CS433
Computer Networks
Fall 2014

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Goal

The goal of this course is to introduce the basic principles and technologies in modern computer networks, which should make you prepared for real communication applications and programming tasks in computer networks, especially in the global inter-networks. Configurations on Cisco routers will also be covered in this course.

Text and Software

The text is Computer Networks, 5^{th} ed., by Tanenbaum. For software we will use Linux C/C++ programming environment and Wiresharks, which can be freely obtained online (just search wireshark using your favorite search engine). Our network programming text is UNIX Network Programming, Vol. 1 by Stevens. The ebook is available from AU library electronically.

Course Outline

We will cover essentially all of Computer Networks. I hope to cover chapters 1-2 by the time of the quiz 1, chapters 3-4 for quiz 2, and chapters 5-8 for the remaining of the semester. The final will be comprehensive. Note this is a Computer Networks course. Specific technologies may become totally obsolete in a couple of years yet the principles have remained unchanged. Thus we will stress more on the concepts and principles with a goal of breath instead of depth. We will also use programming and experimentation to help you learn about networks. To fully benefit from what we do in class, you need to read the text before and after class.

Office Hours

MWF 9:30-11:00, Th 9:30-12, or by appointment

Note: You should feel free to drop by as long as my door is open and I am not in a meeting. I am usually in my office between 9:30 am and 4:00 pm. If you want to guarantee that I will be in at a time other than office hours, you only need to make an appointment.

Homework, Programming Assignments, and Lab

Homework problems will be assigned on a chapter basis, and will be collected and graded. I'll make solutions available after they are due. A list of homework problems is given at the end of this syllabus.

There are two programming assignments throughout this semester (In the second half of this course, we will focus more on network programming exercises). You will have approximately one month to finish each of them. Detailed instructions on these two assignments will be posted on ANGEL later this semester.

There will be a network lab component near the end of the semester during which you will learn how to setup Cisco network switches/routers. We will discuss the lab later in the semester.

All homework is due before class on the announced date. Late work will be assessed with 10% penalty per day, including weekends and holidays. No work will be accepted after being late for more than 2 days.

Web

Course information is available on ANGEL (https://angel.ashland.edu/). I'll post homework solutions, announcements, daily reading assignments, lecture notes, programming assignment solutions, and other course related information there.

Exams/Projects/Grades

We will have 2 quizes and a comprehensive take-home final. You will also complete a project in which you will design and implement one application level protocol. The project report is due near the end of the semester. I'll provide more information about this later. The two quizzes will be worth 150 points. You may bring a 3x5 card with notes written on one side to each quiz. The final is worth 150 points. The two programming assignments are worth 100 points (together) and the project is worth 50 points. Homework is worth 100 points. The networking lab is worth 50 points. I'll drop the lowest homework score from your grade. Course grades are based on total points earned. The final letter grade will be given based on the following scale. Your grades will be posted on angel for your reference throughout the semester.

(100 ≥ A ≥ 94) (94 > A- ≥90) (90 > B+ ≥ 87) (87 > B ≥ 84) (84 > B- ≥ 80) (80 > C+ ≥ 77) (77 > C ≥74) (74 > C- ≥70) (70 > D+ ≥ 67) (67> D ≥ 64) (64> D- ≥ 60) (60 > F ≥ 0)

Exam Schedule

Quiz1, Tuesday, Sep. 16th
Quiz2, Tuesday, Oct. 28th
Final, due by midnight, Sunday, Dec. 7th.

Honor code

All work that you hand in must be signed with the Ashland Honor Code according to the student handbook, I affirm that I have adhered to the Honor Code on this assignment. The pledge should also be typed in any electronically submitted work. Working together on assignments is not allowed. Examples of violations of academic integrity include: copy other students work, collaborate on homework or labs, request assistance online or from other resources other than the instructor, etc. I hope none of this will happen in this class. However, should an academic integrity violation occur, the violator will automatically receive an F for that assignment. If there is a second violation of the honor code from the same student, the student will receive an F for the course, and the last incident will be reported to the academic integrity council. You should feel free to ask me any question about any assignment.

