Chapter 1 Review Questions

R1. What is the difference between a host and an end system? List several different types of end systems. Is a Web server an end system?

1. There is no difference. Throughout this text, the words "host" and "end system" are used interchangeably. End systems include PCs, workstations, Web servers, mail servers, PDAs, Internet-connected game consoles, etc.

R2. The word *protocol* is often used to describe diplomatic relations. How does Wikipedia describe diplomatic protocol?

2. From Wikipedia: Diplomatic protocol is commonly described as a set of international courtesy rules. These well-established and time-honored rules have made it easier for nations and people to live and work together. Part of protocol has always been the acknowledgment of the hierarchical standing of all present. Protocol rules are based on the principles of civility.

R3. Why are standards important for protocols?

3. Standards are important for protocols so that people can create networking systems and products that interoperate.

R4. List six access technologies. Classify each one as home access, enterprise access, or wide-area wireless access.

4. 1. Dial-up modem over telephone line: home; 2. DSL over telephone line: home or small office; 3. Cable to HFC: home; 4. 100 Mbps switched Ethernet: enterprise; 5. Wifi (802.11): home and enterprise: 6. 3G and 4G: wide-area wireless.

R5. Is HFC transmission rate dedicated or shared among users? Are collisions possible in a downstream HFC channel? Why or why not?

5. HFC bandwidth is shared among the users. On the downstream channel, all packets emanate from a single source, namely, the head end. Thus, there are no collisions in the downstream channel.

R6. List the available residential access technologies in your city. For each type of access, provide the advertised downstream rate, upstream rate, and monthly price.

6. In most American cities, the current possibilities include: dial-up; DSL; cable modem; fiber-to-the-home.

R7. What is the transmission rate of Ethernet LANs?

Ethernet LANs have transmission rates of 10 Mbps, 100 Mbps, 1 Gbps and 10 Gbps.

R8. What are some of the physical media that Ethernet can run over?

Today, Ethernet most commonly runs over twisted-pair copper wire. It also can run over fibers optic links.

R9. Dial-up modems, HFC, DSL and FTTH are all used for residential access. For each of these access technologies, provide a range of transmission rates and comment on whether the transmission rate is shared or dedicated.

9. Dial up modems: up to 56 Kbps, bandwidth is dedicated; ADSL: up to 24 Mbps downstream and 2.5 Mbps upstream, bandwidth is dedicated; HFC, rates up to 42.8 Mbps and upstream rates of up to 30.7 Mbps, bandwidth is shared. FTTH: 2-10Mbps upload; 10-20 Mbps download; bandwidth is not shared.

R10. Describe the most popular wireless Internet access technologies today. Compare and contrast them.

10. There are two popular wireless Internet access technologies today:

a) Wifi (802.11) In a wireless LAN, wireless users transmit/receive packets to/from an base station (i.e., wireless access point) within a radius of few tens of meters. The base station is typically connected to the wired Internet and thus serves to connect wireless users to the wired network.
b) 3G and 4G wide-area wireless access networks. In these systems, packets are transmitted over the same wireless infrastructure used for cellular telephony, with the base station thus being managed by a telecommunications provider. This provides wireless access to users within a radius of tens of kilometers of the base station.

R11. Suppose there is exactly one packet switch between a sending host and a receiving host. The transmission rates between the sending host and the switch and between the switch and the receiving host are $R1$ and $R2$, respectively. Assuming that the switch uses store-and-forward packet switching, what is the total end-to-end delay to send a packet of length L? (Ignore queuing, propagation delay, and processing delay.)

11. At time t_0 the sending host begins to transmit. At time $t_1 = L/R_1$, the sending host completes transmission and the entire packet is received at the router (no propagation delay). Because the router has the entire packet at time t_1, it can begin to transmit the packet to the receiving host at time t_1. At time $t_2 = t_1 + L/R_2$, the router completes transmission and the entire packet is received at the receiving host (again, no propagation delay). Thus, the end-to-end delay is $L/R_1 + L/R_2$.

R12. What advantage does a circuit-switched network have over a packet-switched network? What advantages does TDM have over FDM in a circuit-switched network?

12. A circuit-switched network can guarantee a certain amount of end-to-end bandwidth for the duration of a call. Most packet-switched networks today (including the Internet) cannot make any end-to-end guarantees for bandwidth. FDM requires sophisticated analog hardware to shift signal into appropriate frequency bands.

