

## **Week #3**

# **Understanding Persistent and Non-persistent HTTP Connections**

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**To understand persistent and non-persistent HTTP connections and corresponding performance impact.**

Create a web page with N (e.g. 10) embedded images. Each image should be of minimum 2 MB size. Configure your browser (Firefox) with following settings (each setting requires repeat of experiment)

- Non persistent connection
- 2 persistent connections
- 4 persistent connections
- 6 persistent connections
- 10 persistent connections.

**Observation:** Note down the time taken to display the entire page in each of the settings. Ensure that (cache is cleared before starting the web request). Explain the response time differences. What is the optimal number of persistent connections for best performance? Explain your answer.

## Introduction

The Apache HTTP server is the most widely-used web server in the world. It provides many powerful features including dynamically loadable modules, robust media support, and extensive integration with other popular software.

**Objective:** Understand persistent and non-persistent HTTP connections and corresponding performance impact.

**Experiment:** Create a web page with N (e.g. 10) embedded images. Each image should be of minimum 2 MB size. Configure your browser (Firefox) with following settings (each setting requires repeat of experiment)

- a) Non-persistent connection
- b) 2 persistent connections
- c) 4 persistent connections
- d) 6 persistent connections
- e) 10 persistent connections

Note down the time taken to display the entire page in each of the settings. **Ensure that cache is cleared before starting the web request.** Explain the response time differences. What is the optimal number of persistent connections for best performance? Explain your answer.

**Note:** To install Apache server, use the following command,

```
sudo apt-get install apache2
```

If there is any error during installation, update the package manager by issuing the command,

```
sudo apt-get update
```

```
root@Ubuntu2:~# sudo apt-get install apache2
Reading package lists... Done
Building dependency tree... Done
Reading state information... Done
The following package was automatically installed and is no longer required
:
  systemd-hwe-hwdb
Use 'sudo apt autoremove' to remove it.
The following additional packages will be installed:
  apache2-bin apache2-data apache2-utils libapr1 libaprutil1
  libaprutil1-dbd-sqlite3 libaprutil1-ldap
Suggested packages:
  apache2-doc apache2-suexec-pristine | apache2-suexec-custom
  www-browser
The following NEW packages will be installed:
  apache2 apache2-bin apache2-data apache2-utils libapr1 libaprutil1
  libaprutil1-dbd-sqlite3 libaprutil1-ldap
0 upgraded, 8 newly installed, 0 to remove and 272 not upgraded.
```

```
root@Ubuntu2:~# sudo apt-get update
Hit:1 http://in.archive.ubuntu.com/ubuntu jammy InRelease
Hit:2 http://security.ubuntu.com/ubuntu jammy-security InRelease
Hit:3 http://in.archive.ubuntu.com/ubuntu jammy-updates InRelease
Hit:4 http://in.archive.ubuntu.com/ubuntu jammy-backports InRelease
Reading package lists... Done
```

## EXECUTION STEPS

**Step 1:** Connect 2 desktops using switch and cables as shown below. (Use 2 VMs on Virtualbox or VMware instead of physical connections.)

**Server**



172.16.10.1/24

**Client**



172.16.10.2/24

### Server Side:

**Step 2:** Check your Web Server

At the end of the installation process, Ubuntu 16.04 starts Apache. The web server should already be up and running. We can check with the `systemctl` command to make sure the service is running by typing:

**`sudo systemctl status apache2`**

**or**

**`sudo service apache2 status`**

```
nagavenigowda@Ubuntu2:~$ su -
Password:
root@Ubuntu2:~# sudo systemctl status apache2
● apache2.service - The Apache HTTP Server
   Loaded: loaded (/lib/systemd/system/apache2.service; enabled; vendor p
  rese>
   Active: active (running) since Fri 2023-02-10 21:02:05 IST; 1min 41s a
 go
     Docs: https://httpd.apache.org/docs/2.4/
   Process: 744 ExecStart=/usr/sbin/apachectl start (code=exited, status=0
 /SUC>
   Main PID: 790 (apache2)
     Tasks: 55 (limit: 3707)
    Memory: 7.6M
  LibreOffice Writer
   CGroup: /system.slice/apache2.service
           └─790 /usr/sbin/apache2 -k start
             └─791 /usr/sbin/apache2 -k start
               └─792 /usr/sbin/apache2 -k start

Feb 10 21:02:05 Ubuntu2 systemd[1]: Starting The Apache HTTP Server...
Feb 10 21:02:05 Ubuntu2 systemd[1]: Started The Apache HTTP Server.
lines 1-16/16 (END)
```

As you can see above, the service appears to have started successfully. However, the best way to test this is to actually request a page from Apache. You can access the default Apache landing page to confirm that the software is running properly. You can access this through your server's domain name or IP address.

**Step 3:** Server IP address can be set by the following command



```
$sudo ip addr add 172.16.10.1/24 dev enps0
$sudo ip addr
```

```
root@Ubuntu2:~# sudo ip addr
1: lo: <LOOPBACK,UP,LOWER_UP> mtu 65536 qdisc noqueue state UNKNOWN group default qlen 1000
    link/loopback 00:00:00:00:00:00 brd 00:00:00:00:00:00
    inet 127.0.0.1/8 scope host lo
        valid_lft forever preferred_lft forever
    inet6 ::1/128 scope host
        valid_lft forever preferred_lft forever
2: enp0s3: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc fq_codel state UP group default qlen 1000
    link/ether 08:00:27:68:f0:64 brd ff:ff:ff:ff:ff:ff
    inet 172.16.10.1/24 brd 172.16.10.255 scope global noprefixroute enp0s3
        valid_lft forever preferred_lft forever
    inet6 fe80::e0d7:9c34:4618:84aa/64 scope link noprefixroute
        valid_lft forever preferred_lft forever
root@Ubuntu2:~#
```

Note: If IP address fluctuates, kindly setup the IP address manually using ‘Edit connections’.

