PART I - EXAM AND MIDTERM QUESTIONS 2007
TCP/IP NETWORKING

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The exam rules were the following:
Write your solution into this document and return it to us at the end. You may use additional sheets if needed. Do not forget to put your name on this document and *all* additional sheets of your solution.

If you need to make assumptions in order to solve some questions, write them down explicitly.

All printed documents are allowed. No electronic equipment is allowed.

You can write your solution in English, French or German.

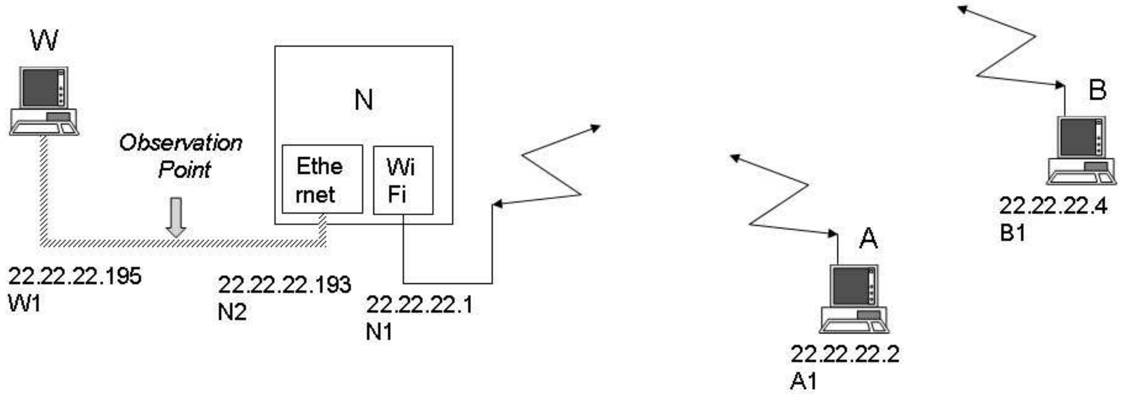

Figure 1: The network used in Questions 1 and 2.

QUESTION 1

Consider the network in Figure 1. A, B and W are computers. A and B are on a wireless LAN, and W is on Ethernet, as shown in the figure. We can consider in this question that the wireless LAN is the same as a shared Ethernet cable.

N is a multi-function box that may be used as a router or a bridge. It has two interfaces, one on Ethernet, one on Wireless LAN.

The figure shows the IP addresses and the MAC addresses. The MAC addresses are written symbolically as $A1, B1, N1, N2$ and $W1$.

All interfaces are configured with network mask $255.255.255.0$.

In this question, N is configured as a bridge.

1. Is the configuration of the masks correct, i.e., is it possible for any machine to reach any other one ? If not, propose a modification that works.

2. All ARP caches are empty in all machines. Then B sends one single IP packet to W with TTL $= 64$. We observe all packets on the Ethernet cable between N and W. Explain which packets, resulting from this activity, will be seen at this observation point. For each of the packets, give the value of the following fields:
   - MAC source address, MAC destination address
   - For those packets that are IP packets, give: source IP address, IP destination address, TTL.

3. An application running on A is wrongly configured and sends by mistake one IP packet to a (non existant) host with IP address = $22.22.22.3$. Explain which packets resulting from this activity, if any, will be seen at the observation point.

QUESTION 2

Consider again the same network as in Question 1, but assume now that N is configured as a router. We keep the same IP addresses for all interfaces.

1. Explain which additional configuration you need to do in hosts A, B and W.

2. All ARP caches are empty in all machines. Then B sends one single IP packet to W with TTL $= 64$. We observe all packets on the Ethernet cable between N and W. Explain which packets, resulting from this activity, will be seen at this observation point. For each of the packets, give the value of the following fields:
   - MAC source address, MAC destination address
   - For those packets that are IP packets, give: source IP address, IP destination address, TTL.

3. W runs iTunes and sends IP packets with IP destination address $=255.255.255.255$ and TTL $= 1$. We observe these packets at the observation point. What are the source and destination MAC and IP addresses in these packets ? Will A and B receive the packets ? (Justify your answer)

4. An application running on A is wrongly configured and sends by mistake one IP packet to a (non existant) host with IP address = $22.22.22.3$. Explain which packets resulting from this activity, if any, will be seen at the observation point.

