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Date: 7th February 2021

Subject: Computer Network Laboratory

WEEK No: 2

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

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.

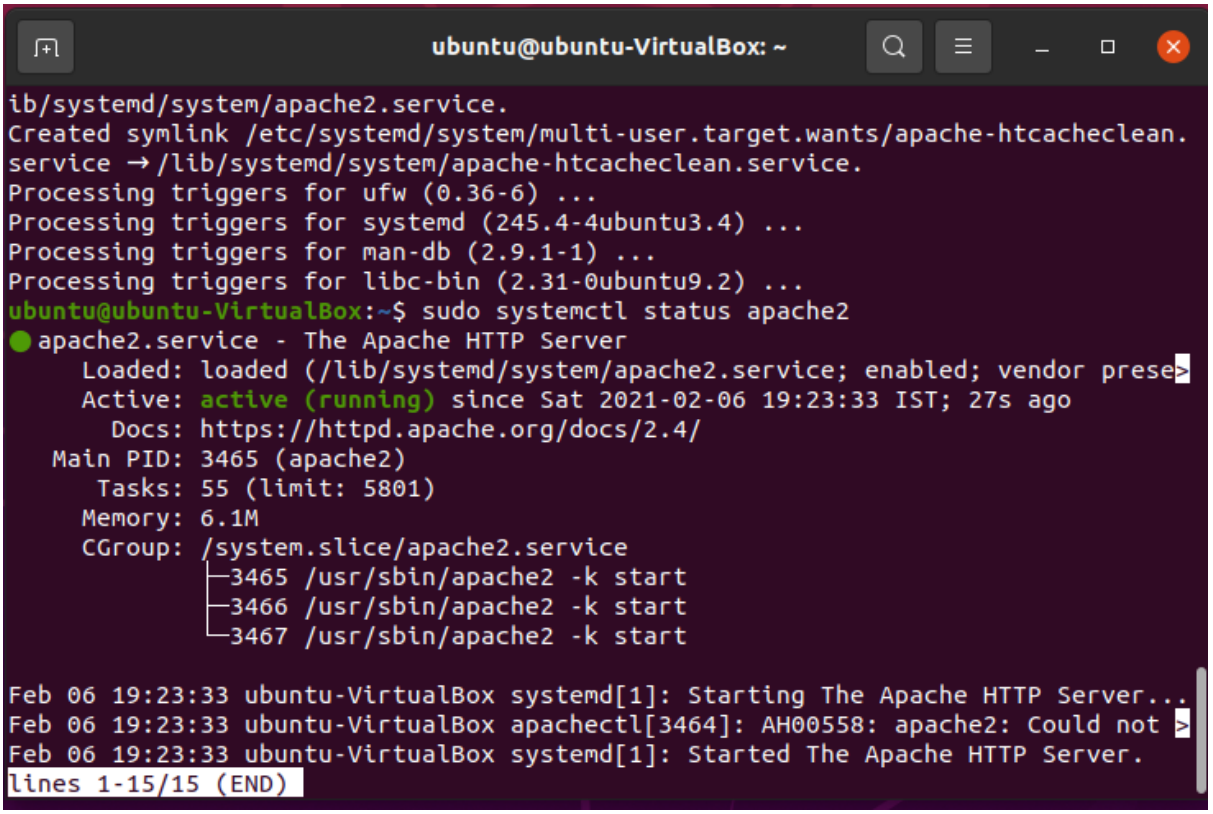
EXECUTION STEPS

Step 1: Connect 2 desktops using switch and cables as shown below. (Use 2 VMs on Virtualbox)

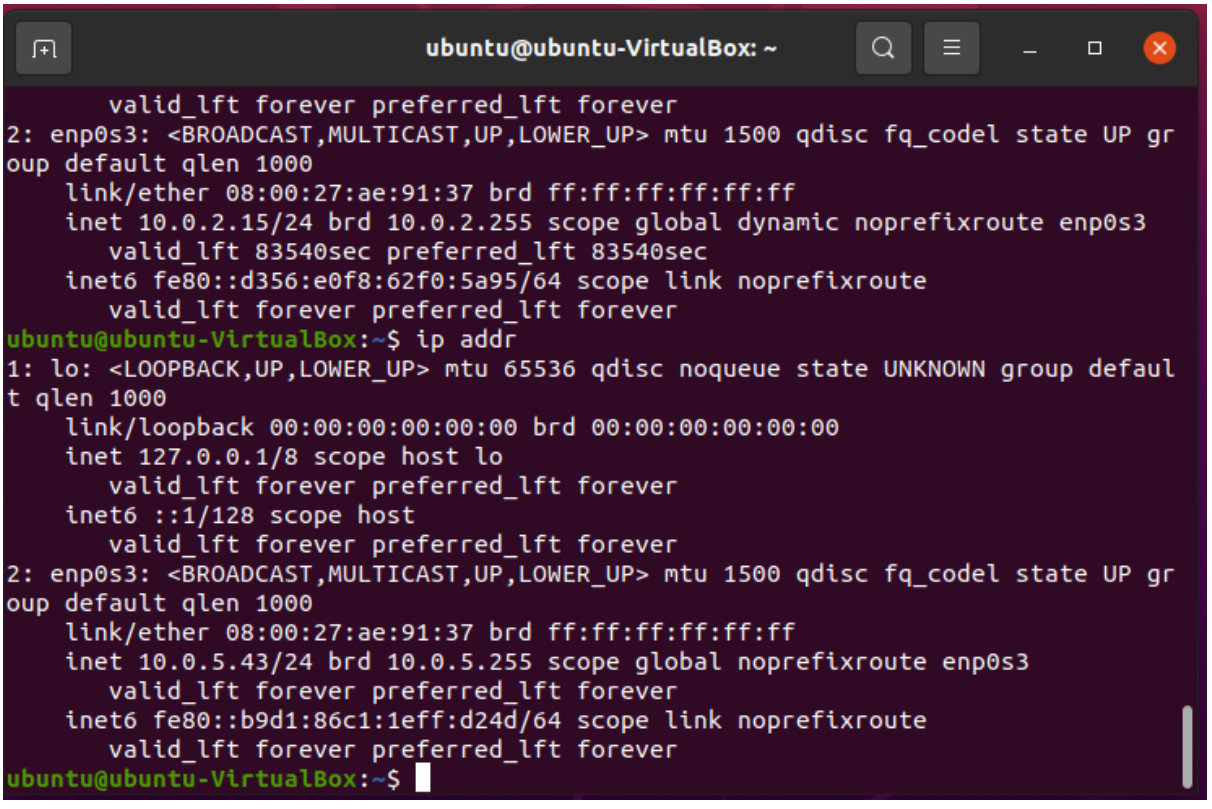
Server Side:

Step 2: Check your Web Server.

