

Computer Networks Lab - Week 2

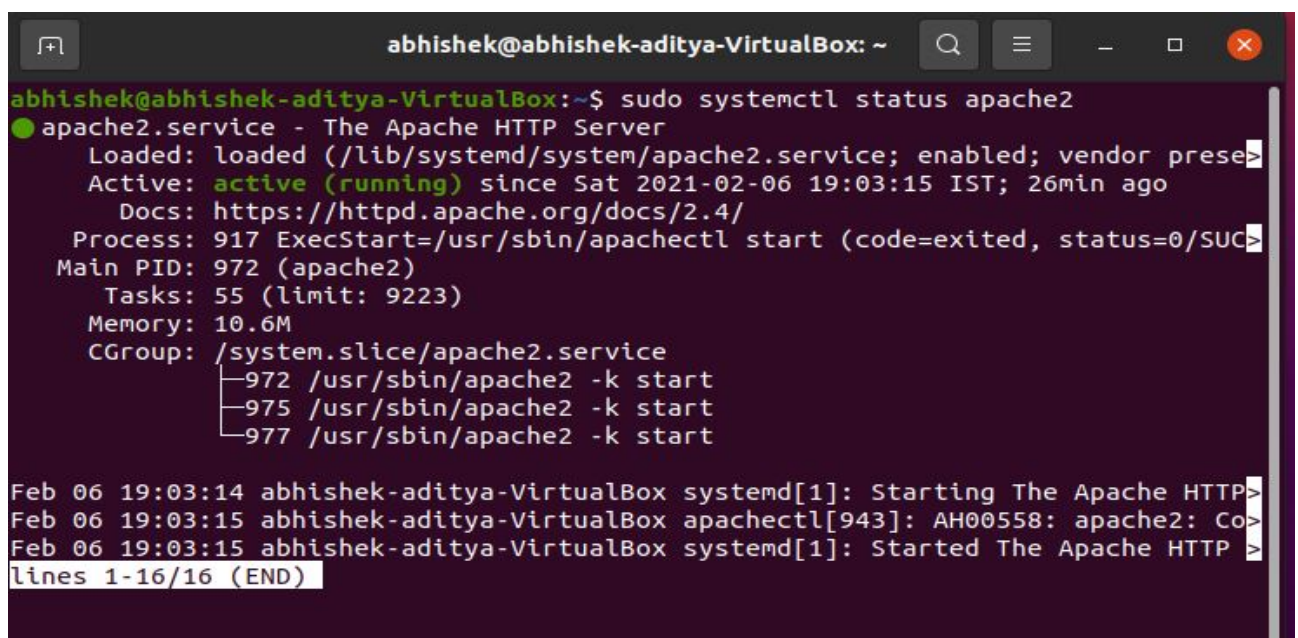
Name : Abhishek Aditya BS
SRN : PES1UG19CS019
Section : A
Semester : 4

1. Configuration of Apache Server and Client Environment

- To create a server – client architecture, two Virtual Machines were set up. The former is referred to as the server machine and the latter is the client machine.
- Apache Server was installed and configured on the server machine, and a static webpage consisting of 10 objects (images) was created and hosted on the local network between these machines.
- We need to observe and determine the effect of the number of persistent connections on the load time of this static webpage.

