Computer Networks Lab – Week 1

PES1UG19CS592

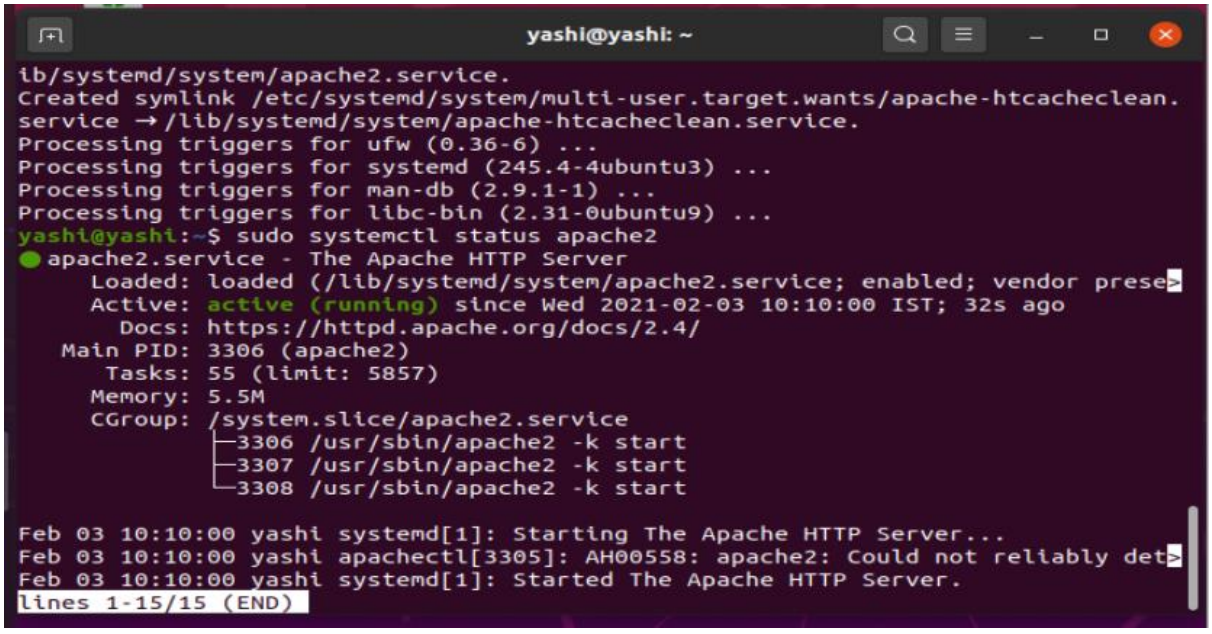
Yashi Chawla

1 Configuration of Apache Server and Client Environment

- Two Virtual Machines were setup to create a server-client architecture.
- Apache Server was installed and configured on the server machine, and a static webpage consisting 10 images was created and hosted on the local network between these machines.
- Now we need to observe and determine the effect of the number of persistent connections on the load time of this static webpage.

