SIMON FRASER UNIVERSITY
SCHOOL OF ENGINEERING SCIENCE

Spring 2023
ENSC 427: COMMUNICATION NETWORKS

Final Examination
Friday, April 21, 2023

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 (20 points)**:

   (a) List the mechanisms employed by reliable data transfer (rdt) to deal with:

      i. Channel with bit errors: How to recover from errors? (4 points)

      ii. Duplicate packets: How to handle duplicates? (4 points)

      iii. Channel with errors and loss: What is the sender's approach? (4 points)

   (b) 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:

      i. TCP is in slow start (1 point)

      ii. TCP is in congestion avoidance (1 point)

      iii. TCP is in fast recovery (1 point)

      iv. packets are lost via timeout (1 point)

      v. packets are lost via triple duplicate ACKs (1 point)

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

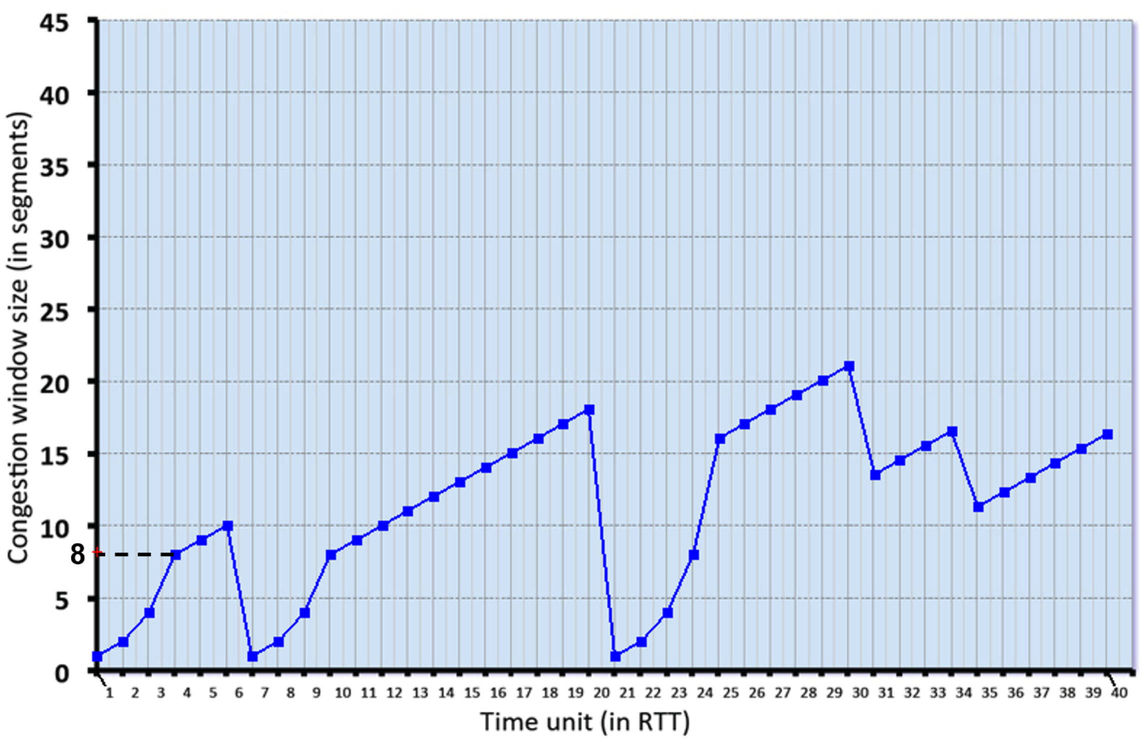

Figure 1: TCP window size as a function of time.

2. **Chapter 4 The Network Layer: Data Plane (18 points)**:

   (a) We made a distinction between the forwarding function and the routing function performed in the network layer. What are the key differences between routing and forwarding? (6 points)

   (b) Describe how packet loss can occur at input ports. Describe how packet loss at input ports can be eliminated (without using infinite buffers). (6 points)

   (c) Suppose there are three routers between a source host and a destination host. Ignoring fragmentation, an IP datagram sent from the source host to the destination host will travel over how many interfaces? How many forwarding tables will be indexed to move the datagram from the source to the destination? (6 points)

3. **Chapter 5 The Network Layer: Control Plane (20 points)**:

   (a) Compare and contrast link-state and distance-vector routing algorithms. (10 points)

   (b) What is the count to infinity problem in distance vector routing? (10 points)

4. **Chapter 6 The Link Layer and LANs (12 points)**:

   (a) Suppose two nodes start to transmit at the same time a packet of length L over a broadcast channel of rate R. Denote the propagation delay between the two nodes as d_{prop}. Will there be a collision if $d_{prop} < L/R$? Why or why not? (6 points)

