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SUBEJCT NAME:	**COMPUTER NETWORKS**

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1 (Data communication Components)	Data Communications and Networking, BEHROUZ A. FOROUZAN, McGraw-Hill, FIFTH EDITION		1	Q1-1 to Q1-11, Q1-13 to Q1-14, P1-1 to P1-5	27-28
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	Data Communications and Networking, BEHROUZ A. FOROUZAN, McGraw-Hill, FIFTH EDITION		4	Q4-2 to Q4-3, P 4-15, P4-17, P4-19	131, 133

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2 (Data Link Layer and Medium Access Sub Layer)	Data Communications and Networking, BEHROUZ A. FOROUZAN, McGraw-Hill, FIFTH EDITION		9	Q9-1 to Q9-6, Q9-10 to Q9-11, Q9-14, P9-1 to P9-2	253-255

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3 (Network layer)	Data Communications and Networking, BEHROUZ A. FOROUZAN, McGraw-Hill, FIFTH EDITION		18,19,20, 22	Q18-1 to Q18-12, P18-1 to 22, Q19-1 to 16, P19-1 to P19-11, Q20-2 to Q20-5, Q20-7 to Q20-15, P20-5, P20-8, P20-9, P20-14, Q22-1 to Q22-6, P22-2, P22-3	557-686
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3 (Transport layer)	Data Communications and Networking, BEHROUZ A. FOROUZAN, McGraw-Hill, FIFTH EDITION		23	Q23-1 to Q23-2, Q23-5 to Q23-7, Q23-10 to Q23-14, P23-3, P23-5, P23-9, P23-22	728-733
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4 (Application layer)	Data Communications and Networking, BEHROUZ A. FOROUZAN, McGraw-Hill, FIFTH EDITION		25, 26, 27, 28 & 29	Q25-1 to Q25-10 Q26-3 to Q26-9, Q26-11 to Q26- 20, Q26-23 to Q26-26 Q27-1 to Q27-10, Q27-24, Q28-28 to Q28-30, Q31-5 to Q31-13, Q31-24 to Q31-25	866 to 1049
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Module 1

Physical Layer

Book: Data Communications and Networking by BA. Forouzan

2 marks

Q1-1. Identify the five components of a data communications system.
Q1-2. What are the three criteria necessary for an effective and efficient network?
Q1-3. What are the advantages of a multipoint connection over a point-to-point one?
Q1-4. What are the two types of line configuration?
Q1-5. Categorize the four basic topologies in terms of line configuration.
Q1-6. What is the difference between half-duplex and full-duplex transmission modes?
Q1-7. Name the four basic network topologies, and cite an advantage of each type.
Q1-8. For n devices in a network, what is the number of cable links required for a mesh, ring, bus, and star topology?
Q1-9. What are some of the factors that determine whether a communication system is a LAN or WAN?
Q1-10. What is an internet? What is the Internet?
Q1-11. Why are protocols needed?

Q1-13. How many point-to-point WANs are needed to connect n LANs if each LAN should be able to directly communicate with any other LAN?
Q1-14. When we use local telephones to talk to a friend, are we using a circuit-switched network or a packet-switched network?

1.7.3 Problems

P1-1. What is the maximum number of characters or symbols that can be represented by Unicode? (2 marks)
P1-2. A color image uses 16 bits to represent a pixel. What is the maximum number of different colors that can be represented? (2 marks)
P1-3. Assume six devices are arranged in a mesh topology. How many cables are needed? How many ports are needed for each device? (2 marks)
P1-4. For each of the following four networks, discuss the consequences if a connection fails.
a. Five devices arranged in a mesh topology
b. Five devices arranged in a star topology (not counting the hub)
c. Five devices arranged in a bus topology
d. Five devices arranged in a ring topology (5 marks)
P1-5. We have two computers connected by an Ethernet hub at home. Is this a LAN or a WAN? Explain the reason. (2 marks)

Q2-2. Which layers of the TCP/IP protocol suite are involved in a link-layer switch? (2 marks)

Q2-3. A router connects three links (networks). How many of each of the following layers can the router be involved with? (2 marks)

a. physical layer b. data-link layer c. network layer

Q2-4. In the TCP/IP protocol suite, what are the identical objects at the sender and the receiver sites when we think about the logical connection at the application layer? (2 marks)

Q2-5. A host communicates with another host using the TCP/IP protocol suite. What is the unit of data sent or received at each of the following layers? (2 marks)

a. application layer b. network layer c. data-link layer

Q2-6. Which of the following data units is encapsulated in a frame? (2 marks)

a. a user datagram b. a datagram c. a segment

Q2-8. Which of the following data units has an application-layer message plus the header from layer 4? (2 marks)

a. a frame b. a user datagram c. a bit

Q2-9. List some application-layer protocols mentioned in this chapter. (2 marks)

Q2-11. What are the types of addresses (identifiers) used in each of the following layers? (2 marks)

a. application layer b. network layer c. data-link layer

P2-5. Assume we have created a packet-switched internet. Using the TCP/IP protocol suite, we need to transfer a huge file. What are the advantage and disadvantage of sending large packets? (2 marks)

P2-6. Match the following to one or more layers of the TCP/IP protocol suite: (5 marks)

a. route determination

b. connection to transmission media

c. providing services for the end user

P2-7. Match the following to one or more layers of the TCP/IP protocol suite: (5 marks)

a. creating user datagrams

b. responsibility for handling frames between adjacent nodes

c. transforming bits to electromagnetic signals

Chapter 3: Introduction to Physical Layer

Q3-5. Distinguish between baseband transmission and broadband transmission. (5 marks)

Q3-6. Distinguish between a low-pass channel and a band-pass channel. (5 marks)

Q3-7. What does the Nyquist theorem have to do with communications? (2 marks)

Q3-8. What does the Shannon capacity have to do with communications? (2 marks)

Q3-9. Why do optical signals used in fiber optic cables have a very short wave length? (2 marks)

P3-4. What is the bandwidth of a signal that can be decomposed into five sine waves with frequencies at 0, 20, 50, 100, and 200 Hz? All peak amplitudes are the same. Draw the bandwidth. (5 marks)

P3-7. What is the bit rate for each of the following signals? (5 marks)

a. A signal in which 1 bit lasts 0.001 s

b. A signal in which 1 bit lasts 2 ms

c. A signal in which 10 bits last 20 μs

P3-8. A device is sending out data at the rate of 1000 bps. (5 marks)

a. How long does it take to send out 10 bits?

b. How long does it take to send out a single character (8 bits)?

c. How long does it take to send a file of 100,000 characters?

P3-15. A signal travels from point A to point B. At point A, the signal power is 100 W. At point B, the power is 90 W. What is the attenuation in decibels? (5 marks)

P3-16. The attenuation of a signal is −10 dB. What is the final signal power if it was originally 5 W? (5 marks)

P3-18. If the bandwidth of the channel is 5 Kbps, how long does it take to send a frame of 100,000 bits out of this device? (5 marks)

P3-29. We have a channel with 4 KHz bandwidth. If we want to send data at 100 Kbps, what is the minimum SNR_{dB}? What is the SNR? (5 marks)

P3-31. What is the length of a bit in a channel with a propagation speed of 2×10^8 m/s if the channel bandwidth is (5 marks)

a. 1 Mbps? b. 10 Mbps? c. 100 Mbps?

P3-32. How many bits can fit on a link with a 2 ms delay if the bandwidth of the link is (2 marks)

a. 1 Mbps? b. 10 Mbps? c. 100 Mbps?

Chapter 4: Digital Transmission

Q4-2. Distinguish between a signal element and a data element. (2 marks)

Q4-3. Distinguish between data rate and signal rate. (2 marks)

P4-15. What is the Nyquist sampling rate for each of the following signals? (5 marks)

a. A low-pass signal with bandwidth of 200 KHz?

b. A band-pass signal with bandwidth of 200 KHz if the lowest frequency is 100 KHz?

P4-17. What is the maximum data rate of a channel with a bandwidth of 200 KHz if we use four levels of digital signaling. (2 marks)

P4-19. We have a baseband channel with a 1-MHz bandwidth. What is the data rate for this channel if we use each of the following line coding schemes?

a. NRZ-L b. Manchester c. MLT-3 d. 2B1Q (5 marks)

Chapter 5: Analog Transmission

2 marks

Q5-1. Define *analog transmission.*

Q5-2. Define *carrier signal* and explain its role in analog transmission.

Q5-3. Define *digital-to-analog conversion.*

Chapter 6: Bandwidth Utilization: Multiplexing and Spectrum Spreading

2 marks

Q6-1. Describe the goals of multiplexing.

Q6-2. List three main multiplexing techniques mentioned in this chapter.

Q6-3. Distinguish between a link and a channel in multiplexing.

Q6-4. Which of the three multiplexing techniques is (are) used to combine analog signals? Which of the three multiplexing techniques is (are) used to combine digital signals?