1.1 Setting up Apache Server

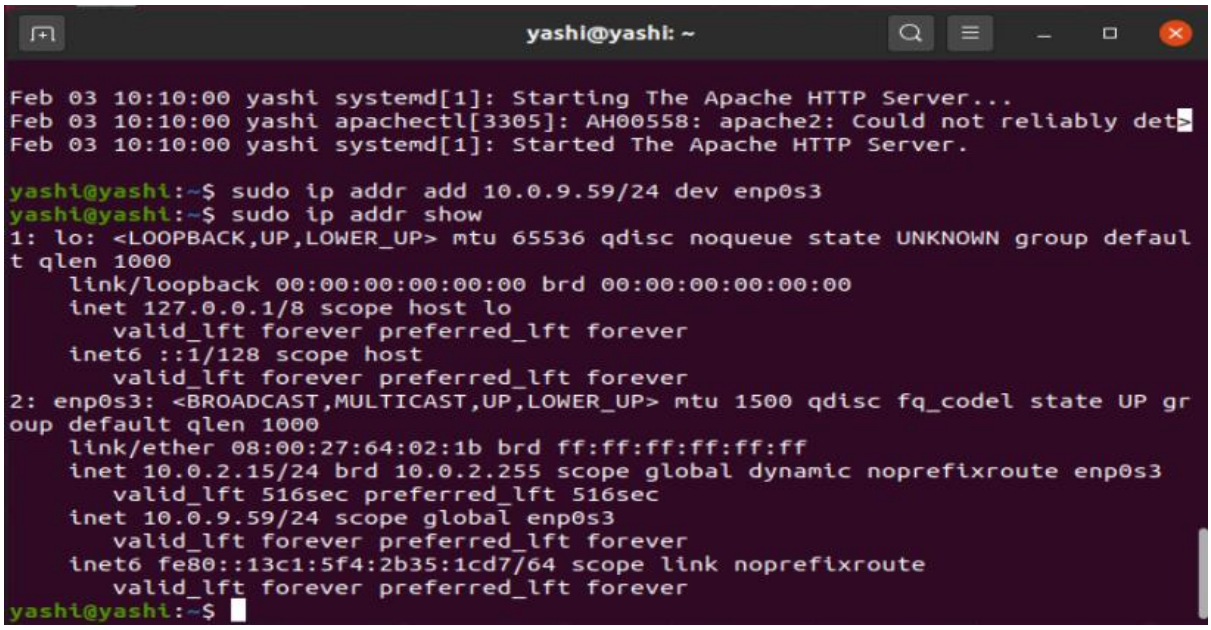
- The Apache Server can be installed with sudo apt install apache2



- The status of the newly installed server can be viewed using sudo system1 status apache2

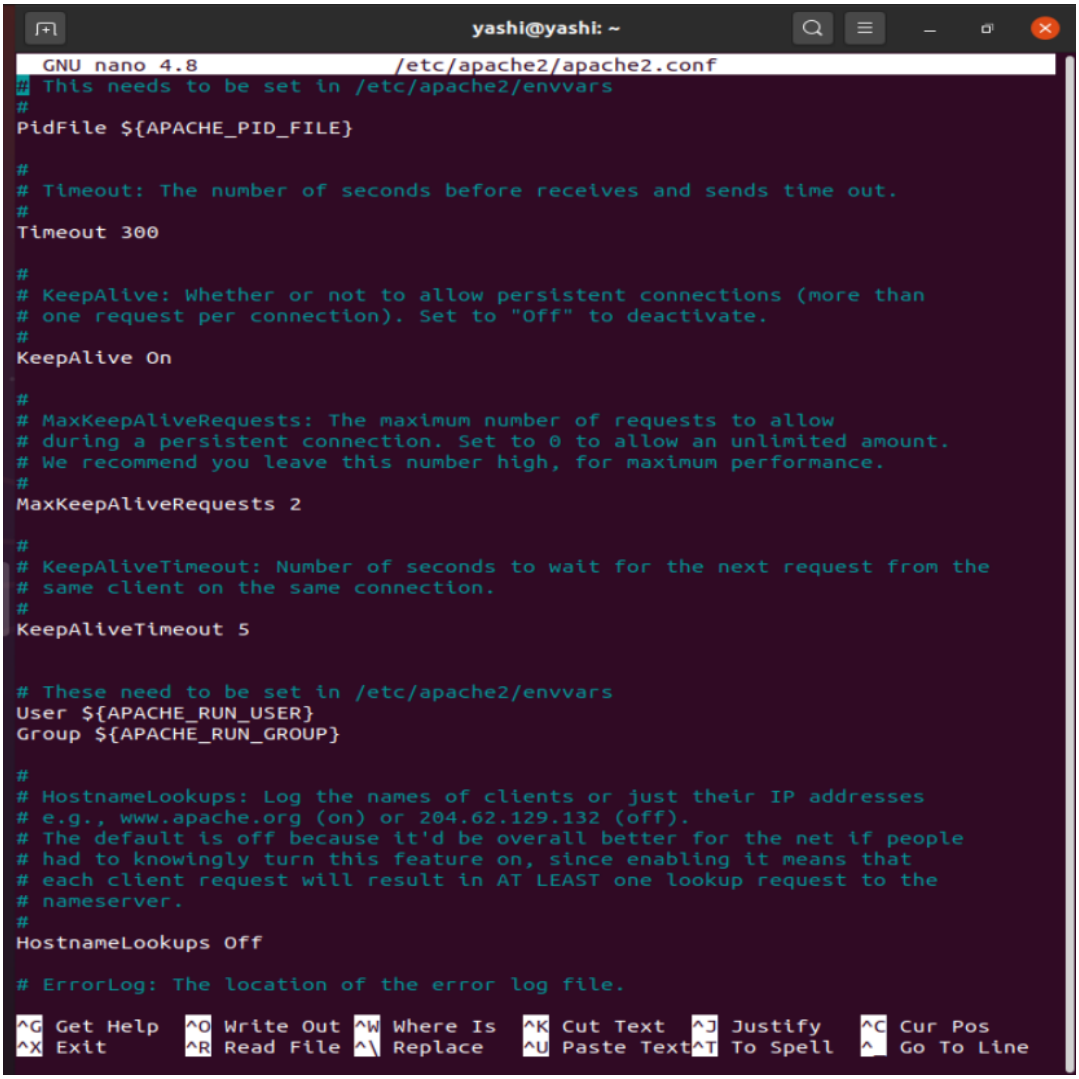
1.2 Custom Adding IP Addresses for Server and Client

