1. Simulate TCP congestion control options. Use RFC793edu TCP agent with

   I additive increase and multiplicative decrease

   II exponential increase and multiplicative decrease

   III AIMD and slow start

   IV AIMD, slow start and fast retransmission (=TCP Tahoe)

   V TCP Reno

   VI TCP Vegas

   For each case, use a 13 s simulation time and use student number (either one) as random number generator seed.

   (a) For each simulation,
   - plot the congestion window
   - explain the events in the congestion window plot. Specifically identify in each picture the different phases:
     - additive increase
     - exponential increase and slow start
     - time out
     - fast retransmit

   (b) Calculate the number of packet arrivals, packet drops and *throughput*,

   $$\text{throughput} = \frac{\#\text{packet\_arrivals} - \#\text{packet\_drops}}{\text{simulation\_time}}, \quad (1)$$

   for each option. Discuss the reasons and consequencies. Which throughput is the best and why?

   Target: The student understands the basic mechanisms of TCP congestion control.

2. Simulate a network that has an bottleneck link with 24 competing TCP connections. There are three sending nodes, each connected with 100 Mbit/s, 100 ms link to the bottleneck link (40 Mbit/s, 50 ms). Each node has eight senders with combinations of congestion control (TCP Tahoe or Forward Ack), segment size (500 or 1500 bytes), and maximum window size (20 or 1000 packets). Run a long simulation (1200 seconds simulated time) and estimate the numbers of packet drops and throughput for all connections. Compare results: did flows with similar settings receive similar throughput, i.e. what was *fairness*. What was the effect of different parameters to throughput.

   Target: The student understands what TCP parameters do have an effect on application throughput and concept of fairness.