Q6-7. Which of the three multiplexing techniques is common for fiber-optic links? Explain the reason.

Q6-8. Distinguish between multilevel TDM, multiple-slot TDM, and pulse-stuffed TDM. (5 marks)

Q6-9. Distinguish between synchronous and statistical TDM. (5 marks)

Q6-10. Define spread spectrum and its goal. List the two spread spectrum techniques discussed in this chapter. (5 marks)

Q6-11. Define FHSS and explain how it achieves bandwidth spreading. (5 marks)

Q6-12. Define DSSS and explain how it achieves bandwidth spreading. (5 marks)

2 marks

P6-1. Assume that a voice channel occupies a bandwidth of 4 kHz. We need to multiplex 10 voice channels with guard bands of 500 Hz using FDM. Calculate the required bandwidth.

P6-2. We need to transmit 100 digitized voice channels using a passband channel of 20 KHz. What should be the ratio of bits/Hz if we use no guard band?

P6-4. We need to use synchronous TDM and combine 20 digital sources, each of 100 Kbps. Each output slot carries 1 bit from each digital source, but one extra bit is added to each frame for synchronization. Answer the following questions:

a. What is the size of an output frame in bits?

b. What is the output frame rate?

c. What is the duration of an output frame?

d. What is the output data rate?

e. What is the efficiency of the system (ratio of useful bits to the total bits)? (10 marks)

P6-6. We have 14 sources, each creating 500 8-bit characters per second. Since only some of these sources are active at any moment, we use statistical TDM to combine these sources using character interleaving. Each frame carries 6 slots at a time, but we need to add 4-bit addresses to each slot. Answer the following questions:

a. What is the size of an output frame in bits?

b. What is the output frame rate?

c. What is the duration of an output frame?

d. What is the output data rate? (10 marks)

P6-7. Ten sources, six with a bit rate of 200 kbps and four with a bit rate of 400 kbps, are to be combined using multilevel TDM with no synchronizing bits. Answer the following questions about the final stage of the multiplexing:

a. What is the size of a frame in bits?

b. What is the frame rate?

c. What is the duration of a frame?

d. What is the data rate? (10 marks)

P6-8. Four channels, two with a bit rate of 200 kbps and two with a bit rate of 150 kbps, are to be multiplexed using multiple-slot TDM with no synchronization bits. Answer the following questions:

a. What is the size of a frame in bits?

b. What is the frame rate?

c. What is the duration of a frame?

d. What is the data rate? (10 marks)

P6-9. Two channels, one with a bit rate of 190 kbps and another with a bit rate of 180 kbps, are to be multiplexed using pulse-stuffing TDM with no synchronization bits. Answer the following questions:

a. What is the size of a frame in bits?

b. What is the frame rate?

c. What is the duration of a frame?

d. What is the data rate? (10 marks)

P6-15. What is the minimum number of bits in a PN sequence if we use FHSS with a channel bandwidth of $B = 4$ KHz and $B_{ss} = 100$ KHz? (2 marks)

P6-16. An FHSS system uses a 4-bit PN sequence. If the bit rate of the PN is 64 bits per second, answer the following questions:

a. What is the total number of possible channels?

b. What is the time needed to finish a complete cycle of PN? (5 marks)

Chapter 7: Transmission Media

2 marks

Q7-1. What is the position of the transmission media in the OSI or the Internet model?

Q7-2. Name the two major categories of transmission media.

Q7-3. How do guided media differ from unguided media?

Q7-4. What are the three major classes of guided media?

Q7-5. What is the function of the twisting in twisted-pair cable?

Q7-6. What is refraction? What is reflection?

Q7-7. What is the purpose of cladding in an optical fiber?

Q7-8. Name the advantages of optical fiber over twisted-pair and coaxial cable.

Q7-9. How does sky propagation differ from line-of-sight propagation?

Q7-10. What is the difference between omnidirectional waves and unidirectional waves?

P7-10. A light signal is travelling through a fiber. What is the delay in the signal if the length of the fiber-optic cable is 10 m, 100 m, and 1 Km (assume a propagation speed of 2×10^8 m)? (5 marks)

Chapter 8: Switching

Q8-1. Describe the need for switching and define a switch. (5 marks)

Q8-2. List the three traditional switching methods. Which are the most common today? (2 marks)

Q8-3. What are the two approaches to packet switching? (2 marks)

Q8-4. Compare and contrast a circuit-switched network and a packet-switched network. (5 marks)

Q8-5. What is the role of the address field in a packet traveling through a datagram network? (2 marks)

Q8-6. What is the role of the address field in a packet traveling through a virtual-circuit network? (2 marks)

Q8-7. Compare space-division and time-division switches. (5 marks)

Q8-8. What is TSI and what is its role in time-division switching? (2 marks)

Q8-9. Compare and contrast the two major categories of circuit switches. (2 marks)

Q8-10. List four major components of a packet switch and their functions. (5 marks)

P8-1. A path in a digital circuit-switched network has a data rate of 1 Mbps. The exchange of 1000 bits is required for the setup and teardown phases. The distance between two parties is 5000 km. Answer the following questions if the propagation speed is 2×10^8 m:

a. What is the total delay if 1000 bits of data are exchanged during the data-transfer phase?

b. What is the total delay if 100,000 bits of data are exchanged during the data-transfer phase?

c. What is the total delay if 1,000,000 bits of data are exchanged during the data-transfer phase?

d. Find the delay per 1000 bits of data for each of the above cases and compare them. What can you infer?

(5 marks)

Module 1

Physical Layer

Book: Computer Networks by Andrew S. Tanenbaum

2. A noiseless 4-kHz channel is sampled every 1 msec. What is the maximum data rate? How does the maximum data rate change if the channel is noisy, with a signal-to-noise ratio of 30 dB? (2 marcks)

3. Television channels are 6 MHz wide. How many bits/sec can be sent if four-level digital signals are used? Assume a noiseless channel. (2 marcks)

4. If a binary signal is sent over a 3-kHz channel whose signal-to-noise ratio is 20 dB, what is the maximum achievable data rate? (2 marcks)

5. What signal-to-noise ratio is needed to put a T1 carrier on a 50-kHz line? (2 marcks)

6. What are the advantages of fiber optics over copper as a transmission medium? Is there any downside of using fiber optics over copper? (2 marcks).

Module-2
Data Link Layer
Book: Data Communications and Networking by BA. Forouzan

as *links*. A path in the Internet from a source host to a destination host is a set of nodes and links through which a packet should travel.

The data-link layer is responsible for the creation and delivery of a frame to another node, along the link. It is responsible for packetizing (framing), flow control, error control, and congestion control along the link. Two data-link layers at the two ends of a link coordinate to deliver a frame from one node to the next.

As with any delivery between a source and destination in which there are many paths, we need two types of addressing. The end-to-end addressing defines the source and destination; the link-layer addressing defines the addresses of the nodes that the packet should pass through. To avoid including the link-layer addresses of all of these nodes in the frame, the Address Resolution Protocol (ARP) was devised to map an IP address to its corresponding link-layer address. When a packet is at one node ready to be sent to the next, the forwarding table finds the IP address of the next node and ARP find its link-layer address.

9.4 PRACTICE SET

9.4.1 Quizzes

A set of interactive quizzes for this chapter can be found on the book website. It is strongly recommended that the student take the quizzes to check his/her understanding of the materials before continuing with the practice set.

9.4.2 Questions

Q9-1. Distinguish between communication at the network layer and communication at the data-link layer.

Q9-2. Distinguish between a point-to-point link and a broadcast link.

Q9-3. Can two hosts in two different networks have the same link-layer address? Explain.

Q9-4. Is the size of the ARP packet fixed? Explain.

Q9-5. What is the size of an ARP packet when the protocol is IPv4 and the hardware is Ethernet?

2 marks

Q9-6. Assume we have an isolated link (not connected to any other link) such as a private network in a company. Do we still need addresses in both the network layer and the data-link layer? Explain. (5 marks)

Q9-10. When we talkabout the broadcast address in a link, do we mean sending a message to all hosts and routers in the link or to all hosts and routers in the Internet? In other words, does a broadcast address have a local jurisdiction or a universal jurisdiction? Explain. (2 marks)

Q9-11. Why does a host or a router need to run the ARP program all of the time in the background?

Q9-14. How many IP addresses and how many link-layer addresses should a router have when it is connected to five links?

2 marks

9.4.3 Problems

P9-1. Assume we have an internet (a private small internet) in which all hosts are connected in a mesh topology. Do we need routers in this internet? Explain.

P9-2. In the previous problem, do we need both network and data-link layers?

of cyclic codes called the cyclic redundancy check (CRC) is used in networks such as LANs and WANs.

A pattern of 0s and 1s can be represented as a polynomial with coefficients of 0 and 1. Traditionally, the Internet has been using a 16-bit checksum, which uses one's complement arithmetic. In this arithmetic, we can represent unsigned numbers between 0 and $2^n - 1$ using only n bits.