- A custom IP address was set for both the Server and the Client machines
- The Server IP Address was set to 10.0.9.59 and the Client IP Address was set to 10.0.9.60
- The IP address were assigned using sudo ip addr add command



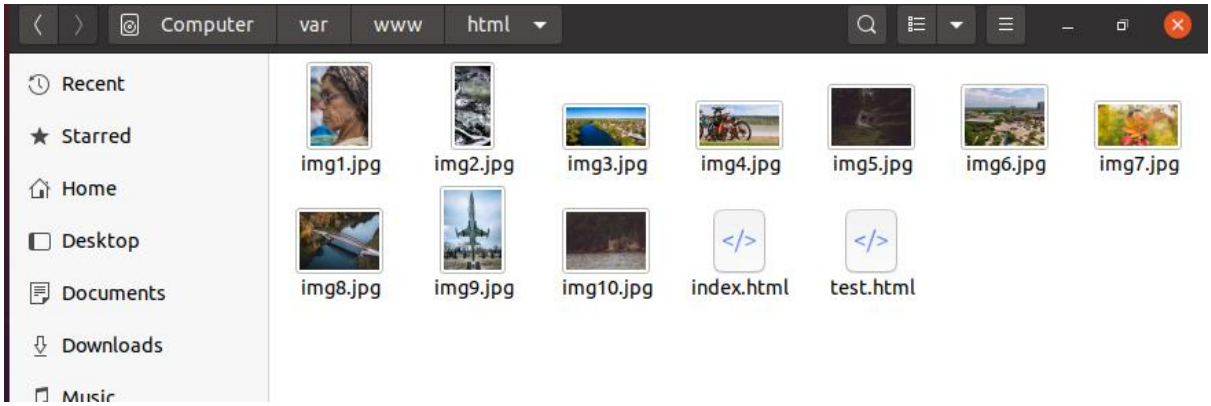
1.3 Configure Apache Server

- The Apache Server also needs to be configured to allow persistent connections. This is done by editing the apache2.conf configuration file and setting the options
- KeepAlive to On
- MaxKeepAliveRequests to 2



