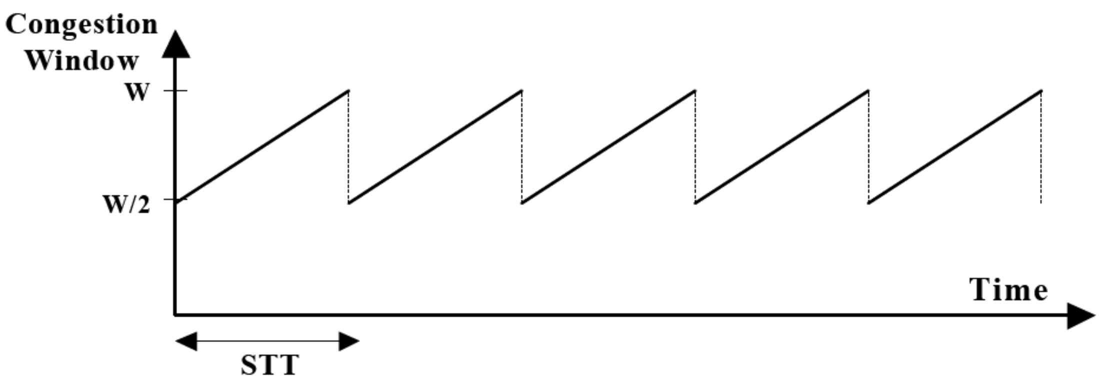
CSc8220: Assignment 3

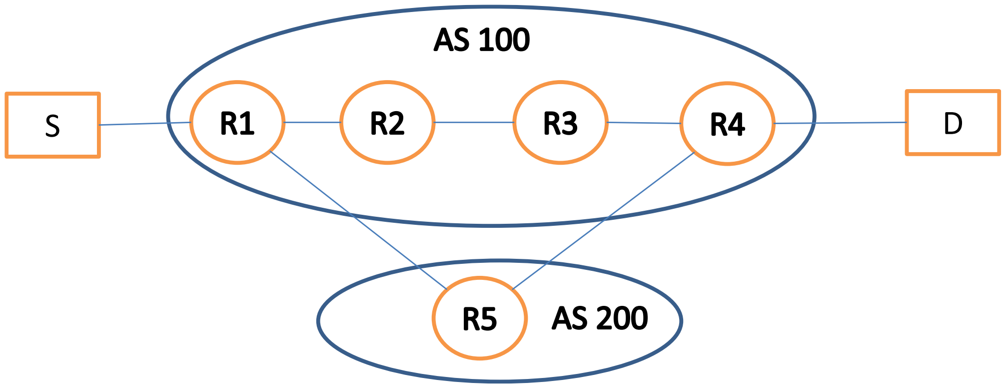
Due at 12:30pm, Apr. 1

1. Ethernet has a minimum packet size to guarantee that collisions are detected. This problem considers an Ethernet-like medium to explore how the minimum packet size is chosen.
   a. How does a minimum packet size help detect collisions?
   b. Assume the speed of propagation through copper Ethernet wire is $2*10^8$ m/s. If the maximum size of your network is 500 m, and you transmit data at 100 Mbits/s, what is the minimum packet size needed to detect collisions?



2. The figure above shows the TCP saw tooth behavior. We are assuming that fast retransmit and fast recovery always work, i.e. there are no timeouts and there is exactly one packet lost at the end of each "tooth". We are assuming that the flow control window is large and that the sender always has data to send, i.e. throughput will be determined by TCP congestion control. In the picture, W represents the congestion window size at which a congestion packet loss occurs (expressed in maximum transfer units). You can assume that W is large, so feel free to approximate (W-1) or (W+1) by W. STT represents the \saw tooth time" expressed in seconds.
   The aim of this exercise is to derive the average throughput of a TCP connection as a function of the roundtrip time (RTT), the maximum transfer unit (MTU), and the packet loss rate (PLR) for the connection. Please use the notation suggested by the figure, i.e. W and STT, as intermediate values if you need them.
   a. Calculate the STT as a function of W, and the RTT. (Hint: the congestion window goes from W/2 to W in one STT, and remember the congestion window is increased by 1 MTU every RTT).
   b. How much data is sent in one STT? (Hint: how much data is sent each RTT?)
   c. What is the average throughput of the connection?
   d. What is the average packet loss rate? (Hint: How many losses occur per STT?)
   e. What is the relationship between the throughput and the packet loss rate?

3. In the following figure, R1, R2, R3, R4 are routers in AS100 and R5 is one router in AS200. If the shortest path routing algorithm is applied, what is the path from S to D. Explain how BGP would route data from S to D.



4. RED
    a. Sketch the RED algorithm's graph of packet drop probability versus queue length.
    b. What is the primary consideration that determines the queue length thresholds in the RED algorithm?
    c. Why do you think that the drop probability P of a RED router does not simply increase linearly from P=0 at min_{th} to P=1 at max_{th}?

5. Max-min fairness
    a. Define max-min fairness;
    b. Given five flows A, B, C, D, E with respective bandwidth demands 1, 1, 2, 3, 3, being scheduled for a link with 9 bandwidth units available, what share will each flow receive?

6. Define the concept of Fair Queuing. What is the inherent source of unfairness in a first-in, first-out (FIFO) scheduling policy? Describe the mechanism used by Fair Queuing to avoid this problem.

7. Suppose a router's drop policy is to drop the highest-cost packet whenever queues are full, where it defines the "cost" of a packet to be the product of its size by the time remaining that it will spend in the queue. (Note that in calculating cost it is equivalent to use the sum of the sizes of the earlier packets in lieu of remaining time.)
    a. What advantages and disadvantages might such a policy offer, compared to tail drop?
    b. Give an example of a sequence of queued packets for which dropping the highest-cost packet differs from dropping the largest packet.
    c. Give an example where two packets exchange their relative cost ranks as time progresses.

8. How does CSFQ work? What are the advantages/disadvantages compared to FQ? What are the key ideas of XCP?