

**VIRGINIA COMMONWEALTH UNIVERSITY
COLLEGE OF ENGINEERING
DEPARTMENT OF COMPUTER SCIENCE**

**CMSC 440: Data Communication and Networking
Spring 2023**

Credits: 3 lecture hours. 3 credits

Instructor: Dr. Tamer Nadeem

Office: ERB 2330, Engineering West Building

Email: tnadeem@vcu.edu
(start the *Subject* line with: CMSC440)

Work Phone: 804-828-0137

Classroom

& Time: Class: Room: W0101
Engineering Building West
Monroe Park Campus

Time: Tuesday & Thursday
9:30am - 10:45pm

Office Hours: Tuesday & Thursday
11:00pm – 12:00pm
or by appointment

Course Web Site: <https://virginiacommonwealth.instructure.com/courses/73911>

Prerequisites/ Co-requisites:

CMSC 257 - Computer Systems with a grade of "C" or better

Textbooks:

Computer Networking: A Top-Down Approach Featuring the Internet, 7th edition, by James F. Kurose and Keith W. Ross, Addison Wesley (May 6, 2016), ISBN-13: 978- 0133594140.

Course Description:

Semester course; 3 lecture hours. 3 credits. Prerequisites: CMSC 257 with a grade of C or better. This course explores computer networking, focusing on the applications and protocols that run on the Internet. We will take a top-down approach to the layered network architecture, studying applications first and then proceeding down the network “stack” towards the physical link. We will look at the operation of applications such as the web, FTP, e-mail, and DNS. At the transport layer, we will study both connectionless UDP and connection-oriented TCP. Since TCP is the protocol that the majority of Internet traffic uses, we will study its operation in-depth, including flow control and congestion control. We will also look at how data is routed through the Internet, regardless of transport protocol. We will also introduce current “hot” topics, such as network security and wireless/mobile network.

Course Goals

By the end of the semester, you should be able to complete the following tasks, among others:

- Design and implement a socket-based application using either TCP or UDP. Examples include chat, echo, a web client, and an FTP client.
- Explain how the choice of a transport protocol can affect networked applications.
- Use networking tools such as ping, traceroute, tcpdump, and dig to investigate a network.
- Explain what happens on the network when you click a link on a web page.
- Explain how an email message you send to a friend is sent and delivered.
- List the two main types of routing algorithms and which protocols use those algorithms. Describe the main differences between the two algorithms.
- Explain why routers cannot have a routing table with an entry for every other router in the Internet.
- Compute the end-to-end delay for a packet given the propagation delay, link bandwidth, and packet size.
- List the five layers of the Internet protocol stack and give an example of each.
- Explain the difference between congestion control and flow control and how each is implemented in TCP

Course requirements include (1) readings for class preparation and class participation, (2) programming assignments, (3) homework, (4) Mid-term exam and (5) final exam.

Learning outcomes and performance indicators:

The Computer Science Learning Objectives that are covered in this course are:

1 Analyze a complex computing problem and to apply principles of computing and other relevant disciplines to identify solutions

Graduates will have the ability to design a computer-based system, process, component or program as well as design non-computing requirements.

Performance indicators:

P.I. Ability to understand and identify the different actions/components of network protocols/services

2 Design, implement, and evaluate a computing-based solution to meet a given set of computing requirements in the context of the program's discipline.

Graduates will have the ability to implement a computer-based system, process, component or program.

Performance indicator:

P.I. Ability to design, implement, and test a networking protocol/service that gives correct results.