1.4 Hosting the Webpage

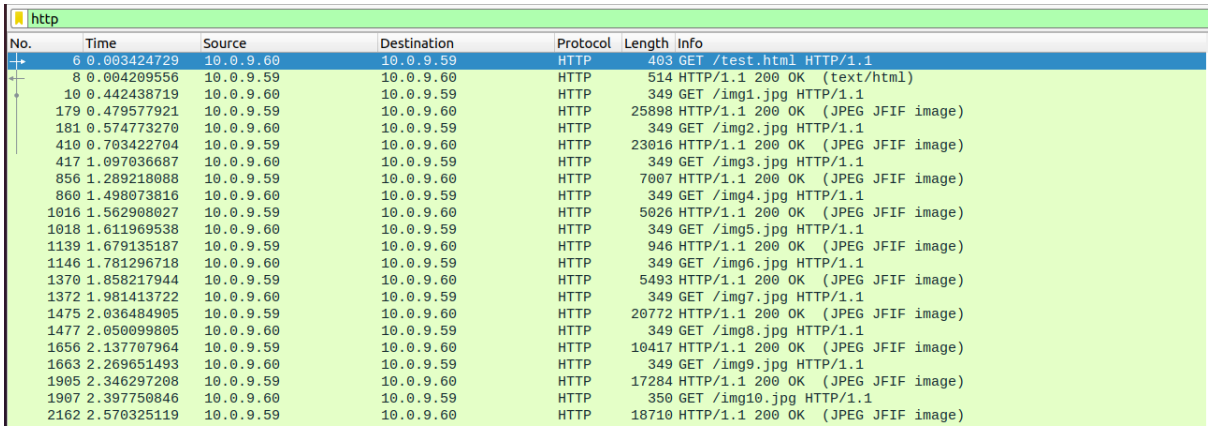
- The webpage can be hosted by moving the html script and the images to the server path
- The server path is /var/www/html



2. Non-Persistent Connection

- To setup a non-persistent connection, we need to configure a few settings on our browser
- On Firefox, we set the max-persistent-connection-per-server to 0 and persistent-settings to false

2.1 Packet Capture Screenshot



http

No.	Time	Source	Destination	Protocol	Length	Info
6	0.003424729	10.0.9.60	10.0.9.59	HTTP	403	GET /test.html HTTP/1.1
8	0.004209556	10.0.9.59	10.0.9.60	HTTP	514	HTTP/1.1 200 OK (text/html)
10	0.442438719	10.0.9.60	10.0.9.59	HTTP	349	GET /img1.jpg HTTP/1.1
179	0.479577921	10.0.9.59	10.0.9.60	HTTP	25898	HTTP/1.1 200 OK (JPEG JFIF image)
181	0.574773270	10.0.9.60	10.0.9.59	HTTP	349	GET /img2.jpg HTTP/1.1
410	0.703422704	10.0.9.59	10.0.9.60	HTTP	23016	HTTP/1.1 200 OK (JPEG JFIF image)
417	1.097036687	10.0.9.60	10.0.9.59	HTTP	349	GET /img3.jpg HTTP/1.1
856	1.289218088	10.0.9.59	10.0.9.60	HTTP	7007	HTTP/1.1 200 OK (JPEG JFIF image)
860	1.498073816	10.0.9.60	10.0.9.59	HTTP	349	GET /img4.jpg HTTP/1.1
1016	1.562908027	10.0.9.59	10.0.9.60	HTTP	5026	HTTP/1.1 200 OK (JPEG JFIF image)
1018	1.611969538	10.0.9.60	10.0.9.59	HTTP	349	GET /img5.jpg HTTP/1.1
1139	1.679135187	10.0.9.59	10.0.9.60	HTTP	946	HTTP/1.1 200 OK (JPEG JFIF image)
1146	1.781296718	10.0.9.60	10.0.9.59	HTTP	349	GET /img6.jpg HTTP/1.1
1370	1.858217944	10.0.9.59	10.0.9.60	HTTP	5493	HTTP/1.1 200 OK (JPEG JFIF image)
1372	1.981413722	10.0.9.60	10.0.9.59	HTTP	349	GET /img7.jpg HTTP/1.1
1475	2.036484905	10.0.9.59	10.0.9.60	HTTP	20772	HTTP/1.1 200 OK (JPEG JFIF image)
1477	2.050099805	10.0.9.60	10.0.9.59	HTTP	349	GET /img8.jpg HTTP/1.1
1656	2.137707964	10.0.9.59	10.0.9.60	HTTP	10417	HTTP/1.1 200 OK (JPEG JFIF image)
1663	2.269651493	10.0.9.60	10.0.9.59	HTTP	349	GET /img9.jpg HTTP/1.1
1905	2.346297208	10.0.9.59	10.0.9.60	HTTP	17284	HTTP/1.1 200 OK (JPEG JFIF image)
1907	2.397750846	10.0.9.60	10.0.9.59	HTTP	350	GET /img10.jpg HTTP/1.1
2162	2.570325119	10.0.9.59	10.0.9.60	HTTP	18710	HTTP/1.1 200 OK (JPEG JFIF image)