Attendance

Attendance in this course is required. You are expected to attend each lecture and to be in class on time. In case of an absence, you must provide a documented excuse of absence or get my consent. I will take 10 rolls during the whole semester and excessive (more than 4) unexcused absences will result in 1% off from your final total percentage.

Students with Disabilities

Students with disabilities who have made contact with Disability Services, Center for Academic Support, Seventh Floor Library (419) 289-5904, are entitled to reasonable academic accommodations under the Americans with Disabilities Act of 1990; the Amendments to the Act of 2008 and Section 504 of the Rehabilitation Act of 1973. Students are encouraged to identify early in the semester. Ashland University makes every effort to provide reasonable equal access to students who qualify.

Electronic Communication Policy

You should use your AU email to communicate with me electronically and check your AU email regularly. Please don't use the ANGEL communication tool to email me. You don't have to turn in a hard copy of your code.

CS433 – Fall 2014. 28 Lectures					
Week	**Date**	**Lecture #**	**Topic**	**Section**	**HW due**
#1	**08/18/2014, Mon**				
	08/19/2014, Tue	**1**	Introduction. Network hardware and software, Layered protocols and protocol stacks. Server-client vs peer-peer.	1.1-1.3	
	08/20/2014, Wed				
	08/21/2014, Thu	**2**	Network protocol functions. OSI reference model. TCP/IP reference model. Middleware. ATM reference model.	1.4-1.7	
	08/22/2014, Fri				
	08/23/2014, Sat				
	08/24/2014, Sun				
#2	**08/25/2014, Mon**				
	08/26/2014, Tue	**3**	The socket interface. Basic characteristics and background. Using a pair of sockets for symetric communication. Setting up a connection. UNIX system calls for socket programming: socket, bind, listen, accept, connect. IP address/host lookup	Extra	
	08/27/2014, Wed				
	08/28/2014, Thu	**4**	Sample program: tcp echo client and server (server code to be implemented by students in programming 1). udp version of the echo client and server. wireshark demo and exercise	Extra	**Ch 1**
	08/29/2014, Fri				
	08/30/2014, Sat				
	08/31/2014, Sun				
#3	**09/01/2014, Mon**		Labor day (no class)		
	09/02/2014, Tue	**5**	physical layer. Some basic concepts. Fourier series. Baud rate, bit rate, and bandwidth. Nyquist's theorem. Shannon's theorem.	2.1	
	09/03/2014, Wed				
	09/04/2014, Thu	**6**	Transmission media(Wire: twisted pair and coaxial cable. Optical fiber. Wireless transmission. Satellite transmission.) Multiplexing (FDM, WDM, and TDM). Switching	2.2-2.5	
	09/05/2014, Fri				
	09/06/2014, Sat				
	09/07/2014, Sun				
#4	**09/08/2014, Mon**				
	09/09/2014, Tue	**7**	Communication system examples: Public telephone system, cable TV systems, and the mobile telephone networks	2.6-2.8	
	09/10/2014, Wed				
	09/11/2014, Thu	**8**	data link layer introduction, framing	3.1.1-3.1.2	**Ch 2**
	09/12/2014, Fri				
	09/13/2014, Sat				
	09/14/2014, Sun				
#5	**09/15/2014, Mon**				
	09/16/2014, Tue	**9**	CRC in data link layer	3.2.2	**Quiz 1 (ch 1 - 2)**
	09/17/2014, Wed				
	09/18/2014, Thu	**10**	Hamming coding	3.2.1	
	09/19/2014, Fri				
	09/20/2014, Sat				
	09/21/2014, Sun				
#6	**09/22/2014, Mon**				
	09/23/2014, Tue	**11**	Flow control	3.3-3.4	
	09/24/2014, Wed				
	09/25/2014, Thu	**12**	Intro to Multiple access protocols. ALOHA CSMA and CSMA/CD.	4.1-4.2.2	
	09/26/2014, Fri				
	09/27/2014, Sat				
	09/28/2014, Sun				
#7	**09/29/2014, Mon**				
	09/30/2014, Tue	**13**	collision free protocols and wireless communication issues	4.2.3-4.2.5	**Ch 3**
	10/01/2014, Wed				
	10/02/2014, Thu	**14**	FTP and wired LAN (ethernet)	4.3	
	10/03/2014, Fri				
	10/04/2014, Sat				
	10/05/2014, Sun				
#8	**10/06/2014, Mon**				
	10/07/2014, Tue		Smuckers and ATIC visit	no reading	
	10/08/2014, Wed				
	10/09/2014, Thu	**15**	Wireless Networks (802.11) and Bluetooth (802.15)	4.4, 4.6	
	10/10/2014, Fri				
	10/11/2014, Sat				
	10/12/2014, Sun				

