Computer Networks - Midterm

October 28, 2016

Duration: 2h15m

- This is a closed-book exam.
- Please write your answers on these sheets in a readable way, in English or in French.
- You can use extra sheets if necessary (don't forget to put your name on them).
- The total number of points is 100.
- This document contains 16 pages.
- Good luck!

Full Name (Nom et Prénom):

SCIPER No:

Division: ☐ Communication Systems ☐ Computer Science
☐ Other (mention it): . . . .

Year: ☐ Bachelor Year 2 ☐ Bachelor Year 3
☐ Other (mention it): . . . .

1 Short questions (10 points)

***For each question, please circle a single best answer*.**

1. The network performance requirements of a voice & video chat application are:
   (a) low latency, low throughput.
   (b) low latency, high throughput.
   (c) high latency, low throughput.
   (d) high latency, high throughput.
2. What is a major drawback of "connection-switching" versus "packet-switching"?
   (a) Network resources are not used efficiently.
   (b) Queuing delays are substantially longer.
   (c) They require the use of optical fibers.
   (d) They do not support DNS resolution queries.
3. All root DNS servers become unreachable. This has the following effect:
   (a) No names can be resolved.
   (b) All names can be resolved, but it takes longer.
   (c) As time passes, fewer and fewer names can be resolved.
   (d) Nothing.
4. Distributed hash tables (DHTs) are typically used in peer-to-peer file sharing applications to:
   (a) store very large files that do not fit in the peers' memory.
   (b) segment content into pieces and distribute them among the peers.
   (c) check the correctness of the shared content.
   (d) locate the peers that store certain content.
5. Which guarantees does TCP offer?
   (a) Guaranteed security
   (b) Guaranteed performance
   (c) Reliable delivery
   (d) All of the above

6. A process can use the same socket to communicate with multiple remote processes in:
   (a) TCP
   (b) UDP
   (c) None of the above
   (d) Both TCP and UDP
7. A client application creates two TCP sockets and successfully connects them in parallel to a remote TCP server application that is listening to port 9000. All packets that the client application sends to the server application share the same source address and destination IP address. Which of the following is true?
   (a) Both client sockets can generate packets with destination port 9000. (at the same time)
   (b) Both client sockets can generate packets with source port 9000. (at the same time)
   (c) Both the above are correct.
   (d) Both of the above are false.
8. Consider a link with a transmission rate of 10Mbps, which is shared between multiple users that want to transfer data at a rate of 1Mpbs. How many concurrent transfers can be supported?
   (a) There is no limit.
   (b) ≤ 10
   (c) > 10
   (d) It depends on whether we use connection switching or packet switching.
9. Consider a switch that forwards packets of size 500bits over a link with transmission rate of 1Kbps, using a buffer size of 10Kbits. What is the maximum queuing delay that the packets may experience?
   (a) 10 seconds.
   (b) 9.5 seconds.
   (c) ∞
   (d) We cannot say. It depends on the arrival pattern (burstiness) of the packets.
10. A host has recently accessed www.epfl.ch, which contains two images. The host knows the IP address of the web server. How many round-trip-times (RTTs) are necessary to retrieve the entire page again?
    (a) At most 5 RTTs.
    (b) At least 3 RTTs.
    (c) At most 3 RTTs.
    (d) At least 2 RTTs.

2 Web Browsing and DNS (38 points)

Setup:

Two users, Alice and Bob, are logged into the workstations `alice.ethz.ch` and `bob.ethz.ch`, all located inside ETHZ's network.

ETHZ offers a web server `www.ethz.ch`, a local name server `ns.ethz.ch` and a web proxy `proxy.ethz.ch`. EPFL offers a web server `www.epfl.ch` and a local name server `ns.epfl.ch`.

The setup is illustrated in Figure 1. Make the following assumptions:

- All DNS and HTTP caches are initially empty.
- All web-browsing traffic originating in the ethz.ch domain goes through the web proxy.
- All web browsers in the ethhz.ch domain know the IP address of the web proxy.
- The DNS server `ns.ethz.ch` is also the *authoritative* DNS server for the `ethz.ch` domain.
- The DNS server `ns.epfl.ch` is also the *authoritative* DNS server for the `epfl.ch` domain.
- Each HTTP message fits in a single packet.
- The web browsers, proxies and servers use persistent HTTP connections.
- The contents of the web server running on `www.epfl.ch` never change.

