CS 655: Introduction to Computer Networks
Fall 2020

Homework 3

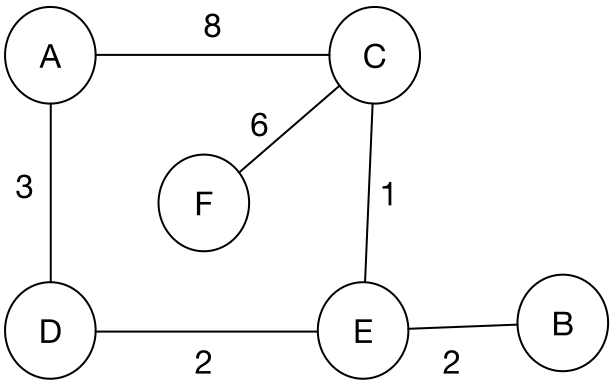
To be completed individually. Please review the academic conduct rules mentioned in the syllabus. Answer all questions. Submit on Gradescope.

This assignment is part of BU CS 655 material and is provided for educational purposes. Please do NOT share or post this assignment handout or your solution, on any public site, *e.g.* github. Of course, you are not allowed to share your solution with classmates.

1. Suppose that you are using an extended version of TCP Reno that allows window sizes much larger than 64K bytes.[1] Suppose you are using it over a 1Gbps link with a round-trip time (RTT) of 200ms to transfer 16M-byte file, and the TCP receiver's advertised window is 2M bytes. If TCP sends 1K-byte segments, and assuming no congestion and no lost segments:

   (a) How many RTTs does it take until the sender's congestion window reaches 2M bytes? Recall that the congestion window is initialized to the size of a single segment, and assume that the slow-start threshold is initialized to a value higher than the receiver's advertised window.
   (b) How many RTTs does it take to send the file?
   (c) If the time to send the file is given by the number of required RTTs times the RTT value, what is the effective throughput for the transfer? What percentage of the link capacity is utilized?

2. Consider the network given in Figure below with link costs indicated. Give the datagram-forwarding (next-hop routing) table for routers (nodes) A, B, and C. Assume that a shortest-path-first algorithm is used to select the (least cost) route to each destination.



[1] A 16-bit receiver's advertised window in the TCP segment means that 2^{16} = 64K bytes is traditionally a maximum limit on the send window.

3. Consider a campus-area network that runs the distance-vector routing protocol RIP (Routing Information Protocol), where router K has the following routing table.

Destination	Distance	Next-Hop
Net 1	0	direct
Net 2	0	direct
Net 5	8	Router L
Net 17	6	Router M
Net 24	6	Router J
Net 30	2	Router Q
Net 42	2	Router J

Suppose router K receives the following routing update from router J.

Destination	Distance
Net 1	2
Net 5	4
Net 17	7
Net 22	8
Net 24	5
Net 30	10
Net 42	3

Give router K's routing table after it incorporates this update from router J. Note that RIP assumes that the distance over each network (i.e., between two neighbor routers) is 1.

4. Assume a distance-vector routing algorithm is used in a WAN of 60 switches (nodes). If costs are recorded as 8-bit numbers and cost vectors are exchanged twice a second, how much capacity per (full-duplex) link is chewed up by the distributed routing algorithm? Assume that each node has three links to other nodes.

5. A TCP segment of 2000 bytes is to be transmitted over a network with MTU of 262 bytes. Assuming the header in each IP datagram requires 20 bytes, would fragmentation take place? Explain why or why not? If fragmentation takes place, derive the number of datagrams (fragments) required. Also, show how many bytes are in each fragment, and how many of those bytes correspond to headers and data (payload) fields. [*Hint*: in IPv4, the fragmentation-offset field is expressed in multiple of 8 bytes (see Section 4.3.2 on IP Datagram Fragmentation in textbook), i.e. the amount of original payload data from the original datagram that each fragment carries (except the last fragment) must be multiple of 8 bytes.]

6. What are the CIDR addresses for a network if all its addresses start with 145.98? And if this network has exactly two subnets, what are the CIDR addresses for each of its subnets?

7. How many addresses are spanned by the CIDR address 214.13.192.0/21, and what range do they span?

8. Suppose P, Q, and R, are network service providers, with respective CIDR address allocations C1.0.0.0/8, C2.0.0.0/8, and C3.0.0.0/8 (using hexadecimal dotted notation with mask). Each provider's customers initially receive address allocations that are a subset of the provider's address space.
   P has the following customers:
   - PA, with allocation C1.B3.0.0/16, and
   - PB, with allocation C1.A0.0.0/12.

   Q has the following customers:
   - QA, with allocation C2.0B.10.0/20, and
   - QB, with allocation C2.0A.0.0/16.

   (a) Assume there are no other providers or customers, and that each provider connects to both of the others. Give the routing table for a router in provider **P** and indicate, for each destination entry, the next hop using the name of the domain (provider or customer). Also assume that we want to be able to send a datagram to any destination address, i.e. we have routing entries for the address range/subrange that contains that destination. Also, you may assume that the path selection is based on the shortest AS path criterion. (Please make any other assumptions clear in your answer.)

   (b) Now suppose customer PB switches to provider Q and customer QA switches to provider R. Use the CIDR longest prefix match rule to give the routing table for a router in **P** that allows PB and QA to switch without renumbering (i.e., keeping their initial address allocations).