10.7 PRACTICE SET

10.7.1 Quizzes

A set of interactive quizzes for this chapter can be found on the book website. It is strongly recommended that the student take the quizzes to check his/her understanding of the materials before continuing with the practice set.

10.7.2 Questions

2 marks

Q10-1. How does a single-bit error differ from a burst error?

Q10-5. What is the minimum Hamming distance?

Q10-6. If we want to be able to detect two-bit errors, what should be the minimum Hamming distance?

10.7.3 Problems

5 marks

P10-1. What is the maximum effect of a 2-ms burst of noise on data transmitted at the following rates?

a. 1500 bps b. 12 kbps c. 100 kbps d. 100 Mbps

P10-7. What is the Hamming distance for each of the following codewords?

a. d (10000, 00000) b. d (10101, 10000)
c. d (00000, 11111) d. d (00000, 00000)

P10-10. Assuming even parity, find the parity bit for each of the following data units.

a. 1001011 b. 0001100 c. 1000000 d. 1110111

P10-12. Given the dataword 101001111 and the divisor 10111, show the generation of the CRC codeword at the sender site (using binary division). (5 marks)

Data-link protocols have been designed to handle communication between two nodes. We discussed two protocols in this chapter. In the Simple Protocol, there is no flow and error control. In the Stop-and-Wait Protocol, there are both flow and error controls, but communication is a frame at a time.

High-level Data Link Control (HDLC) is a bit-oriented protocol for communication over point-to-point and multipoint links. It implements the Stop-and-Wait protocol. It is the basis of many protocols in practice today. HDLC defines three types of frames: information frames, supervisory frames, and unnumbered frames. The informational frames are used to carry data frames. Supervisory frames are used only to transport control information for flow and error control. Unnumbered frames are reserved for system management and provide connection-oriented service.

One of the most common protocols for point-to-point access is the Point-to-Point Protocol (PPP). PPP uses only one type of frame, but allows multiplexing of different payloads to achieve a kind of connection-oriented service authentication. Encapsulating different packets in a frame allows PPP to move to different states to provide necessary services.

11.6 PRACTICE SET

11.6.1 Quizzes

A set of interactive quizzes for this chapter can be found on the book website. It is strongly recommended that the student take the quizzes to check his/her understanding of the materials before continuing with the practice set.

11.6.2 Questions

Q11-1. Define *framing* and give the reason it is needed. (2 marks)

Q11-2. Explain why flags are needed when we use variable-size frames. (2 marks)

Q11-4. Compare and contrast byte-oriented and bit-oriented protocols. (5 marks)

Q11-5. Compare and contrast byte-stuffing and bit-stuffing. (5 marks)

Q11-6. In a byte-oriented protocol, should we first unstuff the extra bytes and then remove the flags or reverse the process?

Q11-7. In a bit-oriented protocol, should we first unstuff the extra bits and then remove the flags or reverse the process?

2 marks

Q11-8. Compare and contrast flow control and error control.

Q11-9. In the Stop-and-Wait Protocol, assume that the sender has only one slot in which to keep the frame to send or the copy of the sent frame. What happens if the network layer delivers a packet to the data-link layer at this moment? (2 marks)

Q11-18. Define *piggybacking* and its benefit. (5 marks)

Q11-22. Compare and contrast HDLC with PPP. (5 marks)

Q11-23. Compare the flag byte and the escape byte in PPP. Are they are the same? Explain. (5 marks)

instructions. In the token-passing method, the stations in a network are organized in a logical ring. Each station has a predecessor and a successor. A special packet called a *token* circulates through the ring.

Channelization is a multiple-access method in which the available bandwidth of a link is shared in time, frequency, or through code, between different stations. We discussed three channelization protocols: FDMA, TDMA, and CDMA. In frequency-division multiple access (FDMA), the available bandwidth is divided into frequency bands. Each station is allocated a band to send its data. In other words, each band is reserved for a specific station, and it belongs to the station all the time. In time-division multiple access (TDMA), the stations share the bandwidth of the channel in time. Each station is allocated a time slot during which it can send data. Each station transmits its data in its assigned time slot. In code-division multiple access (CDMA), the stations use different codes to achieve multiple access. CDMA is based on coding theory and uses sequences of numbers called *chips*. The sequences are generated using orthogonal codes such as the Walsh tables.

12.5 PRACTICE SET

12.5.1 Quizzes

A set of interactive quizzes for this chapter can be found on the book website. It is strongly recommended that the student take the quizzes to check his/her understanding of the materials before continuing with the practice set.

12.5.2 Questions

5 marks

Q12-4. Stations in a pure Aloha network send frames of size 1000 bits at the rate of 1 Mbps. What is the vulnerable time for this network?

Q12-5. Stations in an slotted Aloha network send frames of size 1000 bits at the rate of 1 Mbps. What is the vulnerable time for this network?

Q12-6. In a pure Aloha network with $G = 1/2$, how is the throughput affected in each of the following cases?

a. G is increased to 1. b. G is decreased to 1/4.

Q12-7. In a slotted Aloha network with $G = 1/2$, how is the throughput affected in each of the following cases?

a. G is increased to 1. b. G is decreased to 1/4.

Q12-14. Assume the propagation delay in a broadcast network is 5 μs and the frame transmission time is 10 μs. (10 marks)

a. How long does it take for the first bit to reach the destination?

b. How long does it take for the last bit to reach the destination after the first bit has arrived?

c. How long is the network involved with this frame (vulnerable to collision)?

Q12-15. Assume the propagation delay in a broadcast network is 3 μs and the frame transmission time is 5 μs. Can the collision be detected no matter where it occurs?

Q12-16. Assume the propagation delay in a broadcast network is 6 μs and the frame transmission time is 4 μs. Can the collision be detected no matter where it occurs?

Q12-17. Explain why collision is an issue in random access protocols but not in controlled access protocols.

Q12-18. Explain why collision is an issue in random access protocols but not in channelization protocols.

(5 marks)

Q12-19. Assume the propagation delay in a broadcast network is 5 μs and the frame transmission time is 10 μs. (10 marks)

a. How long does it take for the first bit to reach the destination?

b. How long does it take for the last bit to reach the destination after the first bit has arrived?

c. How long is the network involved with this frame (vulnerable to collision)?

Q12-20. Assume the propagation delay in a broadcast network is 12 μs and the frame transmission time is 8 μs. (10 marks)

a. How long does it take for the first bit to reach the destination?

b. How long does it take for the last bit to reach the destination after the first bit has arrived?

c. How long is the network involved with this frame (vulnerable to collision)?

Q12-21. List some strategies in CSMA/CA that are used to avoid collision.

Q12-23. There is no acknowledgment mechanism in CSMA/CD, but we need this mechanism in CSMA/CA. Explain the reason.

Q12-24. What is the purpose of NAV in CSMA/CA?

P12-14. In a bus CSMA/CD network with a data rate of 10 Mbps, a collision occurs 20 μs after the first bit of the frame leaves the sending station. What should the length of the frame be so that the sender can detect the collision?

P12-23. Check to see if the following set of chips can belong to an orthogonal system.

$[+1, +1]$ and $[+1, -1]$

P12-24. Check to see if the following set of chips can belong to an orthogonal system.

$[+1, +1, +1, +1]$, $[+1, -1, -1, +1]$, $[-1, +1, +1, -1]$, $[+1, -1, -1, +1]$

(5 marks)

method and framing. Each station on an Ethernet network has a unique 48-bit address imprinted on its network interface card (NIC). The minimum frame length for 10-Mbps Ethernet is 64 bytes; the maximum is 1518 bytes.

The common implementations of 10-Mbps Ethernet are 10Base5 (thick Ethernet), 10Base2 (thin Ethernet), 10Base-T (twisted-pair Ethernet), and 10Base-F (fiber Ethernet). The 10Base5 implementation of Ethernet uses thick coaxial cable. 10Base2 uses thin coaxial cable. 10Base-T uses four twisted-pair cables that connect each station to a common hub. 10Base-F uses fiber-optic cable. A bridge can increase the bandwidth and separate the collision domains on an Ethernet LAN. A switch allows each station on an Ethernet LAN to have the entire capacity of the network to itself. Full-duplex mode doubles the capacity of each domain and removes the need for the CSMA/CD method.

Fast Ethernet has a data rate of 100 Mbps. In Fast Ethernet, autonegotiation allows two devices to negotiate the mode or data rate of operation. The common Fast Ethernet implementations are 100Base-TX (two pairs of twisted-pair cable), 100Base-FX (two fiber-optic cables), and 100Base-T4 (four pairs of voice-grade, or higher, twisted-pair cable).

Gigabit Ethernet has a data rate of 1000 Mbps. Gigabit Ethernet access methods include half-duplex mode using traditional CSMA/CD (not common) and full-duplex mode (most popular method). The common Gigabit Ethernet implementations are 1000Base-SX (two optical fibers and a short-wave laser source), 1000Base-LX (two optical fibers and a long-wave laser source), and 1000Base-T (four twisted pairs).

