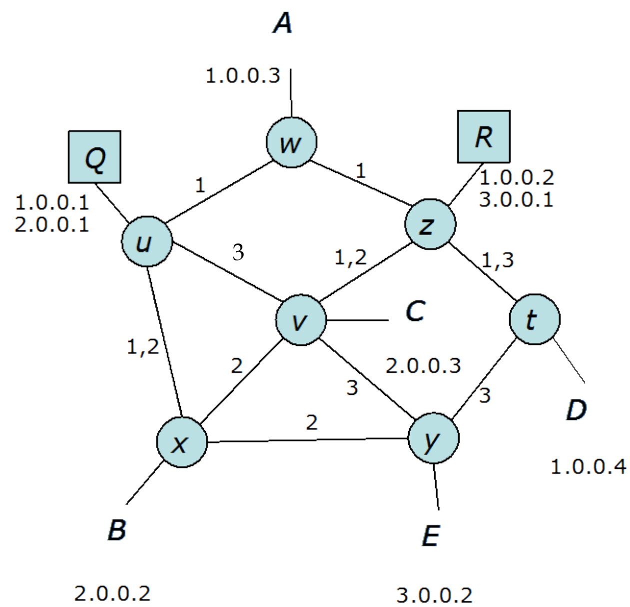
CSE 473 – Introduction to Computer Networks *Roch Guérin*

Final Exam Review

12/4/2014

1) The diagram at right shows a switched Ethernet LAN with two routers (labeled *Q* and *R*), seven switches and five hosts. The switches are configured with three VLANs and the labels next to each link show the VLANs active on the link (note, some links are active in multiple VLANs).

Each VLAN is assigned an IP subnet. Specifically, VLAN 1 is assigned subnet 1.0.0.0/8, VLAN 2 subnet 2.0.0.0/8 and VLAN 3 subnet 3.0.0.0/8. The two routers each belong to two subnets and can send/receive packets using two VLAN ids. Both routers are on subnet 1.0.0.0/8, but router R is the default gateway for the subnet. Hosts are configured with the VLAN corresponding to their IP subnet.



a) If host *B* sends a packet to host *C*, what switches and routers does the packet pass through? Explain why and list them in order, repeating any switch the packet traverses more than once. Note that each VLAN forms a spanning tree to start with.

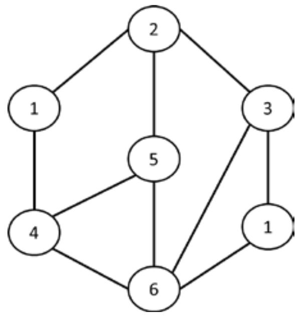
b) If host *A* sends a packet to host *B*, what switches and routers does it pass through?

c) If *B* sends a packet to *E*, what switches and routers does it pass through?

d) If *C* transfers a large file to *E* while *B* transfers a large file to *D*, what maximum data rate could each approximately get, assuming that the links are all 1 Gb/s duplex links?

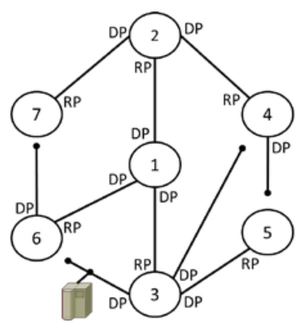
e) What maximum bandwidth could they each get if *E* was in subnet 2.0.0.0/8 instead?

2) Consider the bridged Ethernet network shown below, where circles represent Ethernet bridges, and lines Ethernet LAN segments connecting them. All LAN segments operate at the same speed of 1 Gbps (10^9 bits/sec). The number inside each circle indicates the priority level of the bridge, with lower values corresponding to higher priority. Because of an error made by the network administrator who decided to over-ride the default configuration in a bridge, two bridges have been assigned the highest priority value of 1.



a) Describe the final spanning tree configuration for this network, and identify the state of every single port in the network, i.e., RP, DP or blocking. Justify your results and explain any problem created by the fact that two bridges were assigned priority 1.

