

**New York University**  
**Computer Science Department**  
**Courant Institute of Mathematical Sciences**

**Course Title:** Data Communication & Networks  
**Instructor:** Jean-Claude Franchitti

**Course Number:** g22.2662-001  
**Session:** 4

**Assignment #4**

**I. Due**

Thursday, October 14 2021 at the beginning of class.

**II. Objectives**

1. Learn link layer (links, access networks, and LANs) concepts.

**III. References**

1. Slides and handouts posted on the course Web site
2. Textbook chapter 6

**IV. Software Required**

1. Microsoft Word.
2. Win Zip as necessary.

**V. Assignment**

**Problem 1:**

- a. Describe the difference between router and switch
- b. List three broad classes of Medium Access (MAC) Protocols
- c. How big the MAC address space?

**Problem 2:**

- a. Consider the following data to be sent. Using two-dimensional even bit parity, calculate the row and column parity bits.

10100101  
10001001

00101100

- b. Assume an 8-bit data to be sent via a link as: 10101101, assume G as 1001. Using Cyclic redundancy check calculate the R.
- c. In CSMA/CD, after the 4<sup>th</sup> collision what is the probability that a node chooses K=3?

**Problem 3:** Considering an 11-bit data sequence 10101011100 and generator polynomial  $P(X) = X^4 + X^3 + X^2 + 1$ .

- a. Calculate CRC and indicate bit sequence transmitted
- b. Assume that the 9th data bit (from left) has been changed in the transmission system. Show how the detecting algorithm will identify the error.

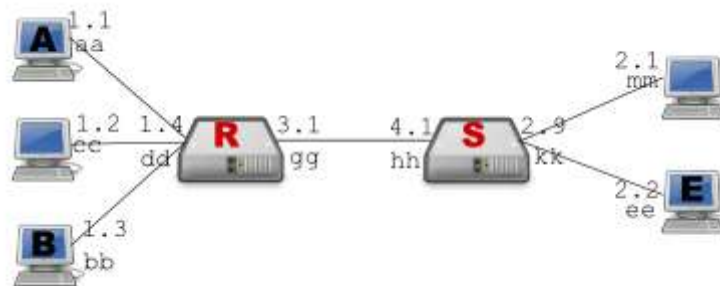
**Problem 4:** Consider a CSMA/CD network running at 100 Gbps over a 10 kilometer long cable (without repeaters). Assume that the signal speed in the cable is 500,000 kilometers/sec. What is the minimum frame size?

**Problem 5:** Consider a network that consists of two nodes A and B that are located on opposite ends of a 1 kilometer cable, and both nodes have a single 1,500 bits frame (inclusive of all headers and preambles) to send to each other. Assume that both nodes attempt to start transmission at time  $t = 0$  and that there are four repeaters between A and B, each inserting a 33 bit delay. We will assume for the purpose of this exercise that the transmission rate is 100 Mbps and that CSMA/CD is used for medium sharing with backoff intervals of multiples of 512 bits. Also assume that after the first collision, node A draws  $K = 0$  and node B draws  $K = 1$  as part of their exponential back-off step. You can ignore the use of a Jam signal and a 96 bit time delay.

- a. Assuming a propagation speed of  $2 \times 10^8$  meters/second, what is the (one way) propagation delay between A and B in seconds? (Note: the propagation delay should include the repeater delays)
- b. At what time will the packet coming from node A be completely delivered to node B? (Note: the time computed should be expressed in seconds)
- c. If node A is the only node that has a packet to send and the repeaters are replaced by switches, at what time will the packet coming from node A be completely delivered at node B? (Note: you may assume that each switch has a twenty bit processing delay in addition to a store and forward delay, and the time computed should be expressed in seconds)

**Problem 6:** An organization uses one Ethernet and one Token Ring LAN. They wish to have these two LANs communicate with one another using a protocol conversion bridge rather than a router. Take a look at the MAC protocol and frame format for the Ethernet (IEEE 802.3) and the Token Ring (IEEE 802.5) LAN standards. Explain how a bridge would allow the two networks to communicate. Please provide a diagram of the LAN and bridge setup to substantiate your answer and describe the modifications required to the MAC frames and their fields. Also describe how the MAC layer acknowledgements might be handled on each side of the bridge.

**Problem 7:** Consider the following network which uses “simplified” IP addresses of the form #.# where the number to the left of the period is the network portion and the number to the right of the period is the host portion. This network also uses “simplified” MAC addresses of the form @@.

