

# COMPUTER NETWORKS LABORATORY

## WEEK #2

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SEMESTER : 4

SECTION : H

SRN : PESIUG19CS485

### **Note:**

For this assignment, I have used macOS as CLIENT and Ubuntu from Virtual Box as SERVER.

I installed Apache in the server side, that is, in Ubuntu.

### **1. INSTALLATIONS:**

#### **• Setting Up Apache Server On Ubuntu (Server):**

- Apache Server can be installed with **sudo apt-get install apache2**.
- The status of the installed server can be viewed using **systemctl status apache2**.

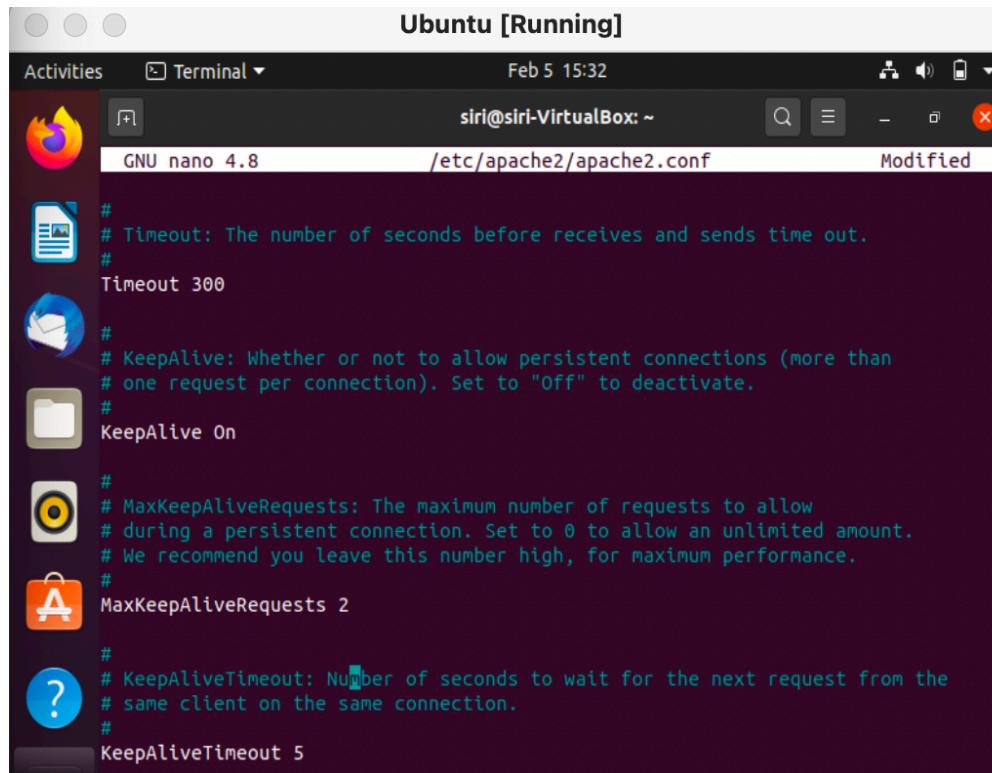
```
Ubuntu [Running]
Activities Terminal Feb 5 15:17
siri@siri-VirtualBox:~$ sudo systemctl status apache2
● apache2.service - The Apache HTTP Server
   Loaded: loaded (/lib/systemd/system/apache2.service; enabled; vendor pres>
   Active: active (running) since Fri 2021-02-05 15:10:56 IST; 1min 29s ago
     Docs: https://httpd.apache.org/docs/2.4/
   Main PID: 2370 (apache2)
      Tasks: 55 (limit: 2316)
     Memory: 5.5M
    CGroup: /system.slice/apache2.service
            └─2370 /usr/sbin/apache2 -k start
                ├─2371 /usr/sbin/apache2 -k start
                ├─2372 /usr/sbin/apache2 -k start

Feb 05 15:10:56 siri-VirtualBox systemd[1]: Starting The Apache HTTP Server...
Feb 05 15:10:56 siri-VirtualBox apachectl[2369]: AH00558: apache2: Could not r>
Feb 05 15:10:56 siri-VirtualBox systemd[1]: Started The Apache HTTP Server.
lines 1-15/15 (END)
```

- **Allowing Persistent Connections on Apache Server:**

Changing setting in apache2.conf

- KeepAlive to On
- MaxKeepAliveRequests to 2



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

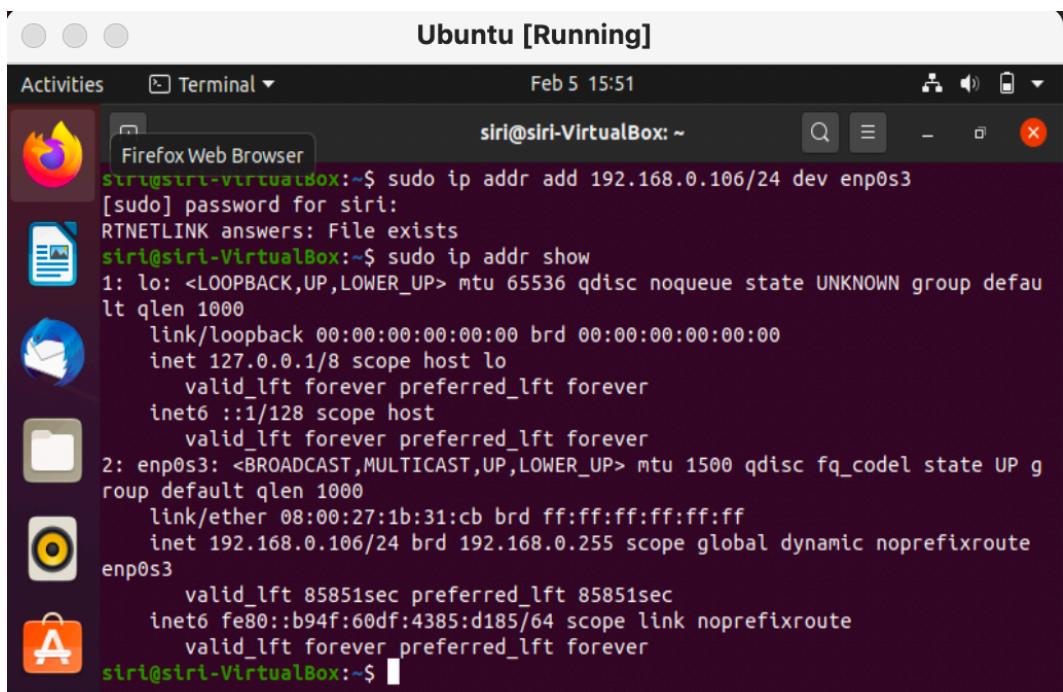
#
# KeepAlive: Whether or not to allow persistent connections (more than
# one request per connection). Set to "Off" to deactivate.
#
KeepAlive On