R13. Suppose users share a 2 Mbps link. Also suppose each user transmits continuously at 1 Mbps when transmitting, but each user transmits only 20 percent of the time. (See the discussion of statistical multiplexing in Section 1.3.)

a) When circuit switching is used, how many users can be supported?
b) For the remainder of this problem, suppose packet switching is used. Why will there be essentially no queuing delay before the link if two or fewer users transmit at the same time? Why will there be a queuing delay if three users transmit at the same time?
c) Find the probability that a given user is transmitting.
d) Suppose now there are three users. Find the probability that at any given time, all three users are transmitting simultaneously. Find the fraction of time during which the queue grows.

13. a) 2 users can be supported because each user requires half of the link bandwidth.

b) Since each user requires 1Mbps when transmitting, if two or fewer users transmit simultaneously, a maximum of 2Mbps will be required. Since the available bandwidth of the shared link is 2Mbps, there will be no queuing delay before the link. Whereas, if three users transmit simultaneously, the bandwidth required will be 3Mbps which is more than the available bandwidth of the shared link. In this case, there will be queuing delay before the link.

c) Probability that a given user is transmitting = 0.2

d) Probability that all three users are transmitting simultaneously = $\binom{3}{3} p^3 (1-p)^{3-3}$

= $(0.2)^3$ = 0.008. Since the queue grows when all the users are transmitting, the fraction of time during which the queue grows (which is equal to the probability that all three users are transmitting simultaneously) is 0.008.

R14. Why will two ISPs at the same level of the hierarchy often peer with each other? How does an IXP earn money?

14. If the two ISPs do not peer with each other, then when they send traffic to each other they have to send the traffic through a provider ISP (intermediary), to which they have to pay for carrying the traffic. By peering with each other directly, the two ISPs can reduce their payments to their provider ISPs. An Internet Exchange Points (IXP) (typically in a standalone building with its own switches) is a meeting point where multiple ISPs can connect and/or peer together. An ISP earns its money by charging each of the the ISPs that connect to the IXP a relatively small fee, which may depend on the amount of traffic sent to or received from the IXP.

R15. Some content providers have created their own networks. Describe Google's network. What motivates content providers to create these networks?

15. Google's private network connects together all its data centers, big and small. Traffic between the Google data centers passes over its private network rather than over the public Internet. Many of these data centers are located in, or close to, lower tier ISPs. Therefore, when Google delivers content to a user, it often can bypass higher tier ISPs. What motivates content providers to create these networks? First, the content provider has more control over the user experience, since it has to use few intermediary ISPs. Second, it can save money by sending less traffic into provider networks. Third, if ISPs decide to charge more money to highly profitable content providers (in countries where net neutrality doesn't apply), the content providers can avoid these extra payments.

R16. Consider sending a packet from a source host to a destination host over a fixed route. List the delay components in the end-to-end delay. Which of these delays are constant and which are variable?

16. The delay components are processing delays, transmission delays, propagation delays, and queuing delays. All of these delays are fixed, except for the queuing delays, which are variable.

R18. How long does it take a packet of length 1,000 bytes to propagate over a link of distance 2,500 km, propagation speed 2.5 · 108 m/s, and transmission rate 2 Mbps? More generally, how long does it take a packet of length L to propagate over a link of distance d, propagation speed s, and transmission rate R bps? Does this delay depend on packet length? Does this delay depend on transmission rate?

18. 10msec; d/s; no; no

R19. Suppose Host A wants to send a large file to Host B. The path from Host A to Host B has three links, of rates $R1 = 500$ kbps, $R2 = 2$ Mbps, and $R3 = 1$ Mbps.
   a) Assuming no other traffic in the network, what is the throughput for the file transfer?
   b) Suppose the file is 4 million bytes. Dividing the file size by the throughput, roughly how long will it take to transfer the file to Host B?
   c) Repeat (a) and (b), but now with $R2$ reduced to 100 kbps.

19. a) 500 kbps
    b) 64 seconds
    c) 100kbps; 320 seconds

R20. Suppose end system A wants to send a large file to end system B. At a very high level, describe how end system A creates packets from the file. When one of these packets arrives to a packet switch, what information in the packet does the switch use to determine the link onto which the packet is forwarded? Why is packet switching in the Internet analogous to driving from one city to another and asking directions along the way?