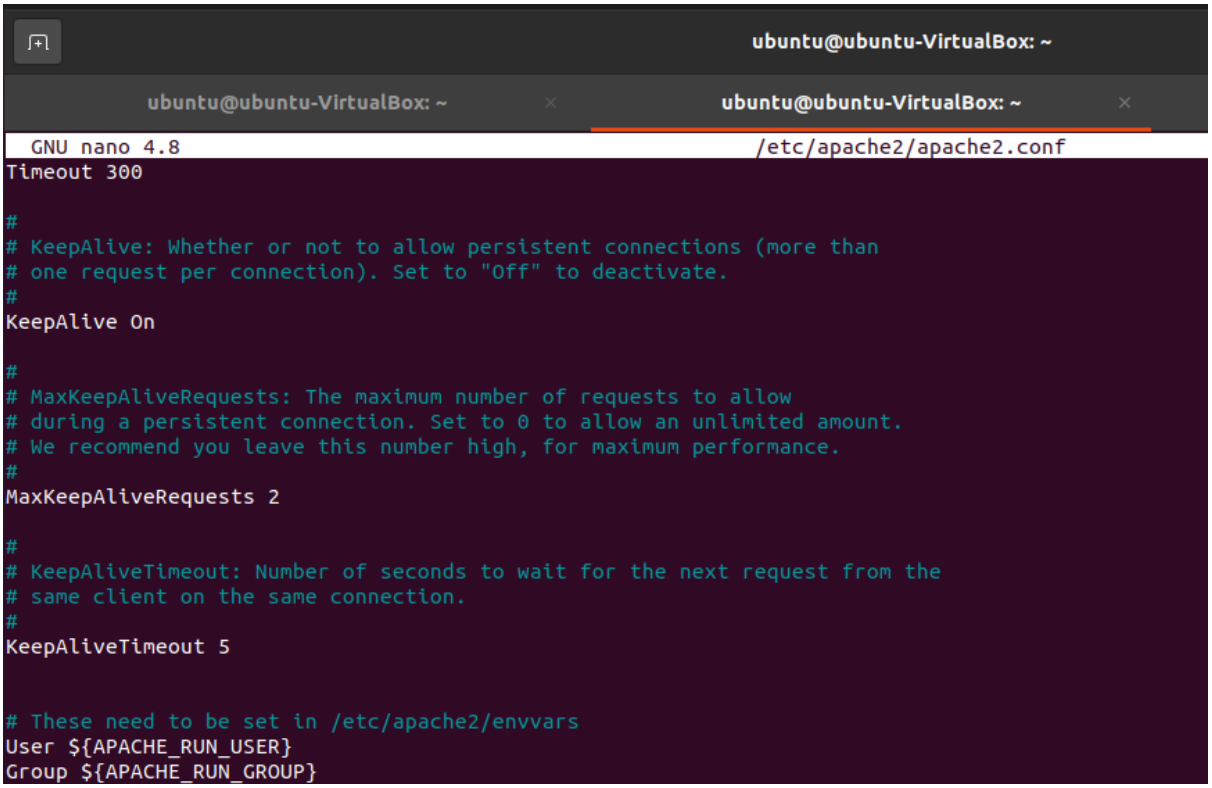
sudo systemctl status apache2 or sudo service apache2 status



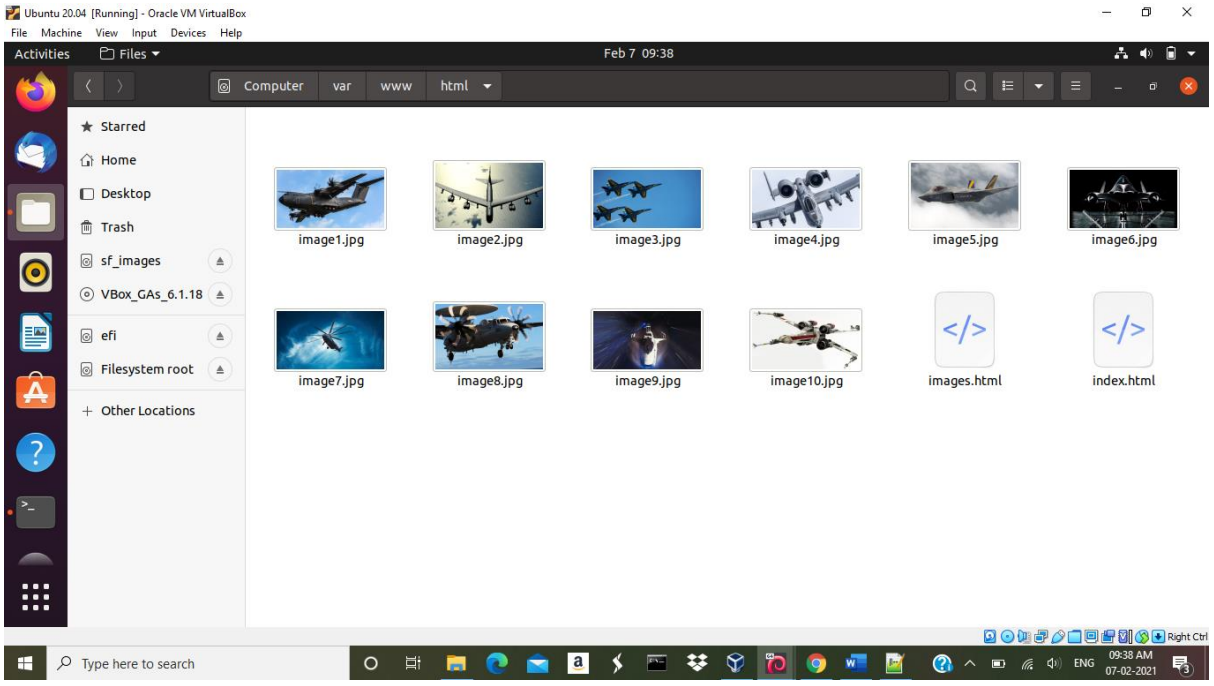
Step 3: Server IP address can be set by the following command:



Step 4: The **apache2.conf** file present in the **etc /apache2** directory is modified as:
-The **keep-alive** option was set (i.e. value was made **ON**)
-The **MaximumKeepAliveRequests** were set to **2**

