First name: _____ Family name: _____

FINAL EXAM - SLOT 1
TCP/IP NETWORKING
Duration: 90 min.
With Solutions

Jean-Yves Le Boudec

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The exam is in two time slots. Slot 1 must be completed entirely (sheets returned to us) before starting slot 2. Its duration is indicated on the top of this document.

Slot 1 covers part 2 of the course and is mandatory for everyone.

Slot 2 starts once slot 1 is over and covers part 1 of the course. If you had the maximum grade at the mid term, you should skip slot 2. If you are finished with slot 1 ahead of time, you may leave the room and come back for the beginning of slot 2.

Reminder: Your final theory grade is

$$T = \frac{\max(M_1, F_1) + F_2}{2}$$

where F_1, F_2 are your grades at this exam, and M_1 is your grade at the mid term. Slot 1 gives you grade F_2, slot 2 gives grade F_1.

Write your solution into this document and return it to us. 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, please write them down explicitly.

No documents, no electronic equipments are allowed.

You can write your solution in English or French.

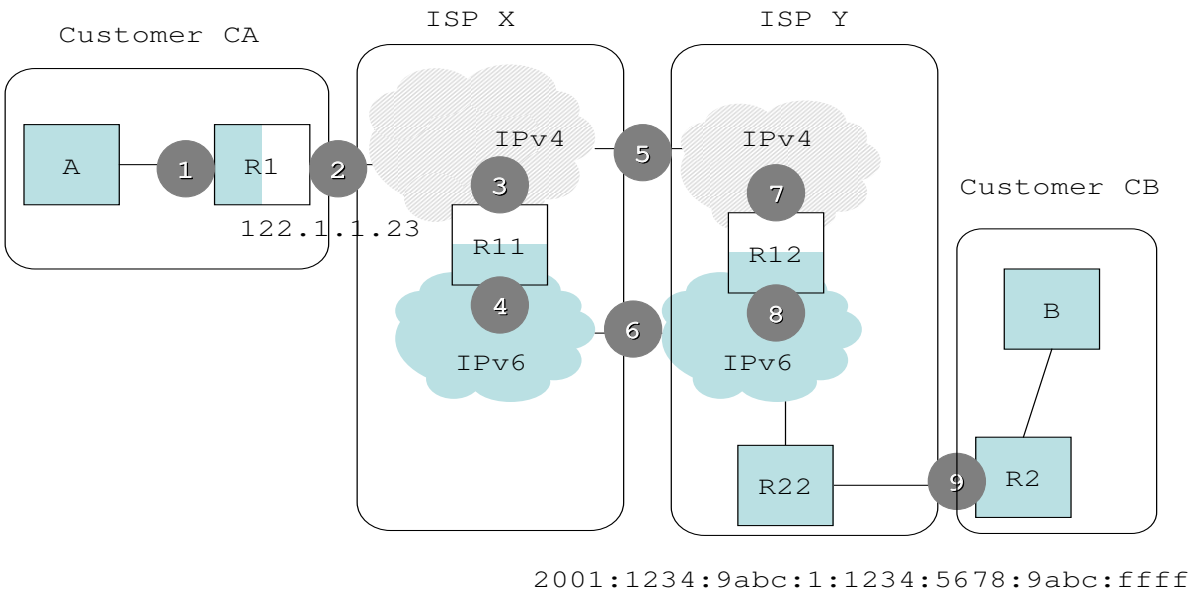

Figure 1: The network used in Question 1.1

QUESTION 1.1

Consider the network in Figure 1. Customers CA and CB have IPv6 networks, all of their hosts are IPv6 only. CB is connected to the IPv6 internet (by means of Internet Service Provider Y). In contrast, CA is connected only to the IPv4 internet (by means of Internet Service Provider X).

Both X and Y are connected to both the IPv4 and IPv6 internets.

CA's connection to X is by means of router R1, which has an IPv6 interface (1 on the figure) and an IPv4 interface (2 on the figure). The IPv4 address of interface 2 is `122.1.1.23`.

CB's connection to Y is by means of by means of router R2, which has only IPv6 interfaces. The address of interface 9 (see figure) is `2001:1234:9abc:1:1234:5678:9abc:ffff`.

1. What is the value of the 49th to 64th bits of interface 9's IPV6 address ? Of the 128th bit ?
   Bits 49 to 63 are 0, bit 64 is 1, bit 128 is 1.
2. Give a possible value for A's IP address.
   2002:7a01:0117::EUI_A. Note that 7a01:0117 is the translation of 122.1.1.23 to hexadecimal notation.