20. End system A breaks the large file into chunks. It adds header to each chunk, thereby generating multiple packets from the file. The header in each packet includes the IP address of the destination (end system B). The packet switch uses the destination IP address in the packet to determine the outgoing link. Asking which road to take is analogous to a packet asking which outgoing link it should be forwarded on, given the packet's destination address.

R21. Visit the Queuing and Loss applet at the companion Web site. What is the maximum emission rate and the minimum transmission rate? With those rates, what is the traffic intensity? Run the applet with these rates and determine how long it takes for packet loss to occur. Then repeat the experiment a second time and determine again how long it takes for packet loss to occur. Are the values different? Why or why not?

21. The maximum emission rate is 500 packets/sec and the maximum transmission rate is 350 packets/sec. The corresponding traffic intensity is 500/350 =1.43 > 1. Loss will eventually occur for each experiment; but the time when loss first occurs will be different from one experiment to the next due to the randomness in the emission process.

R22. List five tasks that a layer can perform. Is it possible that one (or more) of these tasks could be performed by two (or more) layers?

22. Five generic tasks are error control, flow control, segmentation and reassembly, multiplexing, and connection setup. Yes, these tasks can be duplicated at different layers. For example, error control is often provided at more than one layer.

R23. What are the five layers in the Internet protocol stack? What are the principal responsibilities of each of these layers?

23. The five layers in the Internet protocol stack are – from top to bottom – the application layer, the transport layer, the network layer, the link layer, and the physical layer. The principal responsibilities are outlined in Section 1.5.1.
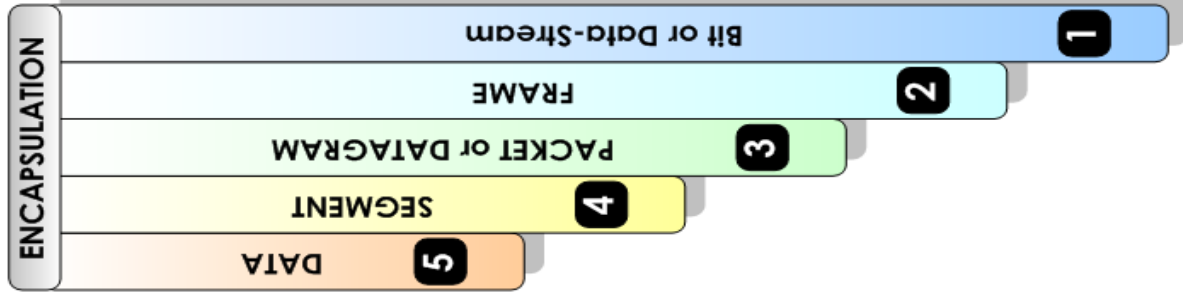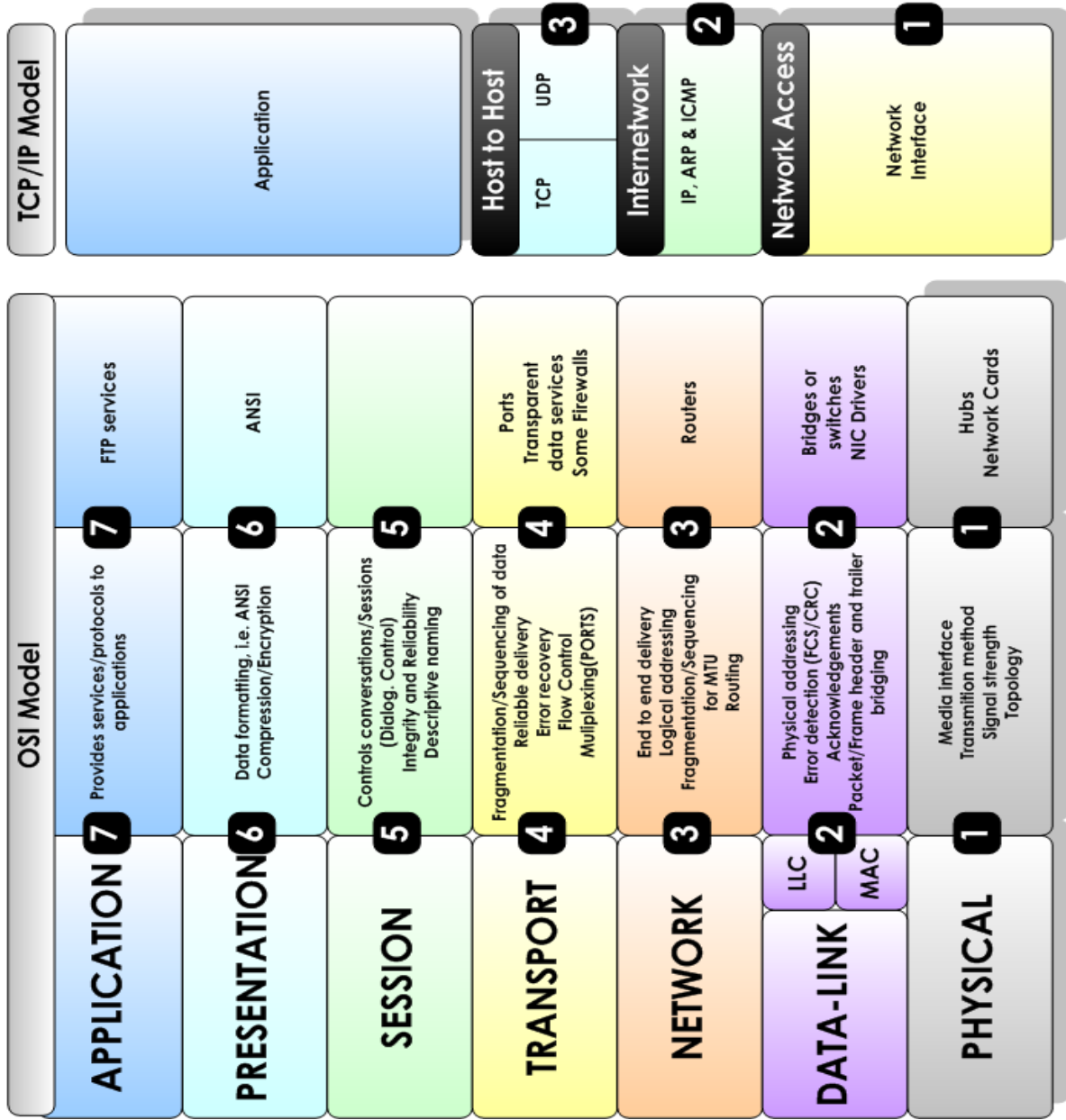
R24. What is an application-layer message? A transport-layer segment? A network-layer datagram? A link-layer frame?

