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COMPUTER NETWORKS LAB

Week #2

Understanding Persistent and Non-persistent HTTP Connections

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.

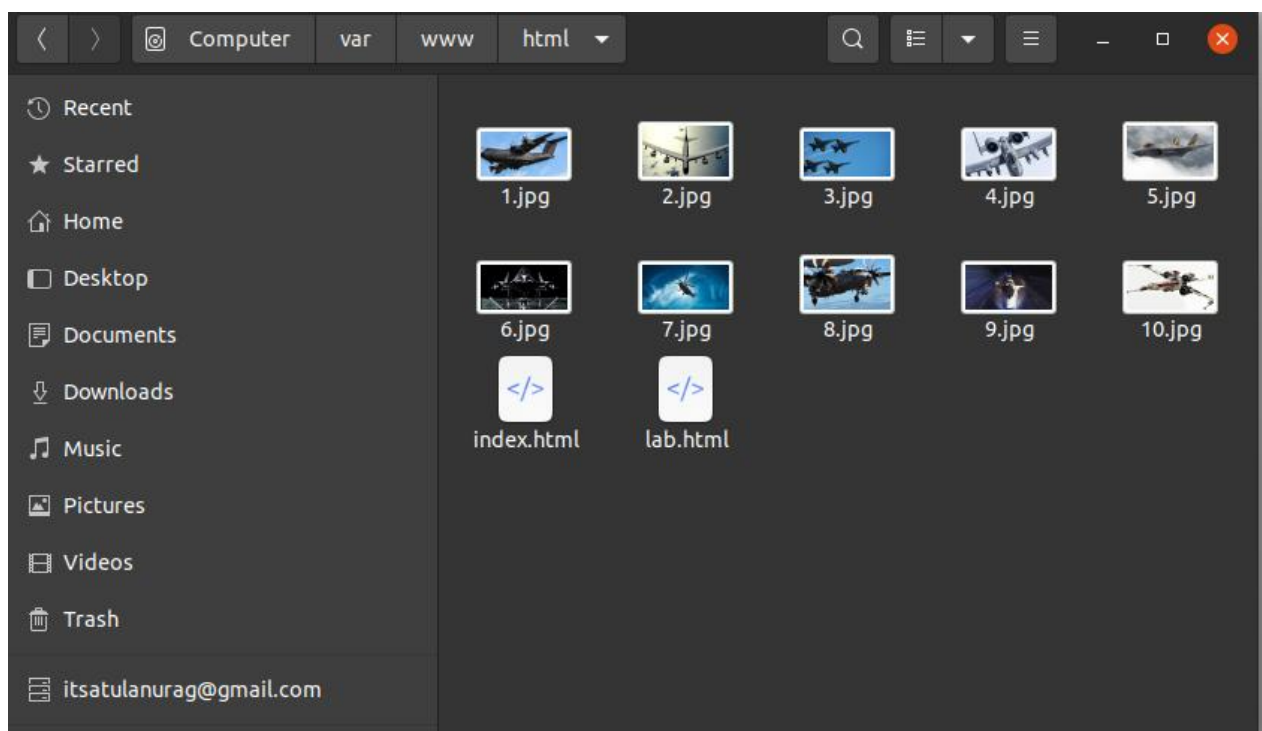
Experiment: Create a web page with N (e.g. 10) embedded images. Each image should be of minimum 2 MB size. Configure your browser (Firefox) with following settings (each setting requires repeat of experiment)