Course Schedule

Table shows class meeting days, topics, and readings. Typically, a weekly assignment will be posted by next day of the class with a due date on Sunday. **Dates and topics are subject to change during the course**

Class Meeting Days	Topics	Readings
Tuesday, January 17	Lec #01 - Course Logistics: Course structure, grading, assignments, etc. Introduction to Computer Network and the Internet (I): What is Internet?	<ul style="list-style-type: none"> • Syllabus • Slides • Kurose & Ross: Chapter 1, Sections: 1.1
Thursday, January 19	Lec #02 - Introduction to Computer Network and the Internet (II): The Network Edge, and The Network Core.	<ul style="list-style-type: none"> • Slides • Kurose & Ross: Chapter 1, Sections: 1.2 - 1.3
Tuesday, January 24	Lec #03 - Introduction to Computer Network and the Internet (III): Delay/Loss/Throughput, and Protocol Layers.	<ul style="list-style-type: none"> • Slides • Kurose & Ross: Chapter 1, Sections: 1.4
Thursday, January 26	Lec #04 - Introduction to Computer Network and the Internet (IV): Protocol Layers, Networks Vulnerability, and History of Computer Networking.	<ul style="list-style-type: none"> • Slides • Kurose & Ross: Chapter 1, Sections: 1.5 - 1.7
Tuesday, January 31	Lec #05 - Application Layer (I): Network Application Principles and Architecture, Client-Server Model.	<ul style="list-style-type: none"> • Slides • Kurose & Ross: Chapter 2, Sections: 2.1
Thursday, February 2	Lec #06 - Application Layer (II): Socket Programming.	<ul style="list-style-type: none"> • Slides • Kurose & Ross: Chapter 2, Sections: 2.7
Tuesday, February 7	Lec #07 - Application Layer (III): HTTP Application.	<ul style="list-style-type: none"> • Slides • Kurose & Ross: Chapter 2, Sections: 2.2 - 2.2.3
Thursday, February 9	Lec #08 - Application Layer (IV): HTTP (cont'd), Mail Applications.	<ul style="list-style-type: none"> • Slides • Kurose & Ross: Chapter 2, Sections: 2.2.4 - 2.3, 2.4 - 2.4.1
Tuesday, February 14	Lec #09 - Application Layer (IV): Mail (cont'd) and DNS Applications.	<ul style="list-style-type: none"> • Slides • Kurose & Ross: Chapter 2, Sections: 2.4.3 - 2.4.4, 2.5
Thursday, February 16	Lec #10 - Transport Layer (I): Introduction, Mux/Demux, and UDP, Intro to Reliable Transmission.	<ul style="list-style-type: none"> • Slides • Kurose & Ross: Chapter 3, Sections: 3.1 - 3.3
Tuesday, February 21	Lec #11 - Transport Layer (II): Reliable Data Transmission, pipelining.	<ul style="list-style-type: none"> • Slides • Kurose & Ross: Chapter 3, Sections: 3.4 - 3.4.1
Thursday, February 23	Lec #12 - Transport Layer (III): Pipelining, TCP.	<ul style="list-style-type: none"> • Slides • Kurose & Ross: Chapter 3, Sections: 3.4.2 - 3.5.1
Tuesday, February 28	Lec #13 - Mid Term Review	
Thursday, March 2	Mid Term Exam	

