SIMON FRASER UNIVERSITY
SCHOOL OF ENGINEERING SCIENCE

Fall 2021
ENSC 427: COMMUNICATION NETWORKS

Final Examination
Friday, December 10, 2021

Duration: 180 minutes. Attempt all problems. Questions are not equally weighted. Please provide detailed answers and include diagrams, graphs, and tables, as needed. Expand all acronyms. Closed book and closed notes. Simple calculators (with no graphing/programming functions) are permitted. PDAs, laptops, and wireless phones are not permitted. Please write legibly. Illegible text will not be graded. Please use a pen (no pencils, please).

1. **Chapter 3 Transport Layer (35 points)**:

   (a) Descibe main phases of TCP congestion control. (6 points)

   (b) List TCP mechanisms used to detect packet loss. How does TCP react to each type of detected packet loss? (10 points)

   (c) Give the expression for calculating average TCP throughput. (7 points)

   (d) Consider Fig. 1. Assume that TCP Reno is the protocol experiencing the shown behavior. In all cases, provide a short discussion justifying your answer. The initial value of *cwnd* (congestion window) is 1 and the initial value of *ssthresh* (slow start threshold) is 8. Identify the times at which: (12 points)

      i. TCP is in slow start (2 points)

      ii. TCP is in congestion avoidance (2 points)

      iii. TCP is in fast recovery (2 points)

      iv. packets are lost via timeout (2 points)

      v. packets are lost via triple duplicate ACKs (2 points)

      vi. the value of ssthresh changes (if it changes between $t = 3$ and $t = 4$, use $t = 4$ in your answer). (2 points)

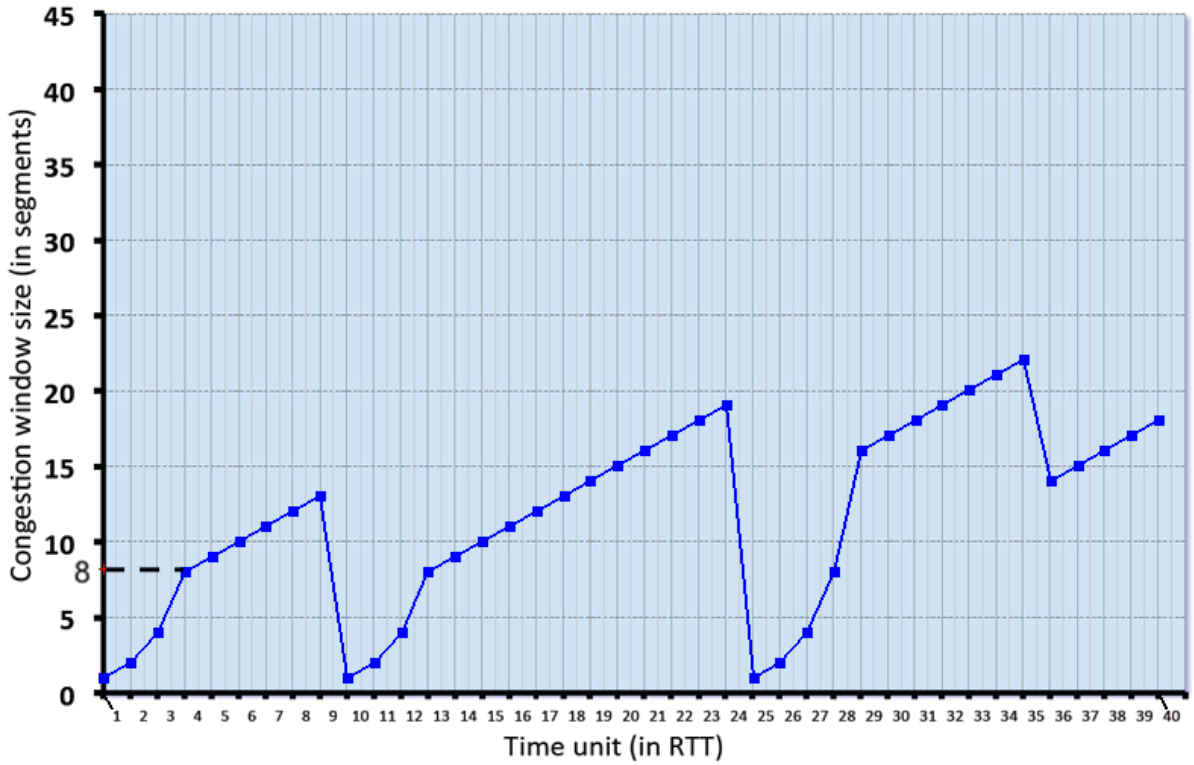

Figure 1: TCP window size as a function of time.