3. A sends one packet to B. Say at which of the points labeled 1 to 9 the packet will be visible. At each of these points, give *all* IP addresses (IPv4, IPv6, source, destination) that may be visible in the packet. Same question for a packet sent by B to A.
   Let IPv$\{4,6\}$X be the IPv$\{4,6\}$ address of machine X, X = A, B, R1, etc.
   In the direction from A to B:

Point	src IPv4	dst IPv4	src IPv6	dst IPv6
1	–	–	IPv6A	IPv6B
2	122.1.1.23	192.88.99.1	IPv6A	IPv6B
3	122.1.1.23	192.88.99.1	IPv6A	IPv6B
4,6,9	–	–	IPv6A	IPv6B

   The packet will not be observed at points 5,7,8, since R11 (and not R12) is the most likely 192.88.99.1 router that the packet will be forwarded to.

In the direction from B to A:

Point	src IPv4	dst IPv4	src IPv6	dst IPv6
9,8	–	–	IPv6B	IPv6A
7,5,2	IPv4R12	122.1.1.23	IPv6B	IPv6A
1	–	–	IPv6B	IPv6A

No packets at 6,4,3.

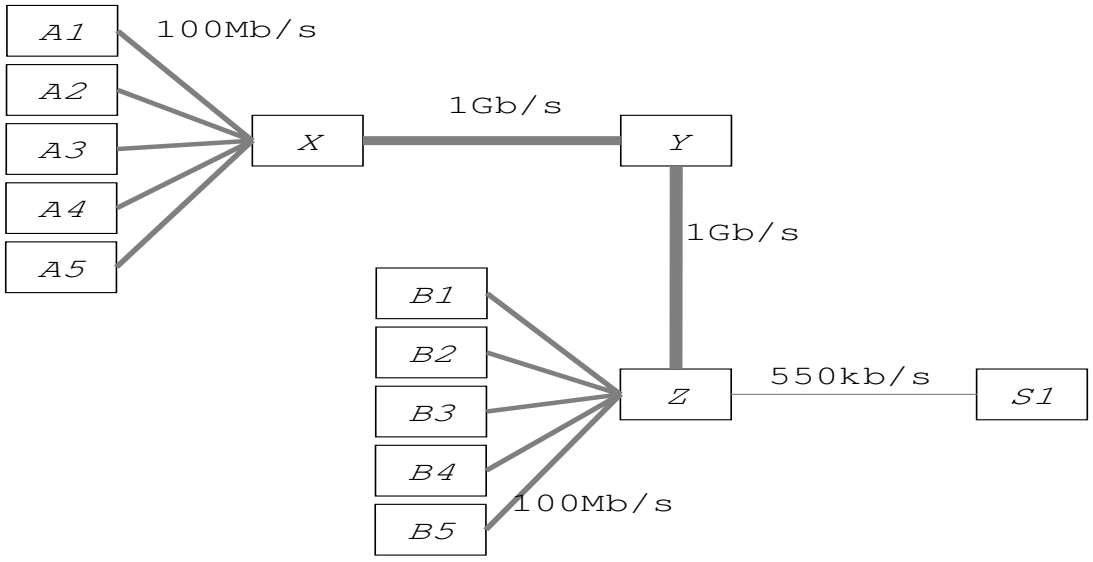

Figure 2: The network used in Question 1.2

QUESTION 1.2

Consider the network in Figure 2. Hosts $A1$ to $A5$ and $B1$ to $B5$ are downloading content from server $S1$. The boxes X, Y, Z are routers, unless otherwise specified.

- The link rates are indicated on the figure. In particular, the link rates between Ai and X as well as between Bi and Z are 100 Mb/s, for $i = 1$ to 5.
- All links are full duplex with same rate in both directions.
- There is no other system than shown on the figure, and we neglect all flows other than from $S1$ to Ai and Bi. We also neglect the impact of the acknowledgement flows in the reverse direction.
- The round trip time from $S1$ to Ai is 200 ms. The round trip time from $S1$ to Bi is 20 ms. These numbers include all processing times.
- We neglect all overheads and assume that the link capacities can be fully utilized.
- The MSS is the same for all flows.