#
# 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
```

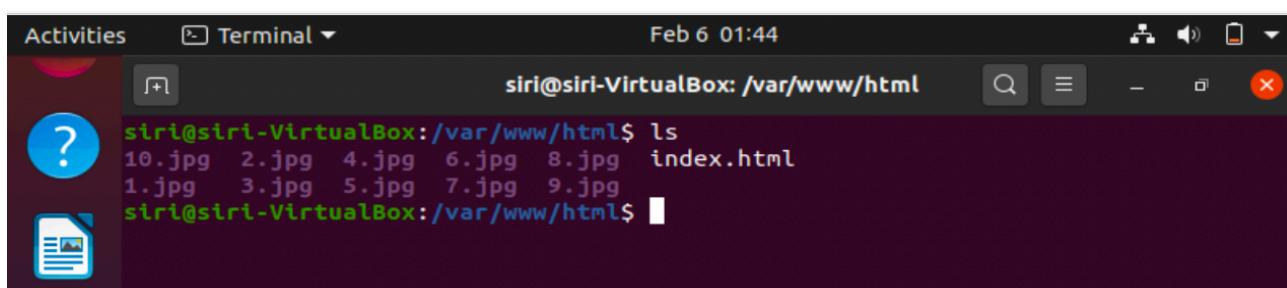
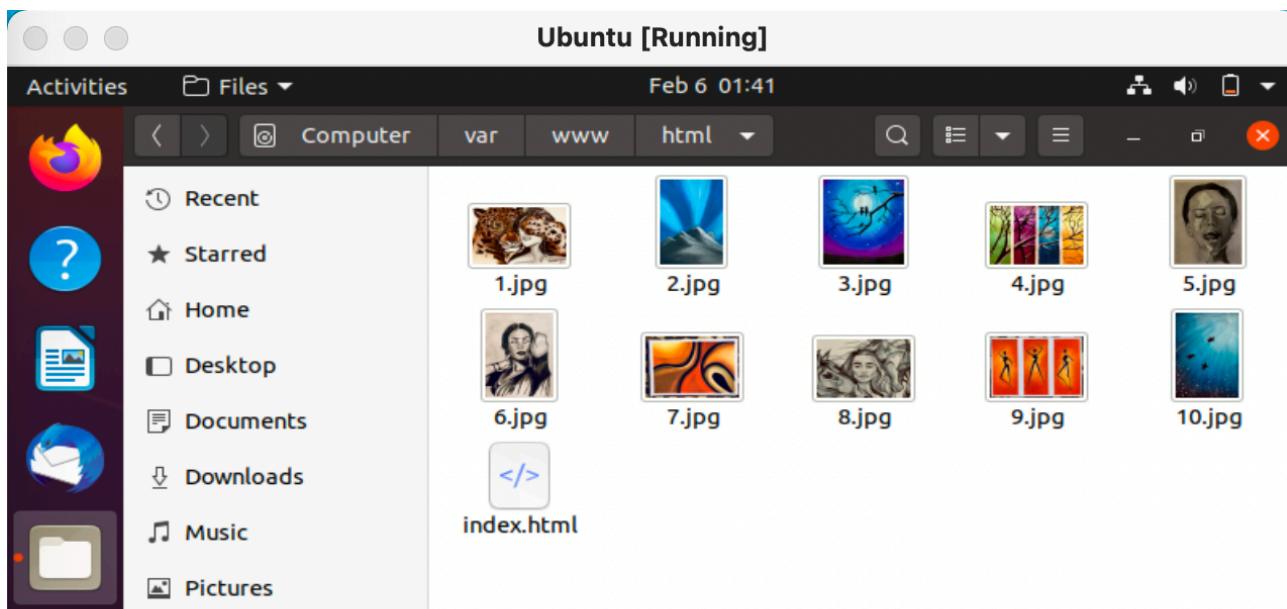
- **Setting Server IP address:**

- The server IP address was set to 192.168.0.106 while the client IP address was set to 192.168.0.100

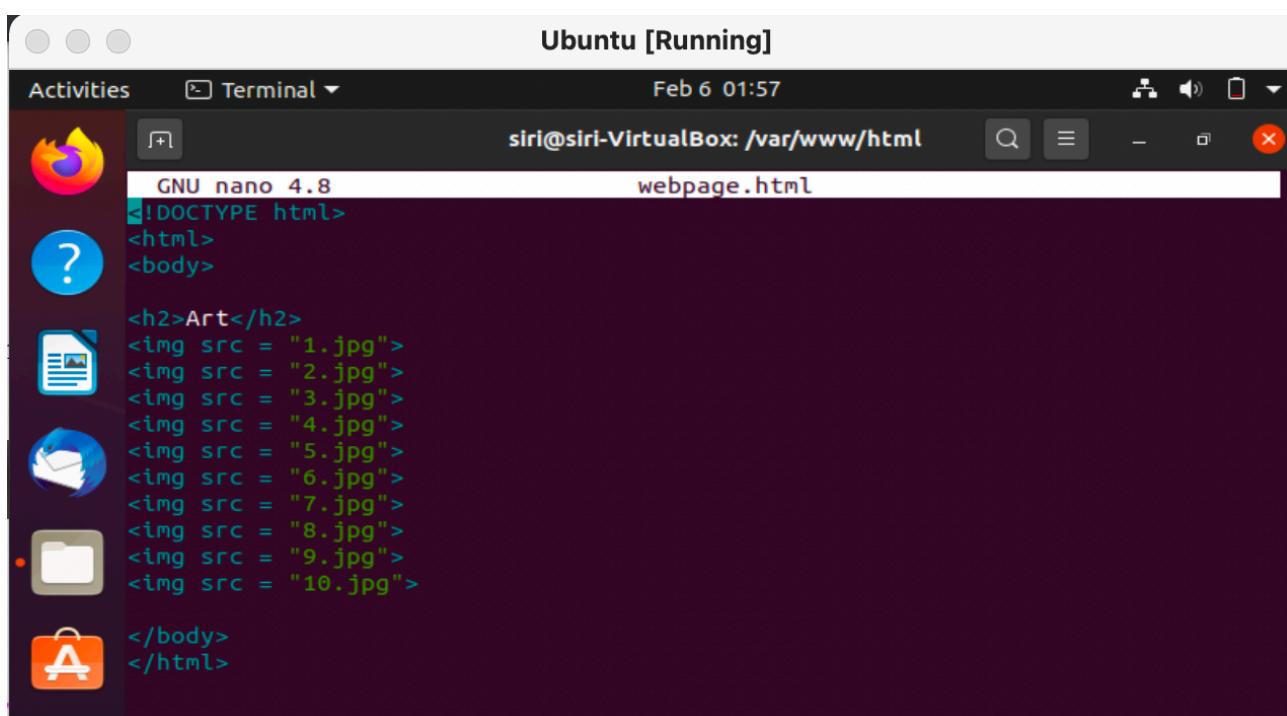