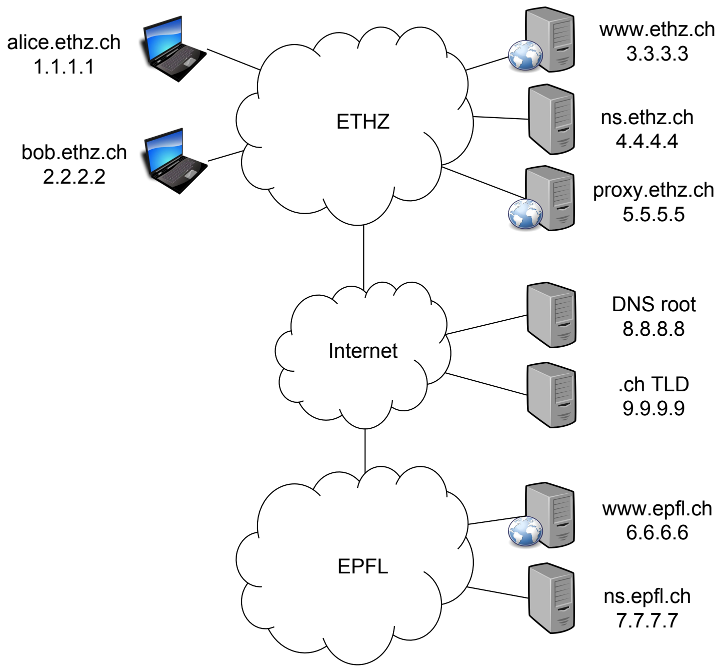

Figure 1: The setup for the exercise on Web browsing and DNS

Question 1 (10 points):

Alice uses her web browser to access URL `http://www.epfl.ch/index.html`. This page includes an image with URL `http://www.epfl.ch/logo.png`.

List all packets that are exchanged in the entire network, including any connection-setup packets, by filling Table 1. For each packet, show the source and destination IP address, the application-layer protocol, the transport-layer protocol and the purpose of the packet, as in the two examples.

Packet	Source IP	Dest. IP	Application protocol	Transport protocol	Purpose
ex.1	`1.0.0.1`	`1.0.0.2`	HTTP		HTTP reply with `image.png`
ex.2	`2.0.0.1`	`2.0.0.2`	DNS		What is the IP address of `example.com`?
1					
2					

Table 1: Packets transmitted on the Internet, in Question 1

Question 2 (8 points):

Right after Alice views `http://www.epfl.ch/index.html`, Bob uses his web browser to access URL `http://www.epfl.ch/quiz.html`. This page includes an image with URL `http://www.epfl.ch/logo.png`.

List all packets that are exchanged in the entire network, including any connection-setup packets, by filling Table 2. For each packet, show the source and destination IP address, the application-layer protocol, the transport-layer protocol and the purpose of the packet.

Packet	Source IP	Dest. IP	Application protocol	Transport protocol	Purpose
1					
2					

Table 2: Packets transmitted on the Internet, in Question 2

Question 3 (6 points):

Now suppose that the web server at `www.epfl.ch` uses cookies. Do you think that this might change your answer to Question 2? If so, briefly describe how (you do not need to list all the packets again, just explain what would be the difference, if any, in a couple of sentences).

Clarification: we have not discussed cookies in detail, so you are not expected to immediately know the answer. Just try to make a guess, based on your understanding of the role of cookies.

Question 4 (8 points):

Web caching and DNS caching use two different mechanisms for ensuring that the cached data is not stale.

a. Why is that?

b. Would it make sense for web caching to use the mechanism used by DNS caching and vice versa?

Question 5 (6 points):

Many ETHZ users often visit the URL *http://www.bank.ch*. Alice wants to launch an attack in order to redirect the traffic between all these users and *www.bank.ch* to her own machine, which has IP address 1.1.1.1. At some point, there is a power failure on the ETHZ campus, which causes all the servers to reboot and brings them back to their initial state (the one they had at the beginning of Problem 2). Alice uses this as an opportunity to launch her attack.

a. Explain briefly how she will do it, i.e., what traffic will she send out and what will that cause.

b. Why is the server reboot necessary for Alice to launch her attack?

3 Traffic log (12 points)

Consider a machine on the EPFL campus that hosts a web server. The machine has two hostnames: *moodle.epfl.ch* and *images.epfl.ch* (in other words, both of these hostnames map to the same IP address). Suppose *http://moodle.epfl.ch/index.html* references *http://images.epfl.ch/logo.jpg* and *http://images.epfl.ch/background.jpg*.

The following log was captured at the web server:

Index	Time	Source	Destination	Protocol	Length	Description
1	0	1.2.3.4	5.6.7.8	HTTP	76	TCP handshake request
2	0	5.6.7.8	1.2.3.4	HTTP	76	TCP handshake reply
3	0.1	1.2.3.4	5.6.7.8	HTTP	100	GET request for /index.html, Host: moodle.epfl.ch
4	0.1	5.6.7.8	1.2.3.4	HTTP	480	GET reply with /index.html
5	0.4	1.2.3.4	5.6.7.8	HTTP	76	TCP handshake request
6	0.4	5.6.7.8	1.2.3.4	HTTP	76	TCP handshake reply
7	0.5	1.2.3.4	5.6.7.8	HTTP	109	GET request for /logo.jpg, Host: images.epfl.ch
8	0.5	5.6.7.8	1.2.3.4	HTTP	960	GET reply with /logo.jpg
9	0.6	1.2.3.4	5.6.7.8	HTTP	76	TCP handshake request
10	0.6	5.6.7.8	1.2.3.4	HTTP	76	TCP handshake reply
11	0.7	1.2.3.4	5.6.7.8	HTTP	100	GET request for /background.jpg, Host: images.epfl.ch
12	0.7	5.6.7.8	1.2.3.4	HTTP	1250	GET reply with /background.jpg (packet 1 of 4)
13	0.71	5.6.7.8	1.2.3.4	HTTP	1250	GET reply with /background.jpg (packet 2 of 4)
14	0.72	5.6.7.8	1.2.3.4	HTTP	1250	GET reply with /background.jpg (packet 3 of 4)
15	0.73	5.6.7.8	1.2.3.4	HTTP	1250	GET reply with /background.jpg (packet 4 of 4)

Table 3: Packet capture log. Time is shown in seconds, with 2 decimal places; the packet length is shown in bytes.