CS433 – Fall 2014. 28 Lectures					
Week	**Date**	**Lecture #**	**Topic**	**Section**	**HW due**
	10/13/2014, Mon				
	10/14/2014, Tue	**16**	Data link layer devices and routing in data link layer	4.8	
	10/15/2014, Wed				
#9	**10/16/2014, Thu**	**17**	Begin network layer. Switching: circuit vs. packet. Virtual circuits and datagrams. Routing algorithms in network layer. Dijkstra's algorithm	5.1-5.2.2	**Ch4**
	10/17/2014, Fri				
	10/18/2014, Sat				
	10/19/2014, Sun				
	10/20/2014, Mon		Fall break (no class)		
	10/21/2014, Tue		Fall break (no class)		
	10/22/2014, Wed				
#10	**10/23/2014, Thu**	**18**	flood routing, distant vector routing, and link state routing	5.2.3-5.2.5	
	10/24/2014, Fri				
	10/25/2014, Sat				
	10/26/2014, Sun				
	10/27/2014, Mon				
	10/28/2014, Tue	**19**	Hierarchical routing, Broadcast routing,	5.2.6-5.2.7	**Quiz 2 (ch 3-4)**
	10/29/2014, Wed				
#11	**10/30/2014, Thu**	**20**	multicast routing, Mobile routing and Internetwork routing	5.2.8-5.2.10, 5.5	
	10/31/2014, Fri				
	11/01/2014, Sat				
	11/02/2014, Sun				
	11/03/2014, Mon				
	11/04/2014, Tue	**21**	IP. Datagram format. IP addressing. Subnets. CIDR. IP protocols (DHCP)	5.6	
	11/05/2014, Wed				
#12	**11/06/2014, Thu**	**22**	NAT, ICMP, ARP, Exercise	5.6	
	11/07/2014, Fri				
	11/08/2014, Sat				
	11/09/2014, Sun				
	11/10/2014, Mon				
	11/11/2014, Tue	**23**	IPv6, Transport layer intro	5.6, 6.1, 6.4, 6.5	
	11/12/2014, Wed				
#13	**11/13/2014, Thu**	**24**	TCP connection establishment and tear down. Sliding window and congestion control	6.2-6.3	**Ch5**
	11/14/2014, Fri				
	11/15/2014, Sat				
	11/16/2014, Sun				
	11/17/2014, Mon				
	11/18/2014, Tue	**25**	Application layer principle, DNS, Email	7.1-7.2	**Ch6**
	11/19/2014, Wed		Thanksgiving break (no class)		
#14	**11/20/2014, Thu**		Thanksgiving break (no class)		
	11/21/2014, Fri		Thanksgiving break (no class)		
	11/22/2014, Sat				
	11/23/2014, Sun				
	11/24/2014, Mon				
	11/25/2014, Tue	**26**	Multimedia and P2P	7.4	
	11/26/2014, Wed				
#15	**11/27/2014, Thu**	**27**	Network security – cryptography	Ch 8	
	11/28/2014, Fri				
	11/29/2014, Sat				
	11/30/2014, Sun				
	12/01/2014, Mon				
	12/02/2014, Tue	**28**	Network security – communication and authentication / final review	Ch8	**Ch7**
	12/03/2014, Wed				
#16	**12/04/2014, Thu**				
	12/05/2014, Fri				
	12/06/2014, Sat				
	12/07/2014, Sun		Final Exam due		

Problem 1

Imagine that you have trained your St. Bernard, Ashley, to carry a box of three 8-mm tapes instead of a flask of brandy. (When your disk fills up, you consider that an emergency.) These tapes each contain 12 gigabytes. The dog can travel to your side, wherever you may be, at 18km/hour. For what range of distances does Ashley have a higher data rate than a transmission line whose data rate (excluding overhead) is 200Mbps? How does your answer change if

1. Ashley's speed is doubled;
2. each tape capacity is doubled;
3. the data rate of the transmission is doubled.

Problem 2

A factor in the delay of a store-and-forward packet-switching system is how long it takes to store and forward a packet through a switch. If switching time is 10μ sec, is this likely to be a major factor in the response of a client-server system where the client is in Ashland OH and the server is in Los Angeles CA? Assume the propagation speed is in copper and fiber to be 2/3 the speed of light in vacuum. You can use google map to figure the distance bewteen the two locations.