```
siri@siri-VirtualBox:~$ sudo ip addr add 192.168.0.106/24 dev enp0s3
[sudo] password for siri:
RTNETLINK answers: File exists
siri@siri-VirtualBox:~$ sudo ip addr show
1: lo: <LOOPBACK,UP,LOWER_UP> mtu 65536 qdisc noqueue state UNKNOWN group default qlen 1000
    link/loopback 00:00:00:00:00:00 brd 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 08:00:27:1b:31:cb brd ff:ff:ff:ff:ff:ff
    inet 192.168.0.106/24 brd 192.168.0.255 scope global dynamic noprefixroute
        valid_lft 85851sec preferred_lft 85851sec
    inet6 fe80::b94f:60df:4385:d185/64 scope link noprefixroute
        valid_lft forever preferred_lft forever
siri@siri-VirtualBox:~$
```

- Downloading 1-3MB images into var/www/html

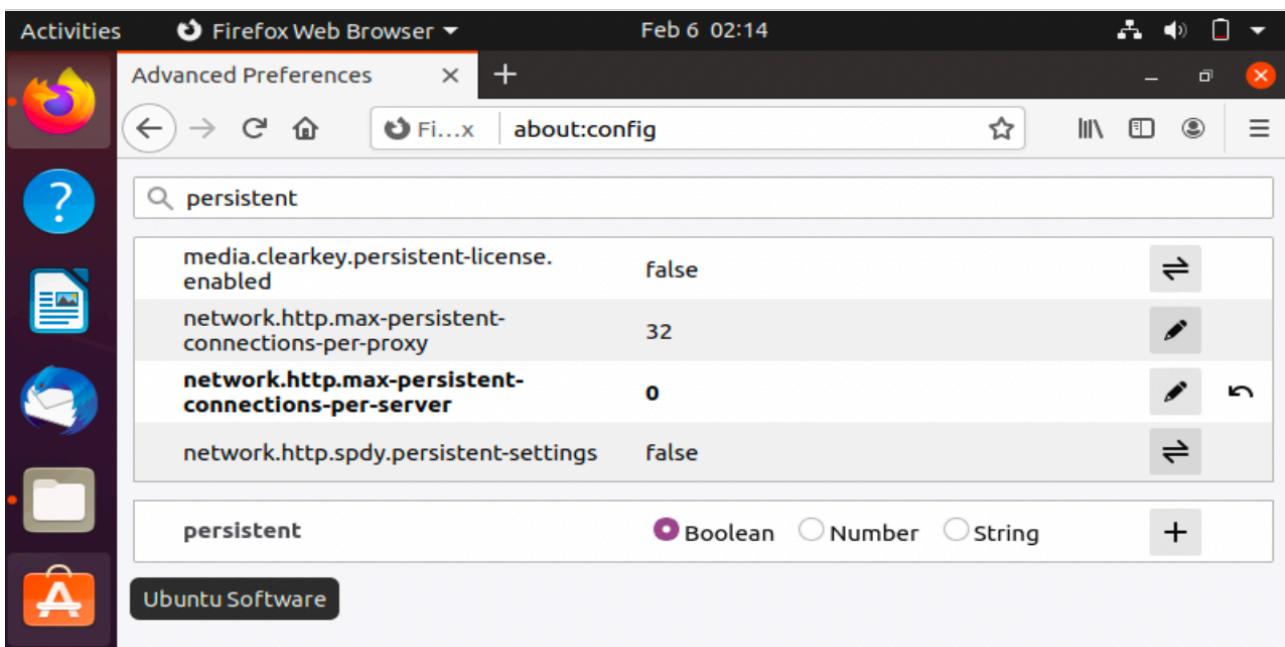


- A html file to add 10 images to prepare a webpage:



## **2. NON PERSISTENT CONNECTIONS:**

- On Firefox, after typing about:config in the browser, and searching for the term ‘persistent’, we make the following changes:
  1. Set max-persistent-connections-per-server to **0**.
  2. Set persistent-settings value to **false**.



- **Accessing the webpage from the Client (macOS) side**

Wireshark Packet Capture between client and server:

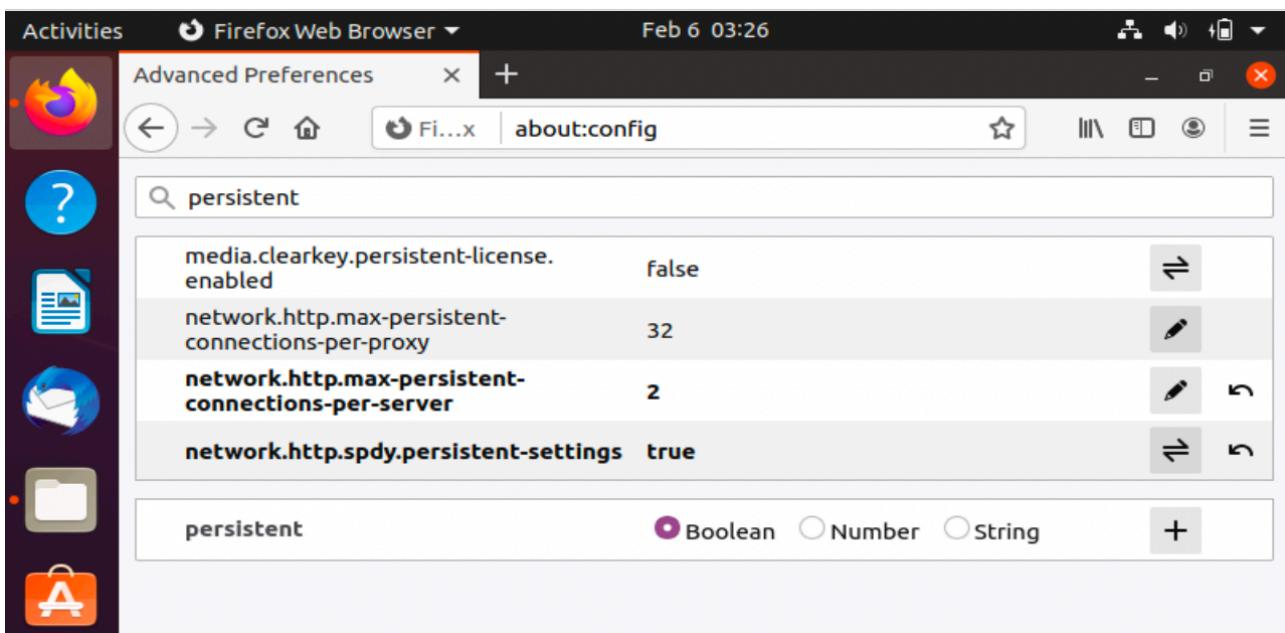
No.	Time	Source	Destination	Protocol	Length	Info
233	10.372689	192.168.0.100	192.168.0.106	HTTP	637	GET /webpage.html HTTP/1.1
235	10.373354	192.168.0.106	192.168.0.100	HTTP	516	HTTP/1.1 200 OK (text/html)
241	10.433235	192.168.0.100	192.168.0.106	HTTP	571	GET /1.jpg HTTP/1.1
243	10.434125	192.168.0.106	192.168.0.100	HTTP	248	HTTP/1.1 304 Not Modified
245	10.434618	192.168.0.100	192.168.0.106	HTTP	571	GET /2.jpg HTTP/1.1
248	10.435259	192.168.0.106	192.168.0.100	HTTP	213	HTTP/1.1 304 Not Modified
265	10.436399	192.168.0.100	192.168.0.106	HTTP	571	GET /4.jpg HTTP/1.1
266	10.436494	192.168.0.100	192.168.0.106	HTTP	571	GET /3.jpg HTTP/1.1
268	10.436562	192.168.0.100	192.168.0.106	HTTP	571	GET /5.jpg HTTP/1.1
269	10.436633	192.168.0.100	192.168.0.106	HTTP	571	GET /6.jpg HTTP/1.1
273	10.437203	192.168.0.106	192.168.0.100	HTTP	248	HTTP/1.1 304 Not Modified
275	10.437734	192.168.0.106	192.168.0.100	HTTP	248	HTTP/1.1 304 Not Modified
276	10.437761	192.168.0.106	192.168.0.100	HTTP	248	HTTP/1.1 304 Not Modified
279	10.438035	192.168.0.106	192.168.0.100	HTTP	248	HTTP/1.1 304 Not Modified