Tuesday, March 7	No Class – Spring Break	
Thursday, March 9	No Class – Spring Break	
Tuesday, March 14	Lec #14 - Transport Layer (IV): TCP, Flow Control, and Connection management.	<ul style="list-style-type: none"> • Slides • Kurose & Ross: Chapter 3, Sections: 3.5.2 - 3.5.5
Thursday, March 16	Lec #15 - Transport Layer (V): TCP Congestion Control.	<ul style="list-style-type: none"> • Slides • Kurose & Ross: Chapter 3, Sections: 3.5.6 - 3.7
Tuesday, March 21	Lec #16 - Network Layer (I): Virtual Circuit vs. Datagram Networks, and Routers, IP.	<ul style="list-style-type: none"> • Slides • Kurose & Ross: Chapter 4, Sections: 4.1 - 4.3.1
Thursday, March 23	Lec #17 - Network Layer (II): IP Fragmentation and IP Addressing.	<ul style="list-style-type: none"> • Slides • Kurose & Ross: Chapter 4, Sections: 4.3.2 - 4.3.3
Tuesday, March 28	Lec #18 - Network Layer (III): Basic routing, NAT, IPv6, and Generalized Forwarding (SDN data plane)	<ul style="list-style-type: none"> • Slides • Kurose & Ross: Chapter 4, Sections: 4.3.4 - 4.4.4
Thursday, March 30	Lec #19 - Network Layer (IV): Routing, Link State Routing, Distance Vector Routing.	<ul style="list-style-type: none"> • Slides • Kurose & Ross: Chapter 5, Sections: 5.1 - 5.2.1
Tuesday, April 4	Lec #20 - Network Layer (V): Scalable routing, intra-domain routing, inter-domain routing, SDN.	<ul style="list-style-type: none"> • Slides • Kurose & Ross: Chapter 5, Sections: 5.3 - 5.4.2, 5.5
Thursday, April 6	Lec #21 – Data Link Layer (I): Introduction, Error Detection and Correction, and Multiple Access.	<ul style="list-style-type: none"> • Slides • Kurose & Ross: Chapter 6, Sections: 6.1 - 6.3.1
Tuesday, April 11	Lec #22 – Data Link Layer (II): Multiple Access, LAN addressing, and Ethernet.	<ul style="list-style-type: none"> • Slides • Kurose & Ross: Chapter 6, Sections: 6.3 - 6.4
Thursday, April 13	Lec #23 – Data Link Layer (III): Switches, Link Virtualization, and a Day in the Life of a Web Page Request.	<ul style="list-style-type: none"> • Slides • Kurose & Ross: Chapter 6, Sections: 6.5 - 6.7
Tuesday, April 18	Lec #24 – Data Link Layer (IV): Introduction to Wireless/Mobile Networks, Wireless Links, and 802.11 Wireless LANs.	<ul style="list-style-type: none"> • Slides • Kurose & Ross: Chapter 7, Sections: 7.1 - 7.3.3
Thursday, April 20	Lec #25 - Security in Computer Networks Introduction, Cryptography, and Message Integrity.	<ul style="list-style-type: none"> • Slides • Kurose & Ross: Chapter 8, Sections: 8.1 - 8.3
Tuesday, April 25	Lec #26 – Final Exam Review	
Thursday, April 27	Backup Class	
Thursday, May 4	Final Exam (8:00am-10:50am)	

Course Grading Criteria

Grading

Your grade in this class will be based on the following:

(Note that these percentages are only approximate and are subject to change, but by no more than 10%.)

Programming Assignments	15%	These are to be completed individually unless otherwise specified and are due before midnight on the due date.
Written Homework Assignments	30%	These are to be completed individually and are due before midnight on the due date.
Midterm Exam	25%	This will be a closed-book and closed-Internet exam. The exam questions will be similar in style and complexity to the written homework assignments.
Final Exam	30%	This will be a closed-book and closed-Internet exam. Our final exam is scheduled for Monday, May 5, 2022 at 8:00am. The final will cover topics from the entire semester in which 25% of the exam will be on the topics covered before the mid-term and the remaining 75% of the exam will be on the topics covered after the mid-term exam.

Grading Scale

The grading scale is as follows:

(+ and - modifiers will be applied as appropriate)

90-100 =	A
80-89 =	B
70-79 =	C
60-69 =	D
0-59 =	F

Programming Assignment Grading Guidelines

- Programs that do not compile will receive a 0.
- Programming assignments will be graded based on how your program performs on a number of test cases. You are strongly encouraged to rigorously test your program before submitting it.
- Programming style (including code comments) and design will also be considered in grading. Sloppy programs that pass 100% of the tests will not receive a grade of 100.
- Include your name, assignment number, due date, and course in the comments of each file that you submit.

Late Assignments

Any assignment submitted after its deadline is considered late. The following penalties for late assignments apply:

- 0-24 hours late: -10%
- 25-48 hours late: -25%
- Over 48 hours late: not accepted, grade = 0

This time limit includes weekends -- they are counted just like weekdays. I reserve the right to specify that late submissions will not be accepted for particular assignments.