Answer the following questions, briefly justifying your answers:

a. What is the IP address of the web server?

b. How many clients connect to the web server? What are their IP addresses?

c. Do the clients use persistent or non-persistent connections?

d. Estimate the round-trip time between the client(s) and the web server.

e. Estimate the time it took the client(s) to perform DNS resolution of *images.epfl.ch*.

f. Estimate the rate of the link connecting the web server to the Internet (hint: from the transfer of */background.jpg*).

4 File Distribution (40 points)

The network in Figure 2 contains the following elements:

- Server S, which stores a file of size F bits.
- Nodes $1, 2, \dots N$, where $N \geq 4$ and N is even $(4, 6, 8, \dots)$.
- Packet switches $S1$ and $S2$, which perform store-and-forward packet switching and introduce insignificant processing delays.
- Each link has length ℓ and propagation speed c.
- The transmission rate of the link between $S1$ and $S2$ is $\frac{R}{k}$ in each direction, where $k > 1$.
- The transmission rate of all the other links is R in each direction.
- The end-systems communicate over UDP which means that, when you compute delays, you do not need to worry about connection setup.
- No other approximations/ simplifying assumptions can be made.

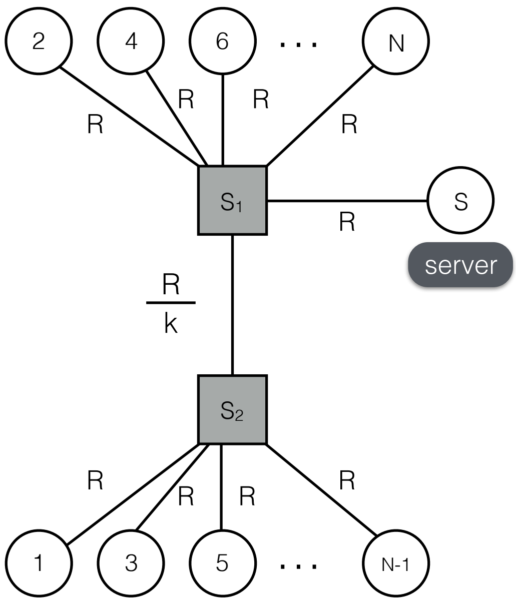

Figure 2

Question 1 (3 points):
Node 1 requests the file from Server S. Suppose the request message fits in a single packet of size Q bits. How long does it take for the request message to reach S?

Question 2 (5 points):
In response to the request of Node 1, Server S splits the file into P packets of equal length and sends them to Node 1, one after the other. Ignore the processing time for splitting the file into packets. How long does it take for the file to be fully delivered to Node 1?
(**Hint**: Careful, there may be queuing delays!)

Question 3 (12 points):
Instead of only Node 1, all nodes $(1, 2, \ldots N)$ request the file from Server S.

a. Suppose all nodes begin transmitting their requests at exactly the same time. Which requests will arrive earlier at the server, the ones coming from the odd nodes $(1, 3, 5, \ldots)$ or the even nodes $(2, 4, 6, \ldots)$?

   Briefly explain why.

b. After having received all N requests, Server S splits the file into P packets of equal length and sends them to the nodes using the client-server approach.

   Suppose that the server handles the requests in the order in which they were received. For example, if the first request to arrive at the server is from Node i, the server will transmit all P packets needed by Node i.

   Based on your answer to (a), how long will it take for the file to be fully delivered to all nodes?

Question 4 (12 points):

a. Instead of using the client-server approach, the server S distributes the file using the following peer-to-peer (P2P) approach:

- The server S first splits the file into 2 equally sized packets (chunks) and sends them to Node 1; when S has sent both packets to Node 1, it stops distributing the file.
- As soon as Node i receives a packet, it sends it to Node $i + 1$; when Node i has sent both packets to Node $i + 1$, it stops redistributing the file.
- So, each of the two packets goes from S to Node 1, then Node 2, etc.

The underlying physical topology is still the one shown in Figure 2. How long will it take for the file to be fully delivered to all nodes? Justify your answer.

b. Briefly describe a different P2P approach that could offer shorter file distribution time.

Question 5 (8 points):

a. An even node wants to launch a “denial-of-service flooding attack” on the server, such that none of the other nodes (odd or even) can reach the server.

   Is that possible? How would such an attack work?

b. Could an odd node launch such an attack?