3. Persistent Connection

- To setup a persistent connection, we need to configure a few settings on our browser
- On Firefox, we set the max-persistent-connections-per-server to anything greater than 0 and persistent-settings to true

3.1 **2** Persistent Connections

http

No.	Time	Source	Destination	Protocol	Length	Info
4	0.000715418	10.0.9.60	10.0.9.59	HTTP	403	GET /test.html HTTP/1.1
6	0.001424400	10.0.9.59	10.0.9.60	HTTP	514	HTTP/1.1 200 OK (text/html)
8	0.183895423	10.0.9.60	10.0.9.59	HTTP	349	GET /img1.jpg HTTP/1.1
23	0.185194927	10.0.9.60	10.0.9.59	HTTP	349	GET /img2.jpg HTTP/1.1
229	0.198432028	10.0.9.59	10.0.9.60	HTTP	31066	HTTP/1.1 200 OK (JPEG JFIF image)
535	0.256167377	10.0.9.59	10.0.9.60	HTTP	3947	HTTP/1.1 200 OK (JPEG JFIF image)
536	0.268155967	10.0.9.60	10.0.9.59	HTTP	349	GET /img3.jpg HTTP/1.1
868	0.364132693	10.0.9.59	10.0.9.60	HTTP	2908	HTTP/1.1 200 OK (JPEG JFIF image)
871	0.423723177	10.0.9.60	10.0.9.59	HTTP	349	GET /img4.jpg HTTP/1.1
1004	0.568650197	10.0.9.60	10.0.9.59	HTTP	349	GET /img5.jpg HTTP/1.1
1141	0.608186604	10.0.9.59	10.0.9.60	HTTP	2394	HTTP/1.1 200 OK (JPEG JFIF image)
1148	0.636011305	10.0.9.60	10.0.9.59	HTTP	349	GET /img6.jpg HTTP/1.1
1369	0.821205898	10.0.9.60	10.0.9.59	HTTP	349	GET /img7.jpg HTTP/1.1
1449	0.863253326	10.0.9.59	10.0.9.60	HTTP	12084	HTTP/1.1 200 OK (JPEG JFIF image)
1451	0.890335225	10.0.9.60	10.0.9.59	HTTP	349	GET /img8.jpg HTTP/1.1
1615	0.950794786	10.0.9.59	10.0.9.60	HTTP	14761	HTTP/1.1 200 OK (JPEG JFIF image)
1622	1.024386511	10.0.9.60	10.0.9.59	HTTP	349	GET /img9.jpg HTTP/1.1
1843	1.159091614	10.0.9.59	10.0.9.60	HTTP	3060	HTTP/1.1 200 OK (JPEG JFIF image)
1851	1.199932643	10.0.9.60	10.0.9.59	HTTP	350	GET /img10.jpg HTTP/1.1
2169	1.305768108	10.0.9.59	10.0.9.60	HTTP	142	HTTP/1.1 200 OK (JPEG JFIF image)