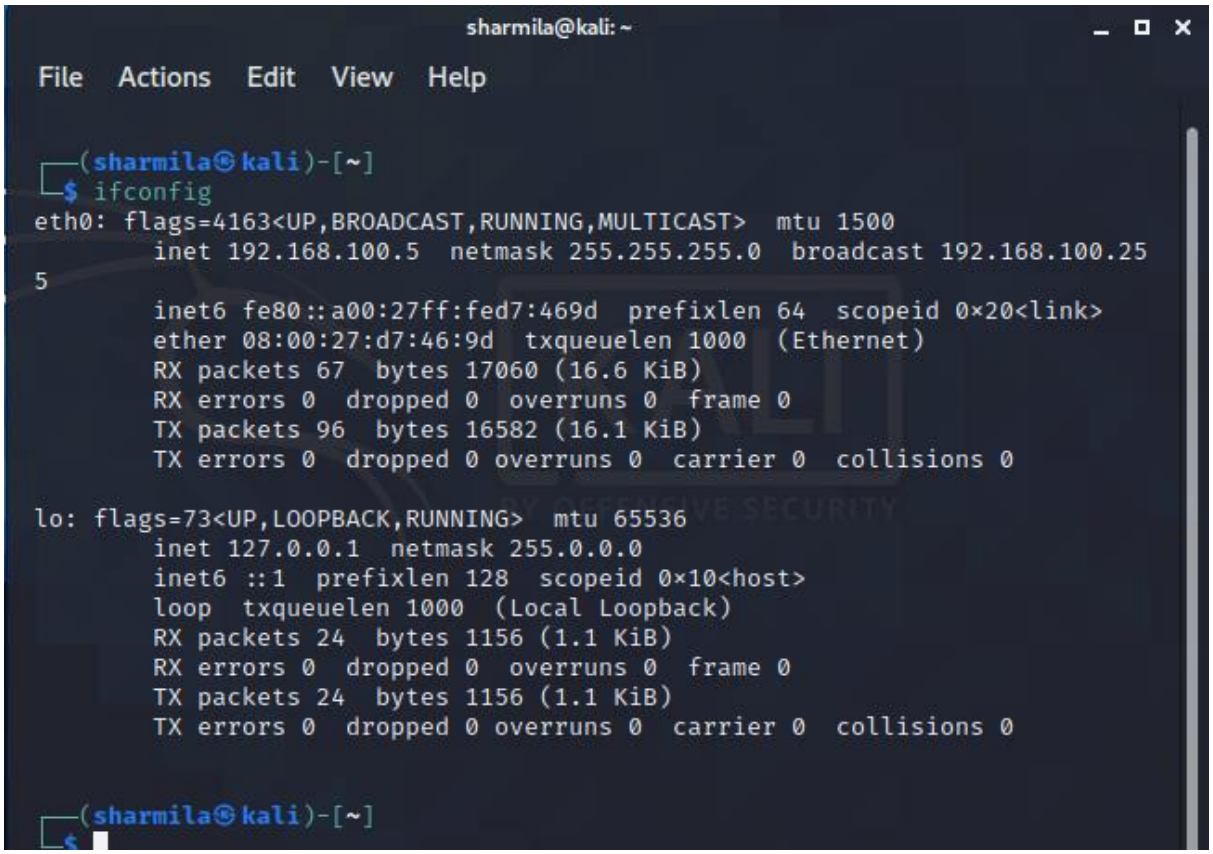


Step 5: Store images in the server path. A html page consisting of 10 images having size > 2MB were placed and accessed by the client. This html page is stored in the location **-/var/www/html/images.html.**



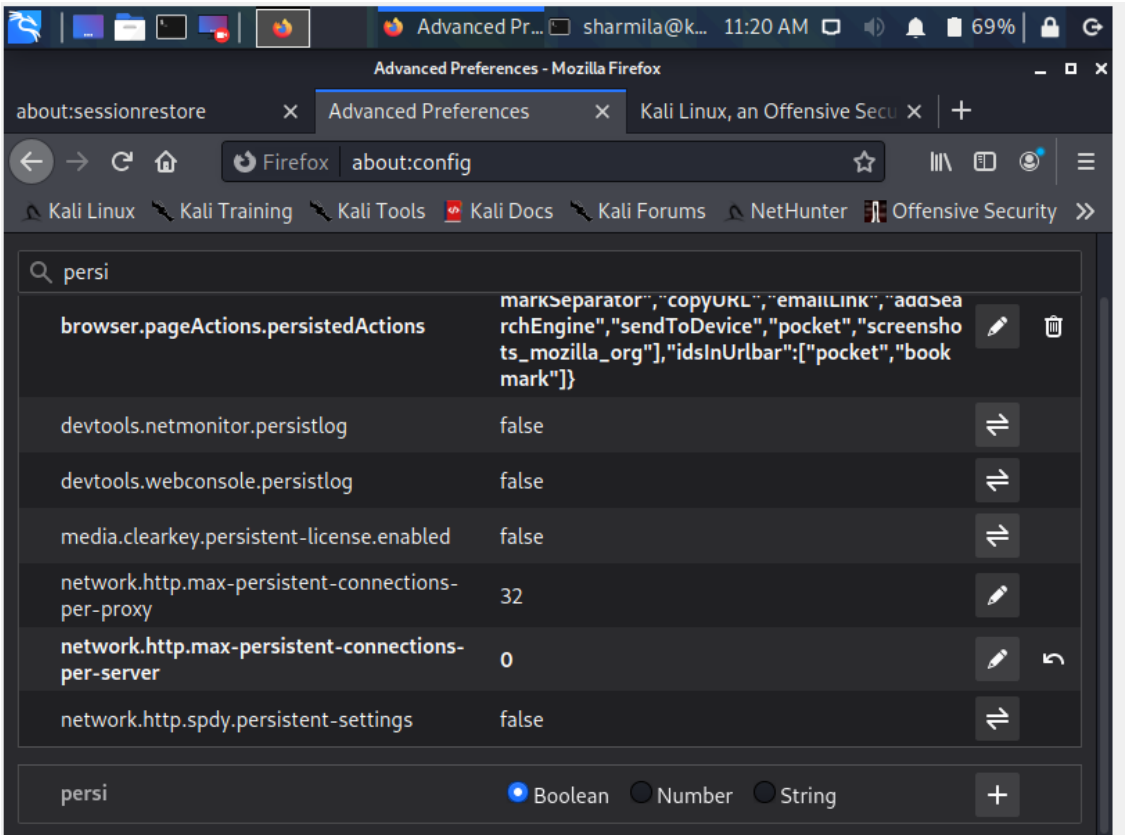
Step 6: Prepare a web page as shown below. The html file needs to add 10 images. (Kindly skip the style attribute in the below image