**Step 4:** The **apache2.conf** file present in the **etc/apache2** directory is modified as:

- a) The **keep-alive** option was set (i.e. value was made **ON**)
- b) The **MaximumKeepAliveRequests** were set to **2**

```
$sudo nano /etc/apache2/apache2.conf
```

```
GNU nano 6.2 /etc/apache2/apache2.conf *
PidFile ${APACHE_PID_FILE}

#
# Timeout: The number of seconds before receives and sends time out.
#
Timeout 300

#
# KeepAlive: Whether or not to allow persistent connections (more than
# one request per connection). Set to "Off" to deactivate.
#
KeepAlive On

#
# MaxKeepAliveRequests: The maximum number of requests to allow
# during a persistent connection. Set to 0 to allow an unlimited amount.
# We recommend you leave this number high, for maximum performance.
#
MaxKeepAliveRequests 2

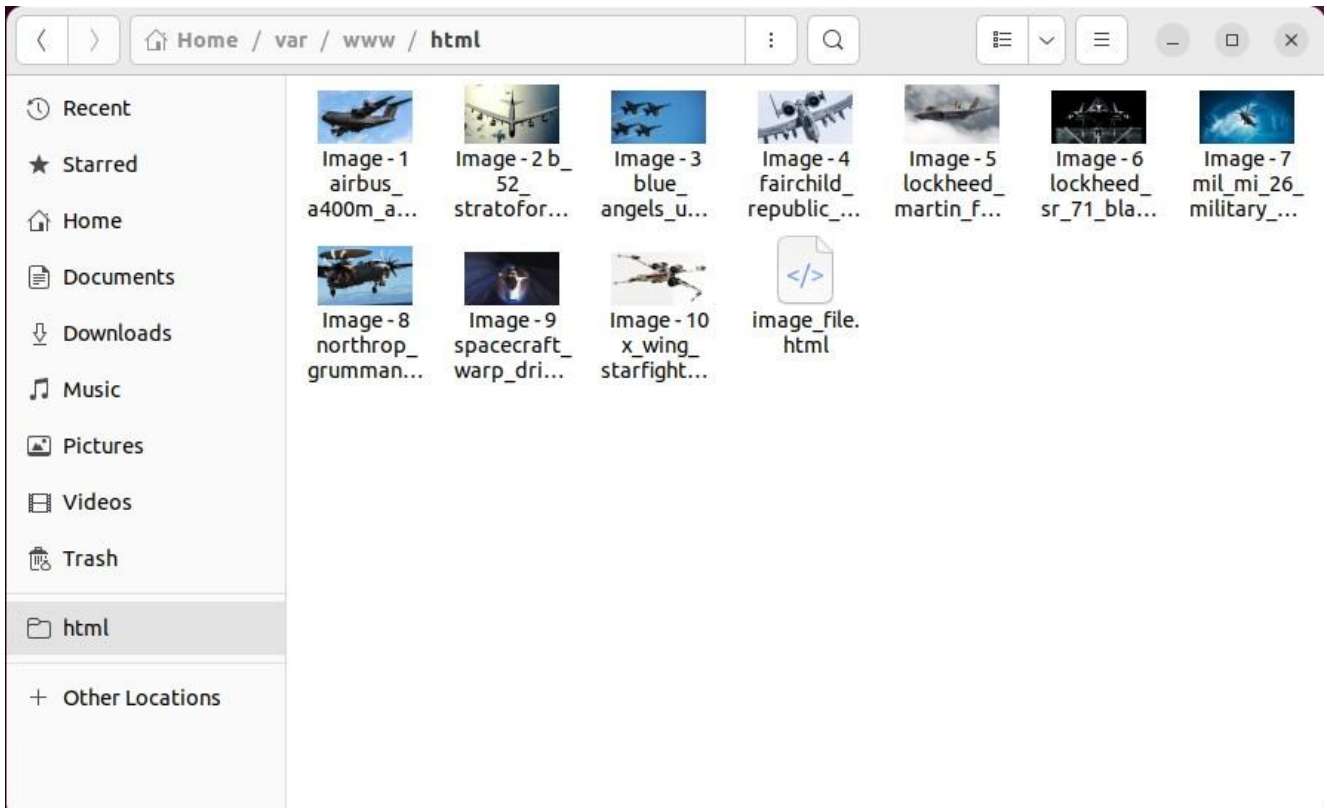
# KeepAliveTimeout: Number of seconds to wait for the next request from the
# same client on the same connection.
#
KeepAliveTimeout 5

# These need to be set in /etc/apache2/envvars
User ${APACHE_RUN_USER}
Group ${APACHE_RUN_GROUP}
```

**Step 5:** Store images in the server path. A html page consisting of 10 images having size > 2MB were placed and accessed by the client. This html page is stored in the location - **/var/www/html/file\_name.html**.

Note: Use the images provided by faculty incharges.





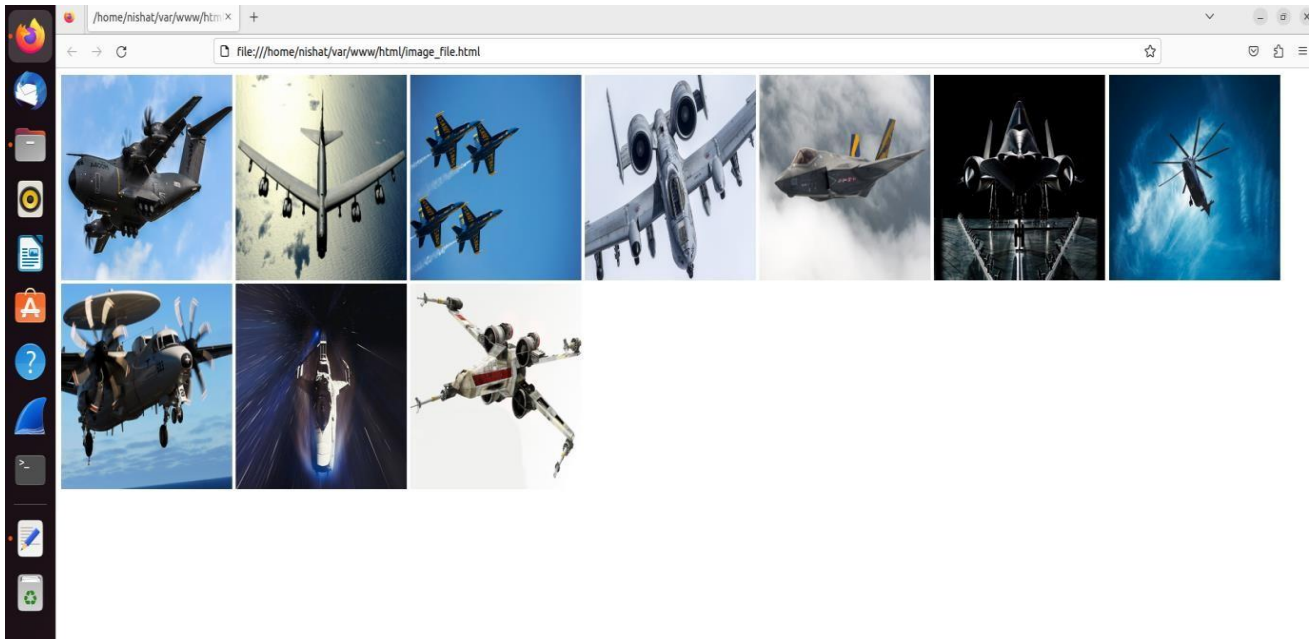
**Step 6:** Prepare a web page as shown below. The html file needs to add 10 images. (Kindly skip the style attribute in the below image)

```

Open  [icon]  *image_file.html
~ / var / www / html

1 <!DOCTYPE html>
2 <html>
3 <body>
4
5 
6 
7 
8 
9 
10 
11 
12 
13 
14 
15
16 </body>
17 </html>
18

```



### **Client side:**

Client IP address can be set by the following command.

```
$sudo ip addr add 172.16.10.2/24 dev enps0  
$sudo ip addr
```

Note: If IP address fluctuates, kindly setup the IP address manually using 'Edit connections'.

```
root@Ubuntu:~# sudo ip addr
1: lo: <LOOPBACK,UP,LOWER_UP> mtu 65536 qdisc noqueue state UNKNOWN group default qlen 1000
    link/loopback 00:00:00:00:00:00 brd 00:00:00:00:00:00
    inet 127.0.0.1/8 scope host lo
        valid_lft forever preferred_lft forever
    inet6 ::1/128 scope host
        valid_lft forever preferred_lft forever
2: enp0s3: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc fq_codel state UP group default qlen 1000
    link/ether 08:00:27:0c:3c:65 brd ff:ff:ff:ff:ff:ff
    inet 172.16.10.2/24 brd 172.16.10.255 scope global noprefixroute enp0s3
        valid_lft forever preferred_lft forever
    inet6 fe80::8a49:204a:2f59:4202/64 scope link noprefixroute
        valid_lft forever preferred_lft forever
root@Ubuntu:~#
```

There are broadly two parts of execution:

