

## CSC358 Tutorial 9

### Question 1: Concept Review

Consider the following four desirable characteristics of a broadcast channel. Which of these characteristics are satisfied by pure FDMA, ALOHA, slotted ALOHA, and CSMA? Let  $R$  be the bandwidth of channel.

- (a) When only one node has data to send, that node has a throughput of  $R$ .
- (b) When  $M$  nodes have data to send, each of these nodes, on average, has a fair share of the channel bandwidth.
- (c) The protocol is decentralized, i.e., there is no master node that represents a single point of failure.
- (d) The protocol is simple, so that it is inexpensive to implement.

### Question 2: Pure ALOHA: Proof for Efficiency

In the lecture, we performed a proof that the maximum efficiency of slotted ALOHA is  $1/e$  when  $N \rightarrow \infty$ . In this question, carry out a similar proof for pure ALOHA, i.e., show that its maximum efficiency is  $1/(2e)$ . Write down all steps of your derivation carefully.

### Question 3: Slotted ALOHA: Performance Analysis

Consider two nodes, A and B, that use the slotted ALOHA protocol to contend for a channel with bandwidth  $R$ . Suppose node A has more data to transmit than node B, and node A's retransmission probability  $p_A$  is greater than node B's retransmission probability,  $p_B$ .

- (a) Provide a formula for node A's average throughput.
- (b) Provide a formula for node B's average throughput.
- (c) What is the total efficiency of the protocol with these two nodes?
- (d) If  $p_A = 2p_B$ , is node A's average throughput twice as large as that of node B? Why or why not? If not, how can you choose  $p_A$  and  $p_B$  to make that happen?
- (e) In general, suppose there are  $N$  nodes, among which node A has retransmission probability  $2p$  and all other nodes have retransmission probability  $p$ . Provide expressions to compute the average throughputs of node A and any other node.

### Question 4: Visualization

Graph the efficiency of slotted ALOHA and pure ALOHA as a function of  $p$  for  $N = 20, 40, 60$  (using whichever plotting tool). Compare them and explain their differences.