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

EXECUTION STEPS

```
itsatul@itsatul-VirtualBox: ~  
itsatul@itsatul-VirtualBox:~$ sudo service apache2 status  
● apache2.service - The Apache HTTP Server  
   Loaded: loaded (/lib/systemd/system/apache2.service; enabled; vendor preset: enabled)  
   Active: active (running) since Tue 2021-02-16 22:53:51 IST; 1h 47min ago  
     Docs: https://httpd.apache.org/docs/2.4/  
   Process: 721 ExecStart=/usr/sbin/apachectl start (code=exited, status=0/SUCCESS)  
   Process: 2852 ExecReload=/usr/sbin/apachectl graceful (code=exited, status=0/SUCCESS)  
   Main PID: 775 (apache2)  
     Tasks: 55 (limit: 3522)  
    Memory: 26.2M  
   CGroup: /system.slice/apache2.service  
           └─ 775 /usr/sbin/apache2 -k start  
             └─ 2856 /usr/sbin/apache2 -k start  
               └─ 2857 /usr/sbin/apache2 -k start  
  
Feb 16 22:53:44 itsatul-VirtualBox systemd[1]: Starting The Apache HTTP Server...  
Feb 16 22:53:50 itsatul-VirtualBox apachectl[741]: AH00558: apache2: Could not reliably determine the server's fully qualified domain name, please see the http://httpd.apache.org/docs/2.4/faq.html#listenhostname section on how to http://httpd.apache.org/docs/2.4/faq.html#listenhostname it.  
Feb 16 22:53:51 itsatul-VirtualBox systemd[1]: Started The Apache HTTP Server.  
Feb 17 00:00:57 itsatul-VirtualBox systemd[1]: Reloading The Apache HTTP Server.  
Feb 17 00:00:57 itsatul-VirtualBox apachectl[2855]: AH00558: apache2: Could not reliably determine the server's fully qualified domain name, please see the http://httpd.apache.org/docs/2.4/faq.html#listenhostname section on how to http://httpd.apache.org/docs/2.4/faq.html#listenhostname it.  
Feb 17 00:00:57 itsatul-VirtualBox systemd[1]: Reloaded The Apache HTTP Server.  
lines 1-20/20 (END)  
  
itsatul@itsatul-VirtualBox:~$ ip addr show  
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 08:00:27:34:8c:be brd ff:ff:ff:ff:ff:ff  
    inet 10.0.2.15/24 brd 10.0.2.255 scope global dynamic noprefixroute enp0s3  
        valid_lft 325sec preferred_lft 325sec  
    inet6 fe80::be83:960e:a6cf:b0ed/64 scope link noprefixroute  
        valid_lft forever preferred_lft forever  
itsatul@itsatul-VirtualBox:~$
```

```
itsatul@itsatul-VirtualBox: ~  
itsatul@itsatul-VirtualBox:~$ ip addr show  
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:bb:1d:9e brd ff:ff:ff:ff:ff:ff  
    inet 10.0.2.4/24 brd 10.0.2.255 scope global dynamic noprefixroute enp0s3  
        valid_lft 383sec preferred_lft 383sec  
    inet6 fe80::7f8f:323c:5516:b941/64 scope link noprefixroute  
        valid_lft forever preferred_lft forever  
itsatul@itsatul-VirtualBox:~$
```



PART 1: NON-PERSISTENT CONNECTION

No.	Time	Source	Destination	Protocol	Length	Info
8	9.877415314	10.0.2.4	10.0.2.15	HTTP	404	GET /lab.html HTTP/1.1
10	9.322908039	10.0.2.15	10.0.2.4	HTTP	573	HTTP/1.1 200 OK (text/html)
12	9.572290518	10.0.2.4	10.0.2.15	HTTP	347	GET /1.jpg HTTP/1.1
122	9.627794675	10.0.2.15	10.0.2.4	HTTP	11786	HTTP/1.1 200 OK (JPEG JFIF image)
126	9.634655162	10.0.2.4	10.0.2.15	HTTP	347	GET /2.jpg HTTP/1.1
184	9.654040396	10.0.2.15	10.0.2.4	HTTP	1061	HTTP/1.1 200 OK (JPEG JFIF image)
196	9.657424471	10.0.2.4	10.0.2.15	HTTP	347	GET /3.jpg HTTP/1.1
246	9.671608925	10.0.2.15	10.0.2.4	HTTP	40700	HTTP/1.1 200 OK (JPEG JFIF image)
249	9.675364231	10.0.2.4	10.0.2.15	HTTP	347	GET /4.jpg HTTP/1.1
294	9.713729163	10.0.2.15	10.0.2.4	HTTP	4410	HTTP/1.1 200 OK (JPEG JFIF image)
296	9.718121543	10.0.2.4	10.0.2.15	HTTP	347	GET /5.jpg HTTP/1.1
331	9.736617262	10.0.2.15	10.0.2.4	HTTP	64660	HTTP/1.1 200 OK (JPEG JFIF image)
334	9.740078782	10.0.2.4	10.0.2.15	HTTP	347	GET /6.jpg HTTP/1.1
403	9.761846098	10.0.2.15	10.0.2.4	HTTP	45061	HTTP/1.1 200 OK (JPEG JFIF image)
408	9.763858689	10.0.2.4	10.0.2.15	HTTP	347	GET /7.jpg HTTP/1.1
437	9.768201315	10.0.2.15	10.0.2.4	HTTP	50400	HTTP/1.1 200 OK (JPEG JFIF image)
440	9.785337443	10.0.2.4	10.0.2.15	HTTP	347	GET /8.jpg HTTP/1.1
474	9.794271653	10.0.2.15	10.0.2.4	HTTP	21936	HTTP/1.1 200 OK (JPEG JFIF image)
476	9.802070782	10.0.2.4	10.0.2.15	HTTP	347	GET /9.jpg HTTP/1.1
534	9.823695187	10.0.2.15	10.0.2.4	HTTP	19861	HTTP/1.1 200 OK (JPEG JFIF image)
536	9.827416189	10.0.2.4	10.0.2.15	HTTP	348	GET /10.jpg HTTP/1.1
616	9.844199557	10.0.2.15	10.0.2.4	HTTP	11750	HTTP/1.1 200 OK (JPEG JFIF image)
618	9.876295310	10.0.2.4	10.0.2.15	HTTP	353	GET /favicon.ico HTTP/1.1
619	9.876542911	10.0.2.15	10.0.2.4	HTTP	555	HTTP/1.1 404 Not Found (text/html)