Technology Support - Engineering & VCU Resources:

- **Personal Computer Requirement:** For our current system requirements and recommendations, see: <https://egr.vcu.edu/admissions/accepted/computer-recommendations/>
- **Remote Access to Public Lab computers:** To provide remote access, we use the Citrix App2Go environment to provide full and exclusive control over "the next available" computer in the lab. See this link for more details: <https://wiki.vcu.edu/x/Oa0tBg>
- **VCU provides a lot of software available for students to download to their personal computers.** For a list of software and the specifics for each, see: <https://ts.vcu.edu/software-center/>. In particular, [Microsoft Office](#) is available free to students.
- **VCU has transitioned to Canvas.** See the Canvas Student Guide at this link: <https://community.canvaslms.com/t5/Student-Guide/tkb-p/student>
- **For IT help in the College of Engineering,** see our Wikipedia for "student" help at: <https://wiki.vcu.edu/display/EGRITHELP>
- **VCU's Technology Services (TS) provides support for "central IT" services.** If you have a technical issue with any of the following services, please submit a ticket with VCU Technology Services at <https://itsupport.vcu.edu/> or call (804) 828-2227. VCU TS maintains and supports these services and will be able to provide assistance to you.
 - VCU Cisco VPN
 - 2Factor or Dual Authentication (DUO)
 - Canvas
 - Gmail or other Google Apps
 - Zoom videoconferencing
 - VCU App2Go (Application server)
 - Resetting VCU password
- **For IT issues related to College of Engineering teaching and research,** email egrfixit@vcu.edu
- **For loaner Chromebooks for emergency purposes:** See this link for more details: <https://vcutsmpc.getconnect2.com/>

Student Responsibilities

(source: One VCU: Responsible Together available at:

<https://together.vcu.edu/students/>)

1. All students are required to complete the *Responsible Together Course* (<https://students.vcu.edu/dsa/rtc/>) by the time you arrive on campus for move-in, on-campus classes or to access any activities on campus.
2. Vaccination **is required** for all students who live, learn, work or will be on campus for any reason (excluding those with religious or health exemptions).
3. If you have not yet received your COVID-19 vaccination, you can make an appointment on-campus through University Student Health Services (<https://health.students.vcu.edu/web-portal/>) or at a provider near you (search vaccine availability at www.vaccines.gov).
4. Students who receive vaccination exemptions must follow safety guidelines for their health and for the health of our community
5. Masking indoors has been reinstated throughout the university and remains in effect for health system facilities.

Some VCU References

- One VCU: Better Together
 - <https://together.vcu.edu/>
- One VCU: Better Together – For Students
 - <https://together.vcu.edu/students/>
- Tips for Keep on Being Well
 - <https://students.vcu.edu/about/keep-on-being-well-at-vcu/>
- University Student Health Services
 - <https://health.students.vcu.edu/immunizations/submitting-immunization-records/>
- Student vaccine FAQ
 - <https://together.vcu.edu/faq/student-vaccine/>

Course Policies

Attendance

I expect you to attend class and to arrive on time. Your grade may be affected if you are consistently tardy. If you have to miss a class, you are responsible checking the course Canvas to find any assignments or notes you may have missed. Students may leave after 15 minutes if the instructor or a guest lecturer does not arrive in that time.

Computer Account and Email

Students should have a VCU email and Canvas accounts. This will allow you to log into the course's Canvas site. All VCU students automatically receive these accounts, though you may need to activate yours, particularly if you are new to VCU.

Students should activate their VCU e-mail accounts and check them every day. If a student chooses to have his/her messages forwarded to another account, it is the student's responsibility to take the necessary steps to have them forwarded.

All students in this course are responsible for making sure they have working accounts prior to the first assignment.