QUESTION 3

1. Computers $C1$ and $C2$ are connected by means of a line with a bit rate $c = 10$ Mb/s ($= 10^7$ bits per second). The propagation time is 5 ms in each direction.
   Host $C1$ is at EPFL. The name of host $C2$ is `www.new-zealand.com`. Is it possible that $C2$ is physically located in New Zealand ? (Justify your answer in max 7 lines).
2. $C1$ sends packets of length $L = 5 \cdot 10^3$ bits to $C2$ using a sliding window protocol. For every packet received, $C2$ sends one acknowledgement. The time spent by $C2$ between receiving a packet and sending the first bit of the acknowledgement is 0.45 ms. The length of the acknowledgement is $5 \cdot 10^2$ bits.
   The sliding window protocol uses a fixed window size equal to W (counted in packets).
   We assume that there is no loss (no packet is lost, no acknowledgement is lost).
   (a) What is the throughput that can be achieved by $C1$ as a function of the window size W ?
   (b) What is the smallest value of W that achieves the maximum throughput ?

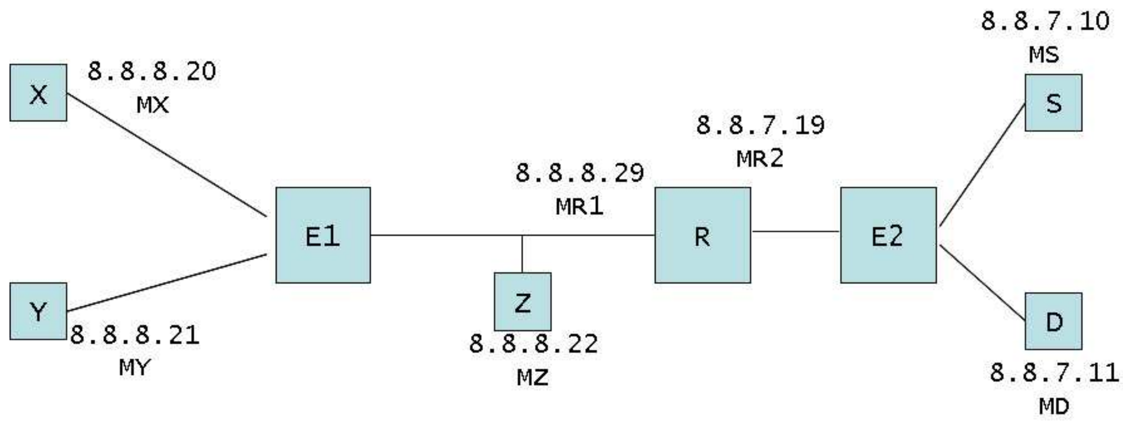

Figure 2: The network used in Question 4.

QUESTION 4

Consider the scenario in Figure 2. X, Y and Z are PCs. R is a router. E1 and E2 are Ethernet hubs; the lines between boxes are Ethernet cables. S is a web server. D is a DNS server.

The IP addresses are shown in the figure. The MAC addresses are shown symbolically as MX, MY, etc. We assume that every machine shown on the figure with one or several IP address values is correctly configured with this or these IP addresses (+ an appropriate netmask). There are no other machines in this network than shown on the figure.

1. What additional configuration information should be present at hosts X, Y, Z and S such that a user on X,Y or Z is able to open a web page located on S by entering the URL of the web page?

2. What additional configuration information should be present at router R to achieve the same goal?

3. Assume all machines are correctly configured. Z acts as a packet sniffer (it copies all traffic flowing between E1 and R). All caches are empty at X. The user at X opens a shell (= command prompt) and types `ping 8.8.7.10`. Explain which packets, resulting from this activity, will be seen at Z. For each of the packets, give the value of the following fields:

   - MAC source address, MAC destination address
   - For those packets that are IP packets, give: source IP address, IP destination address, TTL.

4. Assume now the user at X types `ping 8.8.7.99` (a non-existent address). Explain which packets, resulting from this activity, will be seen at Z. For each of the packets, give the value of the following fields:

- MAC source address, MAC destination address
- For those packets that are IP packets, give: source IP address, IP destination address, TTL.

5. Machine Y is mistakenly configured with the wrong mask `255.255.0.0`. The user at Y opens a shell and types `ping 8.8.7.10`. Explain which packets, resulting from this activity, will be seen at Z. For each of the packets, give the value of the following fields:
   - MAC source address, MAC destination address
   - For those packets that are IP packets, give: source IP address, IP destination address, TTL.

6. Is it possible to change something at router R so that the user at Y can access the web server without changing its configuration mask ? Give the details and justify.