In

this case: $9.876542911 - 9.077415314 = 0.799127597$

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
4	0.000440628	10.0.2.4	10.0.2.15	HTTP	404	GET /lab.html HTTP/1.1
6	0.000882409	10.0.2.15	10.0.2.4	HTTP	573	HTTP/1.1 200 OK (text/html)
8	0.269704212	10.0.2.4	10.0.2.15	HTTP	347	GET /1.jpg HTTP/1.1
126	0.289144956	10.0.2.15	10.0.2.4	HTTP	1650	HTTP/1.1 200 OK (JPEG JFIF image)
132	0.295930884	10.0.2.4	10.0.2.15	HTTP	347	GET /2.jpg HTTP/1.1
160	0.304716248	10.0.2.4	10.0.2.15	HTTP	347	GET /3.jpg HTTP/1.1
337	0.312492405	10.0.2.15	10.0.2.4	HTTP	44502	HTTP/1.1 200 OK (JPEG JFIF image)
362	0.332549494	10.0.2.4	10.0.2.15	HTTP	347	GET /4.jpg HTTP/1.1
425	0.340854070	10.0.2.15	10.0.2.4	HTTP	1514	HTTP/1.1 200 OK (JPEG JFIF image)
434	0.344102937	10.0.2.15	10.0.2.4	HTTP	30564	HTTP/1.1 200 OK (JPEG JFIF image)
438	0.355528251	10.0.2.4	10.0.2.15	HTTP	347	GET /5.jpg HTTP/1.1
496	0.369044265	10.0.2.4	10.0.2.15	HTTP	347	GET /6.jpg HTTP/1.1
552	0.390612167	10.0.2.15	10.0.2.4	HTTP	948	HTTP/1.1 200 OK (JPEG JFIF image)
554	0.396706089	10.0.2.4	10.0.2.15	HTTP	347	GET /7.jpg HTTP/1.1
557	0.397028531	10.0.2.15	10.0.2.4	HTTP	13205	HTTP/1.1 200 OK (JPEG JFIF image)
603	0.410772683	10.0.2.15	10.0.2.4	HTTP	27232	HTTP/1.1 200 OK (JPEG JFIF image)
607	0.414536563	10.0.2.4	10.0.2.15	HTTP	347	GET /8.jpg HTTP/1.1
608	0.414609651	10.0.2.4	10.0.2.15	HTTP	347	GET /9.jpg HTTP/1.1
679	0.430171221	10.0.2.15	10.0.2.4	HTTP	34968	HTTP/1.1 200 OK (JPEG JFIF image)
748	0.451755328	10.0.2.15	10.0.2.4	HTTP	8277	HTTP/1.1 200 OK (JPEG JFIF image)
749	0.454125548	10.0.2.4	10.0.2.15	HTTP	348	GET /10.jpg HTTP/1.1
858	0.483474982	10.0.2.15	10.0.2.4	HTTP	46502	HTTP/1.1 200 OK (JPEG JFIF image)
860	0.500451297	10.0.2.4	10.0.2.15	HTTP	353	GET /favicon.ico HTTP/1.1
861	0.500704276	10.0.2.15	10.0.2.4	HTTP	555	HTTP/1.1 404 Not Found (text/html)