All students are expected to know and comply with VCU's Computer and Network Use policy, which can be reviewed at <https://policy.vcu.edu/universitywide-policies/policies/computer-and-network-resources-use.html>

Posting Questions and Getting Help

Questions of general interest should first be posted to either the Canvas Discussions (only if they have not already been answered) so that other students can benefit from the response or have an opportunity to respond to your question. Feel free to answer posted questions from other students too. Only questions of a private nature should be communicated to instructor through email. When sending a message to me, please allow a minimum of 24 hours for a response. Most of the time I will respond much faster, but sometimes meetings and other courses take over my schedule.

Be Proactive in Communication with Instructor

(adapted from [UWSP](#))

If you find that you have any trouble keeping up with assignments or other aspects of the course, make sure you let your instructor know as early as possible. As you will find, building rapport and effective relationships are key to becoming an effective professional. Make sure that you are proactive in informing your instructor when difficulties arise during the semester so that we can help you find a solution.

Tests and Make-ups

If a situation has occurred that requires your time and attention which will prevent submitting your graded activities on time, please notify your instructor 24 hours before the scheduled due date. It is the student's responsibility to give the instructor a written excuse and to arrange for any makeup work to be done. A makeup exam may be different (and possibly more difficult) than the regularly scheduled exam.

Course Disclaimer

Every attempt is made to provide a syllabus that is complete and that provides an accurate overview of the course. However, circumstances and events may make it necessary for the instructor to modify the syllabus during the semester. This may depend, in part, on the progress, needs, and experiences of the students.

Withdrawal

A syllabus constitutes an agreement between the student and the course instructor about course requirements. Participation in this course indicates your acceptance of its teaching focus, requirements, and policies. Please review the syllabus and the course requirements as soon as possible. If you believe that the nature of this course does not meet your interests, needs or expectations, if you are not prepared for the amount of work involved - or if you anticipate that the class meetings, assignment deadlines or abiding by the course policies will constitute an unacceptable hardship for you - you should drop the class by the drop/add deadline. For more information, please check the Records and Registration page (<http://rar.vcu.edu/registration/>).

University Policies

College Classroom Conduct

Please be respectful of your classmates and instructor by minimizing distractions during class. Cell phones must be turned off during class.

VCU Statement on Safety

What to know and do to be prepared for emergencies at VCU:

- Sign up to receive VCU text messaging alerts (<http://www.vcu.edu/alert/notify>). Keep your information up-to-date.
- Know the safe evacuation route from each of your classrooms. Emergency routes are posted in classrooms.
- Listen for and follow instructions from VCU or other designated authorities.
- Know where to go for additional emergency information (<http://www.vcu.edu/alert>).
- Know the emergency phone number for the VCU Police (828-1234). Report suspicious activities and objects.

VCU Honor System (from <https://conduct.students.vcu.edu/vcu-honor-system/>)

VCU recognizes that honesty, truth, and integrity are values central to its mission to advance knowledge and student success both in the world VCU students will enter, or return to, once they have graduated and in the university community as a microcosm of that world. In a community devoted to learning, a foundation of honor must exist if that community is to thrive with respect and harmony. Therefore, all members of the university community must conduct themselves in accordance with the highest standards of academic honesty, ethics, and integrity at all times.

Statement on Americans with Disabilities Act

Section 504 of the Rehabilitation Act of 1973 and the Americans with Disabilities Act of 1990 require Virginia Commonwealth University to provide an 'academic adjustment' and/or a 'reasonable accommodation' to any qualified individual with a physical or mental disability who self-identifies as having such. Students should contact the Disability Support Services office on the Monroe Park Campus (828-2253) or on the MCV Campus (828-9782) for appropriate academic adjustments or accommodations.

Requesting accommodations

(from One VCU: Responsible Together)

The university recognizes that some students who previously did not need Section 504 Academic Accommodations, and who have a qualifying condition or disability, may need support or assistance during the return to campus process. A modified approach for the temporary and more permanent need for accommodation has been developed and implemented to provide students with full access to programs and activities related to their academic majors. Because every case is different, student requests are evaluated on a case-by-case basis. Please share your need for an accommodation with the [Student Accessibility and Education Office](#), or for MCV Campus students, the [Division for Academic Success](#), after you have worked directly with your faculty member.