1. Dealing with non-persistent connections
2. Dealing with persistent connections

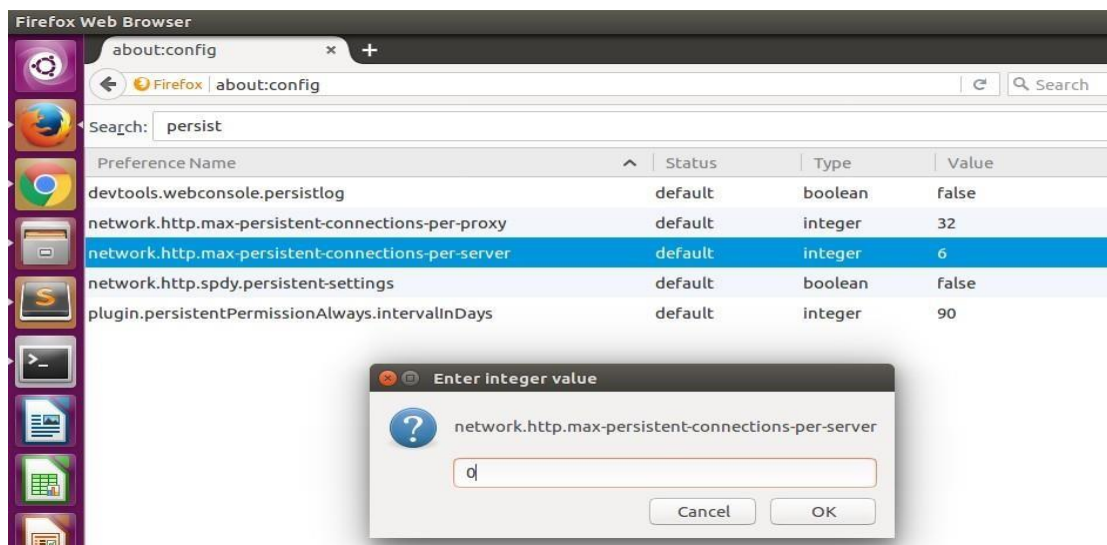
Open Firefox browser to configure for persistent option. Go to browser and type

**about:config** and search for the term '**persistent**'

- While using non-persistent connection experiment, the **max-persistent-connections-per-server** has the value set to **0** and **persistent-settings** value set to false.
- While using persistent connection experiment, the **max-persistent-connections-per-server** should have value greater than 0 (depending on the number of persistent connections needed) and **persistent-settings** value set to true.

## PART 1: NON-PERSISTENT CONNECTION

**Step 1:** This is done by setting the value of max-persistent-connection-per-server to 0 in the client computer.



**Step 2:** Access web page on client-side browser (Firefox)

The client could access the file as:

**172.16.10.1 /file\_name.html** where--> **172.16.10.1** is Server's IP

Here the file name is **a.html** present in server. So, by typing **172.16.10.1/a.html** in client browser, we will be able to open the requested web page.

Note 1: The wireshark should capture the packets between the client and the server while the file is accessed.

Note 2: The images in the HTML page should have all the permissions specified through the server for the proper access.

**Step 3:** Use wireshark. Open wireshark in the server computer while client is trying to access the server's local host webpage. Apply 'http' filter and note the time to capture all the 10 images.

http						
No.	Time	Source	Destination	Protocol	Length	Info
25	0.211530105	172.16.10.1	172.16.10.2	HTTP	568	HTTP/1.1 404 Not Found (text/html)
27	2.070581279	172.16.10.2	172.16.10.1	HTTP	421	GET /a.html HTTP/1.1
28	2.070866155	172.16.10.1	172.16.10.2	HTTP	641	HTTP/1.1 200 OK (text/html)
30	2.117160769	172.16.10.2	172.16.10.1	HTTP	347	GET /images%20(1).jpg HTTP/1.1
35	2.117571913	172.16.10.1	172.16.10.2	HTTP	1200	HTTP/1.1 200 OK (JPEG JFIF image)
36	2.117753115	172.16.10.2	172.16.10.1	HTTP	347	GET /images%20(2).jpg HTTP/1.1
45	2.117944288	172.16.10.1	172.16.10.2	HTTP	463	HTTP/1.1 200 OK (JPEG JFIF image)
51	2.118574057	172.16.10.2	172.16.10.1	HTTP	349	GET /download%20(4).jpg HTTP/1.1
63	2.119058490	172.16.10.1	172.16.10.2	HTTP	242	HTTP/1.1 200 OK (JPEG JFIF image)
65	2.119487932	172.16.10.2	172.16.10.1	HTTP	347	GET /images%20(3).jpg HTTP/1.1
77	2.119784374	172.16.10.1	172.16.10.2	HTTP	565	HTTP/1.1 200 OK (JPEG JFIF image)
79	2.120323770	172.16.10.2	172.16.10.1	HTTP	359	GET /lion-wild-africa-african.jpg HTTP/1.1
94	2.121263792	172.16.10.2	172.16.10.1	HTTP	341	GET /images.jpg HTTP/1.1
110	2.122045168	172.16.10.1	172.16.10.2	HTTP	1226	HTTP/1.1 200 OK (JPEG JFIF image)
117	2.122719543	172.16.10.2	172.16.10.1	HTTP	343	GET /download.jpg HTTP/1.1
138	2.123847115	172.16.10.2	172.16.10.1	HTTP	349	GET /download%20(1).jpg HTTP/1.1
160	2.124700199	172.16.10.2	172.16.10.1	HTTP	362	GET /soap-bubble-1958650_960_720.jpg HTTP/1.1
164	2.124733805	172.16.10.1	172.16.10.2	HTTP	1017	HTTP/1.1 200 OK (JPEG JFIF image)
171	2.125125151	172.16.10.1	172.16.10.2	HTTP	711	HTTP/1.1 200 OK (JPEG JFIF image)
184	2.126599573	172.16.10.2	172.16.10.1	HTTP	349	GET /download%20(2).jpg HTTP/1.1
252	2.131056667	172.16.10.1	172.16.10.2	HTTP	114	HTTP/1.1 200 OK (JPEG JFIF image)
529	2.151487483	172.16.10.1	172.16.10.2	HTTP	73	HTTP/1.1 200 OK (JPEG JFIF image)
3834	2.429637133	172.16.10.1	172.16.10.2	HTTP	1124	HTTP/1.1 200 OK (JPEG JFIF image)

Here it is  $2.429637133 - 2.070581279 = 0.359055854$

## PART 2: PERSISTENT CONNECTIONS

Step 1: For 2 persistent connections, set the value of **max-persistent-connection-per-server** to **2** in the client computer.

Step 2: Repeat the **steps 1-3** in the previous section.

No.	Time	Source	Destination	Protocol	Length	Info
28	0.158495832	172.16.10.1	172.16.10.2	HTTP	568	HTTP/1.1 404 Not Found (text/html)
30	2.685888334	172.16.10.2	172.16.10.1	HTTP	421	GET /a.html HTTP/1.1
31	2.686488793	172.16.10.1	172.16.10.2	HTTP	641	HTTP/1.1 200 OK (text/html)
33	2.734091058	172.16.10.2	172.16.10.1	HTTP	347	GET /images%20(1).jpg HTTP/1.1
38	2.734592637	172.16.10.2	172.16.10.1	HTTP	347	GET /images%20(2).jpg HTTP/1.1
39	2.734696958	172.16.10.1	172.16.10.2	HTTP	1200	HTTP/1.1 200 OK (JPEG JFIF image)
48	2.735025557	172.16.10.1	172.16.10.2	HTTP	463	HTTP/1.1 200 OK (JPEG JFIF image)
49	2.735180365	172.16.10.2	172.16.10.1	HTTP	349	GET /download%20(4).jpg HTTP/1.1
66	2.736079156	172.16.10.1	172.16.10.2	HTTP	243	HTTP/1.1 200 OK (JPEG JFIF image)
68	2.736374643	172.16.10.2	172.16.10.1	HTTP	347	GET /images%20(3).jpg HTTP/1.1
82	2.736755733	172.16.10.1	172.16.10.2	HTTP	565	HTTP/1.1 200 OK (JPEG JFIF image)
85	2.737381832	172.16.10.2	172.16.10.1	HTTP	359	GET /lion-wild-africa-african.jpg HTTP/1.1
92	2.737840608	172.16.10.2	172.16.10.1	HTTP	341	GET /images.jpg HTTP/1.1
101	2.738335480	172.16.10.2	172.16.10.1	HTTP	343	GET /download.jpg HTTP/1.1
119	2.738809142	172.16.10.1	172.16.10.2	HTTP	1226	HTTP/1.1 200 OK (JPEG JFIF image)
121	2.739075438	172.16.10.1	172.16.10.2	HTTP	1016	HTTP/1.1 200 OK (JPEG JFIF image)
139	2.740900738	172.16.10.2	172.16.10.1	HTTP	349	GET /download%20(1).jpg HTTP/1.1
143	2.741014891	172.16.10.2	172.16.10.1	HTTP	362	GET /soap-bubble-1958650_960_720.jpg HTTP/1.1
148	2.741205777	172.16.10.2	172.16.10.1	HTTP	349	GET /download%20(2).jpg HTTP/1.1
179	2.742807473	172.16.10.1	172.16.10.2	HTTP	113	HTTP/1.1 200 OK (JPEG JFIF image)
190	2.743723330	172.16.10.1	172.16.10.2	HTTP	712	HTTP/1.1 200 OK (JPEG JFIF image)
402	2.764054977	172.16.10.1	172.16.10.2	HTTP	72	HTTP/1.1 200 OK (JPEG JFIF image)
3774	3.042252027	172.16.10.1	172.16.10.2	HTTP	1124	HTTP/1.1 200 OK (JPEG JFIF image)