The latest Ethernet standard is 10 Gigabit Ethernet, which operates at 10 Gbps. The four common implementations are 10GBase-SR, 10GBase-LR, 10GBase-EW, and 10GBase-X4. These implementations use fiber-optic cables in full-duplex mode.

13.7 PRACTICE SET

5 marks

Q13-2. Compare the data rates for Standard Ethernet, Fast Ethernet, Gigabit Ethernet, and 10 Gigabit Ethernet.

Q13-8. What is the difference between unicast, multicast, and broadcast addresses?

Q13-10. What is the relationship between a switch and a bridge? (2 marcks).

13.7.3 Problems

P13-1. What is the hexadecimal equivalent of the following Ethernet address?

```
01011010 00010001 01010101 00011000 10101010 00001111
```

P13-2. How does the Ethernet address 1A:2B:3C:4D:5E:6F appear on the line in binary?

P13-3. If an Ethernet destination address is 07:01:02:03:04:05, what is the type of the address (unicast, multicast, or broadcast)?

2 marcks

15.5 PRACTICE SET

15.5.1 Quizzes

A set of interactive quizzes for this chapter can be found on the book website. It is strongly recommended that the student take the quizzes to check his/her understanding of the materials before continuing with the practice set.

15.5.2 Questions

Q15-1. Compare the medium of a wired LAN with that of a wireless LAN in today's communication environment. (2 marcks).

Q15-2. Explain why the MAC protocol is more important in wireless LANs than in wired LANs. (2 marcks)

Q15-3. Explain why there is more attenuation in a wireless LAN than in a wired LAN, ignoring the noise and the interference. (2 marcks).

Q15-4. Why is SNR in a wireless LAN normally lower than SNR in a wired LAN? (2 marcks).

Q15-5. What is multipath propagation? What is its effect on wireless networks?

Q15-6. What are some reasons that CSMA/CD cannot be used in a wireless LAN?

Q15-7. Explain why fragmentation is recommended in a wireless LAN.

2 marcks

Module-2

Data Link Layer

Book: COMPUTER NETWORKS by ANDREW S. TANENBAUM, DAVID J. WETHERALL

2. The following character encoding is used in a data link protocol: (10 marks)
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 methods is used:

(a) Byte count.
(b) Flag bytes with byte stuffing.
(c) Starting and ending flag bytes with bit stuffing.

4. What is the maximum overhead in byte-stuffing algorithm? (2 marks)

5. One of your classmates, Scrooge, has pointed out that it is wasteful to end each frame with a flag byte and then begin the next one with a second flag byte. One flag byte could do the job as well, and a byte saved is a byte earned. Do you agree? (5 marks)

6. A bit string, 0111101111101111110, needs to be transmitted at the data link layer. What is the string actually transmitted after bit stuffing? (2 marks)

8. To provide more reliability than a single parity bit can give, an error-detecting coding scheme uses one parity bit for checking all the odd-numbered bits and a second parity bit for all the even-numbered bits. What is the Hamming distance of this code? (2 marks)

15. Suppose that a message 1001 1100 1010 0011 is transmitted using Internet Checksum (4-bit word). What is the value of the checksum? (2 marks)

16. What is the remainder obtained by dividing $x^7 + x^5 + 1$ by the generator polynomial $x^3 + 1$? (5 marks)

17. 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 bit 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. (10 marks)

27. The distance from earth to a distant planet is approximately 9×10^{10} m. What is the channel utilization if a stop-and-wait protocol is used for frame transmission on a 64 Mbps point-to-point link? Assume that the frame size is 32 KB and the speed of light is 3×10^8 m/s. (5 marks)

3. Consider the delay of pure ALOHA versus slotted ALOHA at low load. Which one is less? Explain your answer. (5 marks)

13. What is the baud rate of classic 10-Mbps Ethernet? (2 marks)

14. Sketch the Manchester encoding on a classic Ethernet for the bit stream 0001110101. (2 marks)

Module-3

Network Layer

Book: Data Communications and Networking by BA. Forouzan

Some problems of address shortage in the current version can be temporarily alleviated using DHCP and NAT protocols.

The section on forwarding helps to understand how routers forward packets. Two approaches are used for this purpose. The first approach, which is used in a connectionless network such as the current Internet, is based on the destination address of the packet. The second approach, which can be used if the Internet is changed to a connection-oriented network, uses the labels in the packets.

18.7 PRACTICE SET

18.7.1 Quizzes

A set of interactive quizzes for this chapter can be found on the book website. It is strongly recommended that the student take the quizzes to check his/her understanding of the materials before continuing with the practice set.

18.7.2 Questions

Q18-1. Why does the network-layer protocol need to provide packetizing service to the transport layer? Why can't the transport layer send out the segments without encapsulating them in datagrams? (5 marks)

Q18-2. Why is routing the responsibility of the network layer? In other words, why can't the routing be done at the transport layer or the data-link layer? (10 marks)

Q18-3. Distinguish between the process of routing a packet from the source to the destination and the process of forwarding a packet at each router. (5 marks)

Q18-4. What is the piece of information in a packet upon which the forwarding decision is made in each of the following approaches to switching? (2 marks)

a. datagram approach b. virtual-circuit approach

Q18-5. If a label in a connection-oriented service is 8 bits, how many virtual circuits can be established at the same time? (5 marks)

Q18-6. List the three phases in the virtual-circuit approach to switching. (2 marks)

Q18-7. Do we have any of the following services at the network layer of TCP/IP? If not, why? (2 marks)

a. flow control b. error control c. congestion control

Q18-8. List four types of delays in a packet-switched network. (2 marks)

Q18-9. In Figure 18.10, assume that the link between R1 and R2 is upgraded to 170 kbps and the link between the source host and R1 is now downgraded to 140 kbps. What is the throughput between the source and destination after these changes? Which link is the bottleneck now? (10 marks)

Q18-10. In classless addressing, we know the first and the last address in the block. Can we find the prefix length? If the answer is yes, show the process. (5 marks)

Q18-11. In classless addressing, we know the first address and the number of addresses in the block. Can we find the prefix length? If the answer is yes, show the process. (5 marks)

Q18-12. In classless addressing, can two different blocks have the same prefix length? Explain. (5 marks)

18.7.3 Problems

P18-1. What is the size of the address space in each of the following systems? (5 marks)

a. A system in which each address is only 16 bits.
b. A system in which each address is made of six hexadecimal digits.
c. A system in which each address is made of four octal digits.

P18-2. Rewrite the following IP addresses using binary notation: (2 marks)

a. 110.11.5.88 b. 12.74.16.18 c. 201.24.44.32

P18-3. Rewrite the following IP addresses using dotted-decimal notation: (2 marks)

a. 01011110 10110000 01110101 00010101
b. 10001001 10001110 11010000 00110001
c. 01010111 10000100 00110111 00001111

P18-4. Find the class of the following classful IP addresses: (2 marks)

a. 130.34.54.12 b. 200.34.2.1 c. 245.34.2.8

P18-5. Find the class of the following classful IP addresses: (2 marks)

a. 01110111 11110011 10000111 11011101
b. 11101111 11000000 11110000 00011101
c. 11011111 10110000 00011111 01011101

P18-6. In classless addressing, show the whole address space as a single block using the CIDR notation. (5 marks)

P18-7. In classless addressing, what is the size of the block (N) if the value of the prefix length (n) is one of the following? (5 marks)

a. $n = 0$ b. $n = 14$ c. $n = 32$

P18-8. In classless addressing, what is the value of the prefix length (n) if the size of the block (N) is one of the following? (5 marks)

a. $N = 1$ b. $N = 1024$ c. $N = 2^{32}$

P18-9. Change each of the following prefix lengths to a mask in dotted-decimal notation: (5 marks)

a. $n = 0$ b. $n = 14$ c. $n = 30$

P18-10. Change each of the following masks to a prefix length: (5 marks)

a. 255.224.0.0 b. 255.240.0.0 c. 255.255.255.128

P18-11. Which of the following cannot be a mask in CIDR? (5 marks)

a. 255.225.0.0 b. 255.192.0.0 c. 255.255.255.6

P18-12. Each of the following addresses belongs to a block. Find the first and the last address in each block. (5 marks)

a. 14.12.72.8/24 b. 200.107.16.17/18 c. 70.110.19.17/16

P18-13. Show the n leftmost bits of the following network-addresses/masks that can be used in a forwarding table. (5 marks)

a. 170.40.11.0/24 b. 110.40.240.0/22 c. 70.14.0.0./18

P18-14. Explain how DHCP can be used when the size of the block assigned to an organization is less than the number of hosts in the organization. (10 marks)

P18-15. Compare NAT and DHCP. Both can solve the problem of a shortage of addresses in an organization, but by using different strategies. (10 marks)