281	10.444032	192.168.0.100	192.168.0.106	HTTP	571	GET /8.jpg HTTP/1.1
283	10.444461	192.168.0.100	192.168.0.106	HTTP	571	GET /9.jpg HTTP/1.1
285	10.444710	192.168.0.100	192.168.0.106	HTTP	572	GET /10.jpg HTTP/1.1
287	10.445239	192.168.0.100	192.168.0.106	HTTP	570	GET /7.jpg HTTP/1.1
289	10.445684	192.168.0.106	192.168.0.100	HTTP	248	HTTP/1.1 304 Not Modified
290	10.445708	192.168.0.106	192.168.0.100	HTTP	248	HTTP/1.1 304 Not Modified
293	10.446482	192.168.0.106	192.168.0.100	HTTP	247	HTTP/1.1 304 Not Modified
294	10.446505	192.168.0.106	192.168.0.100	HTTP	248	HTTP/1.1 304 Not Modified

Load Time:  $10.444710 - 10.372689 = 0.072021\text{s}$

### 3. PERSISTENT CONNECTIONS:

- On Firefox, after typing about:config in the browser, and searching for the term ‘persistent’, we make the following changes.  
Set persistent-settings value to **true**.

#### • 2 Persistent Connections:

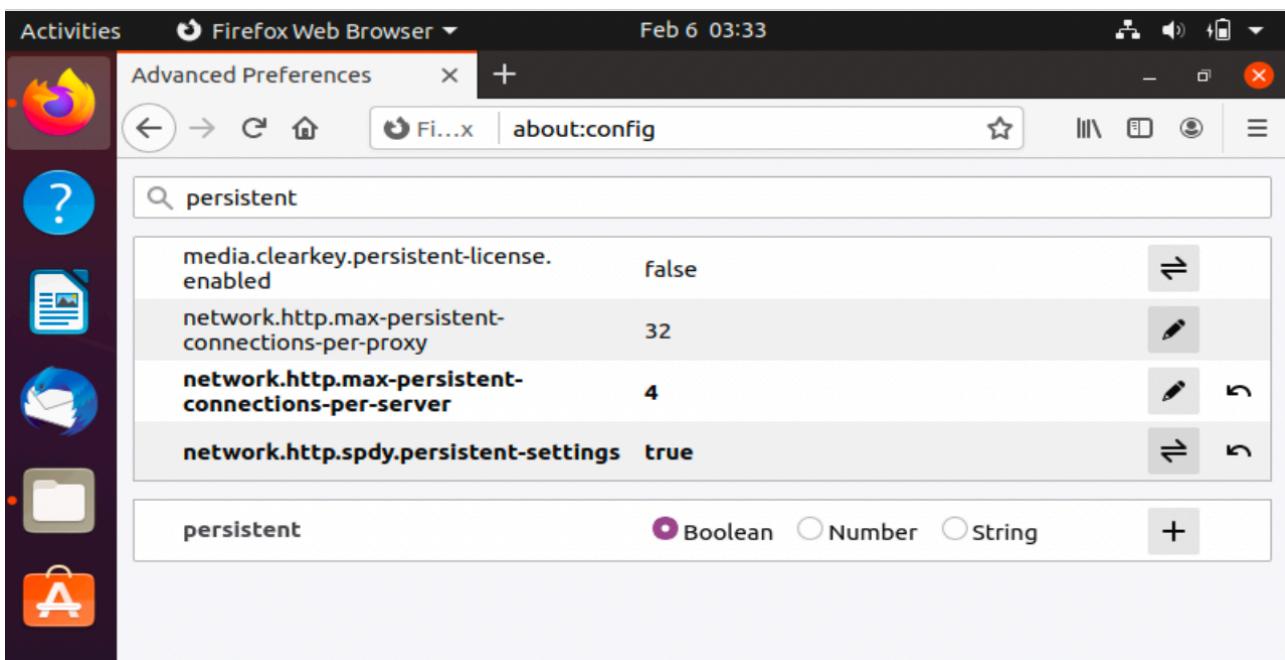


#### Wireshark Packet Capture between client and server:

No.	Time	Source	Destination	Protocol	Length	Info
949	23.558778	192.168.0.100	192.168.0.106	HTTP	637	GET /webpage.html HTTP/1.1
951	23.559705	192.168.0.106	192.168.0.100	HTTP	516	HTTP/1.1 200 OK (text/html)
954	23.624531	192.168.0.100	192.168.0.106	HTTP	571	GET /1.jpg HTTP/1.1
956	23.625930	192.168.0.106	192.168.0.100	HTTP	248	HTTP/1.1 304 Not Modified
958	23.628422	192.168.0.100	192.168.0.106	HTTP	571	GET /5.jpg HTTP/1.1
971	23.629543	192.168.0.100	192.168.0.106	HTTP	571	GET /2.jpg HTTP/1.1
973	23.629734	192.168.0.100	192.168.0.106	HTTP	571	GET /3.jpg HTTP/1.1
974	23.629982	192.168.0.100	192.168.0.106	HTTP	571	GET /4.jpg HTTP/1.1
981	23.630828	192.168.0.106	192.168.0.100	HTTP	248	HTTP/1.1 304 Not Modified
983	23.631129	192.168.0.100	192.168.0.106	HTTP	571	GET /6.jpg HTTP/1.1
984	23.631206	192.168.0.106	192.168.0.100	HTTP	248	HTTP/1.1 304 Not Modified
986	23.631340	192.168.0.106	192.168.0.100	HTTP	248	HTTP/1.1 304 Not Modified
989	23.631497	192.168.0.106	192.168.0.100	HTTP	213	HTTP/1.1 304 Not Modified
994	23.631810	192.168.0.106	192.168.0.100	HTTP	248	HTTP/1.1 304 Not Modified
996	23.631874	192.168.0.100	192.168.0.106	HTTP	570	GET /7.jpg HTTP/1.1
999	23.632198	192.168.0.100	192.168.0.106	HTTP	571	GET /8.jpg HTTP/1.1
1001	23.632677	192.168.0.100	192.168.0.106	HTTP	571	GET /9.jpg HTTP/1.1
