Problem 1

a. (10 points) Describe the operation of slotted ALOHA and Wi-Fi based multiple access schemes and compare their performance features, identifying the key factors that determine their performance efficiency.

b. (40 points) Consider a multiple access wireless channel that is shared by a large number of user devices (stations). A slotted ALOHA multiple access protocol is employed for sharing the channel. Each packet has a data length of 2000 bits and a header with an average length of 25 bytes. The transmission data rate across the channel is equal to 15 Mbps. The occurrence of error events is negligible. The slot duration is equal to the time that it takes to transmit a packet. Measurements show that 32% of the slots include successful packet transmissions. Transmission traffic processes are modeled as Poisson processes.

   i. (10 points) Calculate the average number of packets that are transmitted per slot, whether successful or colliding.

   ii. (10 points) Calculate the average number of times that a packet is retransmitted until it is successfully received.

   iii. (10 points) Assume that a colliding packet will be retransmitted after an average time delay (measured from the end of its previous transmission to the start of its retransmission) that is equal to 60 msec. Calculate the average time delay incurred by a packet, measured from the start time of first message transmission to the completion time of its successful transmission.

   iv. (10 points) Calculate the net throughput rate across the communications channel, expressed in units of bits/sec.

Problem 2

a. (10 points) State the Go-Back-N protocol and describe how you would go about setting the window value N to induce an efficient operation.

b. (40 points) Consider a Full-Duplex wireless communications channel employing a Go-Back-N ARQ error-control scheme. The transmission data rate across the channel (in each direction) is equal to 0.5 Mbps. The (one way) length of the link is 300 Km, and the propagation rate is 5 microsec/Km. An ACK packet contains 200 bits. The frame (on which the error control scheme operates) contains 600 information bits and (additionally) 120 overhead bits. The probability of incorrect ACK reception is negligible. Receive and transmit radio unit reaction times are each equal to 150 microsec. The bit error rate across the channel is equal to $0.8 \cdot 10^{-3}$.

   i. (10 points) Calculate the probability that a packet needs to be retransmitted at least 3 times.

   ii. (10 points) Calculate the preferred value of N.

   iii. (10 points) Calculate the throughput rate across the link in units of packets/sec, also compute the normalized throughput ratio (in %).

   iv. (10 points) The system designer is considering whether to reduce the packet length so that it consists of 400 data bits plus 120 overhead bits. Determine if using this design, the system will yield a higher net throughput rate, and is so by what percentage level.