P18-16. Assume we have an internet with an 8-bit address space. The addresses are equally divided between four networks (N_0 to N_3). The internetwork communication is done through a router with four interfaces (m_0 to m_3). Show the internet outline and the forwarding table (with two columns: prefix in binary and the interface number) for the only router that connects the networks. Assign a network address to each network. (10 marks)

P18-17. Assume we have an internet with a 12-bit address space. The addresses are equally divided between eight networks (N_0 to N_7). The internetwork communication is done through a router with eight interfaces (m_0 to m_7). Show the internet outline and the forwarding table (with two columns: prefix in binary and the interface number) for the only router that connects the networks. Assign a network address to each network. (10 marks)

P18-18. Assume we have an internet with a 9-bit address space. The addresses are divided between three networks (N_0 to N_2), with 64, 192, and 256 addresses respectively. The internetwork communication is done through a router with three interfaces (m_0 to m_2). Show the internet outline and the forwarding table (with two columns: prefix in binary and the interface number) for the only router that connects the networks. Assign a network address to each network. (10 marks)

P18-19. Combine the following three blocks of addresses into a single block: (10 marks)

a. 16.27.24.0/26 b. 16.27.24.64/26 c. 16.27.24.128/25

P18-20. A large organization with a large block address (12.44.184.0/21) is split into one medium-size company using the block address (12.44.184.0/22) and two small organizations. If the first small company uses the block (12.44.188.0/23), what is the remaining block that can be used by the second small company? Explain how the datagrams destined for the two small companies can be correctly routed to these companies if their address blocks still are part of the original company. (10 marks)

P18-21. An ISP is granted the block 16.12.64.0/20. The ISP needs to allocate addresses for 8 organizations, each with 256 addresses. (10 marks)

a. Find the number and range of addresses in the ISP block.

b. Find the range of addresses for each organization and the range of unallocated addresses.

c. Show the outline of the address distribution and the forwarding table.

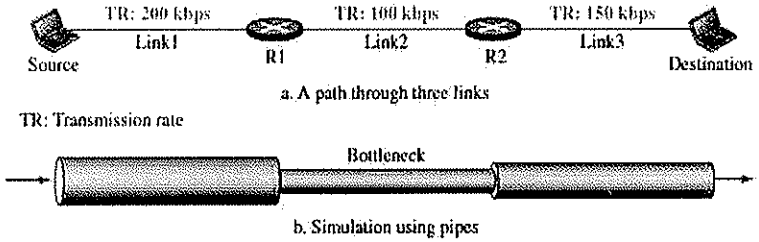
P18-22. An ISP is granted the block 80.70.56.0/21. The ISP needs to allocate addresses for two organizations each with 500 addresses, two organizations each with 250 addresses, and three organizations each with 50 addresses. (10 marks)

a. Find the number and range of addresses in the ISP block.

b. Find the range of addresses for each organization and the range of unallocated addresses.

c. Show the outline of the address distribution and the forwarding table.

Figure 18.10 *Throughput in a path with three links in a series*



19.5 PRACTICE SET

19.5.1 Quizzes

A set of interactive quizzes for this chapter can be found on the book website. It is strongly recommended that the student take the quizzes to check his/her understanding of the materials before continuing with the practice set.

19.5.2 Questions

Q19-1. Can the value of the header length field in an IPv4 packet be less than 5? When is it exactly 5? (5 marks)

Q19-2. A host is sending 100 datagrams to another host. If the identification number of the first datagram is 1024, what is the identification number of the last? (5 marks)

Q19-3. An IP fragment has arrived with an offset value of 100. How many bytes of data were originally sent by the source before the data in this fragment? (5 marks)

Q19-4. Mention the three auxiliary protocols at the network layer of the TCP/IP suite that are designed to help the IPv4 protocol. (2 marks)

Q19-5. In an IPv4 datagram, the value of the header-length (HLEN) field is $(6)_{16}$. How many bytes of options have been added to the packet? (5 marks)

Q19-6. Can each of the following be the value of the TTL in a datagram? Explain your answer. (5 marks)

a. 23 b. 0 c. 1 d. 301

Q19-7. Compare and contrast the protocol field at the network layer with the port numbers at the transport layer. What is their common purpose? Why do we need two port-number fields but only one protocol field? Why is the size of the protocol field only half the size of each port number? (10 marks)

Q19-8. Which field(s) in the datagram is(are) responsible for gluing together all fragments belonging to an original datagram? (2 marks)

Q19-9. Can each of the following be the value of the offset field in a datagram? Explain your answer. (5 marks)

a. 8 b. 31 c. 73 d. 56

Q19-10. Assume a destination computer receives several packets from a source. How can it be sure that the fragments belonging to a datagram are not mixed with the fragments belonging to another datagram? (5 marks)

Q19-11. Explain why the Internet does not create a report message to report the error in an IP datagram that carries an ICMPv4 message. (5 marks)

Q19-12. What are the source and destination IP addresses in a datagram that carries the ICMPv4 message reported by a router? (5 marks)

Q19-13. Explain why the registration request and reply are not directly encapsulated in an IP datagram. Why is there a need for the UDP user datagram? (5 marks)

Q19-14. Is registration required if the mobile host acts as a foreign agent? Explain your answer. (5 marks)

Q19-15. Discuss how the ICMPv4 router solicitation message can also be used for agent solicitation. Why are there no extra fields? (10 marks)

Q19-16. Which protocol is the carrier of the agent advertisement and solicitation messages? (2 marks)

19.5.3 Problems

P19-1. In an IPv4 datagram, the value of total-length field is $(00A0)_{16}$ and the value of the header-length (HLEN) is $(5)_{16}$. How many bytes of payload are being carried by the datagram? What is the efficiency (ratio of the payload length to the total length) of this datagram? (10 marks)

P19-2. An IP datagram has arrived with the following partial information in the header (in hexadecimal):

```
45000054 00030000 2006...
```

10 marks

a. What is the header size?
b. Are there any options in the packet?
c. What is the size of the data?
d. Is the packet fragmented?
e. How many more routers can the packet travel to?
f. What is the protocol number of the payload being carried by the packet?

P19-3. In Figure 19.4, (10 marks)

a. show how wrapped sum can be calculated from the sum using modular arithmetic.
b. show how checksum can be calculated from the wrapped sum using modular arithmetic.

P19-4. In Figure 19.4, show how the sum, wrapped sum, and checksum can be calculated when each word (16 bits) is created instead of waiting for the whole packet to be created. (10 marks)

P19-5. In Figure 19.4, show how the sum, wrapped sum, and checksum can be calculated when the words are given in decimal numbers (the way the words are stored in a computer memory). (10 marks)

P19-6. Which fields of the IPv4 main header may change from router to router? (5 marks)

P19-7. Determine if a datagram with the following information is a first fragment, a middle fragment, a last fragment, or the only fragment (no fragmentation):

5 marks

a. M bit is set to 1 and the value of the offset field is zero.
b. M bit is set to 1 and the value of the offset field is nonzero.

P19-8. A packet has arrived in which the offset value is 300 and the payload size is 100 bytes. What are the number of the first byte and the last byte? (5 marks)

P19-9. Redo the checksum in Figure 19.11 using hexadecimal values. (5 marks)

P19-10. Redo the checksum in Figure 19.11 using decimal values and modular arithmetic. (5 marks)

P19-11. Briefly describe how we can defeat the following security attacks: (10 marks)

a. packet sniffing b. packet modification c. IP spoofing

Figure 19.4 *Example of checksum calculation in IPv4*

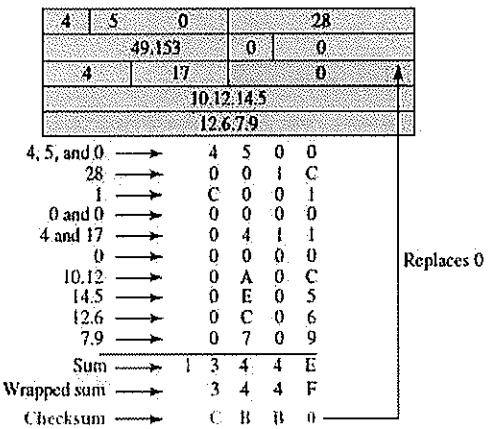
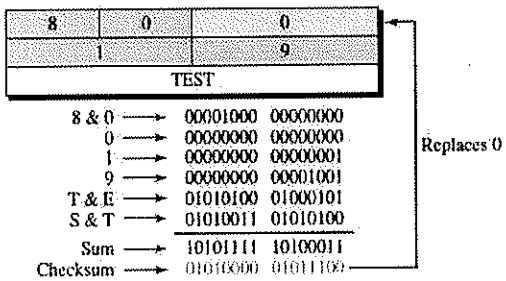
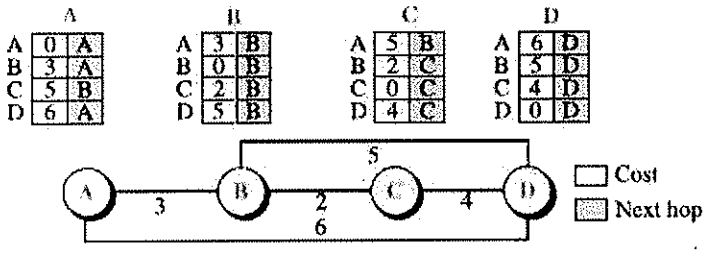