   (b) How big is the MAC address space? The IPv4 address space? The IPv6 address space? (6 points)

5. **Chapter 7 Wireless and Mobile Networks (30 points)**:

(a) What does it mean for a wireless network to be operating in infrastructure mode? If the network is not in infrastructure mode, what mode of operation is it in, and what is the difference between that mode of operation and infrastructure mode? (10 points)

(b) Describe the two possible sleep modes of a 4G/5G mobile device. In each of these sleep modes, will the mobile device remain associated with the same base station between the time it goes to sleep and the time it wakes up and first sends/receives a new datagram? (10 points)

(c) Consider the single-sender CDMA example in Figure 2. What would be the sender's output (for the 2 data bits shown) if the sender's CDMA code were (1, -1, 1, -1, 1, 1, 1, -1)? (10 points)

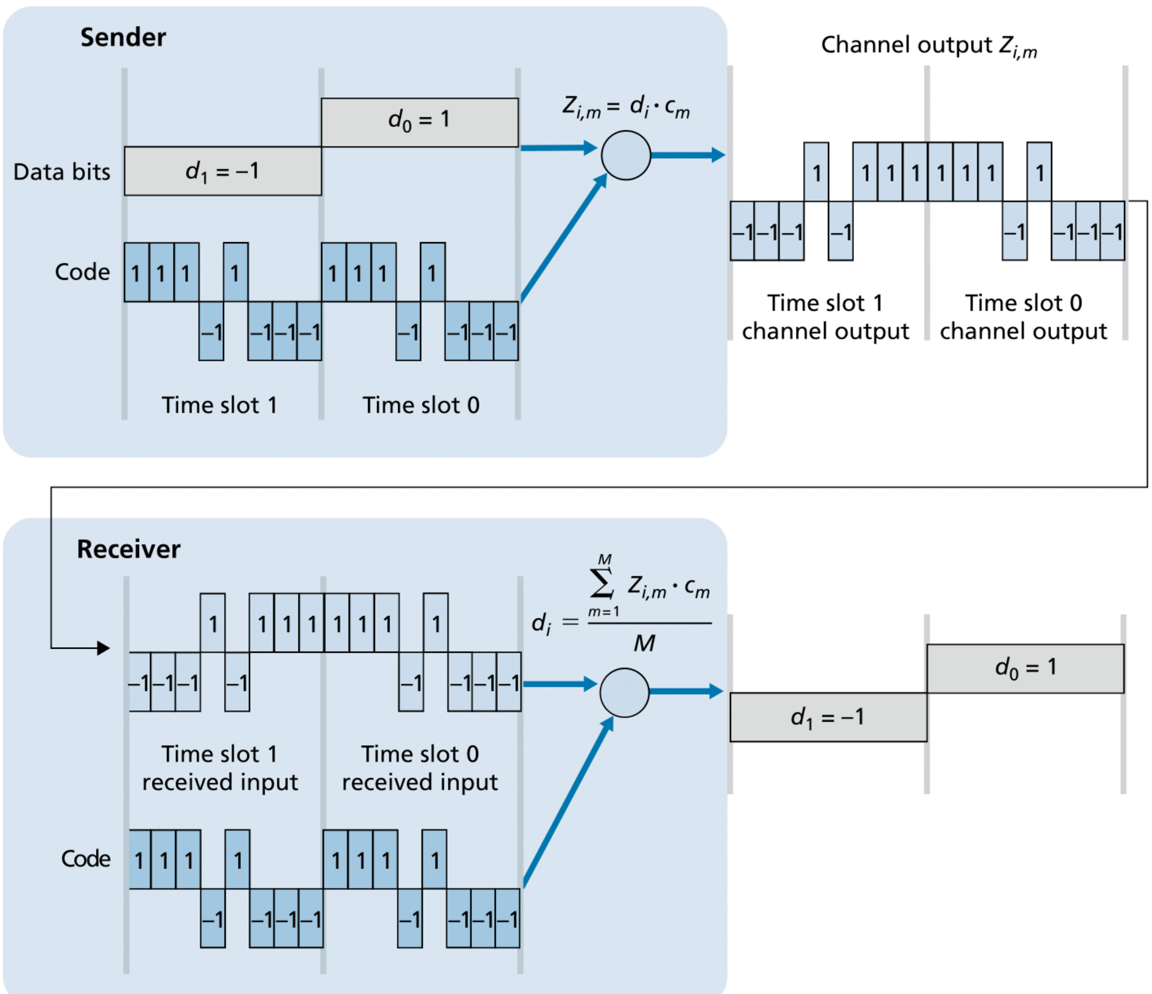

Figure 2: A simple CDMA example: Sender encoding, receiver decoding.