Problem 3

A disadvantage of a broadcast subnet is the capacity wasted when multiple hosts attempt to access the channel at the same time (i.e. contension). As a simplistic example, suppose that time is divided into discrete slots, with each of the n hosts attempting to use the channel with the same probability p during each slot. What fraction of the slots will be wasted due to collision? Keep in mind that once a contension occurs, the channel is wasted for the whole time slot.

Problem 4

A system has an n-layer protocol hierarchy. Applications generate messages of length M bytes. At each of the layers, an h-byte header is added. What fraction of the network bandwidth is filled with headers?

Problem 5

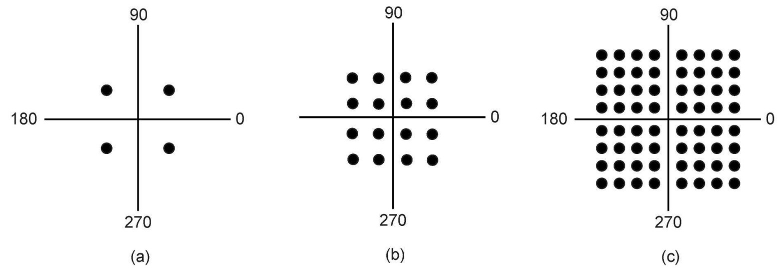
An image is 1900 x 1600 pixels with 4 bytes/pixel. Assume the image is uncompressed. How long does it take to transmit it over a 56k-modem channel? a 6-Mbps cable modem? Over a 100-Mbps Ethernet at AU? Over 10-Gbps Ethernet?

Problem 6

Two networks each provide reliable connection oriented service. One of them offers a reliable byte steam and the other offers a reliable message stream. Are these identical? If so, why is the distinction made? If not, give an example of how they differ.

Problem 1

A modem constellation diagram has data points as show in the figure below. How many bps can a modem with these parameters achieve at 1200 symbols/second?



Problem 2

How many frequencies does a full-duplex QAM-64 modem use? Justify your answer.

Problem 3

Sixteen signals, each requiring 4000hz, are multiplexed onto a single channel using FDM. What is the minimum bandwidth required for the multiplexed channel? Assume that the guard bands are 400Hz wide.

Problem 4

Suppose that A, B, and C are simultaneously transmitting 0, 1, and 0 bits, using a CDMA system with the chip sequence below. What is the resulting chip sequence?

A = (–1 –1 –1 +1 +1 –1 +1 +1)

B = (–1 –1 +1 –1 +1 +1 +1 –1)

C = (–1 +1 –1 +1 +1 +1 –1 –1)

D = (–1 +1 –1 –1 –1 –1 +1 –1)

Problem 5

A CDMA receiver gets the following chips.: (-1 +1 -3 +1 -1 -3 +1 +1). Assuming the chip sequence is the same as in the Fig above, which stations transmitted, and which bits did each one send?

Problem 1

The followling character encoding is used in a data link protocol.
A: 01000111 B: 11100011 FLAG: 01111110 ESC: 11100000
Show the bit sequence transmitted in binary for the four character frame A B ESC FLAG when each of the following framing method is used:

1. Byte count
2. Flag bytes with byte stuffing
3. Starting and ending flag bytes with bit stuffing

Problem 2

The following data fragment occurs in the middle of a data stream for which the byte-stuffing algorithm described in the text is used: C S ESC 4 ESC FLAG FLAG 3 3. What is the output after stuffing?

Problem 3

A bit string, 0111110011111011111110, needs to be transmitted at the data link layer. What is the string actually transmitted after bit stuffing?