Here it is  $3.042252027 - 2.685888334 = 0.356363$

Step 3: For 4 persistent connections, Set the value of **max-persistent-connection-per-server** to **4** in the client computer.

Step 4: Repeat the **steps 1-3** in the previous section.

No.	Time	Source	Destination	Protocol	Length	Info
28	0.152642908	172.16.10.1	172.16.10.2	HTTP	568	HTTP/1.1 404 Not Found (text/html)
30	1.667969551	172.16.10.2	172.16.10.1	HTTP	421	GET /a.html HTTP/1.1
31	1.668311781	172.16.10.1	172.16.10.2	HTTP	641	HTTP/1.1 200 OK (text/html)
33	1.699473631	172.16.10.2	172.16.10.1	HTTP	347	GET /images%20(1).jpg HTTP/1.1
35	1.699692009	172.16.10.2	172.16.10.1	HTTP	347	GET /images%20(2).jpg HTTP/1.1
45	1.699908042	172.16.10.1	172.16.10.2	HTTP	463	HTTP/1.1 200 OK (JPEG JFIF image)
46	1.699913003	172.16.10.1	172.16.10.2	HTTP	1200	HTTP/1.1 200 OK (JPEG JFIF image)
47	1.700012712	172.16.10.2	172.16.10.1	HTTP	349	GET /download%20(4).jpg HTTP/1.1
63	1.700901747	172.16.10.1	172.16.10.2	HTTP	242	HTTP/1.1 200 OK (JPEG JFIF image)
69	1.701341018	172.16.10.2	172.16.10.1	HTTP	347	GET /images%20(3).jpg HTTP/1.1
70	1.701432635	172.16.10.2	172.16.10.1	HTTP	359	GET /lion-wild-africa-african.jpg HTTP/1.1
86	1.701888908	172.16.10.1	172.16.10.2	HTTP	565	HTTP/1.1 200 OK (JPEG JFIF image)
93	1.702192885	172.16.10.2	172.16.10.1	HTTP	341	GET /images.jpg HTTP/1.1
95	1.702219175	172.16.10.2	172.16.10.1	HTTP	343	GET /download.jpg HTTP/1.1
97	1.702228220	172.16.10.2	172.16.10.1	HTTP	349	GET /download%20(1).jpg HTTP/1.1
98	1.702233130	172.16.10.2	172.16.10.1	HTTP	362	GET /soap-bubble-1958650_960_720.jpg HTTP/1.1
122	1.703328136	172.16.10.1	172.16.10.2	HTTP	711	HTTP/1.1 200 OK (JPEG JFIF image)
126	1.703773424	172.16.10.2	172.16.10.1	HTTP	349	GET /download%20(2).jpg HTTP/1.1
157	1.705498971	172.16.10.1	172.16.10.2	HTTP	1227	HTTP/1.1 200 OK (JPEG JFIF image)
159	1.705614894	172.16.10.1	172.16.10.2	HTTP	113	HTTP/1.1 200 OK (JPEG JFIF image)
167	1.706637782	172.16.10.1	172.16.10.2	HTTP	1017	HTTP/1.1 200 OK (JPEG JFIF image)
414	1.724541388	172.16.10.1	172.16.10.2	HTTP	73	HTTP/1.1 200 OK (JPEG JFIF image)
3825	2.005934395	172.16.10.1	172.16.10.2	HTTP	1124	HTTP/1.1 200 OK (JPEG JFIF image)

Here is it  $2.005934395 - 1.667969557 = 0.337964838$

Step 5: For 6 persistent connections, set the value of **max-persistent-connection-per-server** to **6** in the server computer.

Step 6: Repeat the **steps 1-3** in the previous section.



http						
No.	Time	Source	Destination	Protocol	Length	Info
21	0.100232302	172.16.10.2	172.16.10.1	HTTP	306	GET /favicon.ico HTTP/1.1
22	0.100476138	172.16.10.1	172.16.10.2	HTTP	568	HTTP/1.1 404 Not Found (text/html)
24	0.184514911	172.16.10.2	172.16.10.1	HTTP	366	GET /favicon.ico HTTP/1.1
25	0.184789474	172.16.10.1	172.16.10.2	HTTP	568	HTTP/1.1 404 Not Found (text/html)
27	3.915242469	172.16.10.2	172.16.10.1	HTTP	421	GET /a.html HTTP/1.1
28	3.915930950	172.16.10.1	172.16.10.2	HTTP	641	HTTP/1.1 200 OK (text/html)
30	3.934519286	172.16.10.2	172.16.10.1	HTTP	347	GET /images%20(1).jpg HTTP/1.1
31	3.934703623	172.16.10.2	172.16.10.1	HTTP	347	GET /images%20(2).jpg HTTP/1.1
44	3.935084209	172.16.10.1	172.16.10.2	HTTP	1200	HTTP/1.1 200 OK (JPEG JFIF image)
45	3.935091751	172.16.10.1	172.16.10.2	HTTP	463	HTTP/1.1 200 OK (JPEG JFIF image)
50	3.935485109	172.16.10.2	172.16.10.1	HTTP	349	GET /download%20(4).jpg HTTP/1.1
68	3.936344013	172.16.10.1	172.16.10.2	HTTP	243	HTTP/1.1 200 OK (JPEG JFIF image)
74	3.936634551	172.16.10.2	172.16.10.1	HTTP	347	GET /images%20(3).jpg HTTP/1.1
75	3.936649737	172.16.10.2	172.16.10.1	HTTP	359	GET /lion-wild-africa-african.jpg HTTP/1.1
76	3.936654620	172.16.10.2	172.16.10.1	HTTP	341	GET /images.jpg HTTP/1.1
78	3.936684823	172.16.10.2	172.16.10.1	HTTP	343	GET /download.jpg HTTP/1.1
80	3.936696984	172.16.10.2	172.16.10.1	HTTP	349	GET /download%20(1).jpg HTTP/1.1
122	3.937371850	172.16.10.2	172.16.10.1	HTTP	362	GET /soap-bubble-1958650_960_720.jpg HTTP/1.1
123	3.937539442	172.16.10.1	172.16.10.2	HTTP	1227	HTTP/1.1 200 OK (JPEG JFIF image)
160	3.939256627	172.16.10.1	172.16.10.2	HTTP	1017	HTTP/1.1 200 OK (JPEG JFIF image)
167	3.940125154	172.16.10.1	172.16.10.2	HTTP	712	HTTP/1.1 200 OK (JPEG JFIF image)
183	3.941778538	172.16.10.2	172.16.10.1	HTTP	349	GET /download%20(2).jpg HTTP/1.1
229	3.946434434	172.16.10.1	172.16.10.2	HTTP	565	HTTP/1.1 200 OK (JPEG JFIF image)
233	3.946891865	172.16.10.1	172.16.10.2	HTTP	113	HTTP/1.1 200 OK (JPEG JFIF image)
441	3.964535410	172.16.10.1	172.16.10.2	HTTP	72	HTTP/1.1 200 OK (JPEG JFIF image)
3771	4.241013689	172.16.10.1	172.16.10.2	HTTP	1124	HTTP/1.1 200 OK (JPEG JFIF image)

Here it is  $4.241013689 - 3.915242469 = 0.325771229$

Step 7: For 10 persistent connections, set the value of **max-persistent-connection-per-server** to **10** in the client computer.