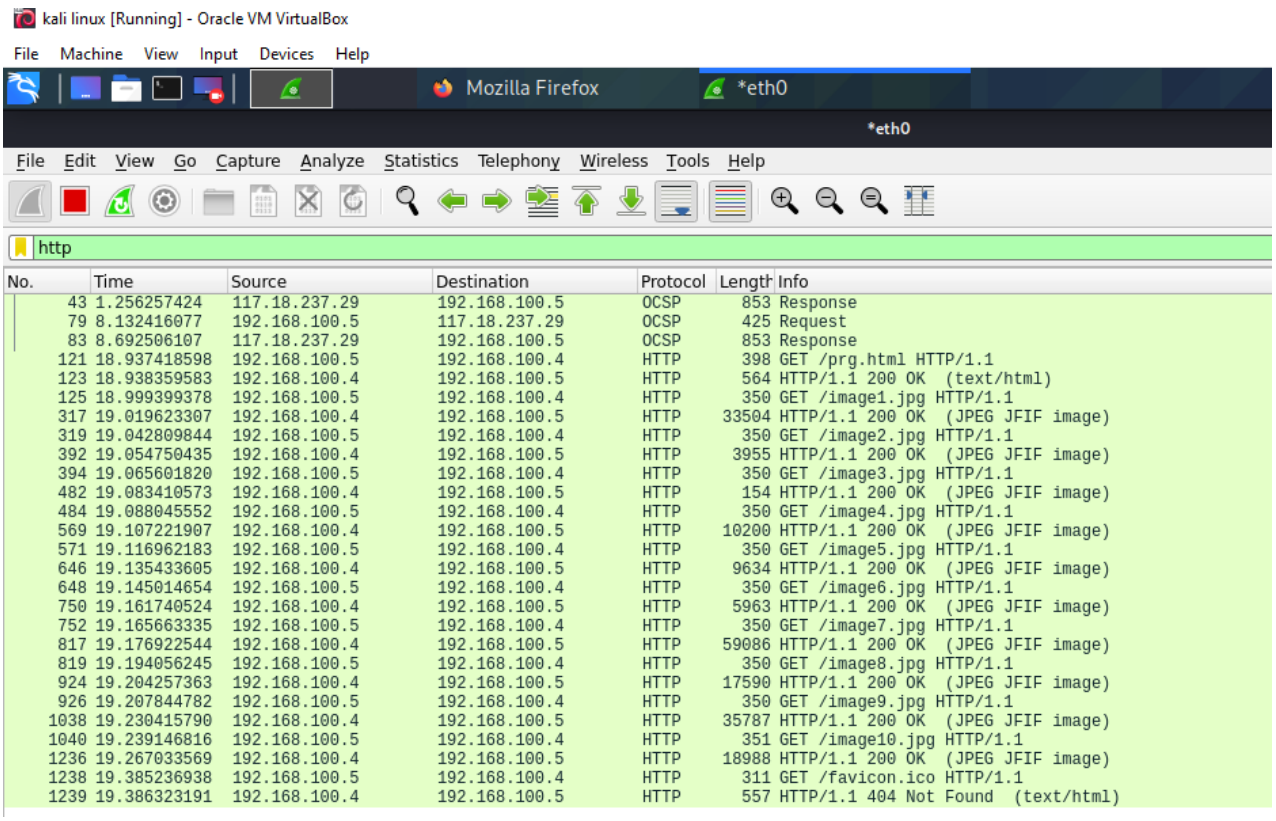
Client side:



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



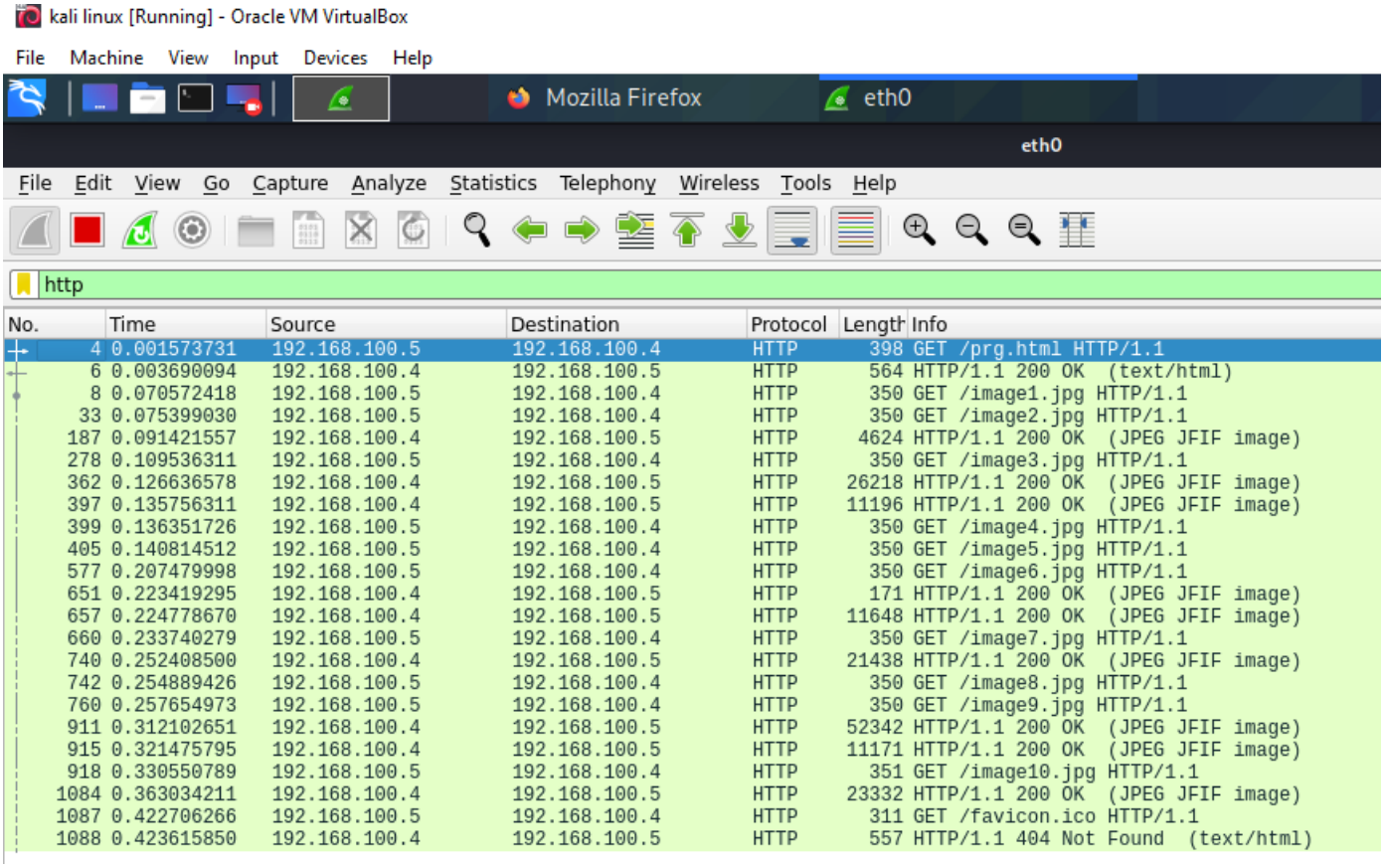


No.	Time	Source	Destination	Protocol	Length	Info
43	1.256257424	117.18.237.29	192.168.100.5	OCSP	853	Response
79	8.132416077	192.168.100.5	117.18.237.29	OCSP	425	Request
83	8.692506107	117.18.237.29	192.168.100.5	OCSP	853	Response
121	18.937418598	192.168.100.5	192.168.100.4	HTTP	398	GET /prg.html HTTP/1.1
123	18.938359583	192.168.100.4	192.168.100.5	HTTP	564	HTTP/1.1 200 OK (text/html)
125	18.999399378	192.168.100.5	192.168.100.4	HTTP	350	GET /image1.jpg HTTP/1.1
317	19.019623307	192.168.100.4	192.168.100.5	HTTP	33504	HTTP/1.1 200 OK (JPEG JFIF image)
319	19.042809844	192.168.100.5	192.168.100.4	HTTP	350	GET /image2.jpg HTTP/1.1
392	19.054750435	192.168.100.4	192.168.100.5	HTTP	3955	HTTP/1.1 200 OK (JPEG JFIF image)
394	19.065601820	192.168.100.5	192.168.100.4	HTTP	350	GET /image3.jpg HTTP/1.1
482	19.083410573	192.168.100.4	192.168.100.5	HTTP	154	HTTP/1.1 200 OK (JPEG JFIF image)
484	19.088045552	192.168.100.5	192.168.100.4	HTTP	350	GET /image4.jpg HTTP/1.1
569	19.107221907	192.168.100.4	192.168.100.5	HTTP	10200	HTTP/1.1 200 OK (JPEG JFIF image)
571	19.116962183	192.168.100.5	192.168.100.4	HTTP	350	GET /image5.jpg HTTP/1.1
646	19.135433605	192.168.100.4	192.168.100.5	HTTP	9634	HTTP/1.1 200 OK (JPEG JFIF image)
648	19.145014654	192.168.100.5	192.168.100.4	HTTP	350	GET /image6.jpg HTTP/1.1
750	19.161740524	192.168.100.4	192.168.100.5	HTTP	5963	HTTP/1.1 200 OK (JPEG JFIF image)
752	19.165663335	192.168.100.5	192.168.100.4	HTTP	350	GET /image7.jpg HTTP/1.1
817	19.176922544	192.168.100.4	192.168.100.5	HTTP	59086	HTTP/1.1 200 OK (JPEG JFIF image)
819	19.194056245	192.168.100.5	192.168.100.4	HTTP	350	GET /image8.jpg HTTP/1.1
924	19.204257363	192.168.100.4	192.168.100.5	HTTP	17590	HTTP/1.1 200 OK (JPEG JFIF image)
926	19.207844782	192.168.100.5	192.168.100.4	HTTP	350	GET /image9.jpg HTTP/1.1
1038	19.230415790	192.168.100.4	192.168.100.5	HTTP	35787	HTTP/1.1 200 OK (JPEG JFIF image)
1040	19.239146816	192.168.100.5	192.168.100.4	HTTP	351	GET /image10.jpg HTTP/1.1
1236	19.267033569	192.168.100.4	192.168.100.5	HTTP	18988	HTTP/1.1 200 OK (JPEG JFIF image)
1238	19.385236938	192.168.100.5	192.168.100.4	HTTP	311	GET /favicon.ico HTTP/1.1
1239	19.386323191	192.168.100.4	192.168.100.5	HTTP	557	HTTP/1.1 404 Not Found (text/html)

Here the value is=19.386323191-18.937418598=0.448904593

PART 2: PERSISTENT CONNECTIONS

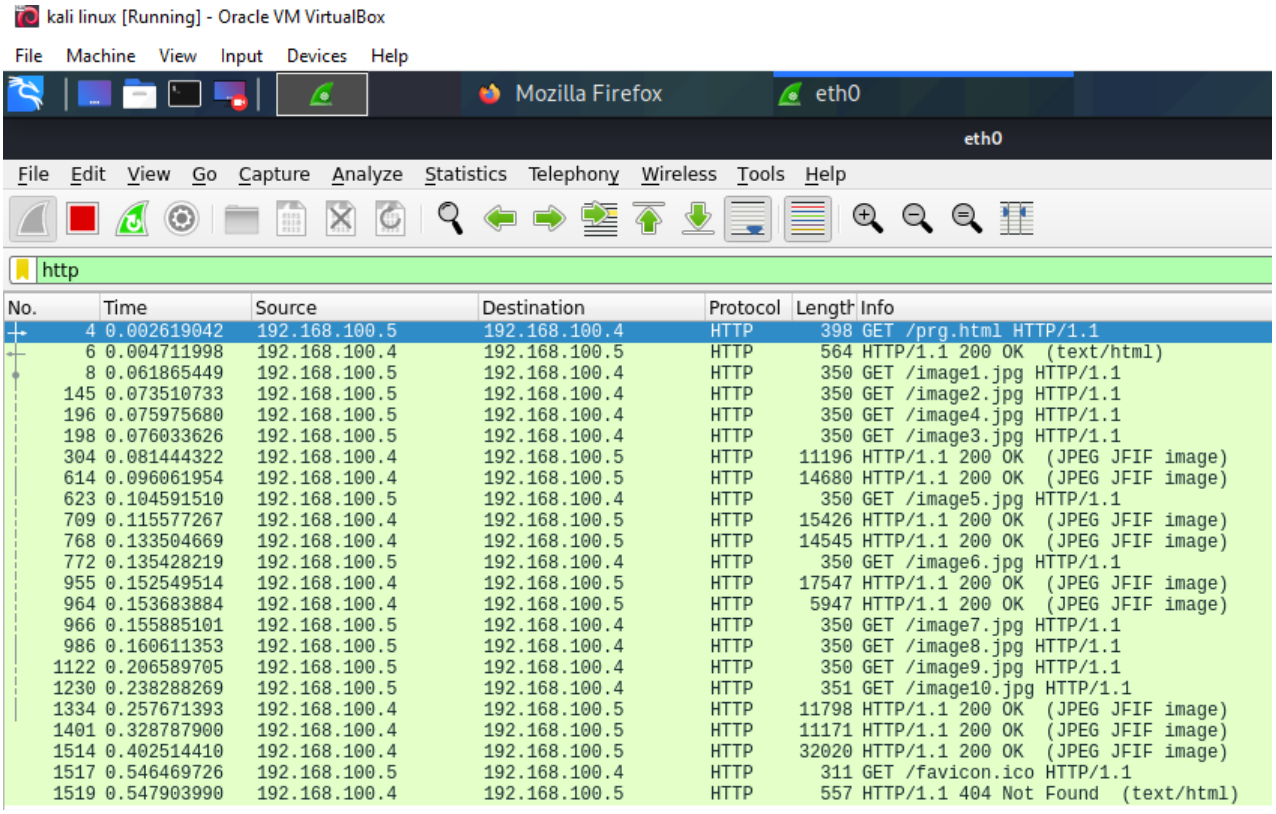
For 2 persistent connections, set the value of **max-persistent-connection-per-server** **to 2** in the client computer



