[简答题]

Chapter 1 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?

[参考答案]主机和终端系统没有不同，二者可以交换使用。终端系统：PC，Linux 工作站，游戏控制台，Web 服务器，PDA，智能手机等。Web 服务器是终端系统。

[简答题]

Chapter 1 R3. Why are standards important for protocols?

[参考答案]只有网络协议遵循相同的标准，不同厂商的网络设备、不同开发商的网络软件才能够互相通信，实现数据传输，才能支持网络的商业化及其大规模的推广应用。

[简答题]

Chapter 1 R4. List four access technologies. Classify each one as home access, enterprise access, or wide-area wireless access.

[参考答案]

家庭接入： DSL, Cable, FTTH, Satellite, WiFi

企业接入: Ethernet, WiFi

广域无线接入: 3/4/5G

[简答题]

Chapter 1 R7. What is the transmission rate of Ethernet LANs?

[参考答案]传输速率有：10 Mbps, 100 Mbps, 1 Gbps, 10Gbps

[简答题]

Chapter 1 R8. What are some of the physical media that Ethernet can run over?

[参考答案]Ethernet 使用的物理介质通常是双绞线（twisted-pair copper wire）或光纤（fiber optics）。

[简答题]

Chapter 1 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?

[参考答案]

电路交换由于在通话（数据传输）前会建立连接，寻路并沿路径预留带宽，然后传输数据。因此在通话期间所有数据都从实现建立好的路径传输，可以确保业务的传输延迟和传输速率，不会产生丢包和乱序。

包交换则不同。在数据传输前不建立连接，每个数据包独立寻路。因此数据传输过程中每个数据包所经过的路径可能不同，会产生丢包和乱序，也不能保证数据的传输延迟和传输速率。但是包交换的优点是可以充分利用网络资源，可以让更多的用户接入网络。

FDM 需要复杂的模拟硬件将信号转换到适当的频率上。

[简答题]

Chapter 1 R13. Suppose users share a 2 Mbps link. Also suppose each user transmits continuously at 1Mbps 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.
[参考答案]
a. 每个用户传输数据都需要一半带宽（1Mbps），所以支持 2 个用户。
b. 两个或小于两个用户，所需要的带宽最大为 2Mbps，所以不会出现排队延迟；当有三个用户时，需要 3Mbps 带宽，大于链路带宽 2Mbps，所以在链路之前会发生排队时延。
c. 概率为 0.2。
d. 三个用户同时传输的概率为$0.2^3 = 0.008$，由于队列增长发生在三个用户同时传输时，所以队列增长的时间百分比为 0.008。

[简答题]
Chapter 1 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?
[参考答案]延迟包括处理延迟、传输延迟、传播延迟和排队延迟。其中排队延迟是变化的，随着网络中业务量而变化；其它的延迟都不变。

[简答题]
Chapter 1 R18. How long does it take a packet of length 1000 bytes to propagate over a link of distance 2500 km, propagation speed 2.5×10^8 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?
[参考答案]

传播时间：$\frac{2500*10^3 m}{2.5*10^8 m/s} = 10ms$

传播时间：d/s
传播时延不依赖 packet 长度，也不依赖传输速率。

[简答题]
Chapter 1 R23. What are the five layers in the Internet protocol stack? What are the principal responsibilities of each of these layers?.
[参考答案]IP 协议栈中的五个层从上到下分别是应用层、传输层、网络层、链路层和物理层。每一层的作用分别是：
(1) 应用层：面向用户提供端到端的网络服务。
(2) 传输层：为应用层提供端到端的数据传输服务。
(3) 网络层：转发和路由。为数据包找到一条从源地址到目的地址的路径。
(4) 链路层：为共享同一条链路的多个用户分配链路资源，以便把数据包传输到网络层指定的相邻节点上。

(5) 物理层：负责把数字信号转换成模拟信号（光/电等），在物理介质上传输。

[简答题]

Chapter 1 R24.What is an application-layer message? A transport-layer segment? A network-layer datagram? A link-layer frame?

[参考答案]

应用层消息：应用程序希望发送并传递到传输层的数据；

传输层数据段：用传输层协议头部封装应用层的消息后形成的数据；

网络层数据报：用网络层协议头部封装传输层的数据段后形成的数据；

链路层帧：用链路层协议头部封装网络层数据报后形成的数据。

[简答题]

Chapter 1 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?