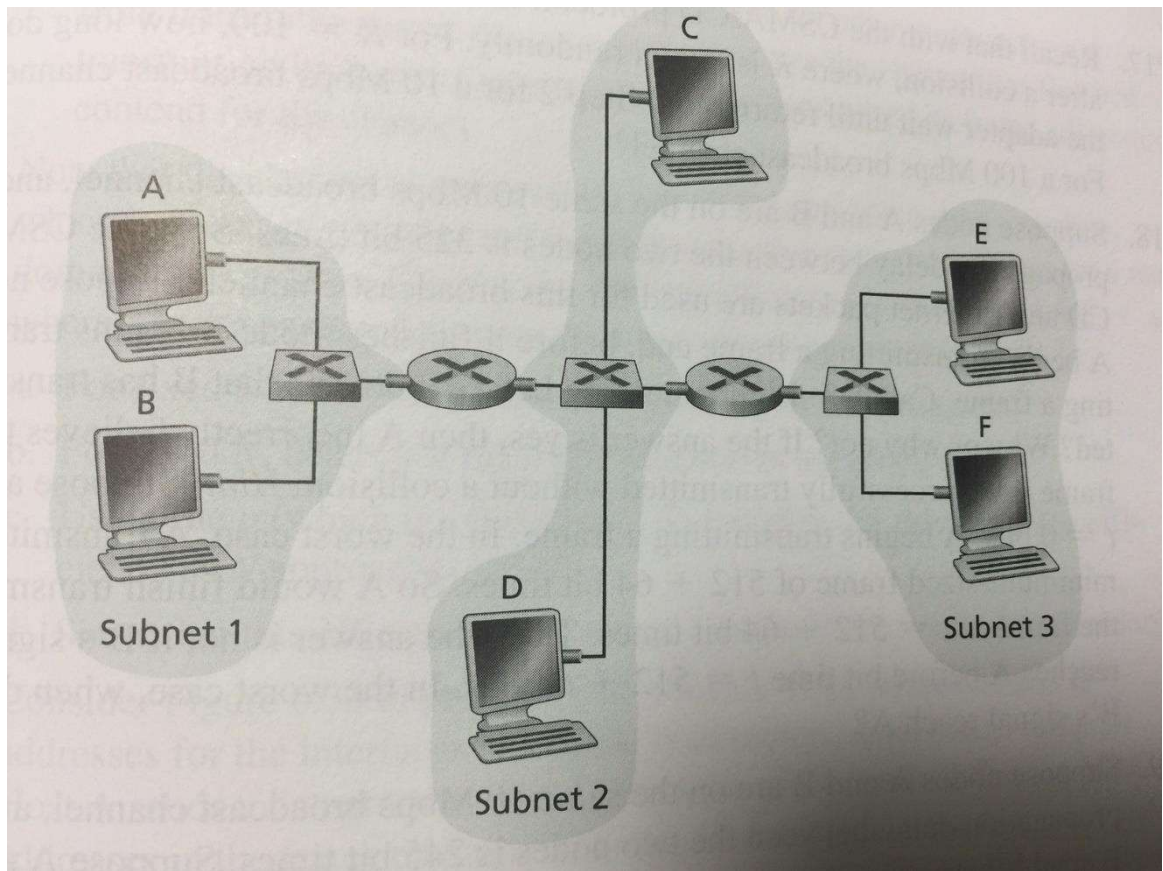


Assume that the device R is both a link layer switch (for aa, bb, cc, dd, and gg) and a network/internetwork layer router. Also assume that the device S is both a link layer switch (for ee, hh, kk, and mm) and a network/internetwork layer router.

Suppose that an application bound to port 2401 on workstation A wants to use UDP to send the message "Hello!" to an application bound to port 1608 on workstation E. Suppose further that the header for the transport layer protocol only contains the FROM port and the TO port, the header for the network/internetwork protocol only contains the FROM IP address and TO IP address, and the header for the physical/link layer protocol only contains the FROM MAC address and the TO MAC address.

- Illustrate the complete physical/link layer frame created by the application on A.
- Illustrate the complete physical/link layer frame when it leaves R.
- Illustrate the complete physical/link layer frame when it leaves S.

**Problem 8:** Textbook chapter 6 problem P15 (page 510-511).



Consider the network configuration shown in the picture above and suppose that the router between subnets 1 and 2 is replaced by a switch S1, and that the router between subnets 2 and 3 is labeled as R1.