1. Assume that, by some mechanism which we do not specify, the rates of the 10 flows (from $S1$ to Ai and Bi) are allocated according to max-min fairness. What are the values of the rates ?
   By water filling, we see that each flow gets 55kb/s.
2. Same question with proportional fairness instead of max-min fairness.
   By the definition of proportional fairness, each flow gets 55kb/s.
3. We now assume that the 10 flows are using TCP. What is the value of the rate of each flow ?
   All flows share the same bottleneck link, so their rates are inversely proportional to their RTTs. Flows from $S1$ to $Bi, i = 1, \ldots, 5$ get 100kb/s each. Flows from $S1$ to $Ai, i = 1, \ldots, 5$ get 10kb/s each.
4. Assume now that Y is a web proxy instead of a router. All flows use TCP. The round trip time from Y to Ai is 190 ms; the round trip time from $S1$ to Y is 20 ms. What is the value of the rate of each flow ?
   All flows get 55kb/s. What matters now for the Ai flows is the RTT from $S1$ to Y.

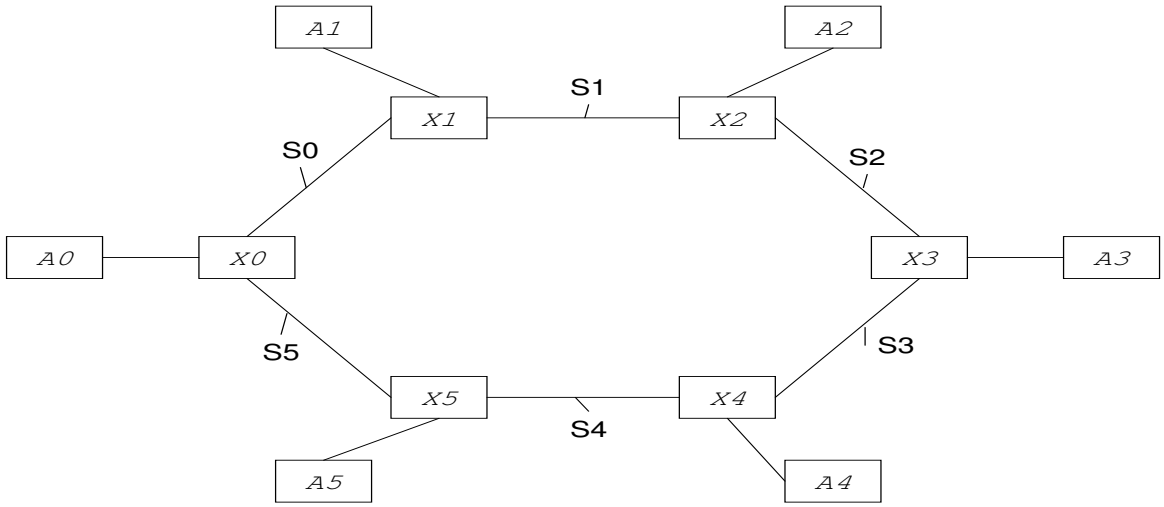

Figure 3: The network used in Question 1.3

QUESTION 1.3

Consider the network in Figure 3. $A0$ to $A5$ are hosts. The links are bi-directional. For every $i = 0, ...5$:

- there is one flow of data from Ai to Aj, with $j = i+2 \mod 6$ (i.e. there are 6 flows of data: $A0 \rightarrow A2$, $A1 \rightarrow A3$, ..., $A4 \rightarrow A0$ and $A5 \rightarrow A1$)
- there is a packet sniffer, called Si on the link between Xi and Xj, with $j = i + 1 \mod 6$. The packet sniffer can see all packets flowing on the link in either direction.

1. $X1$ to $X6$ are routers running OSPF. All link costs are equal. Which of the six flows can be observed at the observation point Si, $i = 0...5$?
   OSPF routes along shortest paths. So, at point $Si, i = 0, \ldots, 5$, flows $A_{i-1 \mod 6} \rightarrow A_{i+1 \mod 6}$ and $A_{i \mod 6} \rightarrow A_{i+2 \mod 6}$ are observed.
2. $X1$ to $X6$ are transparent bridges. Which of the six flows can be observed at the observation point Si, $i = 0...5$?
   The STP (Spanning Tree Protocol) will disable one link. Assume it is the link $X0$-$X1$. There is only one path that each flow can follow.
3. $X1$ to $X6$ are again routers, running some unspecified routing protocol. We would like that the flow $A0 \rightarrow A2$ goes via $X0, X1, X2$ whereas the flow $A1 \rightarrow A3$ should go the long way, i.e. via $X1, X0, X5, X4, X3$. Is this possible ? If not, why ? If so, by which mechanisms ?
   We could set the cost of link $X2$-$X3$ to a high value. We have to assume that the unspecified routing protocol chooses shortest paths.