[参考答案]

路由器处理：网络层，数据链路层和物理层。

数据链路层交换机处理：数据链路层和物理层。

主机处理：应用层，传输层，网络层，数据链路层和物理层。

[简答题]

Chapter 1 P6. This elementary problem begins to explore propagation delay and transmission delay, two central concepts in data networking. Consider two hosts, A and B, connected by a single link of rate R bps. Suppose that the two hosts are separated by m meters, and suppose the propagation speed along the link is s meters/sec. Host A is to send a packet of size L bits to Host B.

a. Express the propagation delay, d_{prop} in terms of m and s.

b. Determine the transmission time of the packet, d_{trans}, in terms of L and R.

c. Ignoring processing and queuing delays, obtain an expression for the end-to-end delay.

d. Suppose Host A begins to transmit the packet at time $t = 0$. At time $t = d_{\text{trans}}$, where is the last bit of the packet?

e. Suppose d_{prop} is greater than d_{trans}. At time $t = d_{\text{trans}}$, where is the first bit of the packet?

f. Suppose d_{prop} is less than d_{trans}. At time $t = d_{\text{trans}}$, where is the first bit of the packet?

g. Suppose 2.5×10^8m/s, $L = 1500$ bytes, and $R = 10$Mbps. Find the distance m so that d_{prop} equals d_{trans}.

[参考答案]

a. $d_{\text{prop}} = m/s$ seconds.

b. $d_{\text{trans}} = L/R$ seconds.

c. $d_{\text{end-to-end}} = (m/s + L/R)$seconds.

d. 最后的 bit 刚离开主机 A.

e. 第一个 bit 在链路中还未到达主机 B

f. 第一个 bit 已经到达主机 B

g. $m = \frac{L}{Rs} = 1500 * 8/10^7 \times 2.5 \times 10^8 = 300$ km.

[简答题]

Chapter 1 P8. Suppose users share a 10 Mbps link. Also suppose each user requires 200 kbps when transmitting, but each user transmits only 10 percent of the time. (See the discussion of packet switching versus circuit switching 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. Find the probability that a given user is transmitting.

c. Suppose there are 120 users. Find the probability that at any given time, exactly *n* users are transmitting simultaneously. (Hint : Use the binomial distribution.)

d. Find the probability that there are 51 or more users transmitting simultaneously.

[参考答案]

a) 可以支持 50.

b) $p = 0.1$.

c) $\binom{120}{n} p^n (1-p)^{120-n}$.

d)

$$\mathbf{1 - \sum_{n=0}^{50} \binom{120}{n} p^n (1-p)^{120-n}}$$

令 X_j 为独立随机变量， $P(X_j = 1) = p$.

$$\mathbf{P("51\ or\ more\ users") = 1 - P\left(\sum_{j=1}^{120} X_j \leq 51\right)}$$

应用中心极限定理近似此概率分布为正态分布，均值为 np=12;标准差为 $\sqrt{n \times p \times (1-p)} = \sqrt{120 \times 0.1 \times 0.9} =$3. 286.

$$\boldsymbol{P\left(\sum_{j=1}^{120} X_j \leq 51\right) = P\left(\frac{\sum_{j=1}^{120} X_j - 12}{\sqrt{120 \times 0.1 \times 0.9}} \leq \frac{39}{\sqrt{120 \times 0.1 \times 0.9}}\right)}$$

$$\boldsymbol{\approx P\left(Z \leq \frac{39}{3.286}\right) = P(Z \leq 11.87) = 1}$$

Z 服从标准正态分布。

因此 $\mathbf{P}$("51 or more users") $\approx \mathbf{0}$。

[简答题]

Chapter 1 P10. Consider a packet of length L that begins at end system A and travels over three links to a destination end system. These three links are connected by two packet switches. Let $d_i, s_i,$ and R_i denote the length, propagation speed, and the transmission rate of link $i, (i = 1,2,3)$ for L. The packet switch delays each packet by d_{proc}. Assuming no queuing delays, in terms of $d_i, s_i,$ R_i $(i = 1,2,3)$, and L, what is the total end-to-end delay for the packet? Suppose now the packet is 1,500 bytes, the propagation speed on all three links is 2.5×10^8m/s, the transmission

rates of all three links are 2.5 Mbps, the packet switch processing delay is 3 msec, the length of the first link is 5,000 km, the length of the second link is 4,000 km, and the length of the last link is 1,000 km. For these values, what is the end-to-end delay?