Problem 4

Sixteen-bit messags are transmitted using a Hamming code. how many check bits are needed to ensure that the receiver can detect and correct single-bit errors? Show the bit pattern transmitted for the message 1101001100110101. Assume that even parity is used in the Hamming code.

Problem 5

A 12-bit Hamming code whose hexadecimal value is 0xE4F arrives at a receiver. What was the original value in hexadecimal? Assume that not more than 1 bit is in error.

Problem 6

Suppose that a message 1001 1100 1010 0011 is transmitted using Internet Checksum (4-bit word). What is the value of the checksum?

Problem 7

What is the remainder obtained by dividing $x^7 + x^5 + 1$ by the generator polynomial $x^3 + 1$?

Problem 8

A bit stream 10011101 is transmitted using the standard CRC method described in the text. The generator polynomial is $x^3 + 1$. Show the actual bit string transmitted. Suppose that the third from the left is inverted during transmission. Show that this error is detected at the receiver's end. Give an example of bit errors in the bit string transmitted that will not be detected by the receiver.

Problem 1

How long does a station, s, have to wait in the worst case before it can start transmitting its frame over a LAN that uses the basic bit-map protocol? How about the worst case for binary-countdown protocol?

Problem 2

Sixteen stations, numbered 1 through 16, are contending for the use of a shared channel using the adaptive tree walk protocol. If all the stations whose addresses are prime numbers suddenly become ready at once, how many bit slots are needed to resolve the contention.

Problem 3

Consider five wireless stations, A, B, C, D, and E. Station A can communicate with all other stations. B can communicate with A, C and E. C can communicate with A, B, and D. D can communicate with A, C and E. E can communicate with A, D, and B.

- When A is sending to B, what other communications are possible?
- When B is sending to A, what other communications are possible?
- When B is sending to C, what other communications are possible?

Problem 4

What is the encoding on a classic Ethernet for the bit stream 0001110101 using

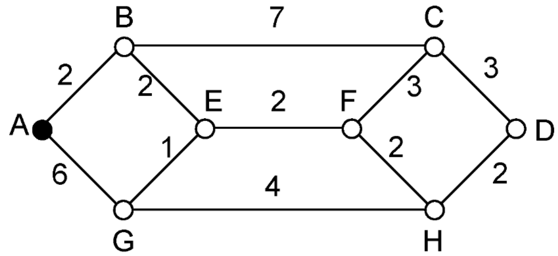
- FSK
- ASK

Problem 5

A 1-km-long, 10-Mbps CSMA/CD LAN has a propagation speed of 200m/μsec. Repeaters are not allowed in this system. Data frames are 256 bits long including 32 bits of header, checksum, and other overhead. The first bit slot after a successful transmission is reserved for the receiver to capture the channel in order to send a 32-bit ack frame. What is the effective data rate, excluding overhead, assuming that there are no collisions?

Problem 1

Consider the network of the following figure but ignore the weights on the lines. Suppose that it uses flooding as the routing algorithm. If a packet sent by A to D has a maximum hop count of 3, list all routes it will take. Also tell how many hops worth of bandwidth it consumes.

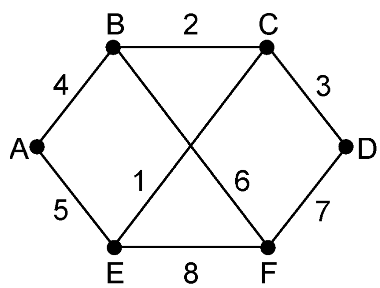


Problem 2

Give a simple heuristic for finding two paths through a network from a given source to a given destination that can survive the loss of any communication line (assuming two such paths exist). The routers are considered reliable enough, so it is not necessary to worry about the possiblity of router crashes.
Hint: Dijkstra's algorithm might be a good starting point.

Problem 3

Consider the subnet in the following figure. Distance vector routing is used, and the following vectors just come into router C: from B: (5, 0, 8, 12, 6, 2); from D: (16, 12, 6, 0, 9, 10); and from E: (7, 6, 3, 9, 0, 4). The measured delays to B, D, and E, are 6, 3, and 5, respectively. What is C's new routing table? Give both the outing line to use and the expected delay.