Step 8: Repeat the **steps 1-3** in the previous section.

http						
No.	Time	Source	Destination	Protocol	Length	Info
27	0.192665375	172.16.10.1	172.16.10.2	HTTP	568	HTTP/1.1 404 Not Found (text/html)
29	1.556964626	172.16.10.2	172.16.10.1	HTTP	421	GET /a.html HTTP/1.1
30	1.557214715	172.16.10.1	172.16.10.2	HTTP	641	HTTP/1.1 200 OK (text/html)
32	1.575716934	172.16.10.2	172.16.10.1	HTTP	347	GET /images%20(1).jpg HTTP/1.1
33	1.575953704	172.16.10.2	172.16.10.1	HTTP	347	GET /images%20(2).jpg HTTP/1.1
46	1.576334520	172.16.10.1	172.16.10.2	HTTP	1200	HTTP/1.1 200 OK (JPEG JFIF image)
47	1.576343533	172.16.10.1	172.16.10.2	HTTP	463	HTTP/1.1 200 OK (JPEG JFIF image)
52	1.576760416	172.16.10.2	172.16.10.1	HTTP	349	GET /download%20(4).jpg HTTP/1.1
70	1.577515601	172.16.10.1	172.16.10.2	HTTP	243	HTTP/1.1 200 OK (JPEG JFIF image)
76	1.577834686	172.16.10.2	172.16.10.1	HTTP	347	GET /images%20(3).jpg HTTP/1.1
77	1.577847379	172.16.10.2	172.16.10.1	HTTP	359	GET /lion-wild-africa-african.jpg HTTP/1.1
78	1.577855269	172.16.10.2	172.16.10.1	HTTP	341	GET /images.jpg HTTP/1.1
80	1.577886802	172.16.10.2	172.16.10.1	HTTP	343	GET /download.jpg HTTP/1.1
82	1.577905312	172.16.10.2	172.16.10.1	HTTP	349	GET /download%20(1).jpg HTTP/1.1
118	1.578606528	172.16.10.2	172.16.10.1	HTTP	362	GET /soap-bubble-1958650_960_720.jpg HTTP/1.1
119	1.578639337	172.16.10.1	172.16.10.2	HTTP	1227	HTTP/1.1 200 OK (JPEG JFIF image)
146	1.580341669	172.16.10.1	172.16.10.2	HTTP	712	HTTP/1.1 200 OK (JPEG JFIF image)
169	1.582240704	172.16.10.2	172.16.10.1	HTTP	349	GET /download%20(2).jpg HTTP/1.1
187	1.583749770	172.16.10.1	172.16.10.2	HTTP	1017	HTTP/1.1 200 OK (JPEG JFIF image)
219	1.586862673	172.16.10.1	172.16.10.2	HTTP	113	HTTP/1.1 200 OK (JPEG JFIF image)
222	1.587108849	172.16.10.1	172.16.10.2	HTTP	565	HTTP/1.1 200 OK (JPEG JFIF image)
455	1.606226568	172.16.10.1	172.16.10.2	HTTP	72	HTTP/1.1 200 OK (JPEG JFIF image)
3814	1.882459413	172.16.10.1	172.16.10.2	HTTP	1124	HTTP/1.1 200 OK (JPEG JFIF image)

Here it is  $1.882459413 - 1.556964626 = 0.325494787$

## OBSERVATIONS REQUIRED ON EDMODO:

Calculate the time taken to load objects from the server for non-persistent and persistent connections (2, 4, 6, 8 & 10). Find out the optimal number of HTTP persistent connections based on your observations.

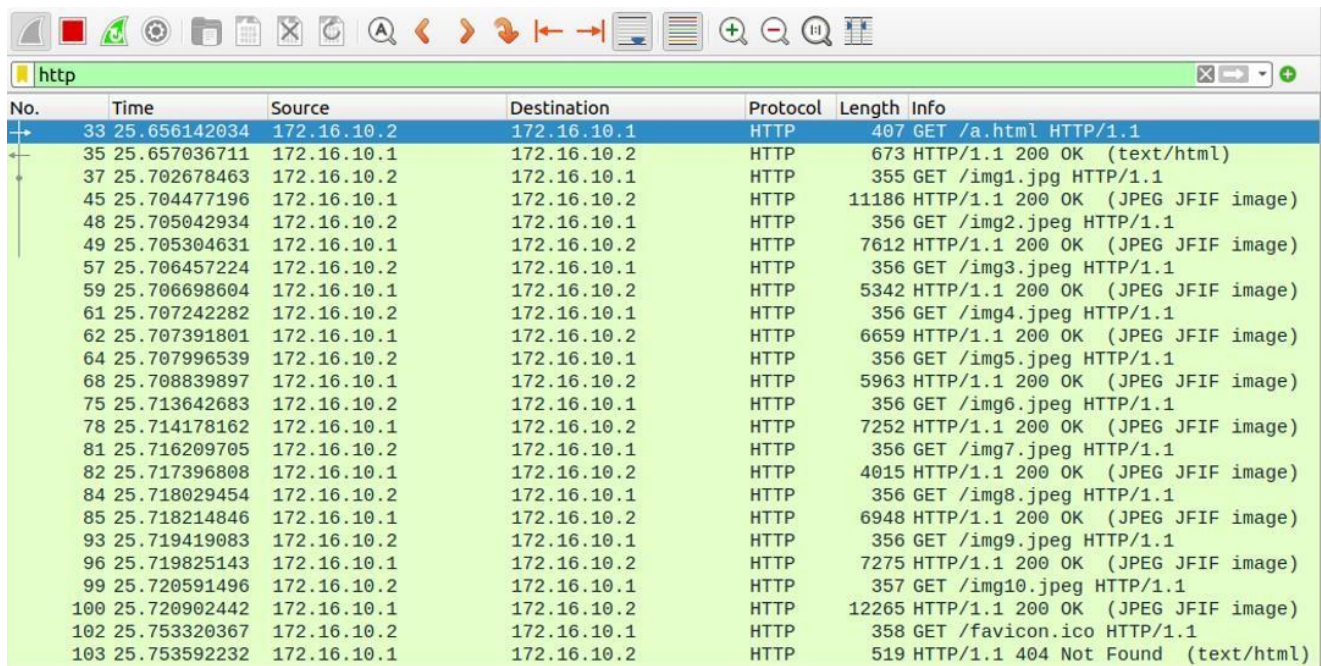
## SCREENSHOTS REQUIRED FOR EDMODO:

- 1) Non-persistent connection wireshark capture (should include all 10 images)
- 2) Persistent connections wireshark capture – 2, 4, 6, 8 & 10 respectively (should include all 10 images).