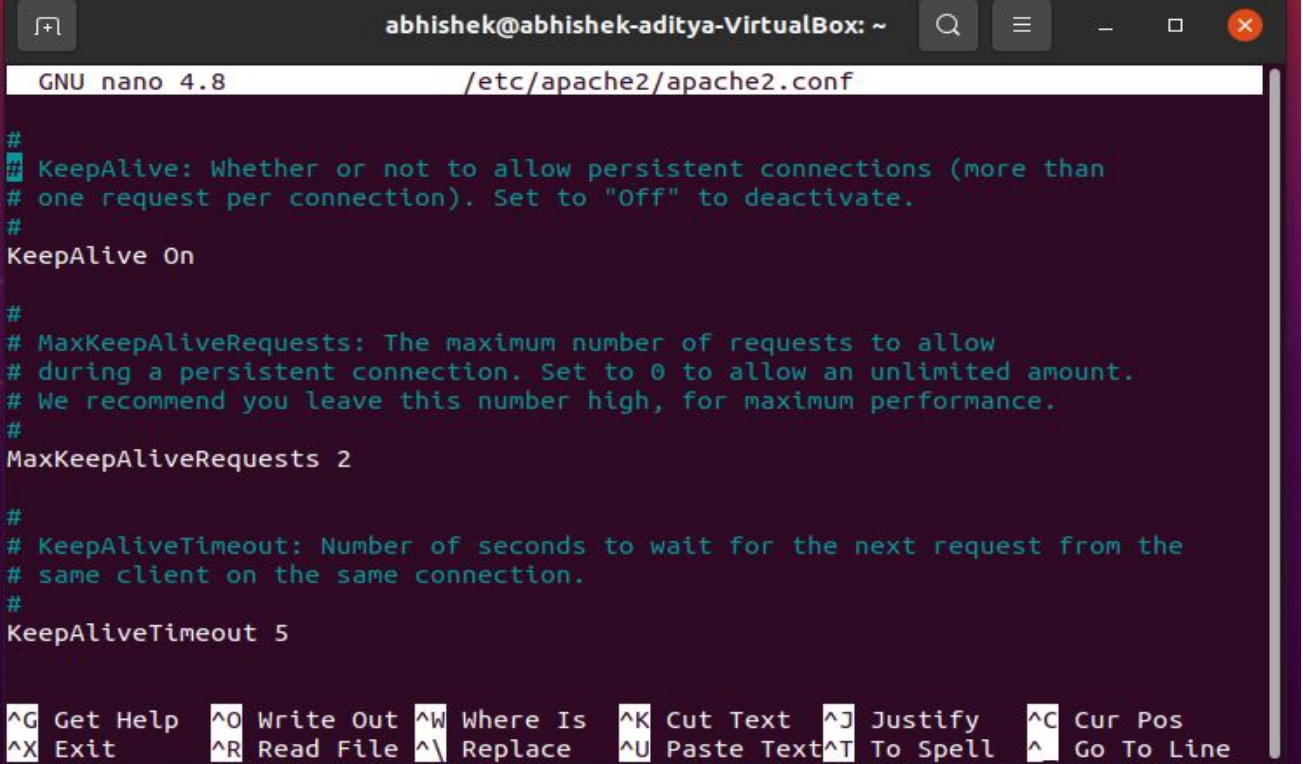
1.1 Setting up Apache Server

- The apache server is installed with the command
sudo apt-get install apache2
- The status of the newly installed server can be verified using
sudo systemctl status apache2



```
abhishek@abhishek-aditya-VirtualBox: ~  
abhishek@abhishek-aditya-VirtualBox:~$ sudo systemctl status apache2  
● apache2.service - The Apache HTTP Server  
   Loaded: loaded (/lib/systemd/system/apache2.service; enabled; vendor prese  
   Active: active (running) since Sat 2021-02-06 19:03:15 IST; 26min ago  
     Docs: https://httpd.apache.org/docs/2.4/  
  Process: 917 ExecStart=/usr/sbin/apachectl start (code=exited, status=0/SUC  
 Main PID: 972 (apache2)  
    Tasks: 55 (limit: 9223)  
   Memory: 10.6M  
    CGroup: /system.slice/apache2.service  
            └─972 /usr/sbin/apache2 -k start  
              └─975 /usr/sbin/apache2 -k start  
                └─977 /usr/sbin/apache2 -k start  
  
Feb 06 19:03:14 abhishek-aditya-VirtualBox systemd[1]: Starting The Apache HTTP  
Feb 06 19:03:15 abhishek-aditya-VirtualBox apachectl[943]: AH00558: apache2: Co  
Feb 06 19:03:15 abhishek-aditya-VirtualBox systemd[1]: Started The Apache HTTP  
lines 1-16/16 (END)
```

- 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
 - The **keepAlive** option was set (i.e. value was made **ON**)
 - The **MaximumKeepAliveRequests** were set to **2**



```
abhishek@abhishek-aditya-VirtualBox: ~  
GNU nano 4.8 /etc/apache2/apache2.conf  
#  
# 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  
  
^G Get Help  ^O Write Out ^W Where Is  ^K Cut Text  ^J Justify   ^C Cur Pos  
^X Exit      ^R Read File ^\ Replace   ^U Paste Text ^T To Spell  ^_ Go To Line
```

