CMPS 4750/6750 Computer Networks – Spring 2020

Homework 1 (25 points)

Due 02/04/20 at the beginning of class

Note: You should clearly justify your answer to each question below. It is insufficient to only give the final result. For this homework assignment, all the questions are required for both undergraduate and graduate students.

1. **Circuit switching (6 points)**

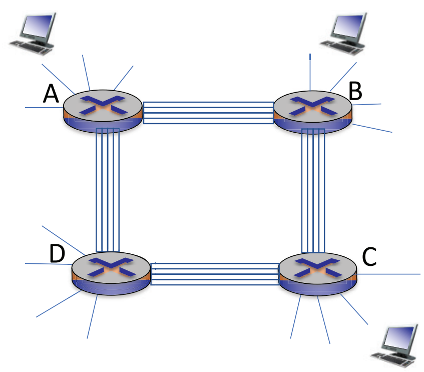

Figure 1: A simple circuit-switched network.

Consider the circuit-switched network shown in Figure 1. There are 4 circuits on each link. Label the four switches A, B, C, and D, going in the clockwise direction.

   (a) Suppose that all connections are between switches A and C. What is the maximum number of simultaneous connections that can be in progress?

   (b) Suppose we want to make four connections between switches A and C, and another four connections between switches B and D. Can we route these calls through the four links to accommodate all eight connections?

2. **Caravan analogy (3 points)**

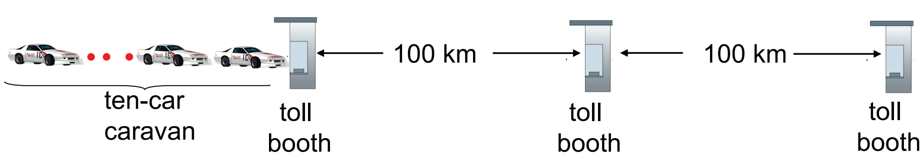

Figure 2: Caravan analogy.

Recall the caravan analogy discussed in class (see Figure 2). Assume that toll booths are 100 km apart, and the cars propagate at 100km/hr. A toll booth services a car at a rate of one car every 12 seconds. Suppose the caravan (with 10 cars) begins in front of one toll booth, passing through a second toolbooth, and finishing just **after** a third toll booth. What is the end-to-end delay? (As we did in class, suppose that whenever the first car of the caravan arrives at a toll booth, it waits at the entrance until the other nine cars have arrived and lined up behind it.)

3. **Delay in packet-switched networks (6 points)**

   Consider sending real-time voice from Host A to Host B over a packet-switched network (VoIP). Host A converts analog voice to a digital 64 Kbps (1 Kbps = 10^3 bps) bit stream on the fly. Host A then groups the bits into 56-byte packets. Hosts A and B are connected by two communication links and a router. For each link, the transmission rate is 2 Mbps (1 Mbps = 10^6 bps) and the propagation delay is 10 msec (1 msec = 10^{-3} sec). Ignore the processing delay at the router. As soon as Host A gathers a packet, it sends it to Host B. As soon as Host B receives an entire packet, it converts the packet's bits to an analog signal. How much time elapses from the time a bit is created (from the original analog signal at Host A) until the bit is decoded (as part of the analog signal at Host B)?

4. **Queueing delay (3 points)**

   A packet switch receives a packet and determines the outbound link to which the packet should be forwarded. When the packet arrives, one other packet is halfway done being transmitted on this outbound link and four other packets are waiting to be transmitted. Packets are transmitted in order of arrival. Suppose all packets are 1,500 bytes and the link rate is 2 Mbps. What is the queueing delay for the packet?

5. **Delay and packet header (7 points)**

   Consider sending a large file of F bits from Host A to Host B. There are three links and two switches between A and B, and the links are uncongested (that is, no queueing delays). Host A segments the file into segments of S bits each and add 80 bits of header to each segment, forming packets of $L = 80 + S$ bits. Each link has a transmission rate of R bps. Disregard processing delay and propagation delay.

   (a) What is the delay of moving the file from Host A to Host B?

   (b) Find the value of S that minimizes the above delay.