Principles of Computer Networks
Tutorial 10

Problem 1: Carrier Sensing Multiple Access with Collision Detection

Recall that with the CSMA/CD protocol, the adapter waits $K \times 512$ bit times after a collision, where K is drawn randomly. For $K = 100$, how long does the adapter wait until returning to Step 2 for a 10 Mbps broadcast channel? How long is it for a 100 Mbps broadcast channel?

Problem 2: CSMA/CD Retransmission

Suppose nodes A and B are on the same 10 Mbps broadcast channel, and the propagation delay between the two nodes is 245 bit times. Suppose A and B send Ethernet frames at the same time, the frames collide, and then A and B choose different values of K in the CSMA/CD algorithm. Assuming no other nodes are active, can the retransmissions from A and B collide? For our purposes, it suffices to work out the following example. Suppose A and B begin transmission at $t = 0$ bit times. They both detect collisions at $t = 245$ bit times. Suppose $K_A = 0$ and $K_B = 1$. At what time does B schedule its retransmission? At what time does A begin transmission? (*Note*: The nodes must wait for an idle channel after returning to Step 2.) At what time does A's signal reach B? Does B refrain from transmitting at its scheduled time?

Problem 3: Packetization Delay

In this problem, we explore the use of small packets for Voice-over-IP applications. One of the drawbacks of a small packet size is that a large fraction of link bandwidth is consumed by overhead bytes. To this end, suppose that the packet consists of P bytes and 5 bytes of header.

- **a)** Consider sending a digitally encoded voice source directly. Suppose the source is encoded at a constant rate of 128 kbps. Assume each packet is entirely filled before the source sends the packet into the network. The time required to fill a packet is the **packetization delay**. In terms of L, determine the packetization delay in milliseconds.
- **b)** Packetization delays greater than 20 msec can cause a noticeable and unpleasant echo. Determine the packetization delay for $L = 1{,}500$ bytes (roughly corresponding to a maximum-sized Ethernet packet) and for $L = 50$ (corresponding to an ATM packet).
- **c)** Calculate the store-and-forward delay at a single switch for a link rate of $R = 622$ Mbps for $L = 1{,}500$ bytes, and for $L = 50$ bytes.
- **d)** Comment on the advantages of using a small packet size.

Problem 4: Efficiency

I. Consider a broadcast channel with N nodes and a transmission rate of R bps. Suppose the broadcast channel uses **polling** (with an additional polling node) for multiple access. Suppose the amount of time from when a node completes transmission until the subsequent node is permitted to transmit (that is, the polling delay) is d_p. Suppose that within a polling round, a given node is allowed to transmit at most L bits. What is the maximum throughput of the broadcast channel?

II. Consider the efficiency of slotted ALOHA. Suppose there are exactly three nodes, all with an infinite number of packets to transmit. Let p be the probability that a node transmits in any slot.

- **a)** As a function of p, find the probability that there is a successful transmission in any given slot.
- **b)** Find the value of p that maximizes this expression.
- **c)** What is the maximum efficiency for $N = 3$?

Problem 5: Putting Protocols Together

In this problem, you will put together much of what you have learned about Internet protocols. Suppose you walk into a room, connect to Ethernet, and want to download a web page. What are all the protocol steps that take place starting from powering on your PC to getting the web page? Assume there is nothing in our DNS or browser caches when you power on your Pc. (Hint: the steps include the use of Ethernet, OHCP, ARP, ONS, TCP, and HTTP protocols.) Explicitly indicate in your steps how you obtain the IP and MAC addresses of a gateway router.