###### *CSE 473S – Introduction to Computer Networks Roch Guérin*

Final Exam

##### *Your Name: 12/20/2017*

**Six (6) Problems for a total of 120 points and a max of 100 points**

**(No points for answers without explanations/justifications)**

1. **[25 points]** Consider an Ethernet network that consists of 9 switches, A to I, as shown below.

I

H

G

F

E

D

C

B

A

The little “clouds” correspond to local LAN segments, *i.e.,* LAN segments to which hosts are attached. Local LAN segments run at 10Gbps, while links between switches are 1Gbps links.

* 1. **[10 points]** Assume that switch priority is in decreasing alphabetical order, *i.e.,* switch A has the highest priority and switch I the lowest. Draw the resulting spanning tree, and for each switch indicate its root port (RP), designated port(s) (DP) and blocked port(s) (BP), if any.

I

H

G

F

E

D

C

B

A

* 1. **[5 points]**  Under the same switch priority assignments as in the previous question and assuming that switches transmit BPDUs every 100ms, how long would it take for the spanning tree to be constructed if all the switches were powered on at the same time? Justify your answer.

* 1. **[5 points]** Assume that servers are connected to local LAN segments attached to switches C, F, and I, with hosts on local LAN segment attached to switches A, D, G having heavy traffic to/from the server attached to switches C, F, and I, respectively, *e.g.,* hosts attached to switch A have heavy traffic to the server attached to switch C. Identify an assignment of priorities to switches that would ensure that traffic between hosts and their respective servers can flow on the most direct paths on the resulting spanning tree. **JUSTIFY YOUR ANSWER**, *e.g.,* identify the corresponding spanning tree and switch priorities, and why it results in the most direct paths.

I

H

G

F

E

D

C

B

A

* 1. **[5 points]** Considering again the Ethernet network of question *a*, what is the maximum total traffic volume that this network could ever carry, and what traffic pattern does it correspond to, *i.e.,* identify the locations and traffic intensities of traffic source and sink hosts for a configuration that achieves this maximum traffic volume?

1. **[10 points]** The network administrator of an office building has been allocated the following seven (7) subnets by its service provider:

|  |  |  |
| --- | --- | --- |
| (a) 192.166.10.0/25 | (b) 192.166.10.129/25 | (c) 192.166.11.0/24 |
| (d) 192.166.12.0/22 | (e) 192.166.8.0/24 | (f) 192.166.9.0/24 |
| (g) 192.166.16.0/21 |  |  |

What is the smallest number of prefixes that the network administrator needs to advertise to the outside world to properly announce reachability to all its users, but no other? Explicitly identify the required prefixes in support of your answer.

1. **[25 points]** Consider three traffic sources, A, B, and C (see below), that are feeding a common multiplexer M connected to a shared 100 Mbps link. All three sources generate fixed size, 10,000 bits packets according to the patterns described in Table 1, with the first packet arriving at M at t=0. There is no packet processing delay in M, so that any delay that packets experience is caused by queueing delays waiting for the transmission of other packets.

A

B

C

**100 Mbps**

|  |  |
| --- | --- |
| Source | Packet generation times (in units of 100μsecs) |
| A | A1=0, A2=1, A3=2, A4=4, A5=5 |
| B | B1=0, B2=2, B3=3, B4=4, B5=5, B6=6, B7=7, B8=8 |
| C | C1=2.5, C2=5.5, C3=8.5 |

*Table 1: Packet arrival times*

1. **[10 points]** Assume that the queueing discipline for the Ethernet link at M is FIFO, and that packets that arrive at the same time are inserted in the FIFO queue in the alphabetical order of their respective source, *e.g,* if packets from sources A, B, and C arrive together, A will be inserted first in the FIFO queue, followed by B, and then C. What is the maximum delay (time between the packet arrival and when it starts transmission on the link) experienced by any packet across all three sources? Justify your answer by showing how you compute this maximum delay value.
2. **[10 points]** The multiplexer now implements a Round-Robin (RR) scheduling policy with separate queues for A, B, and C, which are served in alphabetical order one packet at the time. If multiple packets arrive simultaneously and the multiplexer is idle, it starts serving queues in alphabetical order. Under this assumption, what is the delay experienced by packet C3? Justify your answer by identifying the sequence of packets transmitted up to packet C3.
3. **[5 points]** Under the RR scheduler, when does the last of the packets specified in Table 1 finish transmission on the link?

1. **[20 points]** Consider the OSPF network below that consists of 8 routers, R1 to R8 and one Ethernet switch T, which serves as a transit network inter-connecting routers R2 to R7. Router R*i, i*=1,…,8, has IP address 10.0.*i*.1 and is also connected to local subnets 10.0.*i*.0/24 and 10.*i*.0.0/16. Transit network T maps to subnet 10.128.0.0/24. Link costs are as shown on the diagram below, and the cost to local subnets are set to 1 on all routers.

R1

R2

R3

R4

R5

R7

R6

R8

1

1

10

2

1

3

1

1

1

1

1

10

10

2

1

1. **[15 points]** Compute the routing table at router R2. Rows in the routing table should have the following format: <subnet, next\_hop(s), cost>.

If and when one of the next hops is to be reached through transit network T, identify it as T->R*i*. Justify your answer by identifying all intermediate shortest path computation steps involved in computing the routing table. You can assume that Flooding of LSAs has completed, so that router R2 has access to a full “map” of the network.