No.	Time	Source	Destination	Protocol	Length	Info
4	0.001573731	192.168.100.5	192.168.100.4	HTTP	398	GET /prg.html HTTP/1.1
6	0.003690094	192.168.100.4	192.168.100.5	HTTP	564	HTTP/1.1 200 OK (text/html)
8	0.070572418	192.168.100.5	192.168.100.4	HTTP	350	GET /image1.jpg HTTP/1.1
33	0.075399030	192.168.100.5	192.168.100.4	HTTP	350	GET /image2.jpg HTTP/1.1
187	0.091421557	192.168.100.4	192.168.100.5	HTTP	4624	HTTP/1.1 200 OK (JPEG JFIF image)
278	0.109536311	192.168.100.5	192.168.100.4	HTTP	350	GET /image3.jpg HTTP/1.1
362	0.126636578	192.168.100.4	192.168.100.5	HTTP	26218	HTTP/1.1 200 OK (JPEG JFIF image)
397	0.135756311	192.168.100.4	192.168.100.5	HTTP	11196	HTTP/1.1 200 OK (JPEG JFIF image)
399	0.136351726	192.168.100.5	192.168.100.4	HTTP	350	GET /image4.jpg HTTP/1.1
405	0.140814512	192.168.100.5	192.168.100.4	HTTP	350	GET /image5.jpg HTTP/1.1
577	0.207479998	192.168.100.5	192.168.100.4	HTTP	350	GET /image6.jpg HTTP/1.1
651	0.223419295	192.168.100.4	192.168.100.5	HTTP	171	HTTP/1.1 200 OK (JPEG JFIF image)
657	0.224778670	192.168.100.4	192.168.100.5	HTTP	11648	HTTP/1.1 200 OK (JPEG JFIF image)
660	0.233740279	192.168.100.5	192.168.100.4	HTTP	350	GET /image7.jpg HTTP/1.1
740	0.252408500	192.168.100.4	192.168.100.5	HTTP	21438	HTTP/1.1 200 OK (JPEG JFIF image)
742	0.254889426	192.168.100.5	192.168.100.4	HTTP	350	GET /image8.jpg HTTP/1.1
760	0.257654973	192.168.100.5	192.168.100.4	HTTP	350	GET /image9.jpg HTTP/1.1
911	0.312102651	192.168.100.4	192.168.100.5	HTTP	52342	HTTP/1.1 200 OK (JPEG JFIF image)
915	0.321475795	192.168.100.4	192.168.100.5	HTTP	11171	HTTP/1.1 200 OK (JPEG JFIF image)
918	0.330550789	192.168.100.5	192.168.100.4	HTTP	351	GET /image10.jpg HTTP/1.1
1084	0.363034211	192.168.100.4	192.168.100.5	HTTP	23332	HTTP/1.1 200 OK (JPEG JFIF image)
1087	0.422706266	192.168.100.5	192.168.100.4	HTTP	311	GET /favicon.ico HTTP/1.1
1088	0.423615850	192.168.100.4	192.168.100.5	HTTP	557	HTTP/1.1 404 Not Found (text/html)

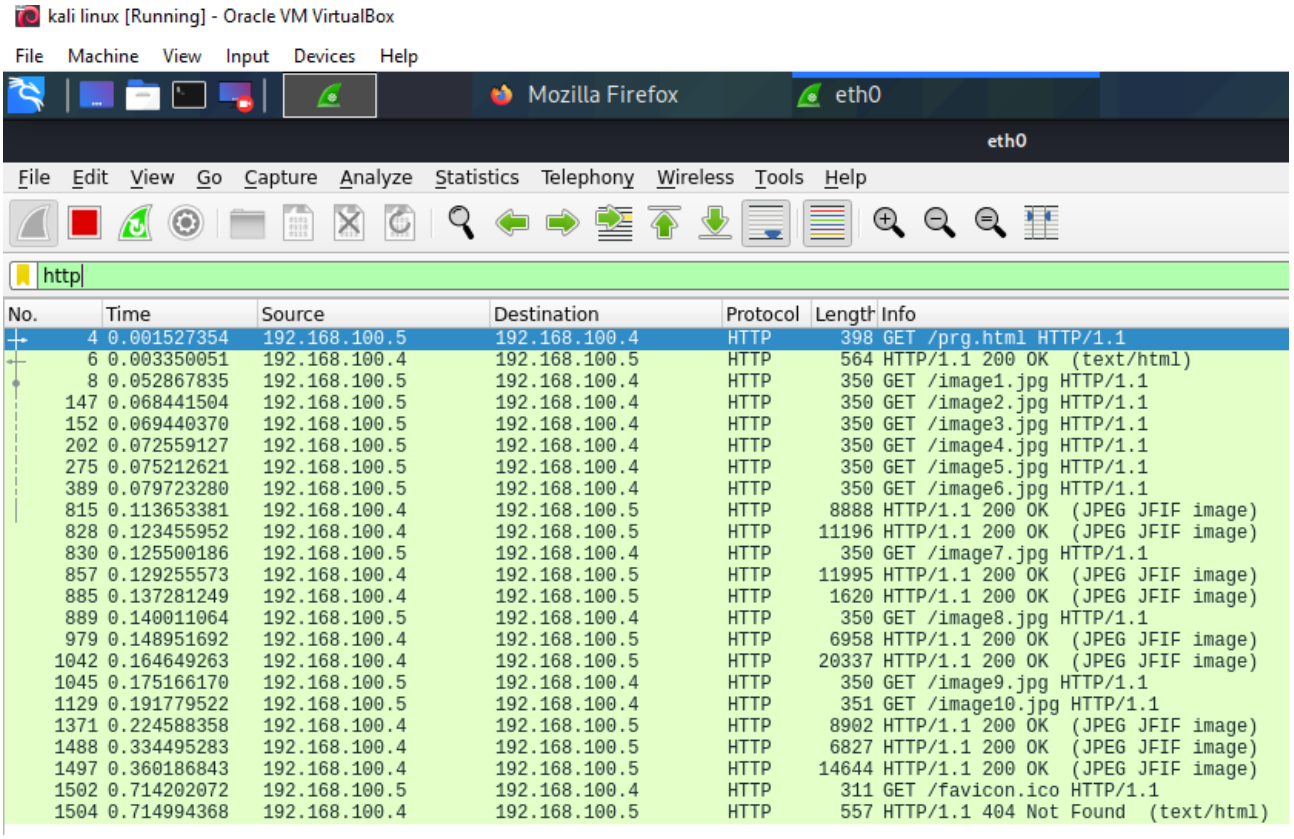
Here it is 0.422706266-0.001573731=**0.421132535**