## OBSERVATIONS:

### Non-Persistent Connection:

Time to capture all 10 images: 25.7209-25.6561 =0.0647



The screenshot shows a Wireshark network traffic capture. The top toolbar includes icons for file operations, network analysis, and search. The packet list pane on the left shows 103 packets. The packet details pane on the right shows the selected packet (No. 33) as an HTTP GET request for /a.html. The packet bytes pane is empty. The main packet list table contains the following data:

No.	Time	Source	Destination	Protocol	Length	Info
33	25.656142034	172.16.10.2	172.16.10.1	HTTP	407	GET /a.html HTTP/1.1
35	25.657036711	172.16.10.1	172.16.10.2	HTTP	673	HTTP/1.1 200 OK (text/html)
37	25.702678463	172.16.10.2	172.16.10.1	HTTP	355	GET /img1.jpg HTTP/1.1
45	25.704477196	172.16.10.1	172.16.10.2	HTTP	11186	HTTP/1.1 200 OK (JPEG JFIF image)
48	25.705042934	172.16.10.2	172.16.10.1	HTTP	356	GET /img2.jpeg HTTP/1.1
49	25.705304631	172.16.10.1	172.16.10.2	HTTP	7612	HTTP/1.1 200 OK (JPEG JFIF image)
57	25.706457224	172.16.10.2	172.16.10.1	HTTP	356	GET /img3.jpeg HTTP/1.1
59	25.706698604	172.16.10.1	172.16.10.2	HTTP	5342	HTTP/1.1 200 OK (JPEG JFIF image)
61	25.707242282	172.16.10.2	172.16.10.1	HTTP	356	GET /img4.jpeg HTTP/1.1
62	25.707391801	172.16.10.1	172.16.10.2	HTTP	6659	HTTP/1.1 200 OK (JPEG JFIF image)
64	25.707996539	172.16.10.2	172.16.10.1	HTTP	356	GET /img5.jpeg HTTP/1.1
68	25.708839897	172.16.10.1	172.16.10.2	HTTP	5963	HTTP/1.1 200 OK (JPEG JFIF image)
75	25.713642683	172.16.10.2	172.16.10.1	HTTP	356	GET /img6.jpeg HTTP/1.1
78	25.714178162	172.16.10.1	172.16.10.2	HTTP	7252	HTTP/1.1 200 OK (JPEG JFIF image)
81	25.716209705	172.16.10.2	172.16.10.1	HTTP	356	GET /img7.jpeg HTTP/1.1
82	25.717396808	172.16.10.1	172.16.10.2	HTTP	4015	HTTP/1.1 200 OK (JPEG JFIF image)
84	25.718029454	172.16.10.2	172.16.10.1	HTTP	356	GET /img8.jpeg HTTP/1.1
85	25.718214846	172.16.10.1	172.16.10.2	HTTP	6948	HTTP/1.1 200 OK (JPEG JFIF image)
93	25.719419083	172.16.10.2	172.16.10.1	HTTP	356	GET /img9.jpeg HTTP/1.1
96	25.719825143	172.16.10.1	172.16.10.2	HTTP	7275	HTTP/1.1 200 OK (JPEG JFIF image)
99	25.720591496	172.16.10.2	172.16.10.1	HTTP	357	GET /img10.jpeg HTTP/1.1
100	25.720902442	172.16.10.1	172.16.10.2	HTTP	12265	HTTP/1.1 200 OK (JPEG JFIF image)
102	25.753320367	172.16.10.2	172.16.10.1	HTTP	358	GET /favicon.ico HTTP/1.1
103	25.753592232	172.16.10.1	172.16.10.2	HTTP	519	HTTP/1.1 404 Not Found (text/html)



# Persistent Connection

## Max-Persistent Connection:2

Time to capture all 10 images:  $3.3987 - 3.2573 = 0.0647$

No.	Time	Source	Destination	Protocol	Length	Info
5	3.257300144	172.16.10.2	172.16.10.1	HTTP	407	GET /a.html HTTP/1.1
7	3.257735596	172.16.10.1	172.16.10.2	HTTP	673	HTTP/1.1 200 OK (text/html)
9	3.322377296	172.16.10.2	172.16.10.1	HTTP	355	GET /img1.jpg HTTP/1.1
16	3.324155676	172.16.10.1	172.16.10.2	HTTP	1050	HTTP/1.1 200 OK (JPEG JFIF image)
20	3.325790365	172.16.10.2	172.16.10.1	HTTP	356	GET /img2.jpeg HTTP/1.1
21	3.326052923	172.16.10.1	172.16.10.2	HTTP	7612	HTTP/1.1 200 OK (JPEG JFIF image)
29	3.327922381	172.16.10.2	172.16.10.1	HTTP	356	GET /img3.jpeg HTTP/1.1
31	3.328221500	172.16.10.1	172.16.10.2	HTTP	5342	HTTP/1.1 200 OK (JPEG JFIF image)
33	3.329086614	172.16.10.2	172.16.10.1	HTTP	356	GET /img4.jpeg HTTP/1.1
34	3.329316415	172.16.10.1	172.16.10.2	HTTP	6659	HTTP/1.1 200 OK (JPEG JFIF image)
36	3.331179707	172.16.10.2	172.16.10.1	HTTP	356	GET /img5.jpeg HTTP/1.1
42	3.332211115	172.16.10.1	172.16.10.2	HTTP	5963	HTTP/1.1 200 OK (JPEG JFIF image)
48	3.332864838	172.16.10.2	172.16.10.1	HTTP	356	GET /img6.jpeg HTTP/1.1
51	3.333161854	172.16.10.1	172.16.10.2	HTTP	7252	HTTP/1.1 200 OK (JPEG JFIF image)
57	3.333635524	172.16.10.2	172.16.10.1	HTTP	356	GET /img7.jpeg HTTP/1.1
58	3.333948631	172.16.10.2	172.16.10.1	HTTP	356	GET /img8.jpeg HTTP/1.1
60	3.333985761	172.16.10.1	172.16.10.2	HTTP	4015	HTTP/1.1 200 OK (JPEG JFIF image)
61	3.334133826	172.16.10.1	172.16.10.2	HTTP	6983	HTTP/1.1 200 OK (JPEG JFIF image)
64	3.334753321	172.16.10.2	172.16.10.1	HTTP	356	GET /img9.jpeg HTTP/1.1
65	3.334960262	172.16.10.1	172.16.10.2	HTTP	14480	HTTP/1.1 200 OK (JPEG JFIF image)
66	3.335028954	172.16.10.2	172.16.10.1	HTTP	357	GET /img10.jpeg HTTP/1.1
70	3.335258514	172.16.10.1	172.16.10.2	HTTP	5025	HTTP/1.1 200 OK (JPEG JFIF image)
74	3.398230811	172.16.10.2	172.16.10.1	HTTP	358	GET /favicon.ico HTTP/1.1
75	3.398729911	172.16.10.1	172.16.10.2	HTTP	519	HTTP/1.1 404 Not Found (text/html)
116	32.618895788	192.168.209.128	91.189.91.48	HTTP	141	GET / HTTP/1.1
118	32.869813857	91.189.91.48	192.168.209.128	HTTP	201	HTTP/1.1 204 No Content