2. **Chapter 5 The Network Layer: Control Plane (25 points)**:

(a) Consider the network shown in Figure 2. With the indicated link costs, use Dijkstra's algorithm to compute the shortest path from u to all network nodes.

i. Show how the algorithm works by computing an appropriate table. (10 points)

ii. Draw the shortest path tree found by the algorithm. (5 points)

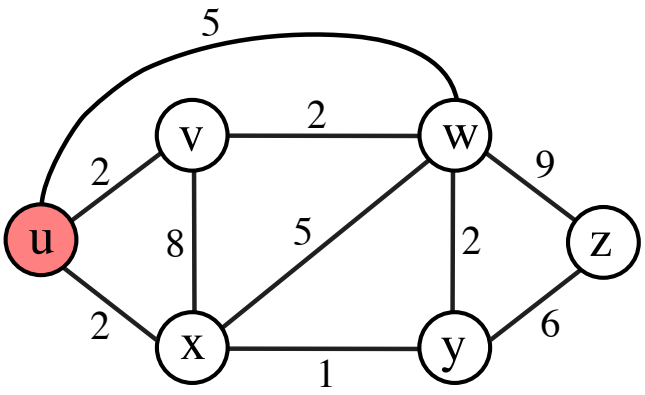

Figure 2: Apply Dijkstra's algorithm to find the shortest path from node u.

(b) Consider the network shown in Figure 3. Assume that each node initially knows the costs to each of its neighbors. Use Bellman-Ford algorithm and show the routing table entries at node v. (10 points)

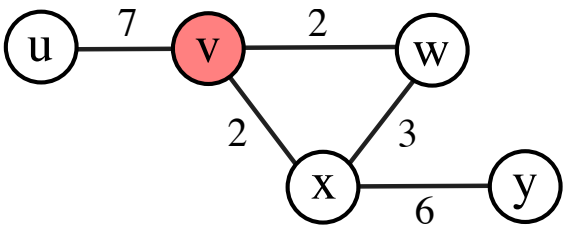

Figure 3: Apply Bellman-Ford algorithm to show the routing table entries at node v.

3. **Chapter 7 Wireless and Mobile Networks (20 points)**:

   (a) List the differences between the following types of wireless channel impairments:

      i. path loss (3 points)
      ii. multipath propagation (3 points)
      iii. interference from other sources? (3 points)

   (b) In 4G/5G networks, what effect will handoff have on end-to-end delays of datagrams between the source and destination? (5 points)

   (c) What is the difference between direct and indirect routing of datagrams to/from a roaming mobile host? (3 points)

   (d) What does "triangle routing" mean? (3 points)

4. **Chapter 8 Security (10 points)**:

   (a) From a service perspective, what is an important difference between a symmetric-key system and a public-key system? (5 points)

   (b) Suppose N people want to communicate with each of $N-1$ other people using symmetric key encryption. All communication between any two people, i and j, is visible to all other people in this group of N, and no other person in this group should be able to decode their communication. How many keys are required in the system as a whole? Now suppose that public key encryption is used. How many keys are required in this this case? (5 points)

5. **Case Study: Data mining and machine learning for analysis of network traffic (10 points)**:

   (a) Describe the Internet traffic model. How does it differ from the traffic model in telephone networks? (2 points)

   (b) What is the model used for Internet topology? (2 points)

   (c) List examples of known Interent traffic anomalies. (2 points)

   (d) Describe the experimental procedure for applying machine learning algorithms to intrusion detection. (2 points)

   (e) List examples of machine learning algorithms used for intrusion detection. (2 points)