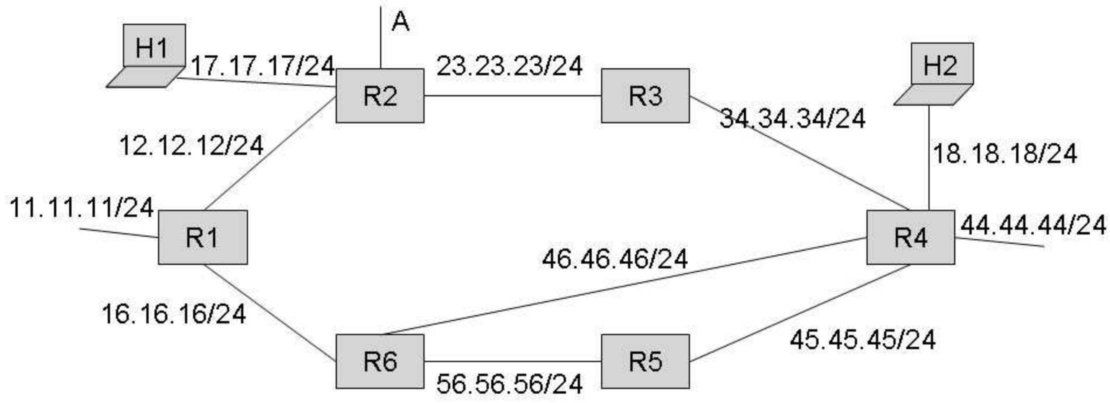

Figure 3: The network used in Question 5.

QUESTION 5

Consider the network in Figure 3. Boxes R1 to R6 are routers. H1 and H2 are end hosts. Each router has 2 or more interfaces, as shown on the figure. All prefixes are 24 bits. All routers run a distance vector routing protocol such as RIP. The cost of a link between two routers is 1. The cost from a router to a directly attached network is 0.

1. Assume that the interface shown with the letter A on router R2 is disabled. Give a possible value of the routing table at router $R1$, assuming the routing protocol has converged and there is no other network than shown in the figure. Give the values in the table below (do not give the value of the"interface" field").

At R1		
Destination Network	Next-Hop	Distance

2. We now enable interface A on router R2. By mistake, it is configured with the prefix 44.44.44/24. Explain what will happen with RIP (explain in at most 15 lines a possible sequence of events, until the routing protocol converges).

Give the routing table at R1 after the routing protocol has converged again.

At R1		
Destination Network	Next-Hop	Distance

3. Now assume you start a program at H1 that continuously pings toward H2. Then, after some time, the router R3 goes down. Explain what will happen with RIP (explain in at most 15 lines a possible sequence of events, until the routing protocol converges). Explain what H1 and H2 will observe regarding all sent pings.

QUESTION 6

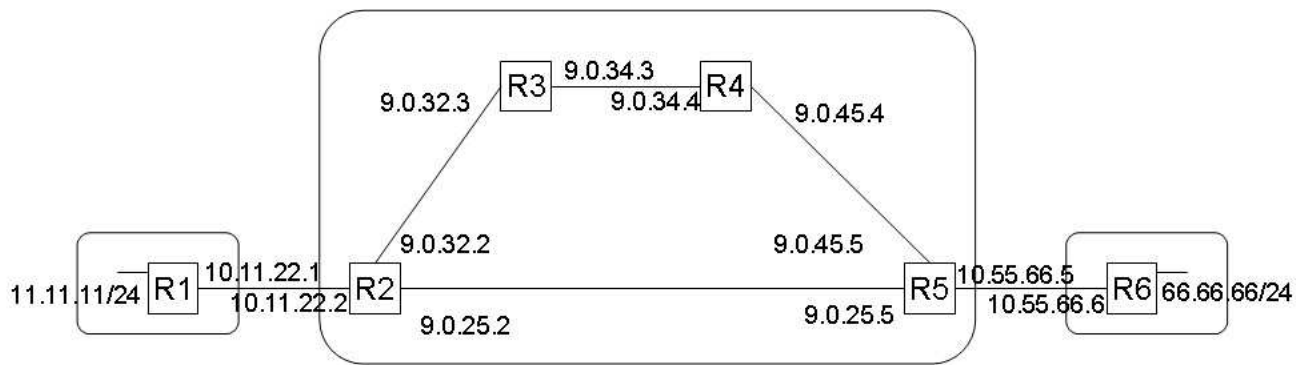

Figure 4: The network used in Question 6.

Consider the network in Figure 4. Boxes R1 to R6 are routers. There are three autonomous routing domains, each shown by a rounded box on the figure. The AS numbers are: 300 for the domain of routers R3, R2, R5 and R4; 100 for the domain of router R1, and 200 for the domain of router R6.

The physical connections are shown by the lines in the figure. There is no other router or prefix than shown on the figure.

All routers in AS 300 run RIP inside their domain. *All* routers run BGP. There is *no* redistribution of BGP into RIP.

There are external BGP sessions between routers R2 and R1, and between R5 and R6. There are internal BGP sessions between BGP routers, as many as required.

The decision process at all routers inside AS 300 is such that the route selected is, by order of decreasing priority

(1) the route that has the shortest sequence of ASs
(2) the route that has the shortest IGP distance from this router to the NEXT-HOP of the route

There is no filtering, all routers accept all announcements.