1002	23.632748	192.168.0.100	192.168.0.106	HTTP	572	GET /10.jpg HTTP/1.1
1005	23.632895	192.168.0.106	192.168.0.100	HTTP	247	HTTP/1.1 304 Not Modified
1007	23.633072	192.168.0.106	192.168.0.100	HTTP	248	HTTP/1.1 304 Not Modified
1009	23.633110	192.168.0.106	192.168.0.100	HTTP	248	HTTP/1.1 304 Not Modified
1011	23.633293	192.168.0.106	192.168.0.100	HTTP	248	HTTP/1.1 304 Not Modified
1031	25.716262	192.168.0.106	34.122.121.32	HTTP	153	GET / HTTP/1.1
1034	25.991752	34.122.121.32	192.168.0.106	HTTP	214	HTTP/1.1 204 No Content

Load Time: 23.632748 - 23.558778 = 0.07397s

- **4 Persistent Connections:**

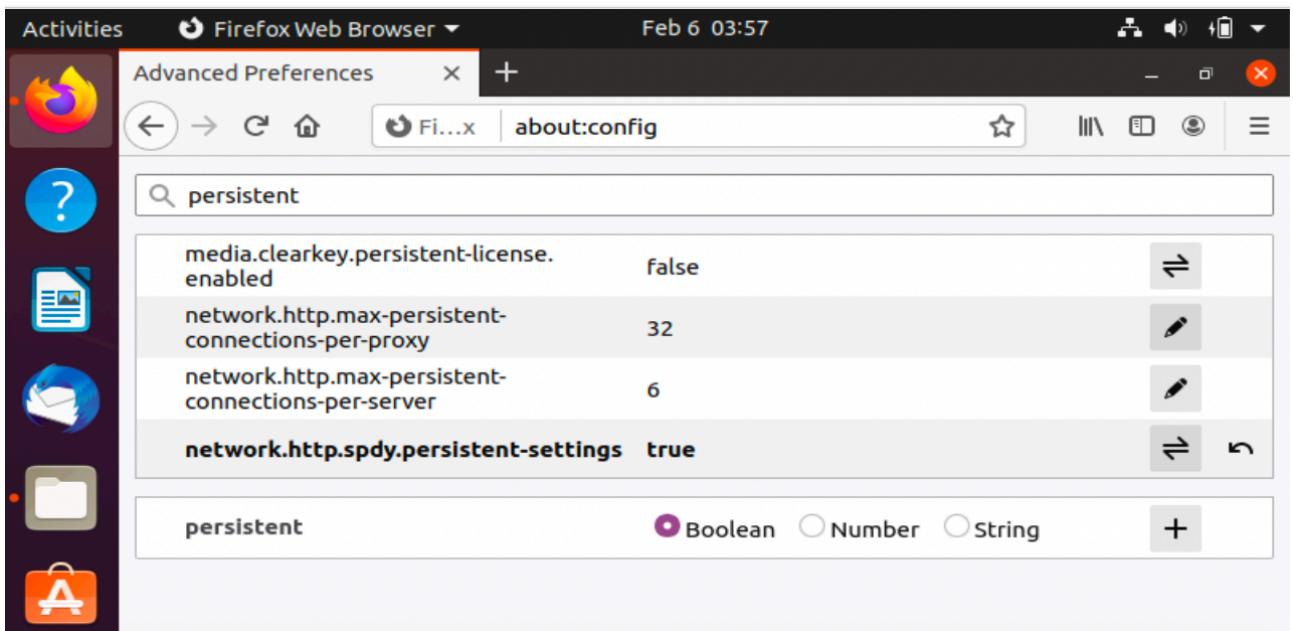


### Wireshark Packet Capture between client and server:

Wi-Fi: en0						
No.	Time	Source	Destination	Protocol	Length	Info
152	15.341140	192.168.0.100	192.168.0.106	HTTP	433	GET /webpage.html HTTP/1.1
154	15.342923	192.168.0.106	192.168.0.100	HTTP	516	HTTP/1.1 200 OK (text/html)
156	15.353156	192.168.0.100	192.168.0.106	HTTP	449	GET /1.jpg HTTP/1.1
458	15.367464	192.168.0.100	192.168.0.106	HTTP	449	GET /2.jpg HTTP/1.1
496	15.370322	192.168.0.100	192.168.0.106	HTTP	449	GET /4.jpg HTTP/1.1
499	15.370616	192.168.0.100	192.168.0.106	HTTP	449	GET /5.jpg HTTP/1.1
502	15.370886	192.168.0.100	192.168.0.106	HTTP	449	GET /6.jpg HTTP/1.1
503	15.371021	192.168.0.100	192.168.0.106	HTTP	449	GET /3.jpg HTTP/1.1
7344	15.488374	192.168.0.106	192.168.0.100	HTTP	746	HTTP/1.1 200 OK (JPEG JFIF image)
7366	15.489579	192.168.0.100	192.168.0.106	HTTP	449	GET /7.jpg HTTP/1.1
8187	15.505938	192.168.0.100	192.168.0.106	HTTP	449	GET /8.jpg HTTP/1.1
8283	15.507150	192.168.0.106	192.168.0.100	HTTP	890	HTTP/1.1 200 OK (JPEG JFIF image)
8449	15.507967	192.168.0.100	192.168.0.106	HTTP	449	GET /9.jpg HTTP/1.1
9439	15.522015	192.168.0.106	192.168.0.100	HTTP	628	HTTP/1.1 200 OK (JPEG JFIF image)
123...	15.539780	192.168.0.106	192.168.0.100	HTTP	1100	HTTP/1.1 200 OK (JPEG JFIF image)
124...	15.540295	192.168.0.100	192.168.0.106	HTTP	450	GET /10.jpg HTTP/1.1
148...	15.558163	192.168.0.106	192.168.0.100	HTTP	818	HTTP/1.1 200 OK (JPEG JFIF image)
149...	15.560346	192.168.0.106	192.168.0.100	HTTP	254	HTTP/1.1 200 OK (JPEG JFIF image)
156...	15.569179	192.168.0.106	192.168.0.100	HTTP	1299	HTTP/1.1 200 OK (JPEG JFIF image)
187...	15.618713	192.168.0.106	192.168.0.100	HTTP	1478	HTTP/1.1 200 OK (JPEG JFIF image)