In this case: $0.500704276 - 0.000440628 = 0.500263648$

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

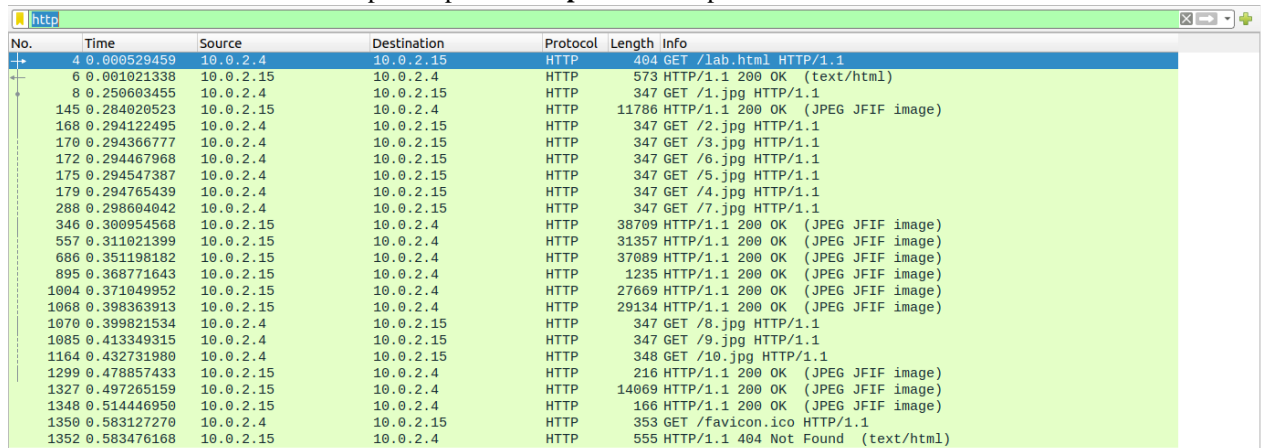
Step 4: Repeat the **steps 1-3** in the previous section.

No.	Time	Source	Destination	Protocol	Length	Info
6	3.319543647	10.0.2.4	10.0.2.15	HTTP	404	GET /lab.html HTTP/1.1
8	3.320259359	10.0.2.15	10.0.2.4	HTTP	573	HTTP/1.1 200 OK (text/html)
10	3.547163425	10.0.2.4	10.0.2.15	HTTP	347	GET /1.jpg HTTP/1.1
127	3.571835204	10.0.2.15	10.0.2.4	HTTP	1650	HTTP/1.1 200 OK (JPEG JFIF image)
141	3.581186246	10.0.2.4	10.0.2.15	HTTP	347	GET /2.jpg HTTP/1.1
144	3.581512363	10.0.2.4	10.0.2.15	HTTP	347	GET /3.jpg HTTP/1.1
145	3.581512443	10.0.2.4	10.0.2.15	HTTP	347	GET /4.jpg HTTP/1.1
195	3.585105665	10.0.2.4	10.0.2.15	HTTP	347	GET /5.jpg HTTP/1.1
330	3.590140593	10.0.2.15	10.0.2.4	HTTP	54637	HTTP/1.1 200 OK (JPEG JFIF image)
425	3.599256004	10.0.2.15	10.0.2.4	HTTP	157	HTTP/1.1 200 OK (JPEG JFIF image)
545	3.607169484	10.0.2.15	10.0.2.4	HTTP	2397	HTTP/1.1 200 OK (JPEG JFIF image)
660	3.618917613	10.0.2.4	10.0.2.15	HTTP	347	GET /6.jpg HTTP/1.1
748	3.627548634	10.0.2.15	10.0.2.4	HTTP	18891	HTTP/1.1 200 OK (JPEG JFIF image)
750	3.630032651	10.0.2.4	10.0.2.15	HTTP	347	GET /7.jpg HTTP/1.1
827	3.643824443	10.0.2.15	10.0.2.4	HTTP	21440	HTTP/1.1 200 OK (JPEG JFIF image)
830	3.646336338	10.0.2.4	10.0.2.15	HTTP	347	GET /8.jpg HTTP/1.1
888	3.655431234	10.0.2.15	10.0.2.4	HTTP	6008	HTTP/1.1 200 OK (JPEG JFIF image)
890	3.658544476	10.0.2.4	10.0.2.15	HTTP	347	GET /9.jpg HTTP/1.1
936	3.662593741	10.0.2.15	10.0.2.4	HTTP	43613	HTTP/1.1 200 OK (JPEG JFIF image)
939	3.663406767	10.0.2.4	10.0.2.15	HTTP	348	GET /10.jpg HTTP/1.1
1074	3.735323412	10.0.2.15	10.0.2.4	HTTP	9725	HTTP/1.1 200 OK (JPEG JFIF image)
1118	3.753742859	10.0.2.15	10.0.2.4	HTTP	33470	HTTP/1.1 200 OK (JPEG JFIF image)
1120	3.827673970	10.0.2.4	10.0.2.15	HTTP	353	GET /favicon.ico HTTP/1.1
1122	3.827989476	10.0.2.15	10.0.2.4	HTTP	555	HTTP/1.1 404 Not Found (text/html)

In this case: $3.827989476 - 3.319543647 = 0.508445829$

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.