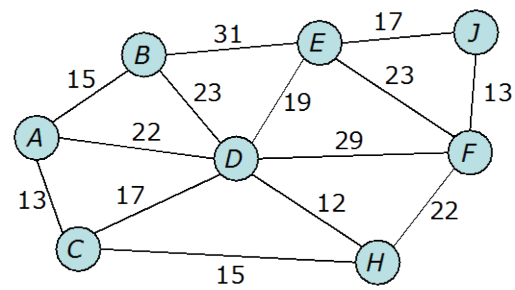
b) Assume next that our network administrator reconfigured the network so that the spanning tree that was finally formed is as shown in the figure below.



(i) Under the spanning tree configuration shown in the figure, is any bridge not forwarding data packets? If no, identify for each bridge the LAN segments to and from which it forwards data packets. If yes, explain why some bridges may not be forwarding data packets.

(ii) As shown in the figure, a major server is located on the LAN for which bridge 3 is the DB. This LAN runs at 10 Gbps, but all other LANs are 1 Gbps LANs. At any given time, there are on average 10 users in each LAN that are downloading material from the server. Given the current spanning tree configuration, the LAN between bridges 1 and 3 is, therefore, the most heavily loaded. Suggest a new configuration that involves lowering down to, say, 0, the priority of a single bridge and that results in the largest reduction in the load of the most loaded LAN. Justify your choice and explicitly identify the ratio by which the load of the most loaded LAN is reduced, *i.e.,* compare the load of the LAN between bridges 1 and 3 in the current configuration to the load of the most loaded LAN in your configuration.

3) In the diagram at right, nodes are IP routers and the numbers on the links are OSPF link weights.



a) If the network uses PIM with reverse-path forwarding, are any links never used for multicast packets coming **from** a host connected to router *J*?

b) Suppose that router *C* is the PIM DR for some layer 2 subnet, and that a host *X* in that subnet sends an IGMP report for address 229.1.2.3. Assume that *J* is the RP for 229.1.2.3 and that no other routers are currently participating in 229.1.2.3. What does router *C* do at this point? Which routers eventually add forwarding state for 229.1.2.3 as a result of *C*'s action?

c) If a host connected to router *B* sent a packet to 229.1.2.3, which routers would the packet pass through in order to reach the host connected to the subnet at *C*? List them in the order in which the packet passes through them.

d) How would the previous answer change if router *C* issued a source-specific join on 229.1.2.3 for the host at router *B*.

e) If the host connected to the subnet at *C* sends a packet to 229.1.2.3, which routers receive a copy? Assume that there has been no other activity on this multicast address, except for what has been described in questions a), b), and c).

4) Consider a corporate network connected to the Internet at two separate locations.

a) The network has been allocated the following blocks of addresses by its Regional Internet Registry (RIR): 149.16.23.0/22; 149.16.24.0/22; and 149.16.30.0/22. What is the smallest number of additional address blocks it would need to request, and what would those blocks be, if it wanted to be able to advertise a single route to the rest of the Internet? And what would that route be?

b) Assume that there are 12 routers in the network and that the three address blocks of the previous question are sub-divided to allocate one subnet of the same size to each router. What is the mask size of the subnet allocated to each router?

c) Two of the twelve routers in the network are connected to the Internet, and are therefore the "exit" points from the network for reaching remote destinations. Those two routers learn of remote routes through the BGP protocol (up to 300,000 routes), but advertising all those routes into the corporate network is not feasible. Suggest a solution that would work independent of the internal routing protocol used in the network and that would allow those two routers to advertise that they can offer connectivity to the Internet.

5) Consider a residential network that connects to the internet via a 4 Mb/s DSL link. Assume that three UDP flows share the link, each sending at rates of 1 Mb/s, 2 Mb/s and 3 Mb/s. Assume that the ISP router has a link buffer that can hold 300 packets (assume all packets have the same length). For each flow, what fraction of the packets it sends is discarded?

a) How many packets does each flow approximately have in the queue?