1.2 Adding Custom IP Addresses for Server and Client

- A custom IP Address was set for both the Server and Client machines
- The **Server IP Address** was set to **10.0.1.18** and the **Client IP Address** was set to **10.0.1.19** as per the serial number.
- The IP address were assigned using **sudo ip addr add**

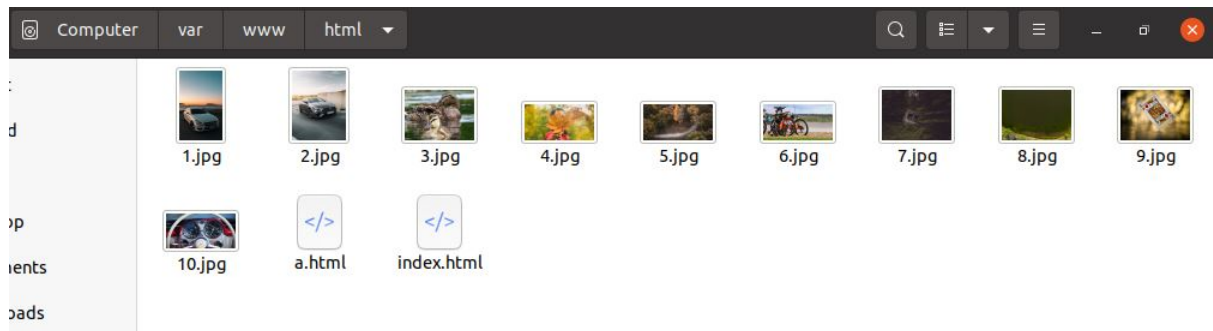
```
dev ens33
abhishek@abhishek-aditya-VirtualBox:~$ sudo ip addr show
1: lo: <LOOPBACK,UP,LOWER_UP> mtu 65536 qdisc noqueue state UNKNOWN
group default qlen 1000
    link/loopback 00:00:00:00:00:00 brd 00:00:00:00:00:00
    inet 127.0.0.1/8 scope host lo
        valid_lft forever preferred_lft forever
    inet6 ::1/128 scope host
        valid_lft forever preferred_lft forever
2: ens33: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc fq_codel
state UP group default qlen 1000
    link/ether 00:0c:29:04:ba:54 brd ff:ff:ff:ff:ff:ff
    altname enp2s1
    inet 192.168.174.128/24 brd 192.168.174.255 scope global dynamic
noprofixroute ens33
        valid_lft 1021sec preferred_lft 1021sec
    inet 10.0.1.18/24 scope global ens33
        valid_lft forever preferred_lft forever
    inet6 fe80::c32e:fd60:5685:2470/64 scope link noprofixroute
        valid_lft forever preferred_lft forever
abhishek@abhishek-aditya-VirtualBox:~$
```

1.3 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/**
- An HTML file was created which contains 10 images(1.jpg,2.jpg,...) each of 2 MB size and the file along with the images were placed at the server path **/var/www/html/**

```
Open  ▾  [icon]  *a.html
/var/www/html

1 <!DOCTYPE html>
2 <html>
3 <body>
4
5 <h2>My webpage</h2>
6 
7 
8 
9 
10 
11 
12 
13 
14 
15 
16
17 </body>
18 </html>
19 |
```

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-connections-per-server** to 0 and **persistent-settings** to false