24. Application-layer message: data which an application wants to send and passed onto the transport layer; transport-layer segment: generated by the transport layer and encapsulates application-layer message with transport layer header; network-layer datagram: encapsulates transport-layer segment with a network-layer header; link-layer frame: encapsulates network-layer datagram with a link-layer header.

R25. Which layers in the Internet protocol stack does a router process? Which layers does a link-layer switch process? Which layers does a host process?

25. Routers process network, link and physical layers (layers 1 through 3). (This is a little bit of a white lie, as modern routers sometimes act as firewalls or caching components, and process Transport layer as well.) Link layer switches process link and physical layers (layers 1 through2). Hosts process all five layers.

The OSI Model (Open Systems Interconnection)

ENCAPSULATION

Layer	Encapsulation Name
1	Bit or Data-Stream
2	FRAME
3	PACKET or DATAGRAM
4	SEGMENT
5	DATA

TCP/IP Model

Layer	Name	Protocols
3	Host to Host	TCP / UDP
	Application	Application
2	Internetwork	IP, ARP & ICMP
1	Network Access	Network Interface

OSI Model

#	Layer	Function	Examples
7	APPLICATION	Provides services/protocols to applications	FTP services
6	PRESENTATION	Data formatting, i.e. ANSI Compression/Encryption	ANSI
5	SESSION	Controls conversations/Sessions (Dialog, Control) Integrity and Reliability Descriptive naming	
4	TRANSPORT	Fragmentation/Sequencing of data Reliable delivery Error recovery Flow Control Multiplexing(PORTS)	Ports Transparent data services Some Firewalls
3	NETWORK	End to end delivery Logical addressing Fragmentation/Sequencing for MTU Routing	Routers
2	DATA-LINK (LLC / MAC)	Physical addressing Error detection (FCS/CRC) Acknowledgements Packet/Frame header and trailer bridging	Bridges or switches NIC Drivers
1	PHYSICAL	Media Interface Transmition method Signal strength Topology	Hubs Network Cards