- a. Consider sending an IP datagram from Host E to Host F. Will Host E ask router R1 to help forward the datagram? Why? In the Ethernet frame containing the IP datagram, what are the source and destination IP and MAC addresses?
- b. Suppose E would like to send an IP datagram to B and assume that E's ARP cache does not contain B's MAC address. Will E perform an ARP query to find B's MAC address? Why? In the Ethernet frame (containing the IP datagram destined to B) that is delivered to router R1, what are the source and destination IP and MAC addresses?
- c. Suppose Host A would like to send an IP datagram to Host B, and neither A's ARP cache contains B's MAC address nor does B's ARP cache contain A's MAC address. Further suppose that the switch S1's forwarding table contains entries for Host B and router R1 only. Thus, A will broadcast an ARP request message. What actions will switch S1 perform once it receives the ARP request message? Will router R1

also receive this ARP request message? If so, will R1 forward the message to Subnet 3? Once Host B receives this ARP request message, it will send back to Host A an ARP response message. But will it send an ARP query message to ask for A's MAC address? Why? What will switch S1 do once it receives an ARP response message from Host B.

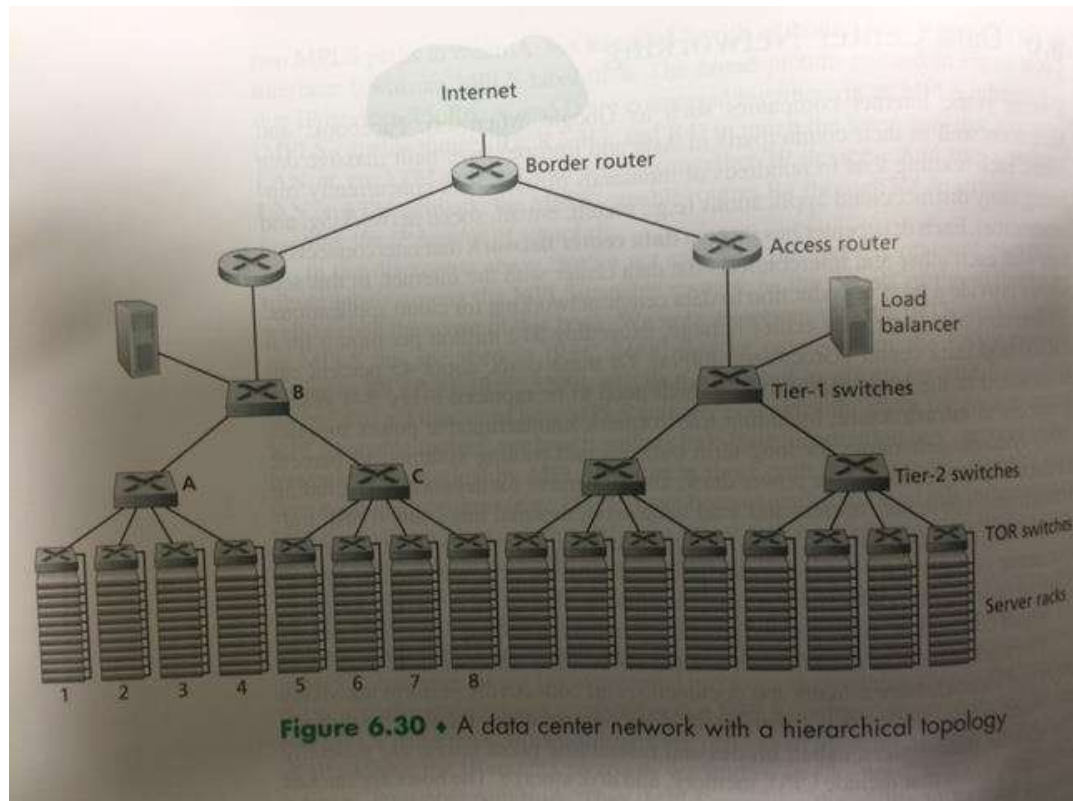
**Problem 9:** Textbook chapter 6 problem P27 (page 514).

In this problem, we explore the use of small packets for Voice-over-IP applications. One of the drawbacks of a small packet size is that a large fraction of link bandwidth is consumed by overhead bytes. To this end, suppose that the packet consists of  $P$  bytes and 5 bytes of header.

- a. Consider sending a digitally encoded voice source directly. Suppose the source is encoded at a constant rate of 128 kbps. Assume each packet is entirely filled before the source sends the packet into the network. The time required to fill a packet is the "packetization delay". In terms of  $L$ , determine the packetization delay in milliseconds.
- b. Packetization delays greater than 20 msec can cause a noticeable and unpleasant echo. Determine the packetization delay for  $L = 1,500$  bytes (roughly corresponding to a maximum-sized Ethernet packet) and for  $L = 50$  (corresponding to an ATM packet).
- c. Calculate the store-and-forward delay at a single switch for a link rate of  $R = 622$  Mbps for  $L = 1,500$  bytes, and for  $L = 50$  bytes.
- d. Comment on the advantages of using a small packet size.