Packet Capture Screenshot

No.	Time	Source	Destination	Protocol	Length	Info
4	0.000652321	10.0.1.19	10.0.1.18	HTTP	402	GET /a.html HTTP/1.1
6	0.001419574	10.0.1.18	10.0.1.19	HTTP	562	HTTP/1.1 200 OK (text/html)
8	0.028900656	10.0.1.19	10.0.1.18	HTTP	345	GET /1.jpg HTTP/1.1
121	0.038880414	10.0.1.18	10.0.1.19	HTTP	18098	HTTP/1.1 200 OK (JPEG JFIF image)
123	0.045443732	10.0.1.19	10.0.1.18	HTTP	345	GET /2.jpg HTTP/1.1
199	0.053242145	10.0.1.18	10.0.1.19	HTTP	7197	HTTP/1.1 200 OK (JPEG JFIF image)
207	0.055356237	10.0.1.19	10.0.1.18	HTTP	345	GET /3.jpg HTTP/1.1
294	0.062170544	10.0.1.18	10.0.1.19	HTTP	18022	HTTP/1.1 200 OK (JPEG JFIF image)
297	0.062752671	10.0.1.19	10.0.1.18	HTTP	345	GET /4.jpg HTTP/1.1
356	0.069032707	10.0.1.18	10.0.1.19	HTTP	6294	HTTP/1.1 200 OK (JPEG JFIF image)
358	0.069432588	10.0.1.19	10.0.1.18	HTTP	345	GET /5.jpg HTTP/1.1
410	0.083730365	10.0.1.18	10.0.1.19	HTTP	25240	HTTP/1.1 200 OK (JPEG JFIF image)
417	0.086162662	10.0.1.19	10.0.1.18	HTTP	345	GET /6.jpg HTTP/1.1
543	0.102688508	10.0.1.18	10.0.1.19	HTTP	19508	HTTP/1.1 200 OK (JPEG JFIF image)
546	0.104510028	10.0.1.19	10.0.1.18	HTTP	345	GET /7.jpg HTTP/1.1
623	0.118711865	10.0.1.18	10.0.1.19	HTTP	37183	HTTP/1.1 200 OK (JPEG JFIF image)
625	0.126528138	10.0.1.19	10.0.1.18	HTTP	345	GET /8.jpg HTTP/1.1
679	0.132677355	10.0.1.18	10.0.1.19	HTTP	24747	HTTP/1.1 200 OK (JPEG JFIF image)
687	0.134426454	10.0.1.19	10.0.1.18	HTTP	345	GET /9.jpg HTTP/1.1
787	0.144713548	10.0.1.18	10.0.1.19	HTTP	49793	HTTP/1.1 200 OK (JPEG JFIF image)
789	0.144928802	10.0.1.19	10.0.1.18	HTTP	346	GET /10.jpg HTTP/1.1
851	0.149593941	10.0.1.18	10.0.1.19	HTTP	5094	HTTP/1.1 200 OK (JPEG JFIF image)
853	0.154002114	10.0.1.19	10.0.1.18	HTTP	351	GET /favicon.ico HTTP/1.1

Frame 4: 402 bytes on wire (3216 bits), 402 bytes captured (3216 bits) on interface any, id 0
 Linux cooked capture
 Internet Protocol Version 4, Src: 10.0.1.19, Dst: 10.0.1.18
 Transmission Control Protocol, Src Port: 49346, Dst Port: 80, Seq: 1, Ack: 1, Len: 334
 Hypertext Transfer Protocol

Time taken to capture images

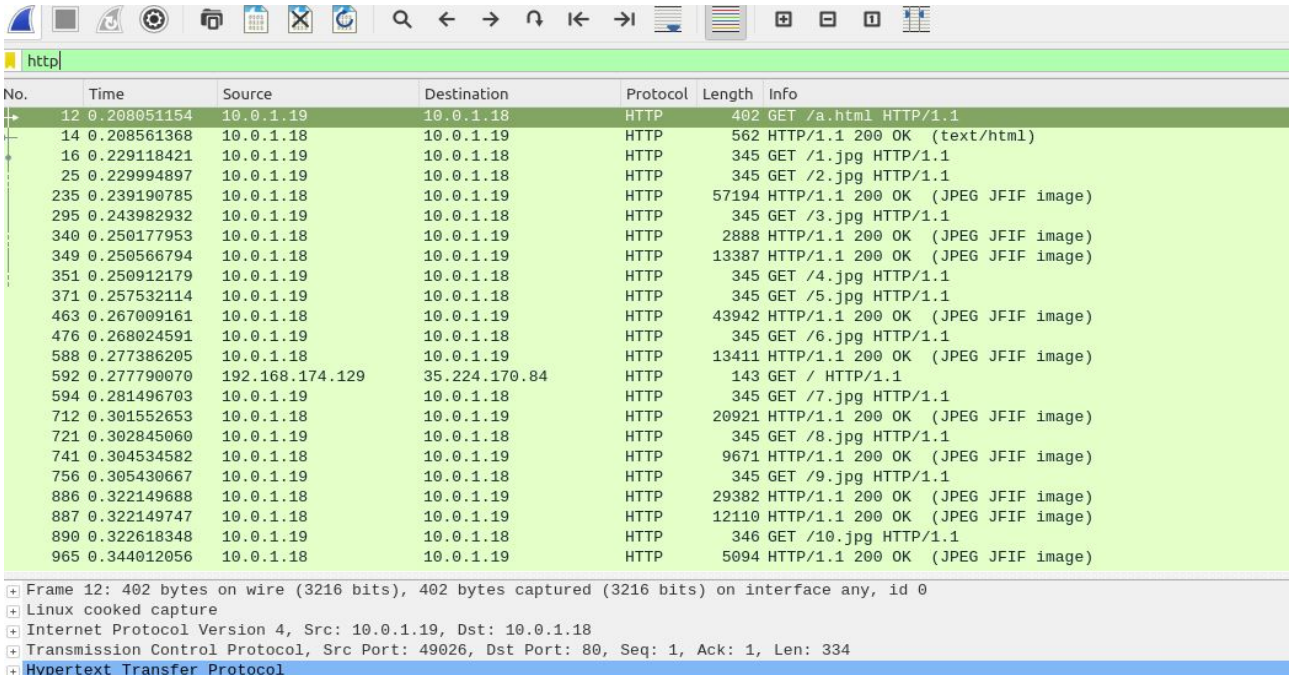
$$0.149593941 - 0.000652321 = 0.14894162$$

