1 Networking

1.1 Lecture: Basic networking concepts

- Client, Server, Protocol Stack, throughput, RTT, HTTP request/response

1.2 Exercise: Measure RTTs and throughputs under different network conditions

- Download and install Java
  - https://www.java.com/en/download/help/windows_manual_download.html
- Download HTTPClient.java file from: https://github.com/nvduc/HTTPClient
- Compile and run HTTPClient.java program
  - Open 'Command Prompt' (Windows) or 'Terminal' (Ubuntu or Mac)
  - Type the following commands in the Terminal to compile and run

```
javac HTTPClient.java
java HTTPClient
```

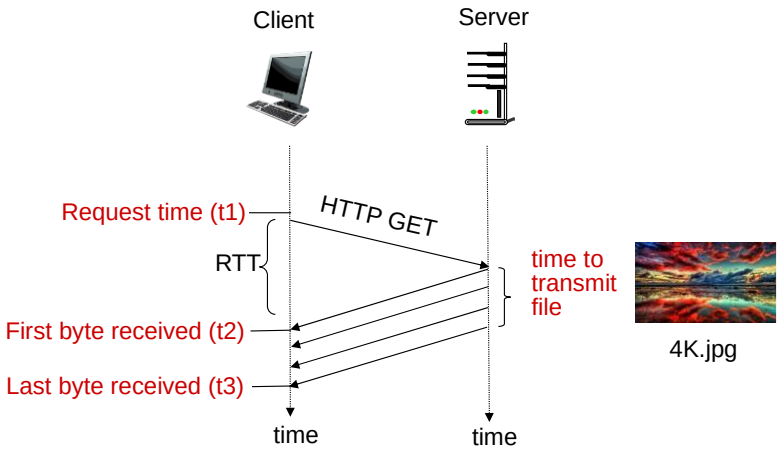
The following text should be displayed on the Terminal. Verify that file '4K.jpg' has been saved in the same folder as that of HTTPClient.java.

```
nguyen@doukkunoMacBook-Pro VinUni % java HTTPClient
***GET message:
GET /4K.jpg HTTP/1.1
Host: 172.16.5.162
Connection: keep-alive


***Response's Header:
HTTP/1.1 200 OK
Date: Mon, 26 Dec 2022 07:07:59 GMT
Server: Apache/2.4.53 (Unix)
Last-Modified: Fri, 23 Dec 2022 05:03:46 GMT
ETag: "b0fd9-5f077b5d59080"
Accept-Ranges: bytes
Content-Length: 724953
Keep-Alive: timeout=5, max=100
Connection: Keep-Alive
Content-Type: image/jpeg

Requested file saved to: 4K.jpg
```

The above program downloads an image file (4K.jpg) from a HTTP server by

1) Establishing a TCP connection to the server
2) Sending a HTTP GET request message
3) Receiving the requested file and save to a local file

Exercises:



1. RTT (Round-trip Time) delay is the time delay between the time when the client sends the GET request (t1) and the time when the first byte is received (t2). Modify the original HTTPClient.java program to measure and display the RTT value in milliseconds.

   In Java, the current time can be obtained by the following function:

   long t_now = System.currentTimeMillis(); /*current time in milliseconds */

2. Modify the original HTTPClient.java program to measure and display the average throughput during the file download process. The average throughput (T^{avg}) is calculated as the total data size (value of the content-length field) divided by the download time (t3 – t1).

$$T^{avg} = \frac{content\_len}{(t3 - t1)}$$

   In the original program, the value of the content-length field is stored in the variable 'content_len'. In Java, displaying variables' content on the display can be performed by the following function:

   System.out.printf("average download throughput: %.2f¥n", T_avg);

3. Change the download file name (line 11 of HTTPClient.java) to those in Table I, run the program and record RTTs and throughput values for different files.

FileName	FileSize (bytes)	RTT	Throughput
4K.jpg	725KB		
2M.dat	2.1MB		
5M.dat	5.2MB		
10M.dat	10.5MB		

Discuss how the RTT and throughput values change when the file size increases.