

### 0. (WFQ)

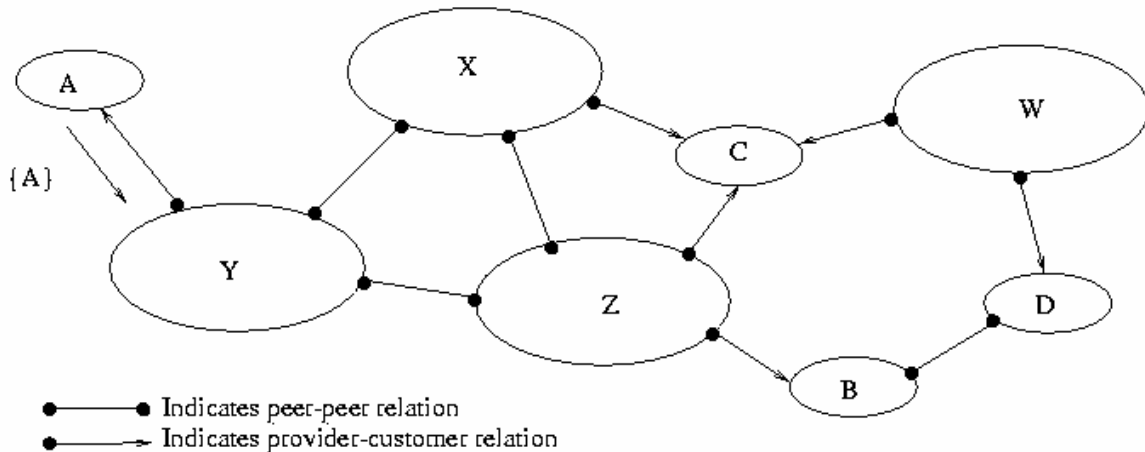
Consider two token bucket policed flows arriving to a link with weighted fair queuing scheduling. The first flow has a token bucket rate of 5 packets/second and a bucket size of 10 packets. The second flow has a token bucket rate of 1 packet/second and a bucket size of 15 packets. The WFQ link is capable of transmitting at a rate of 8 packets/second. The first flow is given a weight of 3 and the second flow is given a weight of 1.

a. Find the maximum delay experienced by a packet of each flow.

b. Suppose that for the first flow, 10 packets arrive between  $t=0$  and  $t=1$  second, 7 packets arrive between  $t=1$  and  $t=2$  seconds, 5 packets arrive between  $t=2$  and  $t=3$  seconds, and 8 packets arrive between  $t=3$  and  $t=4$  seconds. Assuming that the token bucket is initially full, does this arrival pattern stay within the bounds of the token bucket filter? What is the minimum value of bucket size for which the arrival pattern remains within the bounds of the token bucket filter if the token bucket rate is 5 packets/second?

c. Is the service order of packets in fair queuing the same as if the packets were served using a bit-by-bit round-robin scheme? Why or why not?

### 1. (BGP)



Consider the above network topology where A, B, C, and D are customer networks and X, Y, Z, and W are provider networks. The interpretation/meaning of the arrows between the networks are as indicated above on the bottom left of the figure.

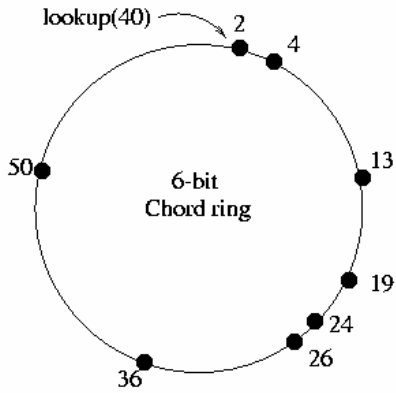
a. Consider BGP route advertisements originating at A. Show how these advertisements propagate in the network by showing the AS-SPATH attribute values of the advertisements. Use arrows to indicate the direction of the advertisements as they propagate between the networks. The first step (propagation of the advertisement from network A to network Y) is done above. Follow this pattern in your answer.

b. Show the AS-level route for data packets originating at a node in network B and destined to a node in network A.

### 2. (Chord paper) Consider a Chord system that uses 6-bit ID space ( $m=6$ bits).

Assume that currently we have 8 nodes in our Chord system with nodeIDs 2, 4, 13, 19, 24, 26,

36, and 50. Assume that the Chord node with nodeID=2 is asked a query about an item with keyID=40 (i.e., a lookup(40) query issued to node 2). Show the steps of the query forwarding in the Chord system until the query reaches to its final destination. Also, show the finger tables of all the nodes that are involved in the query lookup operation (the nodes that are visited during the query forwarding). You DO NOT need to show the finger tables of the nodes that are not involved in the query lookup operation.



Finger tables of the nodes visited during query routing  
(use more tables if you need more)