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1. **[5 points]** The link R6-R7 goes down. How is this detected, if at all, by router R2, and how does it affect its routing table? Justify your answer.

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1. **[20 points]** Consider the corporate network below with three routers, R1, R2, and R3, which are interconnected using an Ethernet networks consisting of three VLANs numbered 1, 2 and 3, with links labeled according to the VLAN(s) they belong to. VLAN 1 is associated with subnet 11.1.0.0/16, VLAN 2 with subnet 11.2.0.0/16, and VLAN 3 with subnet 11.3.0.0/16. In addition, router R2 provides connectivity to the rest of the Internet and consequently advertises a default route 0.0.0.0/0 that it itself receives from its ISP. Finally, router R1 provides connectivity to the rest of the corporate network, and therefore also advertises connectivity to 11.0.0.0/8.

R1

R3

1,2,3

1

1

1

3

3

3

3

2

2

2

2

2

0.0.0.0/0

11.0.0.0/8

R2

1,3

3

ISP

* 1. **[5 points]** Consider host 11.3.25.12 that has just booted and that issues a DNS query to DNS server 53.125.45.87. Identifies which Ethernet switches in the corporate network should contain a forwarding entry for the MAC address of host 11.3.25.12 and that of the DNS server as a result of its DNS query. Justify your answer.

* 1. **[5 points]** Assume that the three routers are running a standard IGP such as OSPF or EIGRP. What routes are present in the routing table of each router?
  2. **[10 points]** Host 11.23.34.56 starts an ftp connection to host 150.12.58.61. Identify the set of switches and routers from the above network that the packets will traverse.

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1. **[20 points]** Consider AS 1234 comprised of 4 routers that run iBGP among themselves and that each connect to other routers in other ASes using eBGP. A logical representation of the AS is shown below with the numbers next to each link indicating the shortest paths between pairs of routers, as also shown in the table on the left. Router R*i* has BGP identifier 10.0.0.*i.*

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | R1 | R2 | R3 | R4  5  AS 1234  R1  R2  R4  R3  10  11  10  7  8 |
| R1 | 0 | 10 | 8 | 10 |
| R2 | 10 | 0 | 11 | 5 |
| R3 | 8 | 11 | 0 | 7 |
| R4 | 10 | 5 | 7 | 0 |

The four routers advertise to their iBGP peers the following routes that are all learned from their eBGP peers.

|  |  |
| --- | --- |
| R1 | 0.0.0.0/0, AS\_PATH: <32>, LOCAL\_PREF=200  153.0.0.0/8, AS\_PATH: <32-1235-6578>, LOCAL\_PREF=50  153.10.0.0/16, AS\_PATH: <32-1235-6578>, LOCAL\_PREF=50  153.10.10.0/24, AS\_PATH: <32-1235-6578>, LOCAL\_PREF=50  153.10.11.0/24, AS\_PATH: <32-1235-6578>, LOCAL\_PREF=50  72.12.34.0/24, AS\_PATH: <32-4444-3498-1278>, LOCAL\_PREF=50 |
| R2 | 153.0.0.0/8, AS\_PATH: <22-5432-4333-6578>, LOCAL\_PREF=100  153.10.0.0/16, AS\_PATH: <22-1235-4333-6578>, LOCAL\_PREF=50  72.12.34.0/24, AS\_PATH: <22-1278>, LOCAL\_PREF=50  72.12.0.0/16, AS\_PATH: <22-3498-1278>, LOCAL\_PREF=50  53.40.51.0/24, AS\_PATH: <22-235-3343-5278>, LOCAL\_PREF=100 |
| R3 | 0.0.0.0/0, AS\_PATH: <1>, LOCAL\_PREF=100  153.0.0.0/8, AS\_PATH: <1-6578>, LOCAL\_PREF=50  153.10.11.0/24, AS\_PATH: <1-6578>, LOCAL\_PREF=50  72.12.34.0/24, AS\_PATH: <1-3498-1278>, LOCAL\_PREF=50  14.34.0.0/16, AS\_PATH: <1-784>, LOCAL\_PREF=50  14.34.10.0/24, AS\_PATH: <1-784>, LOCAL\_PREF=50 |
| R4 | 153.0.0.0/8, AS\_PATH: <11-459-6578>, LOCAL\_PREF=50  153.10.11.0/24, AS\_PATH: <11-459-6578>, LOCAL\_PREF=60  72.12.34.0/24, AS\_PATH: <11-3498-1278>, LOCAL\_PREF=50  14.34.0.0/16, AS\_PATH: <11-784>, LOCAL\_PREF=50  14.34.10.0/24, AS\_PATH: <11-784>, LOCAL\_PREF=50 |

Assume that none of the routes include a MED attribute, and that all have the same ORIGIN value.

1. **[15 points]** Identify the routing tables at each of the four routers. For each route entry, identify the next hop router (use “*local*” when it is the router itself), and the reason for selecting the route. **No points will be awarded to answers without justifications.** For conciseness, give the routing table at R1, and for other routers only identify differences between their routing table and that of R1.

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1. **[5 points]**For each route known in AS 1234, with the exception of the default route 0.0.0.0/0, identify the AS to which the prefix belongs.