192...	15.626571	192.168.0.106	192.168.0.100	HTTP	855	HTTP/1.1 200 OK (JPEG JFIF image)
198...	15.634745	192.168.0.106	192.168.0.100	HTTP	1110	HTTP/1.1 200 OK (JPEG JFIF image)
198...	15.809948	192.168.0.100	192.168.0.106	HTTP	386	GET /favicon.ico HTTP/1.1
198...	15.810629	192.168.0.106	192.168.0.100	HTTP	556	HTTP/1.1 404 Not Found (text/html)

Load Time: 15.540295 - 15.341140 = 0.199155s

- **6 Persistent Connections:**

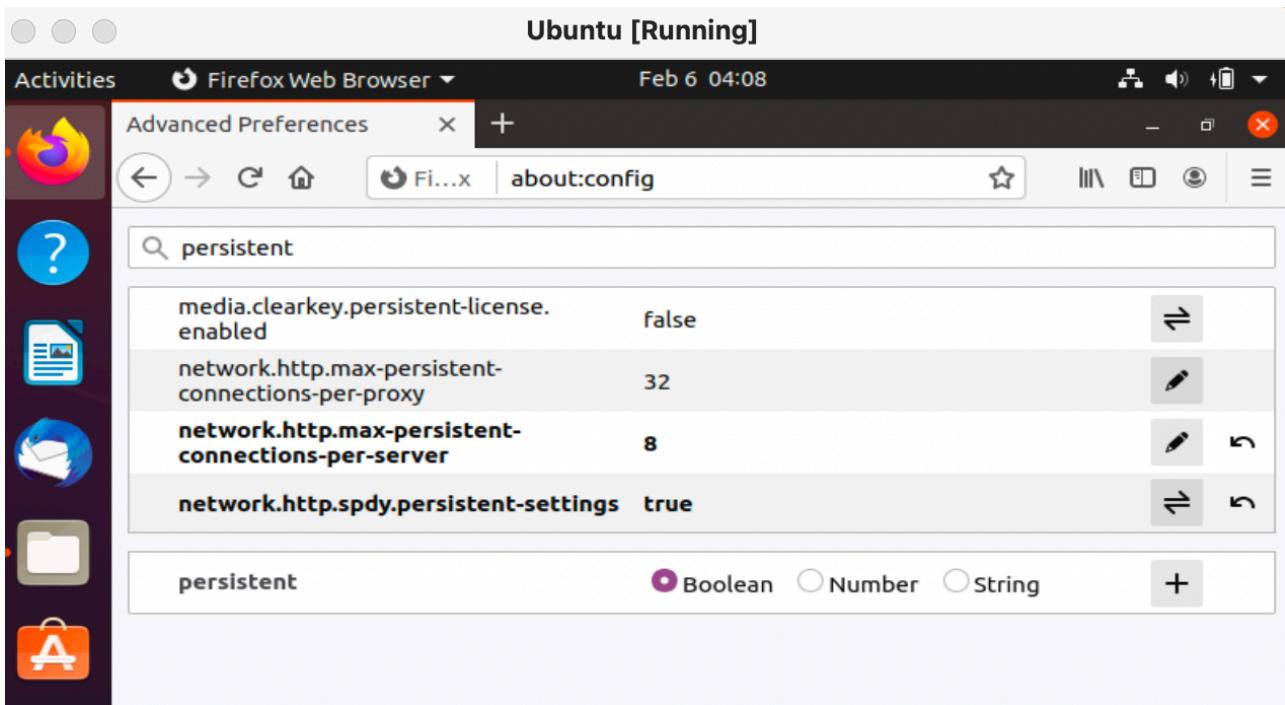


- Wireshark Packet Capture between client and server:

Wi-Fi: en0						
No.	Time	Source	Destination	Protocol	Length	Info
474	37.499410	192.168.0.100	192.168.0.106	HTTP	433	GET /webpage.html HTTP/1.1
476	37.499914	192.168.0.106	192.168.0.100	HTTP	516	HTTP/1.1 200 OK (text/html)
774	53.254660	192.168.0.100	192.168.0.106	HTTP	637	GET /webpage.html HTTP/1.1
776	53.255986	192.168.0.106	192.168.0.100	HTTP	516	HTTP/1.1 200 OK (text/html)
778	53.316283	192.168.0.100	192.168.0.106	HTTP	571	GET /1.jpg HTTP/1.1
780	53.317977	192.168.0.106	192.168.0.100	HTTP	248	HTTP/1.1 304 Not Modified
782	53.319748	192.168.0.100	192.168.0.106	HTTP	571	GET /3.jpg HTTP/1.1
788	53.322952	192.168.0.106	192.168.0.100	HTTP	213	HTTP/1.1 304 Not Modified
802	53.325555	192.168.0.100	192.168.0.106	HTTP	571	GET /2.jpg HTTP/1.1
803	53.325945	192.168.0.100	192.168.0.106	HTTP	571	GET /5.jpg HTTP/1.1
804	53.326222	192.168.0.100	192.168.0.106	HTTP	571	GET /6.jpg HTTP/1.1
805	53.326398	192.168.0.100	192.168.0.106	HTTP	571	GET /4.jpg HTTP/1.1
810	53.327446	192.168.0.106	192.168.0.100	HTTP	248	HTTP/1.1 304 Not Modified
812	53.328503	192.168.0.106	192.168.0.100	HTTP	248	HTTP/1.1 304 Not Modified
814	53.328602	192.168.0.106	192.168.0.100	HTTP	248	HTTP/1.1 304 Not Modified
815	53.328623	192.168.0.106	192.168.0.100	HTTP	248	HTTP/1.1 304 Not Modified
818	53.330214	192.168.0.100	192.168.0.106	HTTP	571	GET /8.jpg HTTP/1.1
820	53.330950	192.168.0.100	192.168.0.106	HTTP	570	GET /7.jpg HTTP/1.1
821	53.331674	192.168.0.106	192.168.0.100	HTTP	248	HTTP/1.1 304 Not Modified
824	53.332420	192.168.0.106	192.168.0.100	HTTP	247	HTTP/1.1 304 Not Modified
826	53.346880	192.168.0.100	192.168.0.106	HTTP	572	GET /10.jpg HTTP/1.1
827	53.347123	192.168.0.100	192.168.0.106	HTTP	571	GET /9.jpg HTTP/1.1
830	53.349414	192.168.0.106	192.168.0.100	HTTP	213	HTTP/1.1 304 Not Modified
