CSE489/589: Modern Networking Concepts
Homework 2

NOTES:

- **Academic integrity**: Print the following statement at the very beginning of your homework file: *"I have read and understood the course academic integrity policy in the syllabus of the class. I confirm that the work presented in this report is my own. Where information has been derived from other sources, I confirm that this has been indicated in the report."* Your homework will NOT be graded if you didn't print the sentence.
- For the calculation, you need to write down how the results are derived and your final answer also should be correct to obtain the credits for that question. Please state any assumptions you are making while answering a question.
- Submit the homework through UBLearns as PDF files.

Question 1

A client sequentially downloads files from three servers, denoted as S_1, S_2, and S_3. The download sequence is as follows:

1. From S_1: Five objects, each with a size of 4 Mbit.
2. From S_2: Two objects, each with a size of 10 Mbit.
3. From S_3: Three objects, each with a size of 8 Mbit.

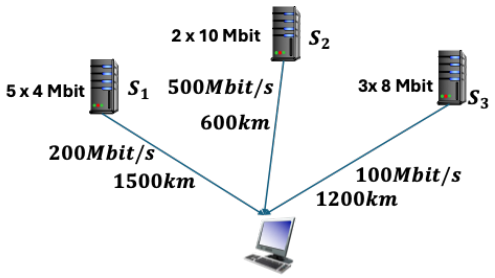

Figure 1: Downloading files using http.

The distances between the client and the servers are as follows:

1. S_1: 1500 km
2. S_2: 600 km
3. S_3: 1200 km

The data rates of the links between the client and the servers are:

1. S_1: 200 Mbit/s
2. S_2: 500 Mbit/s
3. S_3: 100 Mbit/s

Assume that data travels at the speed of light, 3×10^8 m/s. Calculate the time required for the client to download all files from the three servers using both non-persistent HTTP and persistent HTTP. (40 points)

Question 2

Imagine a museum has an Augmented Reality (AR) guide system. The user's mobile app sends the user's "head pose" (yaw/pitch/roll + coordinate) to the server every few milliseconds. The server then pushes back audio/visual explanations based on what the user is looking at.

- **Context A:** The server only needs the "most recent pose" to determine the current content. If some pose updates are lost, the user barely notices because a new update arrives immediately after.

- **Context B:** However, when the user clicks a "Buy Souvenir / Place Order" button in the app, the transaction must be accurate, reliable, and processed exactly once.

Answer the following:

1. Should the "pose update channel" use **TCP** or **UDP**? (5 points)
2. How should the "Purchase/Order" request be transmitted? Which protocol it should use? Why? (5 points)

Question 3

A single server (with a single public IP address) runs three different network applications simultaneously: a **Web Server** (HTTP), an **Email Server** (SMTP), and a **DNS Server**. Can the operating system rely **solely** on the IP address to deliver incoming packets to the correct application? Why or why not? Explain what information is required to identify the specific receiving process. (10 points)

Question 4

Assume an institutional network connects to the Internet via an access link.

- **Bandwidth Assumptions:**
  - **Access Link** (to Internet): $R_{access} = 15$ Mbps.
  - **Local Area Network (LAN):** High-speed (assumed **infinite bandwidth** for calculation purposes).
- **Object Data:** The average size of Web objects requested by users is $L = 100$ kbits.
- **Request Rate:** The total request rate from users within the institution is $\lambda = 150$ requests/sec.
- **Network Delay:**
  - The Round Trip Time (RTT) on the Internet side (access link to origin server) is $RTT_{internet} = 2.0$ seconds.
  - The delay inside the local LAN is negligible (≈ 0 seconds).
- **Delay Model:**
  - If the Access Link Utilization (Traffic Intensity) ≥ 1, the queueing delay approaches infinity.
  - If the Access Link Utilization < 0.8, the queueing delay on the access link is negligible.

Problems:

(a) **No Cache Case:**

- Calculate the **Link Utilization** of the access link. (10 points)
- Based on this utilization, what is the expected **Average Response Time** perceived by the users? (10 points)

(b) **With Cache Case:**

- Now, a Web Cache server is deployed in the local LAN with a **Hit Rate of 40%**.
- Calculate the **New Link Utilization** of the access link. (10 points)
- Calculate the new expected **Average Response Time** for user requests.
  (*Hint: Average Response Time = Hit Rate* $\times$ *Delay_hit + Miss Rate* $\times$ *Delay_miss)* (10 points)