VCU Guidelines for Student Conduct

VCU faculties play a critical role in helping to build an environment that is conducive to the academic success of our students. As you know, VCU has policies and procedures designed to create an environment conducive to academic excellence. One of these policies and procedures can be found in a document entitled “Guidelines for Faculty Members Regarding Student Conduct in the Instructional Settings.” This document is available on the VCU Web at <http://www.students.vcu.edu/studentconduct>.

Understanding these guidelines will help you to encourage classroom behavior that does not detract from the quality of each student’s educational experience. Please read the document and think about your role in promoting a University culture based on mutual respect and civility. As a reminder, both faculty and students should turn off cell phones and pagers while in the classroom.

Student email standard

Email is considered an official method for communication at VCU. Students are expected to check their official VCU email on a frequent and consistent basis (the university recommends daily) in order to remain informed of university-related communications. Students are responsible for the consequences of not reading, in a timely fashion, university-related communications sent to their official VCU student email account. Mail sent to the VCU email address may include notification of university-related actions, including disciplinary action. Students must read this standard in its entirety at <https://ts.vcu.edu/media/technology-services/content-assets/university-resources/ts-groups/information-security/StudentEmailStandard.pdf>

Withdrawal from classes

Before withdrawing from classes, students should consult their instructor as well as other appropriate university offices. Withdrawing from classes may negatively impact a student’s financial aid award and his or her semester charges. To discuss financial aid and the student bill, visit the Student Services Center at 1015 Floyd Avenue (Harris Hall) and/or contact your financial aid counselor regarding the impact on your financial aid.

Religious Observances

It is the policy of VCU to accord students, on an individual basis, the opportunity to observe their traditional religious holidays. Students desiring to observe a religious holiday of special importance must provide advance written notification to each instructor by the end of the second week of classes. Instructors are encouraged to avoid scheduling on these dates one-time-only activities that cannot be replicated. Faculty members are expected to make reasonable accommodations to students who are absent because of religious observance through such strategies as providing alternative assignments or examinations or granting permission for audio or video recordings and the like.

Important Dates

Important dates for the semester are listed in the VCU Academic Calendar:

<https://academiccalendars.vcu.edu/>

Nondiscrimination policy

(from One VCU: Responsible Together)

VCU is committed to providing a safe, equitable and inclusive environment for all its employees, patients and students. Discrimination or discriminatory harassment is not only unlawful, it is harmful to the well-being of our university community. Our university's core values, specifically those related to diversity and inclusion, have withstood many difficult situations and trying times, and they will not falter now.

Reports of discrimination, bullying, harassment and/or stereotyping of persons of color or those impacted by COVID-19 or otherwise, will not be tolerated. Be assured that VCU will make every effort to address and prevent the occurrence of unlawful discrimination and, if necessary, take prompt and appropriate action to remedy and prevent its reoccurrence. Every member of our community is asked to:

- Become familiar with the university's policies on [Preventing and Responding to Discrimination](#) and [Duty to Report and Protection from Retaliation](#) in the VCU Policy Library.
- Consult with [Equity and Access Services](#) or [VCU Human Resources](#) for additional guidance on how to file a report of discrimination.
- Contact the [Office of Institutional Equity, Effectiveness and Success](#) (IES) on how to address and maintain a culture of inclusion.
- Encourage individuals who may need an ADA accommodation for a known or newly acquired disability, to contact the ADA/504 Coordinator in [ADA Services](#).
- Bookmark and share information on university or community agencies that offer support or services, such as [VCU's Counseling Services or Ombudsperson](#).
- Explore training and educational opportunities on diversity and inclusion at [IExcel Education](#) and through the [Office of Institutional Equity, Effectiveness and Success](#).
- Offer nonjudgmental support and empathy to those affected by current events and this health crisis.

Students should visit <http://go.vcu.edu/syllabus> and review all syllabus statement information. The full university syllabus statement includes information on safety, registration, the VCU Honor Code, student conduct, withdrawal and more.