Assignment - 2

CS348, Max. Marks: 34

Note: Document uploaded with your solutions should have the format <rollno>-CS348-hw2.pdf. You can use any software to prepare the document or scan handwritten solutions. This assignment should be done individually. Discussions are allowed, but the final solution should be written down individually.

1. (9 marks) (Analysis of simple MAC protocol) Consider a scenario in which n hosts share the same medium. The medium has bandwidth c. Time is divided into slots of duration T seconds (i.e. $[lT, (l+1)T]$, $l = \ldots, -1, 0, 1, \ldots$). Each host transmits a frame of size cT bits at bit rate c during any given time slot with probability p independent of all other hosts. Such a frame transmission begins at the start of any slot. If only one frame is transmitted in a time-slot then we say the transmission was successful. If more than one frame is transmitted then we say that a "collision" has occured and none of the transmissions in that slot were successful.

   (a) (3 marks) Derive an expression for the expected number of successful transmission in a time-slot in terms of n and p.

   (b) (5 marks) For a fixed number of hosts n, what is the largest possible expected bit rate of successful transmissions (i.e. maximum network throughput) found by varying p? Draw a plot of maximum network throughput as a function of n (from $n = 1, 2, \ldots, 50$). Interpret your results.

   (c) (1 mark) What is the limit of maximum network throughput as $n \to \infty$?

2. (15 marks) Consider an Ethernet LAN in which several nodes are connected to the same co-axial cable bus and all (except one malicious node) run the standard Ethernet CSMA/CD protocol. The malicious node is greedy and wants to transmit at least $N\%$ of successfully transmitted frames, that is $N\%$ of frames which do not face collisions. Here N is a tunable parameter between 0 and 100 which can be set by the person using the malicious protocol. Assume that the malicious node has an infinite amount of data to transmit to some other node(s) in the LAN. Give details of how the malicious node may go about achieving its goal. You should draw a flow chart explaining your protocol. For this question, solutions which are more elegant will receive more marks.

3. (10 marks) A Wi-Fi scenario is shown in Figures 1. All WiFi nodes use virtual carrier sensing to solve the hidden terminal problem. Assume that any node can both carrier sense and also receive packets (RTS, CTS, DATA, or ACK) from another node *if and only if* the two nodes are within distance 3 units of each other. All DATA packets are assumed to be of the same size. Assume that no DATA packets are sent between pairs of nodes other than the ones explicitly mentioned below.

   In Figure 1 we see six Wi-Fi nodes located on a two-dimensional plane: A_1, B_1, and C_1 at (1,0), (3,0), and (5,0) respectively, and A_2, B_2, and C_2 at (1,2), (3,2), and (5,2) respectively. Assume that A_1 has an infinite amount of data to send to A_2, that is, A_1 always has a data packet available to send to A_2. Similarly B_1 has an infinite amount of data to send to B_2, and C_1 has an infinite amount of data to send to C_2. Let T_A denote the resulting data throughput from A_1 to A_2. Let T_B denote the data throughput from B_1 to B_2, and let T_C be the data throughput from C_1 to C_2. Assume that these throughputs are the average throughputs

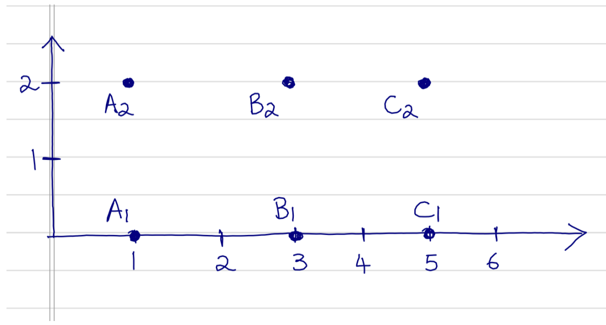

Figure 1: Wi-Fi Three-Pairs topology

measured over a period of time which is large enough to smoothen out the effects of random selection of contention window sizes etc.

Discuss qualitatively the relationship (greater than, less than, equal to etc.) between T_A, T_B, and T_C. Should all three be roughly equal? If so, why? And if not, why? Your answer should be explained in terms of the Wi-Fi virtual carrier sensing protocol.