1. Router R1 sends to R2 the announcement `11.11.11/24 AS-PATH = 100`. Router R6 sends to R5 the announcement `66.66.66/24 AS-PATH = 200`. After BGP has converged, what are the entries in the forwarding table at routers R4 and R3 for destination prefix 11.11.11/24 ? Explain which protocol was used by these routers to learn this information.

2. Router R6 now sends to R5 (by mistake) the additional announcement `11.11.11/24 AS-PATH = 200`. Explain the changes that this causes in the routing tables at all routers in AS 300. Explain which protocol is involved.

   After BGP has converged, what is the path followed by a packet generated at R3 with IP destination address 11.11.11.1 ? Same question if the packet is generated at R4.

3. Router R1 now sends to R2 (by mistake) the additional announcement `66.66.66.128/25 AS-PATH = 100`. Explain the changes that this causes in the routing tables at all routers in AS 300.

After BGP has converged, what is the path followed by a packet generated at R3 with IP destination address 66.66.66.22 ? Same question if the packet is generated at R4. The same previous two questions for packets with IP destination address 66.66.66.222 ?

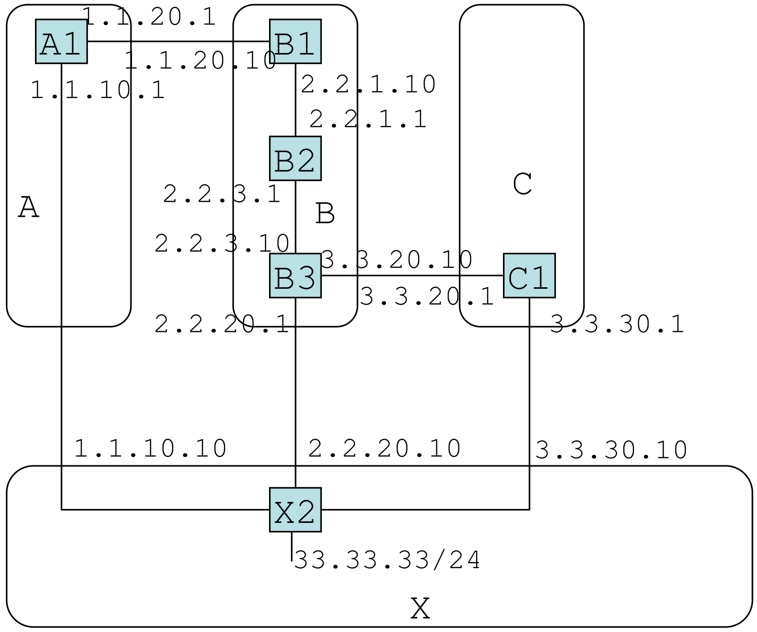

Figure 5: The network used in Question 7.

QUESTION 7

Consider the network in Figure 5. There are four autonomous systems A, B, C and X (we also call A, B, C and X their AS numbers). A, B and C are peers, whereas X is customer of A, B and C. The physical connections are shown by the lines in the figure. There is no other router or prefix than shown on the figure.

All routers in all ASs run RIP inside their domain. *All* routers on the figure run BGP. There is *no* redistribution of BGP into RIP.

There are external BGP sessions between routers in different ASs that are connected by a line on the figure. There are internal BGP sessions between BGP routers, as many as required.

1. The decision process at all routers inside each AS is such that the route selected is, by order of decreasing priority

   (1) route that has the shortest sequence of ASs

   (2) route that has the shortest IGP distance from this router to the NEXT-HOP of the route announced by BGP

   There is no filtering, all routers accept all announcements.
   Router X2 sends to A1, B3 and C1 the announcement `33.33.33/24 AS-PATH=X`. After BGP and RIP have converged in domain B, what are the entries in the forwarding table at router B2 that are used for sending packets toward destinations on network `33.33.33/24` ? Explain which protocol was used by B2 to learn this information.

2. Router A1 now sends by mistake the announcement `33.33/16 AS-PATH = A` to B1. Does this cause a change in router B2's forwarding table ? If so, explain which protocol is involved and give the new forwarding table at B2.

C1 has a packet to forward, with destination = `33.33.11.11`. What is the next hop for this packet ?

3. Assume now that we change the rules of the decision process inside domain B, in the other domains the decision process stays the same. Inside B, the route selected is, by order of decreasing priority:

   (1) route that contains AS A
   (2) route that has the shortest sequence of ASs
   (3) route that has the shortest IGP distance from this router to the NEXT-HOP of the route announced by BGP

   Does this cause a change in router B2's forwarding table ? If so, explain which protocol is involved.

   C1 now has a packet to forward, with destination = `33.33.33.33`. What is the next hop for this packet ?