Figure 19.11 *Example of checksum calculation*



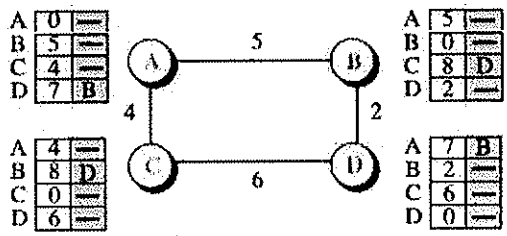
P20-5. In distance-vector routing, good news (decrease in a link metric) will propagate fast. In other words, if a link distance decreases, all nodes quickly learn about it and update their vectors. In Figure 20.33, we assume that a four-node internet is stable, but suddenly the distance between nodes A and D, which is currently 6, is decreased to 1 (probably due to some improvement in the link quality). Show how this good news is propagated, and find the new distance vector for each node after stabilization. (10 marks)

Figure 20.33 *Problem P20-6*



P20-8. Assume that the network in Figure 20.34 uses distance-vector routing with the forwarding table as shown for each node. (10 marks)

Figure 20.34 *Problem P20-8*



If each node periodically announces their vectors to the neighbor using the poison-reverse strategy, what is the distance vector advertised in the appropriate period:

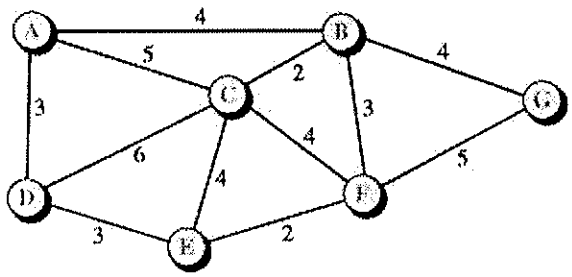
a. from A to B? b. from C to D? c. from D to B? d. from C to A?

P20-9. Assume that the network in Figure 20.34 (previous problem) uses distance-vector routing with the forwarding table as shown for each node. If each node periodically announces their vectors to the neighbor using the split-horizon strategy, what is the distance vector advertised in the appropriate period: (10 marks)

a. from A to B? b. from C to D? c. from D to B? d. from C to A?

P20-14. Use Dijkstra's algorithm to find the shortest path tree and the forwarding table for node A in the Figure 20.35. (10 marks)

Figure 20.35 *Problem P20-14*



Q20-2. Assume the shortest path in a graph from node A to node H is A → B → H. Also assume that the shortest path from node H to node N is H → G → N. What is the shortest path from node A to node N? (5 marks)

Q20-3. Explain why a router using link-state routing needs to receive the whole LSDB before creating and using its forwarding table. In other words, why can't the router create its forwarding table with a partially received LSDB? (10 marks)

Q20-4. Is the path-vector routing algorithm closer to the distance-vector routing algorithm or to the link-state routing algorithm? Explain. (10 marks)

Q20-5. List three types of autonomous systems (ASs) described in the text, and make a comparison between them. (5 marks)

Q20-7. Assume that we have an isolated AS running RIP. We can say that we have at least two different kinds of datagram traffic in this AS. The first kind carries the messages exchanged between hosts; the second carries messages belonging to RIP. What is the difference between the two kinds of traffic when we think about source and destination IP addresses? Does this show that routers also need IP addresses? (10 marks)

Q20-8. Router A sends two RIP messages to two immediate neighboring routers, B and C. Do the two datagrams carrying the messages have the same source IP addresses? Do the two datagrams have the same destination IP addresses? (10 marks)

Q20-9. At any moment, a RIP message may arrive at a router that runs RIP as the routing protocol. Does it mean that the RIP process should be running all the time? (5 marks)

Q20-10. Why do you think RIP uses UDP instead of TCP? (5 marks)

Q20-11. We say that OSPF is a hierarchical intradomain protocol, but RIP is not. What is the reason behind this statement? (5 marks)

Q20-12. In a very small AS using OSPF, is it more efficient to use only one single area (backbone) or several areas? (5 marks)

Q20-13. Why do you think we need only one RIP update message, but several OSPF update messages? (5 marks)

Q20-14. OSPF messages are exchanged between routers. Does this mean that we need to have OSPF processes run all the time to be able to receive an OSPF message when it arrives? (5 marks)

Q20-15. OSPF messages and ICMP messages are directly encapsulated in an IP datagram. If we intercept an IP datagram, how can we tell whether the payload belongs to OSPF or ICMP? (5 marks)

22.6 PRACTICE SET

22.6.1 Quizzes

A set of interactive quizzes for this chapter can be found on the book website. It is strongly recommended that the student take the quizzes to check his/her understanding of the materials before continuing with the practice set.

22.6.2 Questions

Q22-1. Explain the advantages of IPv6 when compared to IPv4. (5 marks)

Q22-2. Explain the use of the flow field in IPv6. What is the potential application of this field? (10 marks)

Q22-3. Distinguish between compatible and mapped addresses and explain their applications. (10 marks)

Q22-4. List three protocols in the IPv4 network layer that are combined into a single protocol in IPv6. (5 marks)

Q22-5. What is the purpose of including the IP header and the first 8 bytes of datagram data in the error-reporting ICMP messages? (5 marks)

Q22-6. If you are assigned an IPv6 address by your ISP for your personal computer at home, what should be the first (leftmost) three bits of this address? (5 marks)

P22-2. Show the unabbreviated colon hex notation for the following IPv6 addresses: (10 marks)

a. An address with 64 0s followed by 32 two-bit (01)s.

b. An address with 64 0s followed by 32 two-bit (10)s.

c. An address with 64 two-bit (01)s.

d. An address with 32 four-bit (0111)s.

P22-3. Show abbreviations for the following addresses: (10 marks)

a. 0000:FFFF:FFFF:0000:0000:0000:0000:0000

b. 1234:2346:3456:0000:0000:0000:0000:FFFF

c. 0000:0001:0000:0000:0000:FFFF:1200:1000

d. 0000:0000:0000:0000:FFFF:FFFF:24.123.12.6

Module-3

Network Layer

Book: Computer Networks by Andrew S. Tanenbaum

28. A network on the Internet has a subnet mask of 255.255.240.0. What is the maximum number of hosts it can handle? (5 marks)

29. While IP addresses are tried to specific networks, Ethernet addresses are not. Can you think of a good reason why they are not? (5 marks)

30. A large number of consecutive IP addresses are available starting at 198.16.0.0. Suppose that four organizations, *A*, *B*, *C*, and *D*, request 4000, 2000, 4000, and 8000 addresses, respectively, and in that order. For each of these, give the first IP address assigned, the last IP address assigned, and the mask in the *w.x.y.z/s* notation. (10 marks)

31. A router has just received the following new IP addresses: 57.6.96.0/21, 57.6.104.0/21, 57.6.112.0/21, and 57.6.120.0/21. If all of them use the same outgoing line, can they be aggregated? If so, to what? If not, why not? (10 marks)

32. The set of IP addresses from 29.18.0.0 to 19.18.128.255 has been aggregated to 29.18.0.0/17. However, there is a gap of 1024 unassigned addresses from 29.18.60.0 to 29.18.63.255 that are now suddenly assigned to a host using a different outgoing line. Is it now necessary to split up the aggregate address into its constituent blocks, add the new block to the table, and then see if any reaggregation is possible? If not, what can be done instead? (10 marks)

34. Many companies have a policy of having two (or more) routers connecting the company to the Internet to provide some redundancy in case one of them goes down. Is this policy still possible with NAT? Explain your answer. (10 marks)

35. You have just explained the ARP protocol to a friend. When you are all done, he says: "I've got it. ARP provides a service to the network layer, so it is part of the data link layer." What do you say to him? (10 marks)

Module-3

Transport Layer

Book: Data Communications and Networking by BA. Forouzan

23.3.3 Summary

The main duty of a transport-layer protocol is to provide process-to-process communication. To define the processes, we need port numbers. The client program defines itself with an ephemeral port number. The server defines itself with a well-known port number. To send a message from one process to another, the transport-layer protocol encapsulates and decapsulates messages. The transport layer at the source performs multiplexing; the transport layer at the destination performs demultiplexing. Flow control balances the exchange of data items between a producer and a consumer.

A transport-layer protocol can provide two types of services: connectionless and connection-oriented. In a connectionless service, the sender sends packets to the receiver without any connection establishment. In a connection-oriented service, the client and the server first need to establish a connection between themselves.