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



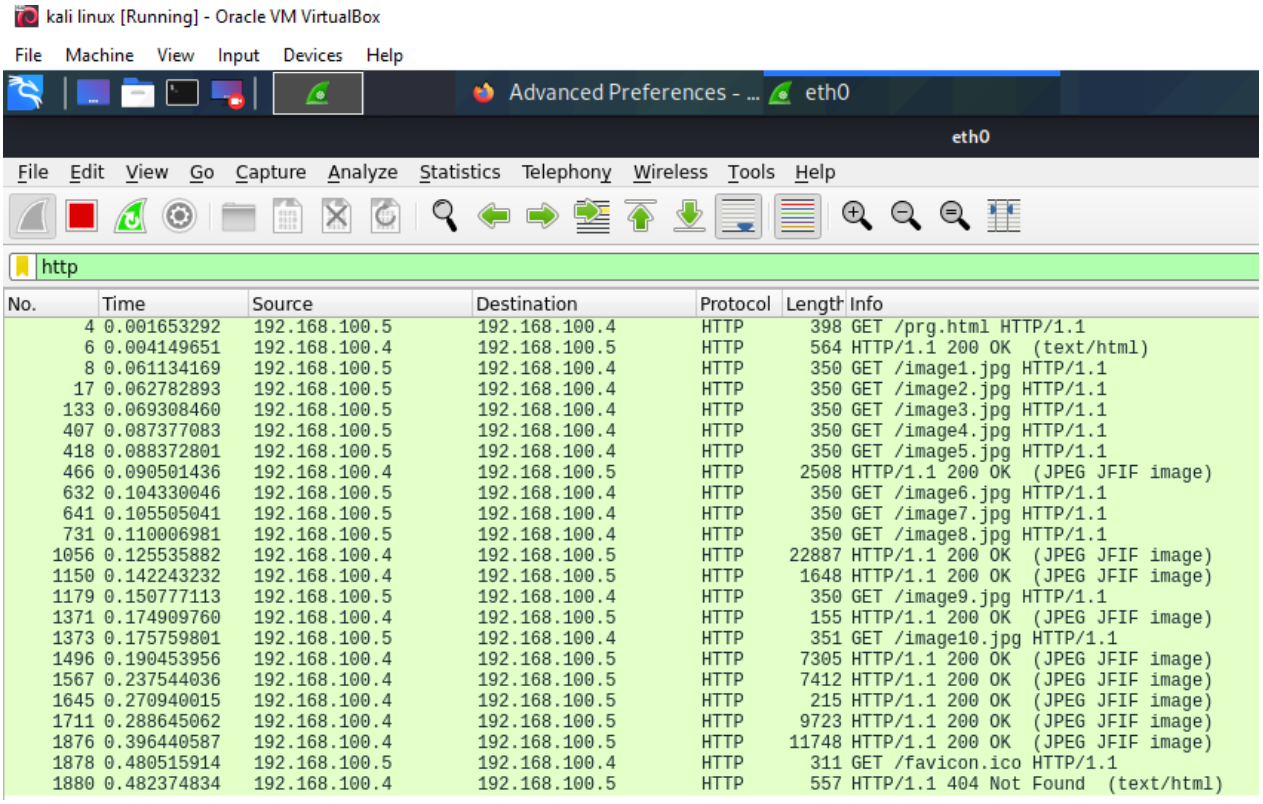
Here it is: 0.402514410-0.002619042= **0.399895368**

For 6 persistent connections, Set the value of **max-persistent-connection-per-server** **to** **6** in the client computer



Here it is: 0.360186843-0.001527354= **0.358659489**

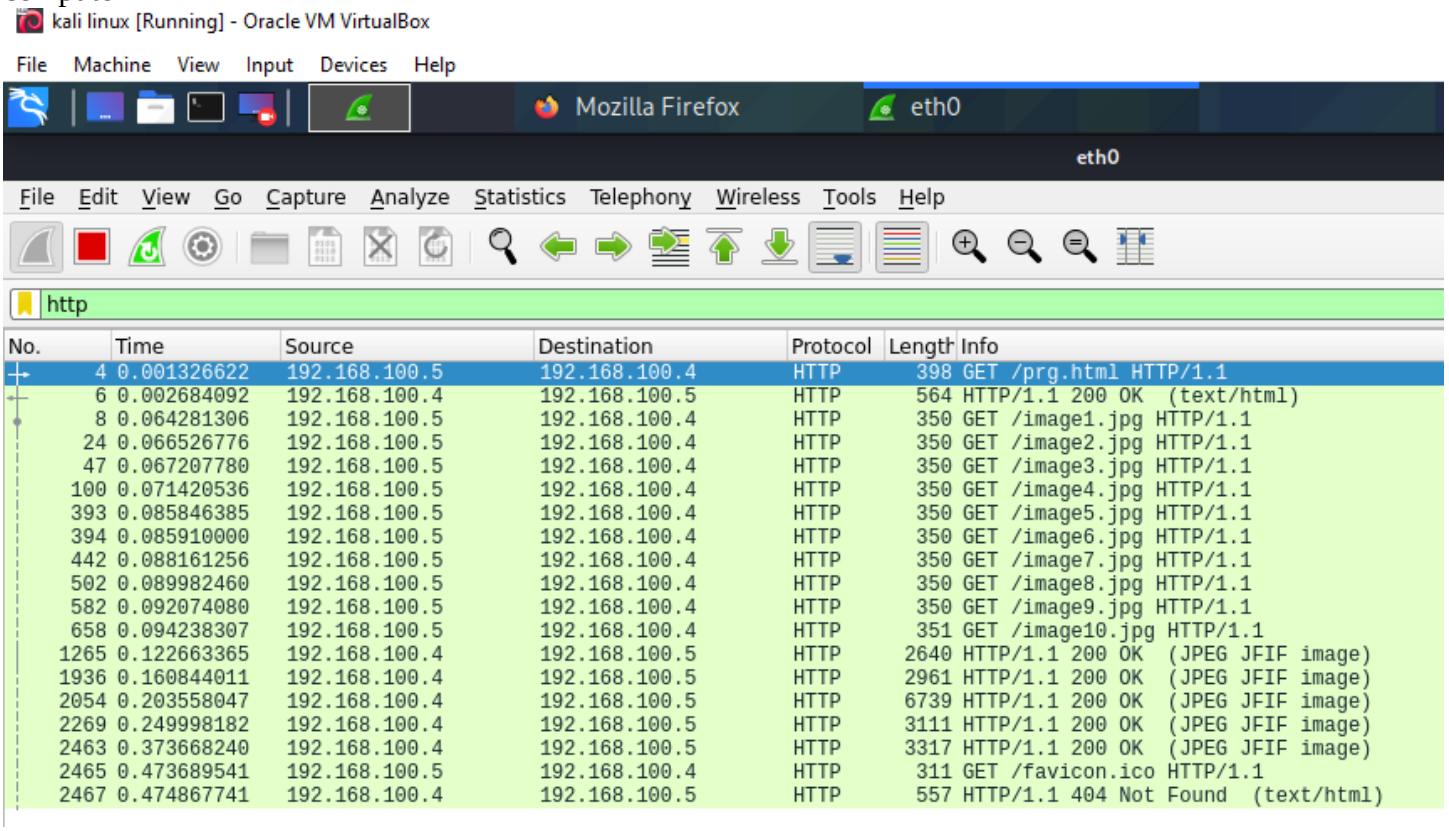
For 8 persistent connections, Set the value of **max-persistent-connection-per-server** **to** **8** in the client computer