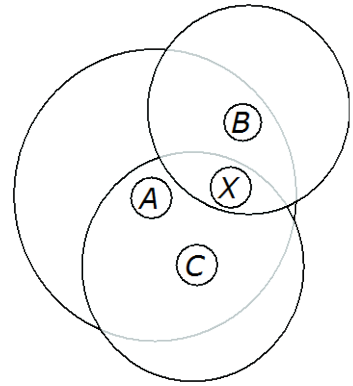
b) Now, suppose the queue at the ISP router is replaced by three queues that can each hold 100 packets and that the queues are scheduled using weighted-fair queueing, where the weights are all 0.33. In this case, what fraction of packets are discarded from each flow?

c) In this configuration, how many packets does each flow have in its queue?

d) Now, suppose the weights are 0.2 for the first flow, 0.6 for the second and 0.2 for the third. In this case, what fraction of packets is discarded from each flow?

e) How many packets does each flow approximately have in its queue?

6) (10 points) The diagram at right shows a WIFI network with an access point, *X* and three hosts, *A*, *B* and *C*. The large circles indicate the *coverage areas* of the three hosts. The coverage area for *X* is not shown, but you may assume that it includes all three hosts. Assume RTS/CTS are not used.



Suppose *X* is transmitting a packet at time 0 and finishes sending it at time 100µs. Also,

- *A* gets a packet to send at time 50 that takes 100µs to send and is assigned a backoff timer of 100µs.
- *B* gets a packet at time 70µs that takes 200µs and is assigned a backoff timer of 50µs.
- *C* gets a packet at time 90µs that takes 150µs and is assigned a backoff timer of 150µs.

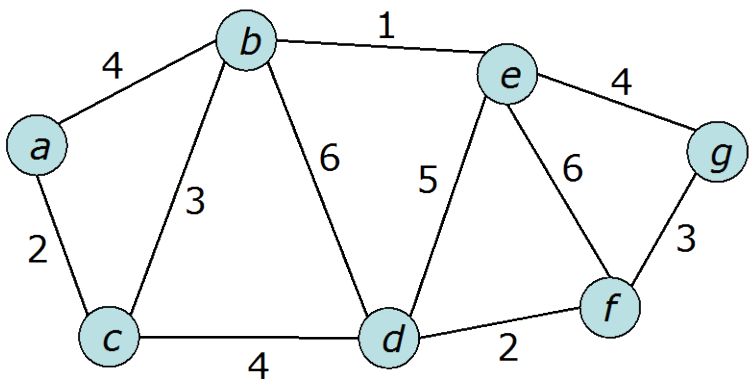
a) For each of the three hosts, what time do they start sending their packets? You may ignore the inter-frame spacing and the time required for acks.

b) Of the three packets sent, which are successfully delivered on the first attempt?

c) For each packet that is not successfully delivered on the first attempt, approximately when does the sending host learn that the packet was lost and must be sent again?

d) Now, suppose RTS/CTS is enabled. In this case, approximately when does each host send its data packet? You may assume that the time needed to send RTS, CTS and ACK packets is negligible.

7) The diagram below represents a network with the numbers on the edges representing link costs, and the circles representing routers. The network uses OSPF as its routing protocol.



a) Are any network links never used when sending packets **<u>to</u>** a host Z connected to router *g*? Simply mark these links with an **X** on the diagram, but explain your reasoning. Assume that the topology is stable, that the link costs do not change and that *g* advertises a route to Z.

b) Assume that router *a* sends a new copy of its router LSA. Suppose a copy of this LSA reaches router *e* after passing through *k* other routers. What is the smallest possible value for *k*? What is the largest possible value for *k*? Justify your answers by identifying the paths the LSA would traverse.

c) Suppose that router *e* receives *n* copies of this LSA, all with the same sequence number. What is the largest possible value for *n*?

8) Recall that an RSA encryption key is a pair of numbers (n,e) and the corresponding decryption key is another pair (n,d). Which of the following could be used as RSA key pairs (ignoring the fact that they are too small)? For those that are valid key pairs, show that they meet all the requirements for a key pair, for those that are not, explain why they are not.