We have discussed several common transport-layer protocols in this chapter. The Stop-and-Wait protocol provides both flow and error control, but is inefficient. The Go-Back-*N* protocol is the more efficient version of the Stop-and-Wait protocol and takes advantage of pipelining. The Selective-Repeat protocol, a modification of the Go-Back-*N* protocol, is better suited to handle packet loss. All of these protocols can be implemented bidirectionally using piggybacking.

23.4 PRACTICE SET

23.4.2 Questions

Q23-1. Assume we have a set of dedicated computers in a system, each designed to perform only a single task. Do we still need host-to-host and process-to-process communication and two levels of addressing? (2 marks)

Q23-2. Operating systems assign a process number to every running application program. Can you explain why these process numbers cannot be used instead of port numbers? (2 marks)

Q23-5. In a network, the size of the receive window is 1 packet. Which of the following protocols is being used by the network? (2 marks)

a. Stop-and-Wait b. Go-Back-*N* c. Selective-Repeat

Q23-6. In a network, the size of the send window is 20 packets. Which of the following protocols is being used by the network? (2 marks)

a. Stop-and-Wait b. Go-Back-*N* c. Selective-Repeat

Q23-7. In a network with fixed value for $m > 1$, we can either use the Go-Back-*N* or the Selective-Repeat protocol. Describe the advantage and the disadvantage of using each. What other network criteria should be considered to select either of these protocols? (5 marks)

Q23-10. Can you explain why some transport-layer packets may be received out of order in the Internet? (2 marks)

Q23-11. Can you explain why some transport-layer packets may be lost in the Internet? (2 marks)

Q23-12. Can you explain why some transport-layer packets may be duplicated in the Internet? (2 marks)

Q23-13. In the Go-Back-N protocol, the size of the send window can be $2^m - 1$, while the size of the receive window is only 1. How can flow control be accomplished when there is a big difference between the size of the send and receive windows? (5 marks)

Q23-14. In the Selective-Repeat protocol, the size of the send and receive windows is the same. Does this mean that there are supposed to be no packets in transit? (2 marks)

23.4.3 Problems

P23-3. A sender sends a series of packets to the same destination using 5-bit sequence numbers. If the sequence numbers start with 0, what is the sequence number of the 100th packet? (2 marks)

P23-5. Using 5-bit sequence numbers, what is the maximum size of the send and receive windows for each of the following protocols? (5 marks)

a. Stop-and-Wait

b. Go-Back-N

c. Selective-Repeat

P23-9. In the Stop-and-Wait protocol, show the case in which the receiver receives a duplicate packet (which is also out of order). Hint: Think about a delayed ACK. What is the reaction of the receiver to this event? (10 marks)

P23-22. An acknowledgment number in the Go-Back-N protocol defines the next packet expected, but an acknowledgment number in the Selective-Repeat protocol defines the sequence number of the packet to be acknowledged. Can you explain the reason? (5 marks)

finite state machine (FSM). TCP uses flow control, implemented as a sliding window mechanism, to avoid overwhelming a receiver with data. The TCP window size is determined by the receiver-advertised window size *(rwnd)* or the congestion window size *(cwnd)*, whichever is smaller. The bytes of data being transferred in each connection are numbered by TCP. The numbering starts with a randomly generated number. TCP uses error control to provide a reliable service. Error control is handled by checksums, acknowledgment, and time-outs. In modern implementations, a retransmission occurs if the retransmission timer expires or three duplicate ACK segments have arrived. TCP uses congestion control to avoid and detect congestion in the network. The slow-start (exponential increase), congestion-avoidance (additive increase), and congestion-detection (multiplicative decrease) strategies are used for congestion control.

SCTP is a message-oriented, reliable protocol that combines the good features of UDP and TCP. SCTP provides additional services not provided by UDP or TCP, such as multiple-stream and multihoming services. SCTP is a connection-oriented protocol, in which a connection is called an *association*. SCTP provides flow control, error control, and congestion control. To distinguish between different streams, SCTP uses the sequence identifier (SI). To distinguish between different data chunks belonging to the same stream, SCTP uses the stream sequence number (SSN). The SCTP acknowledgment SACK reports the cumulative TSN, the TSN of the last data chunk received in order, and selective TSNs that have been received.

24.6 PRACTICE SET

24.6.2 Questions

Q24-1. Some of the application programs can use the services of two transport-layer protocols (UDP or TCP). When a packet arrives at the destination, how can the computer find which transport layer is involved? (2 marks)

Q24-2. A client residing on a host with IP address 122.45.12.7 sends a message to the corresponding server residing on a host with IP address 200.112.45.90. If the well-known port is 161 and the ephemeral port is 51000, what are the pair of socket addresses used in this communication? (2 marks)

Q24-6. Can you explain why we need four (or sometimes three) segments for connection termination in TCP? (2 marks)

Q24-14. What is the maximum size of the TCP header? What is the minimum size of the TCP header? (2 marks)

Q24-17. In TCP, what type of flag can totally close the communication in both directions? (2 marks)

Q24-18. Most of the flags can be used together in a segment. Give an example of two flags that cannot be used simultaneously because they are ambiguous. (2 marks)

Q24-22. Assume Alice uses her browser to open two connections to the HTTP server running on Bob's server. How can these two connections be distinguished by the TCP? (2 marks)

Q24-23. We used the terms *passive open* and *active open* in discussing a connection-oriented communication using TCP. Assume there is a telephone conversation between Alice and Bob. Since a telephone conversation is an example of a connection-oriented communication, assume Alice calls Bob and they talk on the telephone. Who is making a *passive open* connection in this case? Who is making an *active open* connection in this case? (2 marks)

Q24-24. In TCP, can the sender window be smaller, larger, or the same size as the receiver window? (2 marks)

Q24-26. In a TCP segment, what does a sequence number identify? (2 marks)

Q24-27. In a TCP segment, what does an acknowledgment number identify? (2 marks)

24.6.3 Problems

P24-1. Answer the following questions: (5 marks)

a. What is the minimum size of a UDP user datagram?

b. What is the maximum size of a UDP user datagram?

c. What is the minimum size of the application-layer payload data that can be encapsulated in a UDP user datagram?

d. What is the maximum size of the application-layer payload that can be encapsulated in a UDP user datagram?

P24-3. The following is a dump (contents) of a UDP header in hexadecimal format. (10 marks)

0045DF0000580000

a. What is the source port number?

b. What is the destination port number?

c. What is the total length of the user datagram?

d. What is the length of the data?

e. Is the packet directed from a client to a server or vice versa?

f. What is the application-layer protocol?

g. Has the sender calculated a checksum for this packet?

P24-4. Compare the TCP header and the UDP header. List the fields in the TCP header that are not part of the UDP header. Give the reason for each missing field. (10 marks)

P24-5. In TCP, if the value of HLEN is 0111, how many bytes of options are included in the segment? (2 marks)

P24-8. The following is part of a TCP header dump (contents) in hexadecimal format. (10 marks)

E293 0017 00000001 00000000 5002 07FF...

a. What is the source port number?
b. What is the destination port number?
c. What is the sequence number?
d. What is the acknowledgment number?
e. What is the length of the header?
f. What is the type of the segment?
g. What is the window size?

P24-9. To better understand the need for the three-handshake connection establishment, let us go through a scenario. Alice and Bob have no access to telephones or the Internet (think about the old days) to establish their next meeting at a place far from their homes. (10 marks)

a. Suppose that Alice sends a letter to Bob and defines the day and the time of their meeting. Can Alice go to the meeting place and be sure that Bob is there?
b. Suppose that Bob responds to Alice's request with a letter and confirms the date and time. Can Bob go to the meeting place and be sure that Alice is there?
c. Suppose that Alice responds to Bob's letter and confirms the same date and time. Can either one go to the meeting and be sure that the other person is there?