3.2 **4** Persistent Connections

http

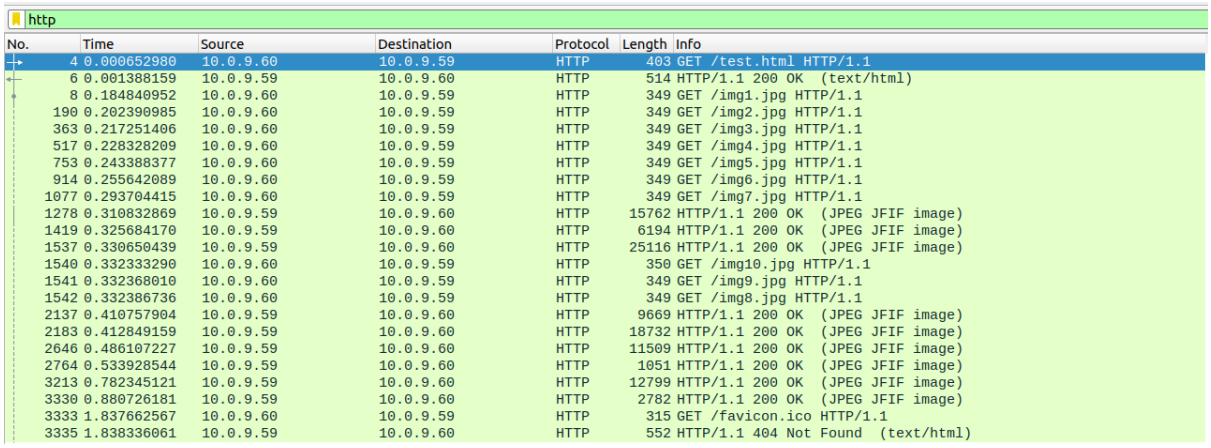
No.	Time	Source	Destination	Protocol	Length	Info
4	0.000605740	10.0.9.60	10.0.9.59	HTTP	403	GET /test.html HTTP/1.1
6	0.001361807	10.0.9.59	10.0.9.60	HTTP	514	HTTP/1.1 200 OK (text/html)
8	0.188102854	10.0.9.60	10.0.9.59	HTTP	349	GET /img1.jpg HTTP/1.1
25	0.189510925	10.0.9.60	10.0.9.59	HTTP	349	GET /img2.jpg HTTP/1.1
335	0.247972414	10.0.9.60	10.0.9.59	HTTP	349	GET /img3.jpg HTTP/1.1
360	0.248935557	10.0.9.59	10.0.9.60	HTTP	14314	HTTP/1.1 200 OK (JPEG JFIF image)
399	0.259391734	10.0.9.60	10.0.9.59	HTTP	349	GET /img4.jpg HTTP/1.1
992	0.315958726	10.0.9.60	10.0.9.59	HTTP	349	GET /img5.jpg HTTP/1.1
1276	0.409281388	10.0.9.59	10.0.9.60	HTTP	18322	HTTP/1.1 200 OK (JPEG JFIF image)
1280	0.424030164	10.0.9.59	10.0.9.60	HTTP	5026	HTTP/1.1 200 OK (JPEG JFIF image)
1503	0.496570559	10.0.9.60	10.0.9.59	HTTP	349	GET /img6.jpg HTTP/1.1
1643	0.515118161	10.0.9.60	10.0.9.59	HTTP	349	GET /img7.jpg HTTP/1.1
1932	0.535595941	10.0.9.59	10.0.9.60	HTTP	14363	HTTP/1.1 200 OK (JPEG JFIF image)
2010	0.557302992	10.0.9.59	10.0.9.60	HTTP	31557	HTTP/1.1 200 OK (JPEG JFIF image)
2016	0.565429029	10.0.9.59	10.0.9.60	HTTP	12340	HTTP/1.1 200 OK (JPEG JFIF image)
2039	0.581242292	10.0.9.60	10.0.9.59	HTTP	349	GET /img8.jpg HTTP/1.1
2108	0.606063746	10.0.9.59	10.0.9.60	HTTP	13079	HTTP/1.1 200 OK (JPEG JFIF image)
2194	0.652725252	10.0.9.59	10.0.9.60	HTTP	4660	HTTP/1.1 200 OK (JPEG JFIF image)
2196	0.670128642	10.0.9.60	10.0.9.59	HTTP	349	GET /img9.jpg HTTP/1.1
2263	0.697145105	10.0.9.60	10.0.9.59	HTTP	350	GET /img10.jpg HTTP/1.1
2378	0.757471510	10.0.9.59	10.0.9.60	HTTP	11492	HTTP/1.1 200 OK (JPEG JFIF image)
2549	0.897153643	10.0.9.59	10.0.9.60	HTTP	12883	HTTP/1.1 200 OK (JPEG JFIF image)