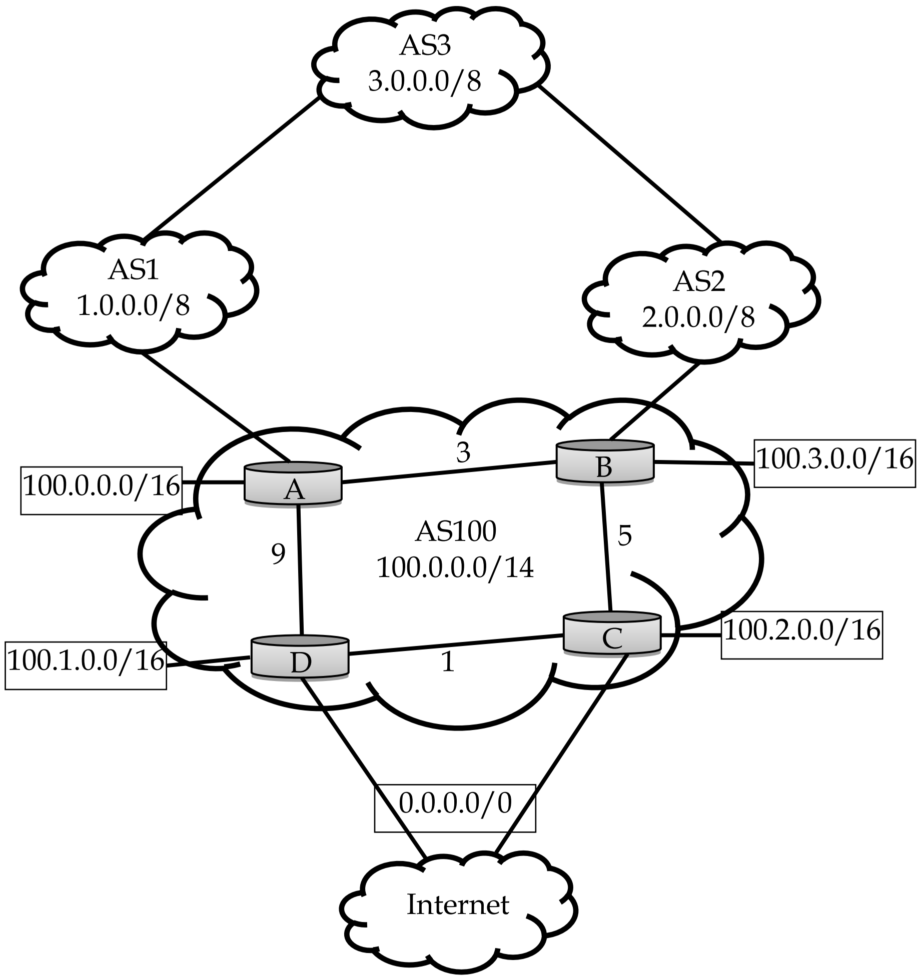
- (31,5), (31,11)

- (301,17), (301,89)

- (55,7), (55,41)

Consider the RSA key pair (91,11), (91,59). Assume the first is the encryption key and the second is the decryption key. What is the encrypted value of the number 8?
Hint: 8^4 mod 91 =1

9) Consider the network shown below. AS100 uses OSPF as its internal routing protocol, and BGP to exchange routes with neighboring ASes. AS100 assigns a LOCAL_PREF value of 100 to all routes learned by routers C and D over their eBGP connection to the "Internet", a LOCAL_PREF value of 50 to routes learned by router B over its eBGP connection with AS2, and a LOCAL_PREF value of 10 to routes learned by router A over its eBGP connection with AS1. The four routers in AS100, A, B, C, and D, are connected by a full iBGP mesh.



a) Specify the routing table at router A, and for each entry identify the next hop(s) in the form of either a local connection, or connections to internal routers, or a neighboring AS.

b) Assume that AS100 wants to ensure that all traffic coming from the "Internet" enters through router D when destined for subnets 100.0.0.0/16 and 100.1.0.0/16, and conversely through router C and when destined for subnets 100.2.0.0/16 and 100.3.0.0/16. Similarly, it wants that all traffic coming from ASes 1, 2, and 3 to enter through router A when destined for subnets 100.0.0.0/16 and 100.1.0.0/16, and conversely through router B and when destined for subnets 100.2.0.0/16 and 100.3.0.0/16. Identify a mechanism that would **guarantee** that this happens, while ensuring that AS100 maintains bidirectional Internet connectivity even if one of its two connections to the Internet or to ASes 1, 2, and 3 breaks.

c) Assume that AS100 is willing to allow traffic from AS2 and AS3 to transit through it to reach the Internet. How could AS100 try to realize this, and would it **guarantee** that its actions have the exact desired outcome. Justify your answer.