833	53.349526	192.168.0.106	192.168.0.100	HTTP	213	HTTP/1.1 304 Not Modified

Load Time: 53.347123 - 53.254660 = 0.092463s

- 8 Persistent Connections:

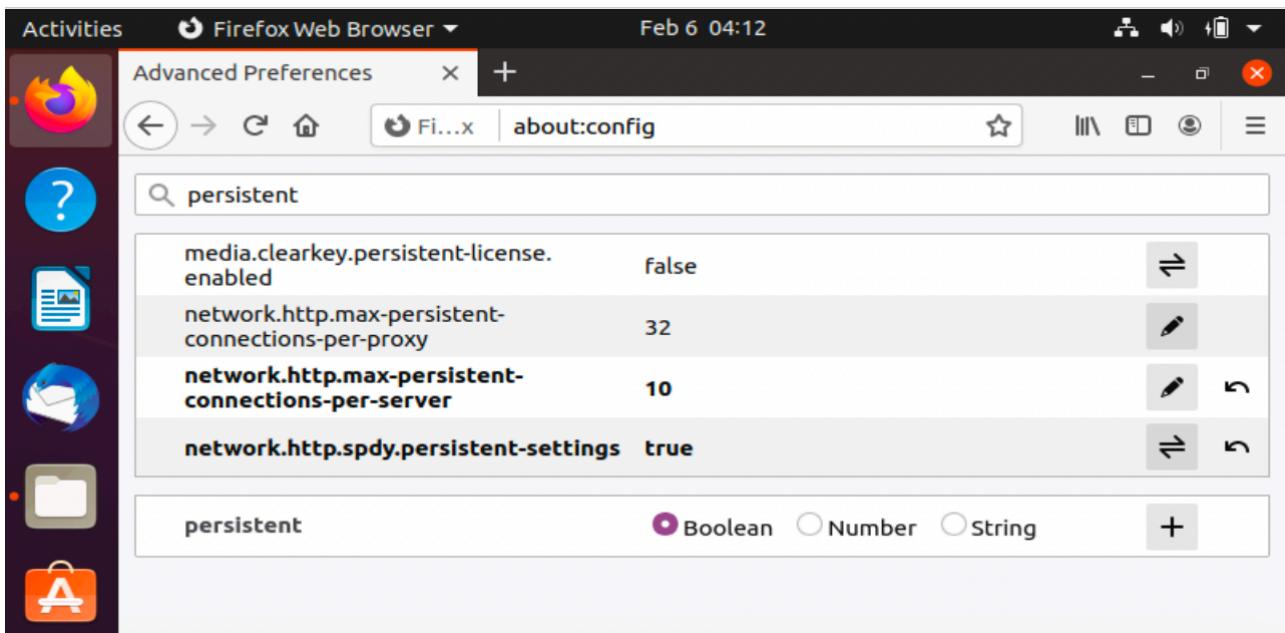


### Wireshark Packet Capture between client and server:

No.	Time	Source	Destination	Protocol	Length	Info
54	7.046678	192.168.0.100	192.168.0.106	HTTP	433	GET /webpage.html HTTP/1.1
56	7.047249	192.168.0.106	192.168.0.100	HTTP	516	HTTP/1.1 200 OK (text/html)
245	23.048002	192.168.0.100	192.168.0.106	HTTP	433	GET /webpage.html HTTP/1.1
247	23.048516	192.168.0.106	192.168.0.100	HTTP	516	HTTP/1.1 200 OK (text/html)
249	23.063681	192.168.0.100	192.168.0.106	HTTP	538	GET /5.jpg HTTP/1.1
251	23.064751	192.168.0.106	192.168.0.100	HTTP	248	HTTP/1.1 304 Not Modified
259	23.068672	192.168.0.100	192.168.0.106	HTTP	538	GET /6.jpg HTTP/1.1
260	23.068888	192.168.0.100	192.168.0.106	HTTP	538	GET /1.jpg HTTP/1.1
262	23.069521	192.168.0.106	192.168.0.100	HTTP	248	HTTP/1.1 304 Not Modified
266	23.071062	192.168.0.106	192.168.0.100	HTTP	248	HTTP/1.1 304 Not Modified
268	23.071232	192.168.0.100	192.168.0.106	HTTP	538	GET /9.jpg HTTP/1.1
272	23.071577	192.168.0.100	192.168.0.106	HTTP	538	GET /4.jpg HTTP/1.1
274	23.071934	192.168.0.106	192.168.0.100	HTTP	213	HTTP/1.1 304 Not Modified
278	23.072399	192.168.0.106	192.168.0.100	HTTP	248	HTTP/1.1 304 Not Modified
284	23.074725	192.168.0.100	192.168.0.106	HTTP	538	GET /2.jpg HTTP/1.1
288	23.074962	192.168.0.100	192.168.0.106	HTTP	537	GET /7.jpg HTTP/1.1
290	23.075167	192.168.0.106	192.168.0.100	HTTP	248	HTTP/1.1 304 Not Modified
293	23.075405	192.168.0.106	192.168.0.100	HTTP	247	HTTP/1.1 304 Not Modified
296	23.076059	192.168.0.100	192.168.0.106	HTTP	538	GET /3.jpg HTTP/1.1
298	23.076806	192.168.0.100	192.168.0.106	HTTP	539	GET /10.jpg HTTP/1.1
299	23.076917	192.168.0.100	192.168.0.106	HTTP	538	GET /8.jpg HTTP/1.1
302	23.077155	192.168.0.106	192.168.0.100	HTTP	248	HTTP/1.1 304 Not Modified
304	23.077498	192.168.0.106	192.168.0.100	HTTP	248	HTTP/1.1 304 Not Modified
306	23.077630	192.168.0.106	192.168.0.100	HTTP	213	HTTP/1.1 304 Not Modified

Load Time: 23.076917 - 23.048002 = 0.028915s

- **10 Persistent Connections:**



Wireshark Packet Capture between client and server:

No.	Time	Source	Destination	Protocol	Length	Info
131	5.861697	35.232.111.17	192.168.0.106	HTTP	214	HTTP/1.1 204 No Content
