CLEMSON
ELECTRICAL AND COMPUTER ENGINEERING

Spring 2024

ECE 4380/6380 Section 1
Computer Communications

Class Location/Time:	227 Riggs Hall, Mondays, Wednesdays, and Fridays, 2:30 – 3:20 p.m.
Instructor:	Associate Professor Harlan B. Russell (harlanr@clemson.edu)
	316 Fluor Daniel Building, Tel: 864-656-7214
Course Modality:	in person
Office Hours:	Thur., and Fri., 3:30-5:00 p.m. in person.
	Other times by appointment
Grader:	none
Prerequisites:	Background in C programming and familiarity with basic probability

Course Description

We will explore the issues for networked communication from local area networks up to the global Internet and we will study a range of solutions to the associated problems. The course goals include the ability to list the concepts in wide-area network architecture, describe protocol layering, and discuss the functional requirements of each layer. By the end of the semester, you will be able to analyze different methods for the design and implementation of computer networks, and evaluate the ability of various protocols and equipment to meet specific performance requirements. Preq: Senior standing in Electrical or Computer Engineering or Computer Science

Course Objectives

Competences: Upon completion of this course, students should be able to:

a) Understand issues and solutions to networked communication from local area networks to the Internet.
b) List the concepts in wide-area network architecture.
c) Describe protocol layering and discuss the functional requirements of each layer.
d) Analyze different methods for the design and implementation of computer networks and evaluate the ability of various protocols and equipment to meet specific performance requirements.

Knowledge: Upon completion of this course, students will have been exposed to the following:

a) Foundation of networks including the classes of applications and the support for common services
b) Requirements for networked communications including user, administrator, and designer perspectives
c) Approaches to achieve scalable connectivity and cost-effective resource sharing
d) Network architecture including layering and protocols with the Internet architecture as the primary example
e) Physical layer models including encoding, framing, and error detection

f) Protocols for point-to-point and multiple-access links, including Ethernet and 802.11
g) Switching at both layer 2 (link layer) and layer 3 (network layer)
h) Layer 2 extended local-area network bridging and spanning tree protocols
i) Layer 3 datagram forwarding (IP), scaling with subnets and supernets, and supporting protocols
j) Routing and tradeoffs between distance-vector and link-state algorithms
k) Hierarchical protocols to scale network connectivity to billions of nodes with BGP and IPv6
l) Support for mobile devices and Mobile IP
m) End-to-end reliability, adaptive timeout, and flow control
n) Congestion control and resource allocation including WFQ, TCP congestion control, RED queue management

Skills: Upon completion of this course, students will be able to:

a) Implement client-server network software with the socket programming interface
b) Analyze network protocols to evaluate throughput and delay
c) Calculate bandwidth-delay products and select window sizes to maximize throughput for sliding window protocols
d) Evaluate local area network performance in the presence of collisions and back off delays
e) Determine latency in the presence of packet errors for multiple ARQ protocols
f) Design extended local area networks with redundant connectivity and select configuration details to provide min-max fairness and traffic balancing
g) Select subnets, masks, and CIDR assignments to maximize utilization of address space and minimize number of entries in forwarding tables
h) Evaluate convergence time and looping problems with distance-vector and link-state protocols
i) Calculate delay and fairness for active queue management strategies including weighted-fair queueing and random-early detection
j) Deploy extended local area network bridges and select spanning tree parameters
k) Configure OSFP routing daemons and observe control traffic in response to changes in connectivity
l) Design alternative state machines to adjust TCP establishment and teardown synchronization

Judgment Skills and Critical Abilities: Upon completion of this course, students will be able to

a) Contrast alternative design approaches to forwarding and routing protocols to address convergence time and scalability
b) Critique approaches to congestion control algorithms that are router-centric and host-centric with respect to TPC friendliness.
c) Determine appropriate performance requirements for destination-based versus virtual-circuit forwarding strategies
d) Evaluate trade-off designs at multiple protocol layers to meet various application performance requirements, including bulk data transfer, streaming content, and near real-time communications

Required Materials

The text for this course is now available as open source at this link: https://book.systemsapproach.org/ . It is freely downloaded and the source is also available. See the book's preface for additional information about the license.