[参考答案]

将目的终端设备记为 B，那么从 A 到 B 需要经过三条 link 和两个 switch，分别将三条 link 和两个 switch 标记为 $link_1$，$link_2$，$link_3$ 和 $switch_1$，$switch_2$。

从 A 到 B 传输一个数据包，依次经过 $link_1$，$switch_1$，$link_2$，$switch_2$，$link_3$ 最后到达 B。所有的时延为三条链路上的传播时延、传输时延以及两个交换机的处理时延，

$$t = \frac{d_1}{s_1} + \frac{d_2}{s_2} + \frac{d_3}{s_3} + \frac{L}{R_1} + \frac{L}{R_2} + \frac{L}{R_3} + d_{proc} + d_{proc}$$

代入数据到上述等式，可得$t = 20 + 16 + 4 + 4.8 + 4.8 + 4.8 + 3 + 3 = 60.4\text{ms}$

[简答题]

Chapter 1 P23. Consider Figure 1.19(a). Assume that we know the bottleneck link along the path from the server to the client is the first link with rate R_s bits/sec. Suppose we send a pair of packets back to back from the server to the client, and there is no other traffic on this path. Assume each packet of size Lbits, and both links have the same propagation delay d_{prop}.

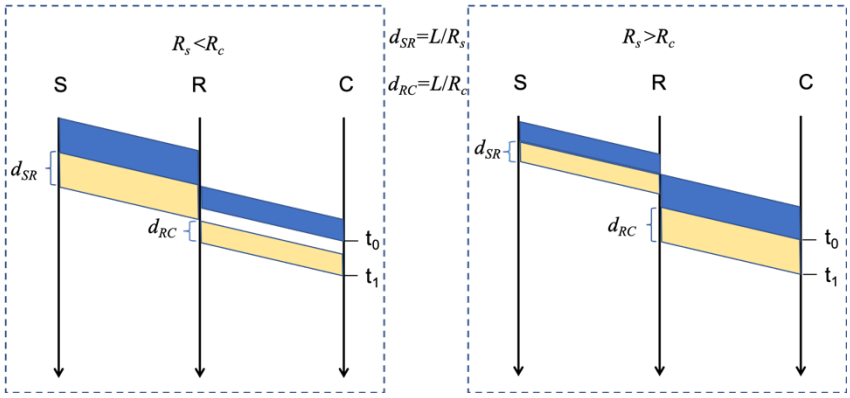
a. What is the packet inter-arrival time at the destination? That is, how much time elapses from when the last bit of the first packet arrives until the last bit of the second packet arrives?

b. Now assume that the second link is the bottleneck link (i.e., $R_c < R_s$). Is it possible that the second packet queues at the input queue of the second link? Explain. Now suppose that the server sends the second packet T seconds after sending the first packet. How large must T be to ensure no queuing before the second link? Explain.

[参考答案]

(a) L/R_s.

(b) 第2个数据包会排队。如果不排队，需要第2个数据包的发送间隔 $\mathrm{T} = \mathrm{d}_{RC} - \mathrm{d}_{SR} = L/R_c - L/R_s$. 解释如下右图所示。因为$R_c < R_s$，第1个数据包在第2条链路上的传输时间大于第1条链路。到达的第2个数据包只能等第1个数据包发完才能发出。



[简答题]

Chapter 1 P25. Suppose two hosts, A and B, are separated by 20,000 kilometers and are connected by a direct link of $R = 5$ Mbps. Suppose the propagation speed over the link is 2.5×10^8m/s.

a. Calculate the bandwidth-delay product, $R \times d_{\text{prop}}$.

b. Consider sending a file of 800,000 bits from Host A to Host B. Suppose the file is sent

continuously as one large message. What is the maximum number of bits that will be in the link at any given time?

c. Provide an interpretation of the bandwidth-delay product.

d. What is the width (in meters) of a bit in the link? Is it longer than a football field?

e. Derive a general expression for the width of a bit in terms of the propagation speed *s*, the transmission rate *R*, and the length of the link *m*.

[参考答案]

a. 时延带宽积$R\times d_{\text{prop}} = 5\ \text{Mbps} \times (20{,}000\ \text{km}/2.5 \times 10^{8}\text{m/s}) = 400\ \text{kb}$。

b. 由上一问可知，最大 bit 数为 400 kb。

c. 一条链路可以容纳的最大 bit 数量。

d. 一个 bit 的宽度为链路长度除以时延带宽积。因此该链路上一个 bit 的宽度为：50 m，小于一个足球场的长度。

e. 根据以上的理解，一个比特的宽度$\frac{m}{R*d_{prop}} = \frac{m}{R*\frac{m}{s}} = \frac{s}{R}$。