Assignment 5

ECE1150 - Introduction to Computer Networks
University of Pittsburgh
(100 points)

Instructions:

- **Show all steps in answering the following questions.**
- **Make sure to put units of measurements (if applicable) in your answers.**
- **Include equations and explanations wherever applicable as points are allocated for all the above!**
- **Make sure to highlight your final answers.**

1. (5 points) How many frequencies are used in an FDD, 64-QAM modem? Justify your answer.
2. (5 points) Assume a voice channel with 4 kHz bandwidth. We need to multiplex 8 voice channels using FDM. In doing so, guard bands of 150 Hz are needed between two neighboring channels. Calculate the total bandwidth required.
3. (15 points) Describe the following medium access control protocols: ALOHA, Slotted ALOHA, CSMA, CSMA/CD, and Polling.
4. (10 points) Prove that the efficiency of slotted Aloha is around 36%. Assume that the number of frames that are generated during a given frame time is modeled with a Poisson distribution with average of G frames/slot.
5. (7 points) A device in a LAN wants to transmit a file of M bits, encapsulated in one packet. Let the header be H bits. The bit rate is B. Due to contention in the medium, the device gets to transmit with a probability Ptx. When the device transmits the packet, there is a probability Pe that the packet will be received in error.
   What is the throughput of the transmission?
   What is the efficiency?
   Ignore propagation delay and consider only the transmission delay. You can approximate (M/M+H) to 1.. Your answer will be in terms of the parameters provided.
6. (28 points) Suppose three active nodes—nodes A, B and C —are competing for access to a channel using slotted ALOHA. Assume each node has an infinite number of packets to send. Each node attempts to transmit in each slot with probability p. The first slot is numbered slot 1, the second slot is numbered slot 2, and so on.
   a. (10 points) What is the probability that node A succeeds for the first time in slot 5?
   b. (8 points) What is the probability that either A, B, or C succeeds in slot 4?

c. (8 points) What is the probability that the first success occurs in slot 3?

d. (2 points) What is the efficiency (probability of success in any slot) of this three-node system?

7. (10 points) Assume a data sequence given by 1011011. If CRC is used for error detection. The generator polynomial is $g(x) = x^3 + x^2 + 1$:

   a. (5 points) Perform the sender-side computation and calculate the CRC. What is the transmitted sequence?

   b. (5 points) Check your computation by performing the receiver-side computation. How does the receiver decide that there is no error in the received sequence?

8. (20 points) Assuming two packets each is of size 20Kbytes. The packets will be transmitted over a link of length L=5km, the speed of signal in the medium is $V=2.5 \times 10^8$m/s, bit rate is 1Gbps. Calculate the throughput of the transmission in the following cases:

   Note : In both cases, assume no errors, negligible overheads in packets. Assume that the acknowledgments (ACK) are of very small size (i.e. ignore the transmission delay of the ACK packets). The ACKs are transmitted immediately after the reception of each packet, and devices are full duplex. Delay is counted from the time the transmitter starts sending until it receives the ACK of the last packet.

   a. (10 points) Stop and Wait ARQ

   b. (10 points) Continuous ARQ with window size of 2