A printed version is available as : L. Peterson and B. Davie, *Computer Networks: A systems approach*, sixth edition, Morgan Kaufmann Publishers, Inc., 2022

Available at library or online: M. J. Donahoo and K. L. Calvert, *The Pocket Guide to TCP/IP Sockets*, *C Version*, Morgan Kaufmann Publishers, Inc., 2001

Topical Outline

Week 1	Introduction to computer network architecture (Reading: 1.1 – 1.3) Implementing network software (Reading: 1.4)
Week 2	Performance and bandwidth-delay product (Reading 1.5) Direct link networks, encoding, framing, and error detection (Reading: 2.1 – 2.4)
Week 3	Reliable transmission, stop-and-wait, sliding windows, (Reading 2.5) Concurrent logical channels and separation of concerns (Reading 2.5)
Week 4	Shared access networks and carrier-sense multiple-access with collision detection Ethernet and multiple-access networks (Reading 2.6)
Week 5	Wireless networks and 802.11 Carrier-sense multiple-access with collision avoidance (Reading: 2.7)
Week 6	Exam 1 Switching and Forwarding (Reading: 3.1)
Week 7	Bridges, learning bridges Spanning tree algorithm (Reading: 3.2)
Week 8	Basic Internetworking, datagram forwarding (IP) Subnetting, classless addressing, ARP, DHCP, ICMP, VPN (Reading: 3.3)
Week 9	Routing Distance vector and link state algorithms, RIP and OSPF (Reading 3.4)
Week 10	Advanced Internetworking, scalability, and routing areas (Reading: 4.1) BGP, IPv6 (Reading: 4.2)
Week 11	Multicast, multiprotocol label switching (Reading: 4.3 - 4.4) Mobile IP (Reading: 4.5)
Week 12	Exam 2 End-to-end protocols, UDP (Reading: 5.1)
Week 13	Reliable byte stream (TPC) Connection establishment and termination, state diagram Sliding window and flow control with advertised window (Reading 5.2)
Week 14	Congestion control and resource allocation Queueing disciplines and weighted fair queueing (Reading: 6.1 – 6.2)
Week 15	TCP congestion control, slow start, fast retransmit/recovery (Reading: 6.3) Congestion-avoidance, random early detection, source-based avoidance (Reading: 6.4)

Grading

Homework assignments:	15%
Projects:	15%
2 Midterm tests:	15% each
Final Exam:	40%

We shall have two in-class exams, and a final exam. The final exam is scheduled for 3:00 p.m. to 5:30 p.m. on Thursday, May 2.

Three **projects** will be assigned. The first will explore network programming in C. The second and third will use a virtual environment to experiment with distributed spanning trees and routing protocols.

Students receiving credit for 6380 will be required to cover some topics in more in-depth (e.g., multicasting and MPLS), and will have additional homework problems and exam questions.

A – 90% - 100%; B – 80 to < 90%; C – 70 to < 80%; D – 60 to < 70 & F – < 60% (4380 Students)
A – 90% - 100%; B – 80-89%; C – 70-79%; & F – < 70% (6380 Students)

Attendance Policy:

You are expected to attend all classes; however, if you anticipate an absence, please notify me beforehand. If you fall ill, please do not come to class, but try and let me know as soon as you can. All absences will be dealt with on a case-by-case basis. Lectures will be recorded, but recordings are only available to students with an approved absence. All requests for approved absences must be submitted through the Notification of Absence tool.

Notification of Absence

The Notification of Absence module in Canvas allows students to quickly notify instructors (via an email) of an absence from class and provides for the following categories: court attendance, death of family member, illness, illness of family member, injury, military duty, religious observance, scheduled surgery, university function, unscheduled hospitalization, other anticipated absence, or other unanticipated absence. The notification form requires a brief explanation, dates and times. Based on the dates and times indicated, instructors are automatically selected, but students may decide which instructors will receive the notification. This does not serve as an "excuse" from class. It is a request for an excused absence and students are encouraged to discuss the absence with instructors, as the instructor is the only person who can excuse an absence. If students are unable to report the absence by computer, they may reach the Office of Advocacy and Success via 864.656.0935. Students with excessive absences who need academic or medical assistance can also contact the Office of Advocacy and Success.

The Office of Advocacy and Success also assists students in identifying various appropriate methods of documenting absences and assists families in using the electronic Notification of Absence system when students are unable to do so themselves

Additional Policies

Examinations: No make-up exams will be given unless an acceptable reason is presented to the instructor at least one week before the examination date. In the event of an emergency, the student must make direct contact with the instructor before an exam takes place or an assignment is due, preferably via email. If it is not possible to make arrangements before the scheduled event, then the student must contact the instructor as soon as it is safe and reasonable to do so. It is the student's responsibility to secure documentation of emergencies.