## Max-Persistent Connection:4

Time to capture all 10 images:  $0.0874 - 0.0006 = 0.0868$

No.	Time	Source	Destination	Protocol	Length	Info
4	0.000611659	172.16.10.2	172.16.10.1	HTTP	407	GET /a.html HTTP/1.1
6	0.001781364	172.16.10.1	172.16.10.2	HTTP	673	HTTP/1.1 200 OK (text/html)
8	0.073100910	172.16.10.2	172.16.10.1	HTTP	355	GET /img1.jpg HTTP/1.1
15	0.074005174	172.16.10.1	172.16.10.2	HTTP	1050	HTTP/1.1 200 OK (JPEG JFIF image)
19	0.074475516	172.16.10.2	172.16.10.1	HTTP	356	GET /img2.jpeg HTTP/1.1
28	0.074769741	172.16.10.1	172.16.10.2	HTTP	7612	HTTP/1.1 200 OK (JPEG JFIF image)
30	0.074862093	172.16.10.2	172.16.10.1	HTTP	356	GET /img3.jpeg HTTP/1.1
32	0.074911401	172.16.10.2	172.16.10.1	HTTP	356	GET /img4.jpeg HTTP/1.1
36	0.075062054	172.16.10.1	172.16.10.2	HTTP	5342	HTTP/1.1 200 OK (JPEG JFIF image)
40	0.075198500	172.16.10.1	172.16.10.2	HTTP	6659	HTTP/1.1 200 OK (JPEG JFIF image)
42	0.085051117	172.16.10.2	172.16.10.1	HTTP	356	GET /img5.jpeg HTTP/1.1
45	0.085486877	172.16.10.2	172.16.10.1	HTTP	356	GET /img6.jpeg HTTP/1.1
46	0.085684310	172.16.10.2	172.16.10.1	HTTP	356	GET /img7.jpeg HTTP/1.1
49	0.085783455	172.16.10.1	172.16.10.2	HTTP	5998	HTTP/1.1 200 OK (JPEG JFIF image)
52	0.085970077	172.16.10.1	172.16.10.2	HTTP	7252	HTTP/1.1 200 OK (JPEG JFIF image)
54	0.086132763	172.16.10.1	172.16.10.2	HTTP	1119	HTTP/1.1 200 OK (JPEG JFIF image)
58	0.086945033	172.16.10.2	172.16.10.1	HTTP	356	GET /img8.jpeg HTTP/1.1
59	0.086945096	172.16.10.2	172.16.10.1	HTTP	356	GET /img9.jpeg HTTP/1.1
60	0.087083125	172.16.10.2	172.16.10.1	HTTP	357	GET /img10.jpeg HTTP/1.1
63	0.087141243	172.16.10.1	172.16.10.2	HTTP	6948	HTTP/1.1 200 OK (JPEG JFIF image)
71	0.087370778	172.16.10.1	172.16.10.2	HTTP	2931	HTTP/1.1 200 OK (JPEG JFIF image)
72	0.087466593	172.16.10.1	172.16.10.2	HTTP	12230	HTTP/1.1 200 OK (JPEG JFIF image)
80	0.201996723	172.16.10.2	172.16.10.1	HTTP	358	GET /favicon.ico HTTP/1.1



## Max-Persistent Connections:6

Time to capture all 10 images:0.0597-0.0005=0.0592

No.	Time	Source	Destination	Protocol	Length	Info
4	0.000509132	172.16.10.2	172.16.10.3	HTTP	407	GET /a.html HTTP/1.1
6	0.001122448	172.16.10.3	172.16.10.2	HTTP	674	HTTP/1.1 200 OK (text/html)
8	0.040404328	172.16.10.2	172.16.10.3	HTTP	355	GET /img1.jpg HTTP/1.1
17	0.041104394	172.16.10.3	172.16.10.2	HTTP	1050	HTTP/1.1 200 OK (JPEG JFIF image)
20	0.041186714	172.16.10.2	172.16.10.3	HTTP	356	GET /img2.jpeg HTTP/1.1
25	0.041446981	172.16.10.3	172.16.10.2	HTTP	408	HTTP/1.1 200 OK (JPEG JFIF image)
28	0.042405900	172.16.10.2	172.16.10.3	HTTP	356	GET /img3.jpeg HTTP/1.1
29	0.042617262	172.16.10.3	172.16.10.2	HTTP	5342	HTTP/1.1 200 OK (JPEG JFIF image)
31	0.049337891	172.16.10.2	172.16.10.3	HTTP	356	GET /img4.jpeg HTTP/1.1
32	0.049755264	172.16.10.3	172.16.10.2	HTTP	6659	HTTP/1.1 200 OK (JPEG JFIF image)
34	0.052226907	172.16.10.2	172.16.10.3	HTTP	356	GET /img5.jpeg HTTP/1.1
35	0.053138214	172.16.10.2	172.16.10.3	HTTP	356	GET /img6.jpeg HTTP/1.1
38	0.053692195	172.16.10.3	172.16.10.2	HTTP	14492	HTTP/1.1 200 OK (JPEG JFIF image)
39	0.053794472	172.16.10.3	172.16.10.2	HTTP	206	HTTP/1.1 200 OK (JPEG JFIF image)
42	0.055097516	172.16.10.2	172.16.10.3	HTTP	356	GET /img7.jpeg HTTP/1.1
43	0.055423065	172.16.10.3	172.16.10.2	HTTP	4015	HTTP/1.1 200 OK (JPEG JFIF image)
45	0.055905089	172.16.10.2	172.16.10.3	HTTP	356	GET /img8.jpeg HTTP/1.1
46	0.056182698	172.16.10.3	172.16.10.2	HTTP	6983	HTTP/1.1 200 OK (JPEG JFIF image)
48	0.057392788	172.16.10.2	172.16.10.3	HTTP	356	GET /img9.jpeg HTTP/1.1
49	0.057703785	172.16.10.3	172.16.10.2	HTTP	14515	HTTP/1.1 200 OK (JPEG JFIF image)
51	0.059418091	172.16.10.2	172.16.10.3	HTTP	357	GET /img10.jpeg HTTP/1.1
52	0.059719981	172.16.10.3	172.16.10.2	HTTP	12265	HTTP/1.1 200 OK (JPEG JFIF image)
54	0.102782907	172.16.10.2	172.16.10.3	HTTP	358	GET /favicon.ico HTTP/1.1
55	0.103076977	172.16.10.3	172.16.10.2	HTTP	554	HTTP/1.1 404 Not Found (text/html)