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

Packet Capture Screenshot



No.	Time	Source	Destination	Protocol	Length	Info
12	0.208051154	10.0.1.19	10.0.1.18	HTTP	402	GET /a.html HTTP/1.1
14	0.208561368	10.0.1.18	10.0.1.19	HTTP	562	HTTP/1.1 200 OK (text/html)
16	0.229118421	10.0.1.19	10.0.1.18	HTTP	345	GET /1.jpg HTTP/1.1
25	0.229994897	10.0.1.19	10.0.1.18	HTTP	345	GET /2.jpg HTTP/1.1
235	0.239190785	10.0.1.18	10.0.1.19	HTTP	57194	HTTP/1.1 200 OK (JPEG JFIF image)
295	0.243982932	10.0.1.19	10.0.1.18	HTTP	345	GET /3.jpg HTTP/1.1
340	0.250177953	10.0.1.18	10.0.1.19	HTTP	2888	HTTP/1.1 200 OK (JPEG JFIF image)
349	0.250566794	10.0.1.18	10.0.1.19	HTTP	13387	HTTP/1.1 200 OK (JPEG JFIF image)
351	0.250912179	10.0.1.19	10.0.1.18	HTTP	345	GET /4.jpg HTTP/1.1
371	0.257532114	10.0.1.19	10.0.1.18	HTTP	345	GET /5.jpg HTTP/1.1
463	0.267009161	10.0.1.18	10.0.1.19	HTTP	43942	HTTP/1.1 200 OK (JPEG JFIF image)
476	0.268024591	10.0.1.19	10.0.1.18	HTTP	345	GET /6.jpg HTTP/1.1
588	0.277386205	10.0.1.18	10.0.1.19	HTTP	13411	HTTP/1.1 200 OK (JPEG JFIF image)
592	0.277790070	192.168.174.129	35.224.170.84	HTTP	143	GET / HTTP/1.1
594	0.281496703	10.0.1.19	10.0.1.18	HTTP	345	GET /7.jpg HTTP/1.1
712	0.301552653	10.0.1.18	10.0.1.19	HTTP	20921	HTTP/1.1 200 OK (JPEG JFIF image)
721	0.302845060	10.0.1.19	10.0.1.18	HTTP	345	GET /8.jpg HTTP/1.1
741	0.304534582	10.0.1.18	10.0.1.19	HTTP	9671	HTTP/1.1 200 OK (JPEG JFIF image)
756	0.305430667	10.0.1.19	10.0.1.18	HTTP	345	GET /9.jpg HTTP/1.1
886	0.322149688	10.0.1.18	10.0.1.19	HTTP	29382	HTTP/1.1 200 OK (JPEG JFIF image)
887	0.322149747	10.0.1.18	10.0.1.19	HTTP	12110	HTTP/1.1 200 OK (JPEG JFIF image)
890	0.322618348	10.0.1.19	10.0.1.18	HTTP	346	GET /10.jpg HTTP/1.1
965	0.344012056	10.0.1.18	10.0.1.19	HTTP	5094	HTTP/1.1 200 OK (JPEG JFIF image)

