Solutions – EFREI 2015

Exercise 1) Negotiation has to do with getting both sides to agree on some parameters or values to be used during the communication. Maximum packet size is one example, but there are many others.

Exercise 2) Both models are based on layered protocols. Both have a network, transport, and application layer. In both models, the transport service can provide a reliable end-to-end byte stream. On the other hand, they differ in several ways. The number of layers is different, the TCP/IP does not have session or presentation layers, OSI does not support internetworking, and OSI has both connection-oriented and connectionless service in the network layer.

Exercise 3) (a) Data link layer. (b) Network layer.

Exercise 3) Among other reasons for using layered protocols, using them leads to breaking up the design problem into smaller, more manageable pieces, and layering means that protocols can be changed without affecting higher or lower ones. One possible disadvantage is the performance of a layered system is likely to be worse than the performance of a monolithic system, although it is extremely difficult to implement and manage a monolithic system.

Exercise 4) In the OSI protocol model, physical communication between peers takes place only in the lowest layer, not in every layer.

Exercise 6) With pure ALOHA, transmission can start instantly. At low load, no collisions are expected so the transmission is likely to be successful. With slotted ALOHA, it has to wait for the next slot. This introduces half a slot time of delay

Exercise 9) A noiseless channel can carry an arbitrarily large amount of information, no matter how often it is sampled. Just send a lot of data per sample. For the 4-kHz channel, make 8000 samples/sec. If each sample is 16 bits, the channel can send 128 kbps. If each sample is 1024 bits, the channel can send 8.2 Mbps. The key word here is ‘‘noiseless.’’ With a normal 4 kHz channel, the Shannon limit would not allow this. A signal-to-noise ratio of 30 dB means S/N = 1000. Using Eq. (2-3) with B = 4000 we get a maximum data rate of about 39.86 kbps.

Solution : 2 B = 2 (4 kHz) ➔ 8000 samples/s
8000 * 16 ➔ 128 kbps

Exercise 10) Using the Nyquist theorem, we can sample 12 million times/sec. Four-level signals provide 2 bits per sample, for a total data rate of 24 Mbps.

Exercise 11) A signal-to-noise ratio of **20 dB means S/N = 100**. Since **$\log_2 101$ is about 6.658**, the **Shannon limit is about 19.975 kbps**. The Nyquist limit is 6 kbps. The bottleneck is therefore the Nyquist limit, giving a maximum channel capacity of 6 kbps

Exercise 12). To send a T1 signal we need $H\log_2(1 + S/N) = 1.544 \times 10^6$ with $H = 50{,}000$. This yields $S/N = 2^{30} - 1$, which is about 93 dB.

Exercise 13). Just compute the four normalized inner products:
(−1 +1 −3 +1 −1 −3 +1 +1) (−1 −1 −1 +1 +1 −1 +1 +1)/8 = 1
(−1 +1 −3 +1 −1 −3 +1 +1) (−1 −1 +1 −1 +1 +1 +1 −1)/8 = −1
(−1 +1 −3 +1 −1 −3 +1 +1) (−1 +1 −1 +1 +1 +1 −1 −1)/8 = 0
(−1 +1 −3 +1 −1 −3 +1 +1) (−1 +1 −1 −1 −1 −1 +1 −1)/8 = 1

The result is that A and D sent 1 bits, B sent a 0 bit, and C was silent

Exercise 14) Here are the chip sequences:
(+1 +1 +1 +1 +1 +1 +1 +1)
(+1 −1 +1 −1 +1 −1 +1 −1)
(+1 +1 −1 −1 +1, +1 −1 −1)
(+1 −1 −1 +1 +1 −1 −1 +1)

When two elements match, their product is +1. When they do not match, their product is −1. To make the sum 0, there must be as many matches as mismatches. Thus, two chip sequences are orthogonal if exactly half of the corresponding elements match and exactly half do not match.

Exercise 15). Yes. Imagine that they are in a straight line and that each station can reach only its nearest neighbors. Then A can send to B while E is sending to F.

Exercise 16) The result is obtained by negating each of A, B, and C and then adding the three chip sequences. Alternatively, the three can be added and then negated. The result is (+3 +1 +1 −1 −3 −1 −1 +1)

Exercise 18) It is both. Each of the 100 channels is assigned its own frequency band (FDM), and on each channel the two logical streams are intermixed by TDM.

Exercise 19) With pure ALOHA the usable bandwidth is 0.184 × 56 kbps = 10.3 kbps. Each station requires 10 bps, so N = 10300/10 = 1030 stations.

Exercise 20). Message switching sends data units that can be arbitrarily long. Packet switching has a maximum packet size. Any message longer than that is split up into multiple packets.

Exercise 22) Please see course slides…

Exercise 23). There are ten 4000 Hz signals. We need nine guard bands to avoid any interference. The minimum bandwidth required is 4000 × 10 + 400 × 9 = 43,600 Hz.

Exercise 24)

A) TDM
B) FDM
C) CDMA

Exercise 25)

(a) With G = 2 the Poisson law gives a probability of e^{-2}.

The channel traffic load rate $G = 50 \times (40 \times 10^{-3}) = 2$ requests/slot. In one slot, k requests happen with the probability $\pi_k = G^k e^{-G} / k!$.

1) First attempt succeed with the probability
   Pr[no other request (new or retransmission) occurs within the first slot]
   $= \pi_0 = e^{-G} = e^{-2} = 0.135$

(b) $(1 - e^{-G})^k e^{-G} = 0.135 \times 0.865^k$.

If assuming that things happening in different slots are independent, the probability is $(1 - e^{-G})^k e^{-G} = 0.135 \times 0.865^k$

(c) The expected number of transmissions is e G = 7.4.

$$E = \text{traffic load / throughput} = G / S = G / Ge^{-G} = e^G = 7.4$$

Exercise 26)

For successful communication we require that the sender can reach (communicate with) the receiver, and that there be no other sender who can reach (now interfere with) the receiver. Also, a station cannot send and receive at the same time

(a) Since all stations will see As packet, it will interfere with receipt of any other packet by any other station. So, no other communication is possible in this case.

(b) Although B's packet will not be seen by D, other nodes, e.g., E, or C, cannot send to D because the packets from these nodes will interfere with the packets from B at A. Therefore, other comminications is not possible at the same time.

(c) B’s packet will be seen by E, A and C, by not by D. Thus, E or A might try to sendto D at the same time. Of these two possibilities, A can communicate with C, sothis would interfere with B’s transmission to A. But E can safely send to D since itwill not interfere with C’s reception.