No.	Time	Source	Destination	Protocol	Length	Info
4	0.001653292	192.168.100.5	192.168.100.4	HTTP	398	GET /prg.html HTTP/1.1
6	0.004149651	192.168.100.4	192.168.100.5	HTTP	564	HTTP/1.1 200 OK (text/html)
8	0.061134169	192.168.100.5	192.168.100.4	HTTP	350	GET /image1.jpg HTTP/1.1
17	0.062782893	192.168.100.5	192.168.100.4	HTTP	350	GET /image2.jpg HTTP/1.1
133	0.069308460	192.168.100.5	192.168.100.4	HTTP	350	GET /image3.jpg HTTP/1.1
407	0.087377083	192.168.100.5	192.168.100.4	HTTP	350	GET /image4.jpg HTTP/1.1
418	0.088372801	192.168.100.5	192.168.100.4	HTTP	350	GET /image5.jpg HTTP/1.1
466	0.090501436	192.168.100.4	192.168.100.5	HTTP	2508	HTTP/1.1 200 OK (JPEG JFIF image)
632	0.104330046	192.168.100.5	192.168.100.4	HTTP	350	GET /image6.jpg HTTP/1.1
641	0.105505041	192.168.100.5	192.168.100.4	HTTP	350	GET /image7.jpg HTTP/1.1
731	0.110006981	192.168.100.5	192.168.100.4	HTTP	350	GET /image8.jpg HTTP/1.1
1056	0.125535882	192.168.100.4	192.168.100.5	HTTP	22887	HTTP/1.1 200 OK (JPEG JFIF image)
1150	0.142243232	192.168.100.4	192.168.100.5	HTTP	1648	HTTP/1.1 200 OK (JPEG JFIF image)
1179	0.150777113	192.168.100.5	192.168.100.4	HTTP	350	GET /image9.jpg HTTP/1.1
1371	0.174909760	192.168.100.4	192.168.100.5	HTTP	155	HTTP/1.1 200 OK (JPEG JFIF image)
1373	0.175759801	192.168.100.5	192.168.100.4	HTTP	351	GET /image10.jpg HTTP/1.1
1496	0.190453956	192.168.100.4	192.168.100.5	HTTP	7305	HTTP/1.1 200 OK (JPEG JFIF image)
1567	0.237544036	192.168.100.4	192.168.100.5	HTTP	7412	HTTP/1.1 200 OK (JPEG JFIF image)
1645	0.270940015	192.168.100.4	192.168.100.5	HTTP	215	HTTP/1.1 200 OK (JPEG JFIF image)
1711	0.288645062	192.168.100.4	192.168.100.5	HTTP	9723	HTTP/1.1 200 OK (JPEG JFIF image)
1876	0.396440587	192.168.100.4	192.168.100.5	HTTP	11748	HTTP/1.1 200 OK (JPEG JFIF image)
1878	0.480515914	192.168.100.5	192.168.100.4	HTTP	311	GET /favicon.ico HTTP/1.1
1880	0.482374834	192.168.100.4	192.168.100.5	HTTP	557	HTTP/1.1 404 Not Found (text/html)

Here it is: 0.396440587-0.001653292= **0.394787295**

For 10 persistent connections, Set the value of **max-persistent-connection-per-server** **to** **10** in the client computer



No.	Time	Source	Destination	Protocol	Length	Info
4	0.001326622	192.168.100.5	192.168.100.4	HTTP	398	GET /prg.html HTTP/1.1
6	0.002684092	192.168.100.4	192.168.100.5	HTTP	564	HTTP/1.1 200 OK (text/html)
8	0.064281306	192.168.100.5	192.168.100.4	HTTP	350	GET /image1.jpg HTTP/1.1
24	0.066526776	192.168.100.5	192.168.100.4	HTTP	350	GET /image2.jpg HTTP/1.1
47	0.067207780	192.168.100.5	192.168.100.4	HTTP	350	GET /image3.jpg HTTP/1.1
100	0.071420536	192.168.100.5	192.168.100.4	HTTP	350	GET /image4.jpg HTTP/1.1
393	0.085846385	192.168.100.5	192.168.100.4	HTTP	350	GET /image5.jpg HTTP/1.1
394	0.085910000	192.168.100.5	192.168.100.4	HTTP	350	GET /image6.jpg HTTP/1.1
442	0.088161256	192.168.100.5	192.168.100.4	HTTP	350	GET /image7.jpg HTTP/1.1
502	0.089982460	192.168.100.5	192.168.100.4	HTTP	350	GET /image8.jpg HTTP/1.1
582	0.092074080	192.168.100.5	192.168.100.4	HTTP	350	GET /image9.jpg HTTP/1.1
658	0.094238307	192.168.100.5	192.168.100.4	HTTP	351	GET /image10.jpg HTTP/1.1
1265	0.122663365	192.168.100.4	192.168.100.5	HTTP	2640	HTTP/1.1 200 OK (JPEG JFIF image)
1936	0.160844011	192.168.100.4	192.168.100.5	HTTP	2961	HTTP/1.1 200 OK (JPEG JFIF image)
2054	0.203558047	192.168.100.4	192.168.100.5	HTTP	6739	HTTP/1.1 200 OK (JPEG JFIF image)
2269	0.249998182	192.168.100.4	192.168.100.5	HTTP	3111	HTTP/1.1 200 OK (JPEG JFIF image)
2463	0.373668240	192.168.100.4	192.168.100.5	HTTP	3317	HTTP/1.1 200 OK (JPEG JFIF image)
2465	0.473689541	192.168.100.5	192.168.100.4	HTTP	311	GET /favicon.ico HTTP/1.1
2467	0.474867741	192.168.100.4	192.168.100.5	HTTP	557	HTTP/1.1 404 Not Found (text/html)

Here it is: 0.373668240-0.001326622= **0.372341618**

OBSERVATIONS:

We can calculate the total load time as the difference between the first GET time which corresponds to the time when the html page was requested and the last response time, which corresponds to when the last image was sent back

The time taken to load images for 4 6 8 persistent connections is greater than 10

Persistent Connections	**Time at first GET**	**Time at last Response**	**Load Time**
0	18.937418598	19.386323191	0.448904593
2	0.001573731	0.422706266	0.421132535
4	0.002619042	0.40251441	0.399895368
6	0.001527354	0.360186843	0.358659489
8	0.001653292	0.396440587	0.394787295
10	0.001326622	0.37366824	0.372341618

HTTP persistent connection has the following advantages:

- Reduced latency in subsequent requests.
- Reduced CPU usage and round-trips because of fewer new connections and TLS handshakes.
- Enables HTTP pipelining of requests and responses.
- Reduced network congestion (fewer TCP connections).
- Errors can be reported without the penalty of closing the TCP connection.

- We can hence see that the optimal number of persistent connections is **6**, since it corresponds to the lowest load time.
- Initially as the number of persistent connections increase, we can observe that the load time decrease gradually and then steeply. This occurs due to the parallelism and pipelining performed while processing and requesting for image objects.
- However, as the number of persistent connections increase, the load time again starts increasing. This is due to the decrease in throughput of each connection with the constant link capacity. Hence the load times increase with an increase in number of persistent connections above a certain threshold.
- It is therefore not suggested to keep an exceedingly high number of persistent connections.