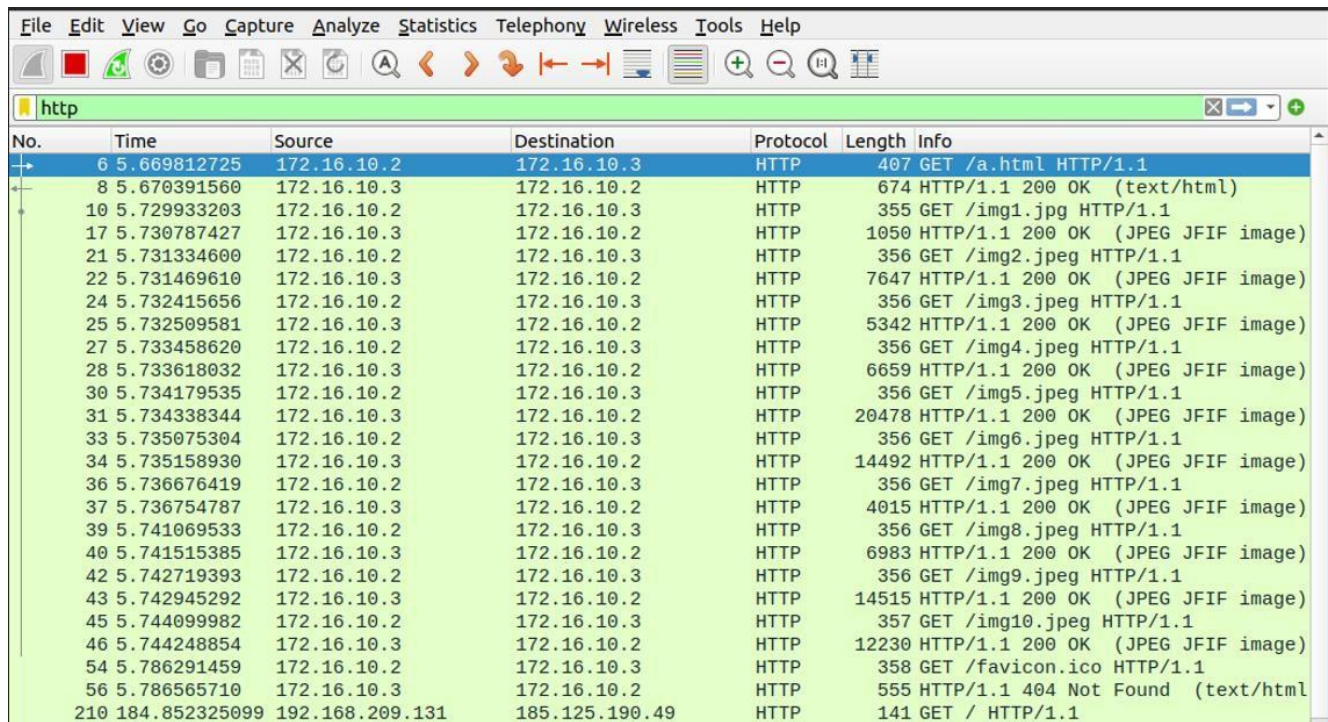
## Max-Persistent Connections:8

Time to capture all 10 images:18.6791-18.6231=0.0560

No.	Time	Source	Destination	Protocol	Length	Info
5	18.623148083	172.16.10.2	172.16.10.3	HTTP	407	GET /a.html HTTP/1.1
7	18.624392935	172.16.10.3	172.16.10.2	HTTP	674	HTTP/1.1 200 OK (text/html)
9	18.661990998	172.16.10.2	172.16.10.3	HTTP	355	GET /img1.jpg HTTP/1.1
17	18.662738318	172.16.10.2	172.16.10.3	HTTP	356	GET /img2.jpeg HTTP/1.1
20	18.662875233	172.16.10.3	172.16.10.2	HTTP	1050	HTTP/1.1 200 OK (JPEG JFIF image)
26	18.663270734	172.16.10.3	172.16.10.2	HTTP	408	HTTP/1.1 200 OK (JPEG JFIF image)
29	18.664176841	172.16.10.2	172.16.10.3	HTTP	356	GET /img3.jpeg HTTP/1.1
30	18.664310988	172.16.10.3	172.16.10.2	HTTP	5342	HTTP/1.1 200 OK (JPEG JFIF image)
32	18.666002091	172.16.10.2	172.16.10.3	HTTP	356	GET /img4.jpeg HTTP/1.1
33	18.666453106	172.16.10.3	172.16.10.2	HTTP	6659	HTTP/1.1 200 OK (JPEG JFIF image)
35	18.668080226	172.16.10.2	172.16.10.3	HTTP	356	GET /img5.jpeg HTTP/1.1
36	18.668383859	172.16.10.3	172.16.10.2	HTTP	20478	HTTP/1.1 200 OK (JPEG JFIF image)
38	18.672723563	172.16.10.2	172.16.10.3	HTTP	356	GET /img6.jpeg HTTP/1.1
39	18.673199378	172.16.10.3	172.16.10.2	HTTP	14492	HTTP/1.1 200 OK (JPEG JFIF image)
41	18.676643880	172.16.10.2	172.16.10.3	HTTP	356	GET /img7.jpeg HTTP/1.1
42	18.676968944	172.16.10.3	172.16.10.2	HTTP	4015	HTTP/1.1 200 OK (JPEG JFIF image)
44	18.677772824	172.16.10.2	172.16.10.3	HTTP	356	GET /img8.jpeg HTTP/1.1
45	18.677925826	172.16.10.3	172.16.10.2	HTTP	6983	HTTP/1.1 200 OK (JPEG JFIF image)
47	18.678696904	172.16.10.2	172.16.10.3	HTTP	356	GET /img9.jpeg HTTP/1.1
48	18.678832587	172.16.10.3	172.16.10.2	HTTP	14515	HTTP/1.1 200 OK (JPEG JFIF image)
49	18.678925995	172.16.10.2	172.16.10.3	HTTP	357	GET /img10.jpeg HTTP/1.1
52	18.679193409	172.16.10.3	172.16.10.2	HTTP	2129	HTTP/1.1 200 OK (JPEG JFIF image)
54	18.700172106	172.16.10.2	172.16.10.3	HTTP	358	GET /favicon.ico HTTP/1.1

## Max-Persistent Connections:10

Time to capture all 10 images:  $5.7442 - 5.6698 = 0.0744$



No.	Time	Source	Destination	Protocol	Length	Info
6	5.669812725	172.16.10.2	172.16.10.3	HTTP	407	GET /a.html HTTP/1.1
8	5.670391560	172.16.10.3	172.16.10.2	HTTP	674	HTTP/1.1 200 OK (text/html)
10	5.729933203	172.16.10.2	172.16.10.3	HTTP	355	GET /img1.jpg HTTP/1.1
17	5.730787427	172.16.10.3	172.16.10.2	HTTP	1050	HTTP/1.1 200 OK (JPEG JFIF image)
21	5.731334600	172.16.10.2	172.16.10.3	HTTP	356	GET /img2.jpeg HTTP/1.1
22	5.731469610	172.16.10.3	172.16.10.2	HTTP	7647	HTTP/1.1 200 OK (JPEG JFIF image)
24	5.732415656	172.16.10.2	172.16.10.3	HTTP	356	GET /img3.jpeg HTTP/1.1
25	5.732509581	172.16.10.3	172.16.10.2	HTTP	5342	HTTP/1.1 200 OK (JPEG JFIF image)
27	5.733458620	172.16.10.2	172.16.10.3	HTTP	356	GET /img4.jpeg HTTP/1.1
28	5.733618032	172.16.10.3	172.16.10.2	HTTP	6659	HTTP/1.1 200 OK (JPEG JFIF image)
30	5.734179535	172.16.10.2	172.16.10.3	HTTP	356	GET /img5.jpeg HTTP/1.1
31	5.734338344	172.16.10.3	172.16.10.2	HTTP	20478	HTTP/1.1 200 OK (JPEG JFIF image)
33	5.735075304	172.16.10.2	172.16.10.3	HTTP	356	GET /img6.jpeg HTTP/1.1
34	5.735158930	172.16.10.3	172.16.10.2	HTTP	14492	HTTP/1.1 200 OK (JPEG JFIF image)
36	5.736676419	172.16.10.2	172.16.10.3	HTTP	356	GET /img7.jpeg HTTP/1.1
37	5.736754787	172.16.10.3	172.16.10.2	HTTP	4015	HTTP/1.1 200 OK (JPEG JFIF image)
39	5.741069533	172.16.10.2	172.16.10.3	HTTP	356	GET /img8.jpeg HTTP/1.1
40	5.741515385	172.16.10.3	172.16.10.2	HTTP	6983	HTTP/1.1 200 OK (JPEG JFIF image)
42	5.742719393	172.16.10.2	172.16.10.3	HTTP	356	GET /img9.jpeg HTTP/1.1
43	5.742945292	172.16.10.3	172.16.10.2	HTTP	14515	HTTP/1.1 200 OK (JPEG JFIF image)
45	5.744099982	172.16.10.2	172.16.10.3	HTTP	357	GET /img10.jpeg HTTP/1.1
46	5.744248854	172.16.10.3	172.16.10.2	HTTP	12230	HTTP/1.1 200 OK (JPEG JFIF image)
54	5.786291459	172.16.10.2	172.16.10.3	HTTP	358	GET /favicon.ico HTTP/1.1
56	5.786565710	172.16.10.3	172.16.10.2	HTTP	555	HTTP/1.1 404 Not Found (text/html)
210	184.852325099	192.168.209.131	185.125.190.49	HTTP	141	GET / HTTP/1.1

## Conclusion:

**We can conclude that, the time taken to capture all the 10 images is lesser in MAX-Persistent Connections = 8connections.**

**THANK YOU**