academia.

Multiple aspects of these types of networks will be explored, including architectures, protocols and tools, metrics and performance, and applications. The students will be encouraged to read research papers in related areas. In addition, the students will learn and practice using network simulation/emulation tools to model and improve the performance of network architectures and protocols, through homework assignments and the course project. The learned knowledge and skills can find excellent use both in industry-oriented job hunting and academic research.

By the end of this course, students should be able to:

- Understand the challenges, goals and principles for network design and implementation in **cloud and edge computing**, and certain P2P systems such as blockchain
- Understand how network protocols and architectures are designed to support modern cloud, edge and P2P applications, with high performance and robustness
- Understand the role and concept of network simulation and emulation tools
- Model and analyze the performance of network architectures and protocols using network simulation/emulation tools
- Identify research problems and trends in related areas by doing literature review
- Make oral presentation of literature review and/or research/reproduction results

**Uniqueness of This Course:**

This course features a combination of theory and. Theory is learnt from lectures and reading, while implementation is learnt from homework assignments and/or project that aim to use NS-3 to validate and reproduce results from the state-of-the-art networking solutions. The covered topics either have been applied in production environments such as Google Data Centers and Amazon EC2, or have inspired extensive research opportunities.

There are also endlessly more research opportunities inspired by these existing works, which can lead to thrillingly exciting new research in this area! For more information about Dr. Yu and his research, please see his homepage: <https://people.engr.ncsu.edu/ryu5/>.

**Location and Time:** EBII 1229, Monday/Wednesday, 3:00pm—4:15pm

**Prerequisites:**

- A networking course at the undergraduate level (CSC/ECE 400+)
- Programming using C/C++
- Basics on using Matlab/Python/other tools to visualize data statistics

**Textbook:** No textbook required. Students are encouraged to read:

- “Cloud Networking: Understanding Cloud-based Data Center Networks,” by Gary Lee.

- “Handbook of Peer-to-Peer Networking,” by Xuemin Shen, Heather Yu, John Buford, and Mursalin Akon.

**Topics:** Covered topics are subject to change depending on time, enrollment, and student opinions.

- Review of Internet Architecture and Introduction to Cloud Networking
- Network Simulation and Emulation; NS-3 Basics
- Data Center Networks: Architecture
  - Switch-, server-, optic- and wireless-oriented cloud architectures
- Data Center Networks: Protocols and Tools (Layer 2/3/4)
  - Advanced TCP, congestion control, ECN, multi-pathing, ...
- Data Center Networks: Application Layer and Cross-Layer Design
- Data Center Networks: Protocols and Tools (Virtualization & SDN)
  - Isolation and SDN
- Beyond Data Centers: Cloud Networking over the Internet
  - Google B4, multi-cloud scheduling
- Edge Computing: Architecture
  - Hierarchical edge-cloud, multi-level ISPs
- Edge Computing: Algorithms
  - Offloading, resource provisioning, QoS
- P2P Overlay: Basics and Architecture
- P2P Overlay: Protocols
  - Sharing, streaming, (blockchain networks)

**Grading:** For CSC 591 students, the final project is a Literature Review of a vertical area related to cloud, edge and P2P networking. For CSC 791 students, the final project is a Research/Reproduction Project using NS-3 (or other simulator/emulator approved by the instructor). For ECE 592 students, the final project can be chosen from a Literature Review or a Research/Reproduction Project. Both types of final project involve a final report, and an oral presentation.

- 50% Homework Assignments
- 20% Exam
- 15% Report for Final Project (Literature Review or Research/Reproduction)
- 15% Oral Presentation for Final Project (Literature Review or Research/Reproduction)

**Cross-listing in other departments:** cross-listed with CSC 591/791-023