330	19.442462	192.168.0.100	192.168.0.106	HTTP	433	GET /webpage.html HTTP/1.1
332	19.443150	192.168.0.106	192.168.0.100	HTTP	516	HTTP/1.1 200 OK (text/html)
575	34.907019	192.168.0.100	192.168.0.106	HTTP	571	GET /1.jpg HTTP/1.1
589	34.908692	192.168.0.106	192.168.0.100	HTTP	248	HTTP/1.1 304 Not Modified
594	34.909137	192.168.0.100	192.168.0.106	HTTP	571	GET /3.jpg HTTP/1.1
595	34.909218	192.168.0.100	192.168.0.106	HTTP	571	GET /4.jpg HTTP/1.1
596	34.909275	192.168.0.100	192.168.0.106	HTTP	571	GET /2.jpg HTTP/1.1
598	34.909329	192.168.0.100	192.168.0.106	HTTP	571	GET /5.jpg HTTP/1.1
600	34.909390	192.168.0.100	192.168.0.106	HTTP	571	GET /6.jpg HTTP/1.1
603	34.909873	192.168.0.100	192.168.0.106	HTTP	570	GET /7.jpg HTTP/1.1
605	34.910029	192.168.0.106	192.168.0.100	HTTP	248	HTTP/1.1 304 Not Modified
608	34.910271	192.168.0.106	192.168.0.100	HTTP	248	HTTP/1.1 304 Not Modified
610	34.910310	192.168.0.106	192.168.0.100	HTTP	248	HTTP/1.1 304 Not Modified
612	34.910948	192.168.0.106	192.168.0.100	HTTP	248	HTTP/1.1 304 Not Modified
614	34.911132	192.168.0.106	192.168.0.100	HTTP	247	HTTP/1.1 304 Not Modified
616	34.911346	192.168.0.106	192.168.0.100	HTTP	248	HTTP/1.1 304 Not Modified
618	34.911542	192.168.0.100	192.168.0.106	HTTP	571	GET /8.jpg HTTP/1.1
619	34.911805	192.168.0.100	192.168.0.106	HTTP	571	GET /9.jpg HTTP/1.1
621	34.911871	192.168.0.100	192.168.0.106	HTTP	572	GET /10.jpg HTTP/1.1
624	34.912520	192.168.0.106	192.168.0.100	HTTP	248	HTTP/1.1 304 Not Modified
626	34.912803	192.168.0.106	192.168.0.100	HTTP	248	HTTP/1.1 304 Not Modified
627	34.912825	192.168.0.106	192.168.0.100	HTTP	248	HTTP/1.1 304 Not Modified

Load Time: 34.911871 - 34.907019 = 0.004852s

## **OBSERVATION:**

Load Time is the difference between the time when the html page was requested and the time when the last image was sent as a response.

Persistent Connections	Time at first GET	Time at Last Image	Load Time (s)
0	10.372689	10.444710	0.072021
2	23.558778	23.632748	0.07397
4	15.341140	15.540295	0.199155
6	53.254660	53.347123	0.092463
8	23.048002	23.076917	0.028915
10	34.907019	34.911871	0.004852

From the above table, we can see that in the case of 10 Persistent Connections, the load time is 0.004852 seconds. Since this is the lowest, we can say that optimal number of persistent connections is 10.