Problem 4

In the following packet buffer for router B of the previous figure, the Boolean OR of the two sets of ACF bits are 111 in every row. Is this just an accident here, or does it hold for all subnets under all circumferences?

			Send flags			ACK flags			
Source	Seq.	Age	A	C	F	A	C	F	Data
A	21	60	0	1	1	1	0	0	
F	21	60	1	1	0	0	0	1	
E	21	59	0	1	0	1	0	1	
C	20	60	1	0	1	0	1	0	
D	21	59	1	0	0	0	1	1	

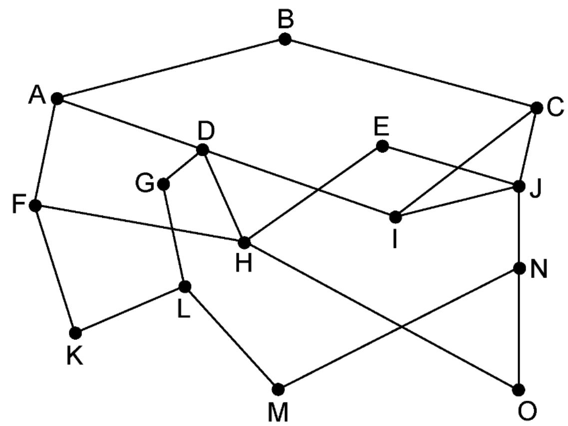
Problem 5

For hierarchical routing with 4800 routers, what region and cluster sizes should be chosen to minize the size of the routing table for a three-layer hierarchy? A good starting place is the hypothesis that a solution with k clusters of k regions of k routers is close to optimal, which means k is about the cube route of 4800 (around 16). Use trial and error to check out combincations where all three parameters are in the general vicinity of 16.

Problem 6

Looking at the subnet below, how many packets are generated by a broadcast from B, using

- reverse path forwarding
- the sink tree

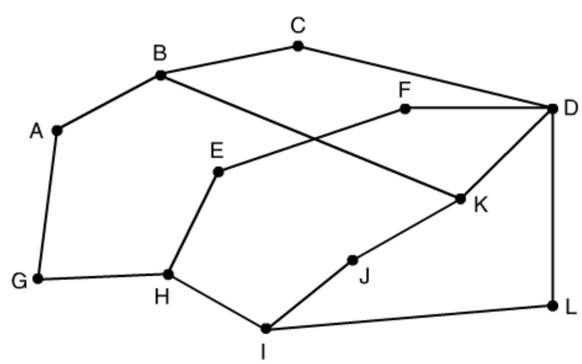


Problem 7

Consider Fig. 5-15(a) in our textbook. Image that once new line is added, between F and G, but the sink tree in Fig. 5-15(b) remains unchanged. What changes occur to Fig. 5-15(c)?

Problem 8

Compute a multicast spanning tree for route C in the following subnet for a group with members at routes A, B, C, D, E, F, I, and K.



Problem 1

Why does the maximum packet lifetime, T, have to be large enough en ensure that not only the packet but also its acknowledgements have vanished?

Problem 2

Why does UDP exist? Would it not have been enough to just let user processes send raw IP packets?

Problem 3

Both UDP and TCp use port numbers to identify the destination entity when delivering a message. Give two reasons for why these protocols invented a new abstract ID (port numbers), instead of using prcocess IDs, which already existed when these protocols were designed.

Problem 4

What is the fastest line speed at which a host can blast out 1500-byte TCP payloads with a 120-sec maximum packet lifetime without having the sequence numbers wrap around? Take TCP, IP, and Ethernet overhead into consideration. Assume that Ethernet frames may be sent continuously.

Problem 1

DNS uses UDP instad of TCP. If a DNS packet is lost, there is no automatic recovery. Does this cause a problem, and if so, how is it solved?

Problem 2

Can a machine with a single DNS name have multiple IP addresses? How could this occur?

Problem 3

In addition to being subject to loss, UDP packets have a maximum length, potentially as low as 576 bytes. What happens when a DNS name to be looked up exceeds this length? Can it be sent in two packets?

Problem 4

Can a computer have two DNS names that fall in different top-level domains? If so, give a plausible example. If not, explain why not.