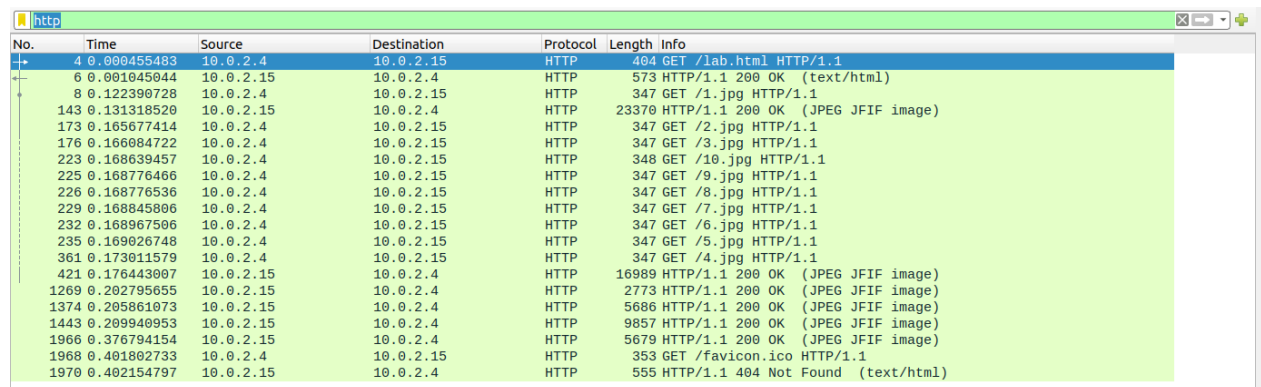


No.	Time	Source	Destination	Protocol	Length	Info
4	0.000529459	10.0.2.4	10.0.2.15	HTTP	404	GET /lab.html HTTP/1.1
6	0.001021338	10.0.2.15	10.0.2.4	HTTP	573	HTTP/1.1 200 OK (text/html)
8	0.250603455	10.0.2.4	10.0.2.15	HTTP	347	GET /1.jpg HTTP/1.1
145	0.284020523	10.0.2.15	10.0.2.4	HTTP	11786	HTTP/1.1 200 OK (JPEG JFIF image)
168	0.294122495	10.0.2.4	10.0.2.15	HTTP	347	GET /2.jpg HTTP/1.1
170	0.294366777	10.0.2.4	10.0.2.15	HTTP	347	GET /3.jpg HTTP/1.1
172	0.294467968	10.0.2.4	10.0.2.15	HTTP	347	GET /6.jpg HTTP/1.1
175	0.294547387	10.0.2.4	10.0.2.15	HTTP	347	GET /5.jpg HTTP/1.1
179	0.294765439	10.0.2.4	10.0.2.15	HTTP	347	GET /4.jpg HTTP/1.1
288	0.298604042	10.0.2.4	10.0.2.15	HTTP	347	GET /7.jpg HTTP/1.1
346	0.300954568	10.0.2.15	10.0.2.4	HTTP	38709	HTTP/1.1 200 OK (JPEG JFIF image)
557	0.311021399	10.0.2.15	10.0.2.4	HTTP	31357	HTTP/1.1 200 OK (JPEG JFIF image)
686	0.351198182	10.0.2.15	10.0.2.4	HTTP	37089	HTTP/1.1 200 OK (JPEG JFIF image)
895	0.368771643	10.0.2.15	10.0.2.4	HTTP	1235	HTTP/1.1 200 OK (JPEG JFIF image)
1004	0.371049952	10.0.2.15	10.0.2.4	HTTP	27669	HTTP/1.1 200 OK (JPEG JFIF image)
1068	0.398363913	10.0.2.15	10.0.2.4	HTTP	29134	HTTP/1.1 200 OK (JPEG JFIF image)
1070	0.399821534	10.0.2.4	10.0.2.15	HTTP	347	GET /8.jpg HTTP/1.1
1085	0.413349315	10.0.2.4	10.0.2.15	HTTP	347	GET /9.jpg HTTP/1.1
1164	0.432731980	10.0.2.4	10.0.2.15	HTTP	348	GET /10.jpg HTTP/1.1
1299	0.478857433	10.0.2.15	10.0.2.4	HTTP	216	HTTP/1.1 200 OK (JPEG JFIF image)
1327	0.497265159	10.0.2.15	10.0.2.4	HTTP	14069	HTTP/1.1 200 OK (JPEG JFIF image)
1348	0.514446950	10.0.2.15	10.0.2.4	HTTP	166	HTTP/1.1 200 OK (JPEG JFIF image)
1350	0.583127270	10.0.2.4	10.0.2.15	HTTP	353	GET /favicon.ico HTTP/1.1
1352	0.583476168	10.0.2.15	10.0.2.4	HTTP	555	HTTP/1.1 404 Not Found (text/html)