Frame 12: 402 bytes on wire (3216 bits), 402 bytes captured (3216 bits) on interface any, id 0

Linux cooked capture

Internet Protocol Version 4, Src: 10.0.1.19, Dst: 10.0.1.18

Transmission Control Protocol, Src Port: 49026, Dst Port: 80, Seq: 1, Ack: 1, Len: 334

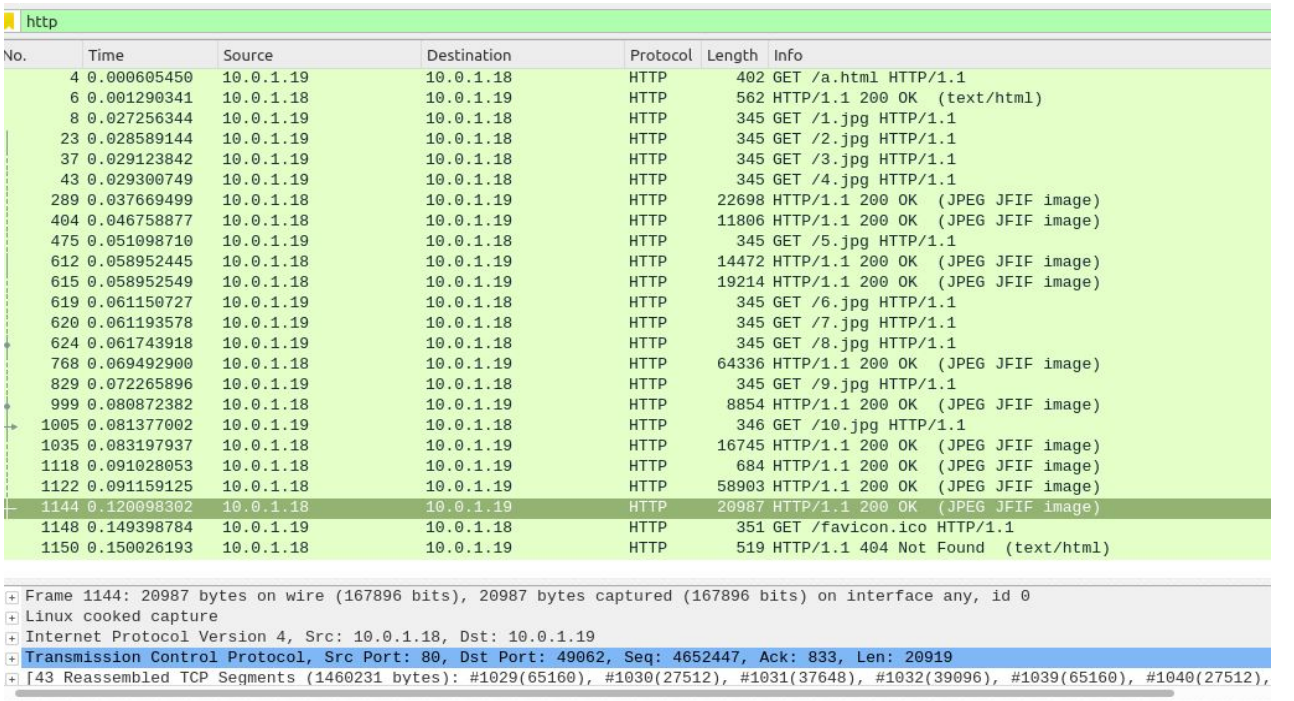
Hypertext Transfer Protocol

Time taken to capture images

$$0.344012056 - 0.208051154 = 0.135960902$$

3.2 4 Persistent Connections

Packet Capture Screenshot



No.	Time	Source	Destination	Protocol	Length	Info
4	0.000605450	10.0.1.19	10.0.1.18	HTTP	402	GET /a.html HTTP/1.1
6	0.001290341	10.0.1.18	10.0.1.19	HTTP	562	HTTP/1.1 200 OK (text/html)
8	0.027256344	10.0.1.19	10.0.1.18	HTTP	345	GET /1.jpg HTTP/1.1
23	0.028589144	10.0.1.19	10.0.1.18	HTTP	345	GET /2.jpg HTTP/1.1
37	0.029123842	10.0.1.19	10.0.1.18	HTTP	345	GET /3.jpg HTTP/1.1
43	0.029300749	10.0.1.19	10.0.1.18	HTTP	345	GET /4.jpg HTTP/1.1
289	0.037669499	10.0.1.18	10.0.1.19	HTTP	22698	HTTP/1.1 200 OK (JPEG JFIF image)
404	0.046758877	10.0.1.18	10.0.1.19	HTTP	11806	HTTP/1.1 200 OK (JPEG JFIF image)
475	0.051098710	10.0.1.19	10.0.1.18	HTTP	345	GET /5.jpg HTTP/1.1
612	0.058952445	10.0.1.18	10.0.1.19	HTTP	14472	HTTP/1.1 200 OK (JPEG JFIF image)
615	0.058952549	10.0.1.18	10.0.1.19	HTTP	19214	HTTP/1.1 200 OK (JPEG JFIF image)
619	0.061150727	10.0.1.19	10.0.1.18	HTTP	345	GET /6.jpg HTTP/1.1
620	0.061193578	10.0.1.19	10.0.1.18	HTTP	345	GET /7.jpg HTTP/1.1
624	0.061743918	10.0.1.19	10.0.1.18	HTTP	345	GET /8.jpg HTTP/1.1
768	0.069492900	10.0.1.18	10.0.1.19	HTTP	64336	HTTP/1.1 200 OK (JPEG JFIF image)
829	0.072265896	10.0.1.19	10.0.1.18	HTTP	345	GET /9.jpg HTTP/1.1