3.3 **6** Persistent Connections

http

No.	Time	Source	Destination	Protocol	Length	Info
6	8.810290864	10.0.9.60	10.0.9.59	HTTP	403	GET /test.html HTTP/1.1
8	8.811141587	10.0.9.59	10.0.9.60	HTTP	514	HTTP/1.1 200 OK (text/html)
10	8.994457544	10.0.9.60	10.0.9.59	HTTP	349	GET /img1.jpg HTTP/1.1
185	9.010406189	10.0.9.60	10.0.9.59	HTTP	349	GET /img2.jpg HTTP/1.1
288	9.017094631	10.0.9.60	10.0.9.59	HTTP	349	GET /img3.jpg HTTP/1.1
604	9.039782075	10.0.9.60	10.0.9.59	HTTP	349	GET /img4.jpg HTTP/1.1
762	9.056422576	10.0.9.60	10.0.9.59	HTTP	349	GET /img5.jpg HTTP/1.1
948	9.078689212	10.0.9.60	10.0.9.59	HTTP	349	GET /img6.jpg HTTP/1.1
1224	9.129035531	10.0.9.59	10.0.9.60	HTTP	7330	HTTP/1.1 200 OK (JPEG JFIF image)
1420	9.164572598	10.0.9.59	10.0.9.60	HTTP	21253	HTTP/1.1 200 OK (JPEG JFIF image)
1448	9.167889241	10.0.9.59	10.0.9.60	HTTP	47667	HTTP/1.1 200 OK (JPEG JFIF image)
1631	9.209432953	10.0.9.59	10.0.9.60	HTTP	6730	HTTP/1.1 200 OK (JPEG JFIF image)
1793	9.271633911	10.0.9.59	10.0.9.60	HTTP	8389	HTTP/1.1 200 OK (JPEG JFIF image)
1795	9.296258769	10.0.9.60	10.0.9.59	HTTP	349	GET /img7.jpg HTTP/1.1
1889	9.302183907	10.0.9.59	10.0.9.60	HTTP	3361	HTTP/1.1 200 OK (JPEG JFIF image)
1911	9.347173935	10.0.9.60	10.0.9.59	HTTP	349	GET /img8.jpg HTTP/1.1
2024	9.417509310	10.0.9.60	10.0.9.59	HTTP	349	GET /img9.jpg HTTP/1.1
2171	9.458095380	10.0.9.60	10.0.9.59	HTTP	350	GET /img10.jpg HTTP/1.1
2451	9.504950217	10.0.9.59	10.0.9.60	HTTP	14796	HTTP/1.1 200 OK (JPEG JFIF image)
2460	9.508479019	10.0.9.59	10.0.9.60	HTTP	20180	HTTP/1.1 200 OK (JPEG JFIF image)
2596	9.558167735	10.0.9.59	10.0.9.60	HTTP	25950	HTTP/1.1 200 OK (JPEG JFIF image)
2601	10.254426130	10.0.9.60	10.0.9.59	HTTP	315	GET /favicon.ico HTTP/1.1
2603	10.255079723	10.0.9.59	10.0.9.60	HTTP	552	HTTP/1.1 404 Not Found (text/html)