In this case: $0.583476168 - 0.000527459 = 0.582948709$

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

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



No.	Time	Source	Destination	Protocol	Length	Info
4	0.000455483	10.0.2.4	10.0.2.15	HTTP	404	GET /lab.html HTTP/1.1
6	0.001045044	10.0.2.15	10.0.2.4	HTTP	573	HTTP/1.1 200 OK (text/html)
8	0.122390728	10.0.2.4	10.0.2.15	HTTP	347	GET /1.jpg HTTP/1.1
143	0.131318520	10.0.2.15	10.0.2.4	HTTP	23370	HTTP/1.1 200 OK (JPEG JFIF image)
173	0.165677414	10.0.2.4	10.0.2.15	HTTP	347	GET /2.jpg HTTP/1.1
176	0.166084722	10.0.2.4	10.0.2.15	HTTP	347	GET /3.jpg HTTP/1.1
223	0.168639457	10.0.2.4	10.0.2.15	HTTP	348	GET /10.jpg HTTP/1.1
225	0.168776466	10.0.2.4	10.0.2.15	HTTP	347	GET /9.jpg HTTP/1.1
226	0.168776536	10.0.2.4	10.0.2.15	HTTP	347	GET /8.jpg HTTP/1.1
229	0.168845806	10.0.2.4	10.0.2.15	HTTP	347	GET /7.jpg HTTP/1.1
232	0.168967506	10.0.2.4	10.0.2.15	HTTP	347	GET /6.jpg HTTP/1.1
235	0.169026748	10.0.2.4	10.0.2.15	HTTP	347	GET /5.jpg HTTP/1.1
361	0.173011579	10.0.2.4	10.0.2.15	HTTP	347	GET /4.jpg HTTP/1.1
421	0.176443007	10.0.2.15	10.0.2.4	HTTP	16989	HTTP/1.1 200 OK (JPEG JFIF image)
1269	0.202795655	10.0.2.15	10.0.2.4	HTTP	2773	HTTP/1.1 200 OK (JPEG JFIF image)
1374	0.205861073	10.0.2.15	10.0.2.4	HTTP	5686	HTTP/1.1 200 OK (JPEG JFIF image)
1443	0.209940953	10.0.2.15	10.0.2.4	HTTP	9857	HTTP/1.1 200 OK (JPEG JFIF image)
1966	0.376794154	10.0.2.15	10.0.2.4	HTTP	5679	HTTP/1.1 200 OK (JPEG JFIF image)
1968	0.401802733	10.0.2.4	10.0.2.15	HTTP	353	GET /favicon.ico HTTP/1.1
1970	0.402154797	10.0.2.15	10.0.2.4	HTTP	555	HTTP/1.1 404 Not Found (text/html)

In this case: $0.402154797 - 0.000455483 = 0.401699314$

OBSERVATIONS:

No. of Persistent Connections	Initial Time	Final Time	Total Response Time
0 (Non-Persistent)	9.077415314	9.876542911	0.799127597
2	0.000440628	0.500704276	0.500263648
4	3.319543647	3.827989476	0.508445829
6	0.000527459	0.583476168	0.582948709
10	0.000455483	0.402154797	0.401699314

Based on the observations, it is observed that load time for the non-persistent connection is slower than when compared to persistent connections. Furthermore, as the value of persistent connection is increased from 2 all the way to 6, it is observed that the load time for 10 images increase gradually. But the load time observed for 10 persistent connection is the fastest among all the connections.

The optimal persistent connection will be 2 as the load time is better than that of non-persistent connection and it does not put too much stress on the server.