P24-14. TCP is sending data at 1 megabyte per second. If the sequence number starts with 7000, how long does it take before the sequence number goes back to zero? (5 marks)

Module-3

Transport Layer

Book: COMPUTER NETWORKS by ANDREW S. TANENBAUM, DAVID J. WETHERALL

8. Why does the maximum packet lifetime, T, have to be large enough to ensure that not only the packet but also its acknowledgements have vanished? (5 marks)

13. Discuss the advantages and disadvantages of credits versus sliding window protocols. (5 marks)

15. Why does UDP exist? Would it not have been enough to just let user processes send raw IP packets? (5 marks)

19. Both UDP and TCP use port numbers to identify the destination entity when delivering a message. Give two reasons why these protocols invented a new abstract ID (port numbers), instead of using process IDs, which already existed when these protocols were designed. (5 marks)

28. The maximum payload of a TCP segment is 65,495 bytes. Why was such a strange number chosen? (2 marks)

46. Design and implement a chat system that allows multiple groups of users to chat. A chat coordinator resides at a well-known network address, uses UDP for communication with chat clients, sets up chat servers for each chat session, and maintains a chat session directory. There is one chat server per chat session. A chat server uses TCP for communication with clients. A chat client allows users to start, join, and leave a chat session. Design and implement the coordinator, server, and client code. (10 marks)

Module 4

Application Layer

Book: Data Communications and Networking

by

BA. FOROUZAN

25.6.2 Questions

Q25-1. Assume we add a new protocol to the application layer. What changes do we need to make to other layers? (5 marks)

Q25-2. Explain which entity provides service and which one receives service in the client-server paradigm. (2 marks)

Q25-3. In the client-server paradigm, explain why a server should be run all the time, but a client can be run when it is needed. (2 marks)

Q25-4. Can a program written to use the services of UDP be run on a computer that has installed TCP as the only transport-layer protocol? Explain. (5 marks)

Q25-5. Most of the operating systems installed on personal computers come with several client processes, but normally no server processes. Explain the reason. (5 marks)

Q25-6. A new application is to be designed using the client-server paradigm. If only small messages need to be exchanged between the client and the server without concern for message loss or corruption, what transport-layer protocol do you recommend? (10 marks)

Q25-7. Which of the following can be a source of data? (2 marks)

a. a keyboard b. a monitor c. a socket

Q25-8. A source socket address is a combination of an IP address and a port number. Explain what each section identifies. (2 marks)

Q25-9. Explain how a client process finds the IP address and the port number to be inserted in a remote socket address. (5 marks)

Q25-10. Assume we design a new client-server application program that requires persistent connection. Can we use UDP as the underlying transport-layer protocol for this new application? (10 marks)

Q26-3. When an HTTP server receives a request message from an HTTP client, how does the server know when all headers have arrived and the body of the message is to follow? (5 marks)

Q26-4. In a nonpersistent HTTP connection, how can HTTP inform the TCP protocol that the end of the message has been reached? (5marks)

Q26-5. Can you find an analogy in our daily life as to when we use two separate connections in communication similar to the control and data connections in FTP? (5marks)

Q26-6. FTP uses two separate well-known port numbers for control and data connection. Does this mean that two separate TCP connections are created for exchanging control information and data?(2marks)

Q26-7. FTP uses the services of TCP for exchanging control information and data transfer. Could FTP have used the services of UDP for either of these two connections? Explain. (5marks)

Q26-8. In FTP, which entity (client or server) starts (actively opens) the control connection? Which entity starts (actively opens) the data transfer connection? (2marks)

Q26-9. What do you think would happen if the control connection were severed before the end of an FTP session? Would it affect the data connection? (5marks)

Q26-11. In FTP, can a server retrieve a file from the client site? (2marks)

Q26-12. In FTP, can a server get the list of the files or directories from the client? (2marks)

Q26-13. FTP can transfer files between two hosts using different operating systems with different file formats. What is the reason? (2marks)

Q26-14. Does FTP have a message format for exchanging commands and responses during control connection? (2marks)

Q26-15. Does FTP have a message format for exchanging files or a list of directories/ files during the file-transfer connection? (2marks)

Q26-16. Can we have a control connection without a data-transfer connection in FTP? Explain. (2marks)

Q26-17. Can we have a data-transfer connection without a control connection in FTP? Explain. (2marks)

Q26-18. Assume we need to download an audio using FTP. What file type should we specify in our command? (2marks)

Q26-19. Both HTTP and FTP can retrieve a file from a server. Which protocol should we use to download a file? (2marks)

Q26-20. Are the HELO and MAIL FROM commands both necessary in SMTP? Why or why not? (5marks)

Q26-23. Assume a TELNET client uses ASCII to represent characters, but the TELNET server uses EBCDIC to represent characters. How can the client log into the server when character representations are different? (5marks)

Q26-24. The TELNET application has no commands such as those found in FTP or HTTP to allow the user to do something such as transfer a file or access a web page. In what way can this application be useful? (5marks)

Q26-25. Can a host use a TELNET client to get services provided by other client-server applications such as FTP or HTTP? (2marks)

Q26-26. In DNS, which of the following are FQDNs and which are PQDNs? (2marks)

a. xxx b. xxx.yyy.net c. zzz.yyy.xxx.edu.

Q27-1. Which of the following is not one of the five areas of network management defined by ISO? (2marks)

a. fault b. performance c. personnel

Q27-2. Which of the following is not part of configuration management? (2marks)

a. reconfiguration b. encryption c. documentation

Q27-3. A network manager decides to replace the old router that connects the organization to the Internet with a more powerful one. What area of network management is involved here? (5 marks)

Q27-4. A network manager decides to replace a version of accounting software with a new version. What area of network management is involved here? (2marks)

Q27-5. Distinguish between reactive fault management and proactive fault management. (5marks)

Q27-6. If network management does not replace a component whose lifetime has been expired, what area in network management has been ignored? (2marks)

Q27-7. Distinguish between internal and external data traffic in an organization. (5marks)

Q27-8. If a student in a college can monopolize access to a piece of software, causing other students to wait for a long time, which area of network management has failed? (2marks)

Q27-9. Which of the following devices cannot be a manager station in SNMP?

a. a router b. a host c. a switch (2marks)

Q27-10. Does an SNMP manager run a client SNMP program or a server SNMP program? (2marks)

Q27-24. What are the source and destination port numbers when an SNMP message carries one of the following PDUs? (2 marks)

a. GetRequest b. Response c. Trap d. Report

Q28-28. Explain why RTP cannot be used as a transport-layer protocol without being run on the top of another transport-layer protocol such as UDP. (5marks)

Q28-29. Both TCP and RTP use sequence numbers. Do sequence numbers in these two protocols play the same role? Explain. (5marks)

Q28-30. Can UDP without RTP provide an appropriate service for real-time interactive multimedia applications? (2marks)

Q31-5. When a sealed letter is sent from Alice to Bob, is this an example of using cryptography or steganography for confidentiality? (2marks)

Q31-6. When a letter is sent from Bob to Alice in a language that only the two can understand, is this an example of cryptography or steganography? (2marks)

Q31-7. Alice has found a way to write secretly to Bob. Each time, she takes a new text, such as an article from the newspaper, but inserts one or two spaces between the words. A single space means a binary digit 0; a double space means a binary digit 1. Bob extracts the binary digits and interprets them using ASCII code. Is this an example of cryptography or steganography? Explain. (10 marks)

Q31-8. Alice and Bob exchange confidential messages. They share a very large number as the encryption and decryption key in both directions. Is this an example of symmetric-key or asymmetric-key cryptography? Explain. (10 marks)

Q31-9. Alice uses the same key when she encrypts a message to be sent to Bob and when she decrypts a message received from Bob. Is this an example of symmetric-key or asymmetric-key cryptography? Explain. (10 marks)

Q31-10. Distinguish between a substitution cipher and a transposition cipher. (5 marks)

Q31-11. In a cipher, all As in the plaintext have been changed to Ds in the ciphertext and all Ds in the plaintext have been changed to Hs in the ciphertext. Is this a monoalphabetic or polyalphabetic substitution cipher? Explain. (10 marks)

Q31-12. Which cipher can be broken more easily, monoalphabetic or polyalphabetic? (5 marks)

Q31-13. Assume Alice and Bob use an additive cipher in modulo 26 arithmetic. If Eve, the intruder, wants to break the code by trying all possible keys (brute-force attack), how many keys should she try on average? (5 marks)

Q31-24. If Alice and Bob need to communicate using asymmetric-key cryptography, how many keys do they need? Who needs to create these keys? (5 marks)

Q31-25. Why do you think asymmetric-key cryptography is used only with small messages. (5 marks)

Module IV

Application Layer

Book: Computer Networks

by

TANENBAUM

PROBLEMS

1. Many business computers have three distinct and worldwide unique identifiers. What are they? (2marks)

3. Consider a situation in which a cyberterrorist makes all the DNS servers in the world crash simultaneously. How does this change one's ability to use the Internet? (5marks)

4. DNS uses UDP instead 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? (5marks)

5. John wants to have an original domain name and uses a randomized program to generate a secondary domain name for him. He wants to register this domain name in the *com* generic domain. The domain name that was generated is 253 characters long. Will the *com* registrar allow this domain name to be registered? (5marks)

6. Can a machine with a single DNS name have multiple IP addresses? How could this occur? (2marks)

7. The number of companies with a Web site has grown explosively in recent years. As a result, thousands of companies are registered in the *com* domain, causing a heavy load on the top-level server for this domain. Suggest a way to alleviate this problem without changing the naming scheme (i.e., without introducing new top-level domain names). It is permitted that your solution requires changes to the client code. (10marks)

8. Some email systems support a *Content Return:* header field. It specifies whether the body of a message is to be returned in the event of nondelivery. Does this field belong to the envelope or to the header? (2marks)

20. Does Webmail use POP3, IMAP, or neither? If one of these, why was that one chosen? If neither, which one is it closer to in spirit? (5marks)

21. When Web pages are sent out, they are prefixed by MIME headers. Why? (2marks)