3.4 **10** Persistent Connections



http

No.	Time	Source	Destination	Protocol	Length	Info
4	0.000652980	10.0.9.60	10.0.9.59	HTTP	403	GET /test.html HTTP/1.1
6	0.001388159	10.0.9.59	10.0.9.60	HTTP	514	HTTP/1.1 200 OK (text/html)
8	0.184840952	10.0.9.60	10.0.9.59	HTTP	349	GET /img1.jpg HTTP/1.1
190	0.202390985	10.0.9.60	10.0.9.59	HTTP	349	GET /img2.jpg HTTP/1.1
363	0.217251406	10.0.9.60	10.0.9.59	HTTP	349	GET /img3.jpg HTTP/1.1
517	0.228328209	10.0.9.60	10.0.9.59	HTTP	349	GET /img4.jpg HTTP/1.1
753	0.243388377	10.0.9.60	10.0.9.59	HTTP	349	GET /img5.jpg HTTP/1.1
914	0.255642089	10.0.9.60	10.0.9.59	HTTP	349	GET /img6.jpg HTTP/1.1
1077	0.293704415	10.0.9.60	10.0.9.59	HTTP	349	GET /img7.jpg HTTP/1.1
1278	0.310832869	10.0.9.59	10.0.9.60	HTTP	15762	HTTP/1.1 200 OK (JPEG JFIF image)
1419	0.325684170	10.0.9.59	10.0.9.60	HTTP	6194	HTTP/1.1 200 OK (JPEG JFIF image)
1537	0.330650439	10.0.9.59	10.0.9.60	HTTP	25116	HTTP/1.1 200 OK (JPEG JFIF image)
1540	0.332333290	10.0.9.60	10.0.9.59	HTTP	350	GET /img10.jpg HTTP/1.1
1541	0.332368010	10.0.9.60	10.0.9.59	HTTP	349	GET /img9.jpg HTTP/1.1
1542	0.332386736	10.0.9.60	10.0.9.59	HTTP	349	GET /img8.jpg HTTP/1.1
2137	0.410757904	10.0.9.59	10.0.9.60	HTTP	9669	HTTP/1.1 200 OK (JPEG JFIF image)
2183	0.412849159	10.0.9.59	10.0.9.60	HTTP	18732	HTTP/1.1 200 OK (JPEG JFIF image)
2646	0.486107227	10.0.9.59	10.0.9.60	HTTP	11509	HTTP/1.1 200 OK (JPEG JFIF image)
2764	0.533928544	10.0.9.59	10.0.9.60	HTTP	1051	HTTP/1.1 200 OK (JPEG JFIF image)
3213	0.782345121	10.0.9.59	10.0.9.60	HTTP	12799	HTTP/1.1 200 OK (JPEG JFIF image)
3330	0.880726181	10.0.9.59	10.0.9.60	HTTP	2782	HTTP/1.1 200 OK (JPEG JFIF image)
3333	1.837662567	10.0.9.60	10.0.9.59	HTTP	315	GET /favicon.ico HTTP/1.1
3335	1.838336061	10.0.9.59	10.0.9.60	HTTP	552	HTTP/1.1 404 Not Found (text/html)

4. 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.

On doing so, we can construct the following observations table-

Persistent Connections	Time at first GET	Time at last Response	Load Time
0	0.003424729	2.570325119	2.56690039
2	0.000715418	1.305768108	1.30505269
4	0.000605740	0.897153643	0.896547903
6	8.810290864	9.558167735	0.747876871
10	0.000652980	1.838336061	1.87683081

- 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.
- This allows for multiple images to be requested at the same time, hence
- decreasing the load time taken and is much lesser than requesting each
- individual image serially and individually.
- 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.