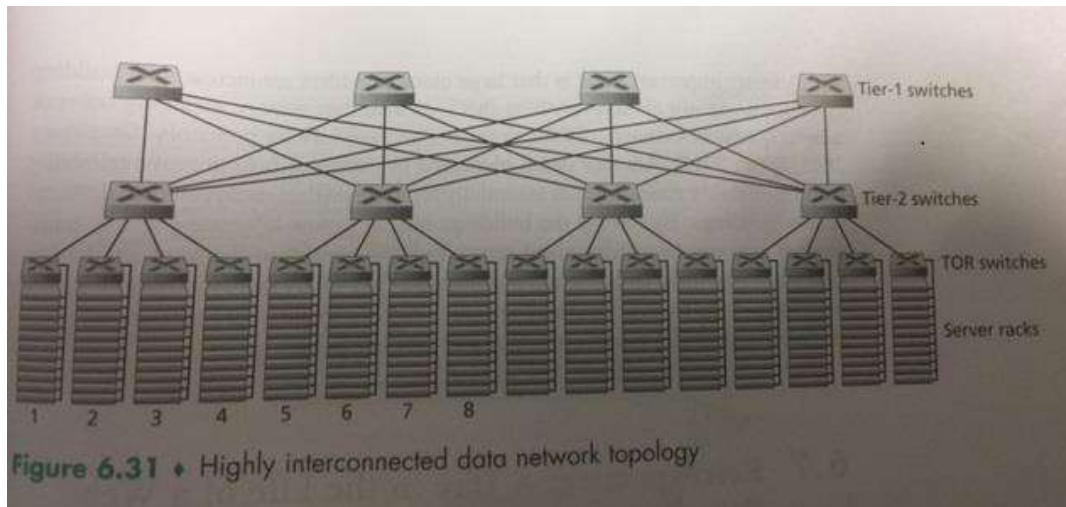
**Problem 10:** Textbook chapter 6 problem P33 (page 515).

Consider the hierarchical network in Figure 6.30 below:



Suppose that the data center needs to support e-mail and video distribution among other applications. Suppose four racks of servers are reserved for e-mail and four racks are reserved for video. For each of the applications, all four racks must lie below a single tier-2 switch since the tier-2 to tier-1 links do not have sufficient bandwidth to support the intra-application traffic. For the e-mail application, suppose that for 99.9 percent of the time only three racks are used, and that the video application has identical usage patterns.

- For what fraction of time does the e-mail application need to use a fourth rack? How about for the video application?
- Assuming e-mail usage and video usage are independent, for what fraction of time do (equivalently, what is the probability that) both applications need their fourth rack?
- Suppose that it is acceptable for an application to have a shortage of servers for 0.001 percent of time or less (causing rare periods of performance degradation for users. Discuss how the topology in Figure 6.31 below can be used so that only seven racks are collectively assigned to the two applications (assuming that the topology can support all the traffic).



### Homework Submission Guidelines:

1. Save the file as a Word document.
2. Name the file “**firstname\_lastname\_hw\_4.docx**” (e.g., “john\_doe\_hw\_4.docx”).
3. Submit your assignment electronically via NYU Classes by the due date.

Use the following naming convention in the subject line of the eMail:  
**“DCN - firstname lastname - homework 4”**  
 (e.g.: “DCN – John Doe - homework 4”).

In the case source code is submitted, include your name as a comment at the top of each file.

(Note: all files submitted should include your name).

## VI. Deliverables

1. Electronic:

Your assignment file must be submitted via NYU Brightspace. The file must be created and sent by the beginning of class. After the class period, the homework is late. The email clock is the official clock.

2. Cover page and other formatting requirements:

The cover page supplied on the next page must be the first page of your assignment electronic submission.

Fill in the blank area for each field.

**NOTE:**

**The sequence of the electronic submission is:**

- 1. Cover sheet**
- 2. Assignment Answer Sheet(s)**

**Assignment Layout (25%)**

- Assignment is neatly assembled on 8 1/2 by 11 layout.
- Cover page with your name (last name first followed by a comma then first name), username and section number with a signed statement of independent effort is included.
- Answers to Problems 1 to 10 in part V are correct.
- File name is correct.

**Answers to Individual Questions:**

**(100 points total, all questions weighted equally)**

- Assumptions provided when required.

**VII. Sample Cover Sheet:**



Name \_\_\_\_\_ Date: \_\_\_\_\_  
(last name, first name)

Section: \_\_\_\_\_

#### **Assignment 4**

**Total in points** (100 points total): \_\_\_\_\_

**Professor's Comments:**

**Affirmation of my Independent Effort:** \_\_\_\_\_  
(Sign here)