Re-grades: Re-grade requests must be submitted via email to the instructor within one week of the return of the graded item.

Homework: All problem sets are due at the time and date specified on the assignment. No late assignments will be accepted. Assignments must be submitted through Canvas.

Projects: Submission of machine problems will be electronically, and policies for late submission will be defined for each machine problem. A passing grade in the course will not be awarded without completion of all programming projects.

We encourage you to discuss interpretations of problems and assignments with each other but we expect that you will construct and write up your own solutions to any assignments that you turn in for credit. If students are found to have collaborated excessively or to have blatantly cheated (e.g., by copying or sharing answers or computer code), all involved will at a minimum receive grades of 0 for the first infraction. Further infractions will result in failure in the course and possibly recommendation for dismissal from the university.

For the programming assignments it is okay to talk with your classmates about the ideas. But when it comes time to write up your answers we expect your words and computer code to be yours alone. Do not share your work with your classmates, as they may not have the same work ethic as you do. Do not ask your classmates to share their files with you, either. In the end, your work should be a reflection of what you understand about the topic, presented in your own words and computer code.

Academic Integrity

As members of the Clemson University community, we have inherited Thomas Green Clemson's vision of this institution as a 'high seminary of learning.' Fundamental to this vision is a mutual commitment to truthfulness, honor, and responsibility, without which we cannot earn the trust and respect of others.

Furthermore, we recognize that academic dishonesty detracts from the value of a Clemson degree. Therefore, we shall not tolerate lying, cheating, or stealing in any form. In instances where academic standards may have been compromised, Clemson University has a responsibility to respond appropriately to charges of violations of academic integrity.

Further information on Academic Integrity can be found in the *Undergraduate Announcements* and in the *Graduate School Policy Handbook*.

Accessibility Statement

Clemson University values the diversity of our student body as a strength and a critical component of our dynamic community. Students with disabilities or temporary injuries/conditions may require accommodations due to barriers in the structure of facilities, course design, technology used for curricular purposes, or other campus resources. Students who experience a barrier to full access to this class should let the professor know, and make an appointment to meet with a staff member in Student Accessibility Services as soon as possible. You can make an appointment by calling 864-656-6848, by emailing studentaccess@lists.clemson.edu, or by visiting Suite 239 in the Academic Success Center building. Appointments are strongly encouraged – drop-ins will be seen if possible, but there could be a significant wait due to scheduled appointments. Students who receive Academic Access Letters are strongly encouraged to request, obtain and present these to their professors as early in the semester as possible so that accommodations can be made in a timely manner. It is the student's responsibility to

follow this process each semester. You can access further information here: https://www.clemson.edu/academics/studentaccess/index.html . Other information is at the university's Accessibility Portal.

Title IX Statement

Clemson University is committed to a policy of equal opportunity for all persons and does not discriminate on the basis of race, color, religion, sex, sexual orientation, gender, pregnancy, national origin, age, disability, veteran's status, genetic information or protected activity in employment, educational programs and activities, admissions and financial aid. This includes a prohibition against sexual harassment and sexual violence as mandated by Title IX of the Education Amendments of 1972.

This policy is located at http://www.clemson.edu/campus-life/campus-services/access/title-ix/ . Ms. Alesia Smith is the Executive Director for Equity Compliance and the Title IX Coordinator. Her office is located at 223 Holtzendorff Hall, phone number is 864.656.3181, and email address is alesias@clemson.edu. Remember, email is not a fully secured method of communication and should not be used to discuss Title IX issues.

Copyright Statement

Materials in some of the courses are copyrighted. They are intended for use only by students registered and enrolled in a particular course and only for instructional activities associated with and for the duration of the course. They may not be retained in another medium or disseminated further. They are provided in compliance with the provisions of the Teach Act. Students should be reminded to refer to the Use of Copyrighted Materials and "Fair Use Guidelines" policy in on the Clemson University website for additional information: https://clemson.libguides.com/copyright.

Modification Statement:

The instructor reserves the right to modify any aspect of the syllabus at any time during the semester for reasons including but not limited to COVID-related situations.

Date of last update: January 7, 2024