999	0.080872382	10.0.1.18	10.0.1.19	HTTP	8854	HTTP/1.1 200 OK (JPEG JFIF image)
1005	0.081377002	10.0.1.19	10.0.1.18	HTTP	346	GET /10.jpg HTTP/1.1
1035	0.083197937	10.0.1.18	10.0.1.19	HTTP	16745	HTTP/1.1 200 OK (JPEG JFIF image)
1118	0.091028053	10.0.1.18	10.0.1.19	HTTP	684	HTTP/1.1 200 OK (JPEG JFIF image)
1122	0.091159125	10.0.1.18	10.0.1.19	HTTP	58903	HTTP/1.1 200 OK (JPEG JFIF image)
1144	0.120098302	10.0.1.18	10.0.1.19	HTTP	20987	HTTP/1.1 200 OK (JPEG JFIF image)
1148	0.149398784	10.0.1.19	10.0.1.18	HTTP	351	GET /favicon.ico HTTP/1.1
1150	0.150026193	10.0.1.18	10.0.1.19	HTTP	519	HTTP/1.1 404 Not Found (text/html)

Frame 1144: 20987 bytes on wire (167896 bits), 20987 bytes captured (167896 bits) on interface any, id 0

Linux cooked capture

Internet Protocol Version 4, Src: 10.0.1.18, Dst: 10.0.1.19

Transmission Control Protocol, Src Port: 80, Dst Port: 49062, Seq: 4652447, Ack: 833, Len: 20919

[43 Reassembled TCP Segments (1460231 bytes): #1029(65160), #1030(27512), #1031(37648), #1032(39096), #1039(65160), #1040(27512),

Time taken to capture images

$$0.120098302 - 0.000605450 = 0.119492852$$

3.3 6 Persistent Connections

Packet Capture Screenshot

http						
No.	Time	Source	Destination	Protocol	Length	Info
4	0.000542428	10.0.1.19	10.0.1.18	HTTP	402	GET /a.html HTTP/1.1
6	0.001590689	10.0.1.18	10.0.1.19	HTTP	562	HTTP/1.1 200 OK (text/html)
8	0.026203944	10.0.1.19	10.0.1.18	HTTP	345	GET /1.jpg HTTP/1.1
18	0.027217323	10.0.1.19	10.0.1.18	HTTP	345	GET /2.jpg HTTP/1.1
51	0.028588176	10.0.1.19	10.0.1.18	HTTP	345	GET /3.jpg HTTP/1.1
70	0.029343803	10.0.1.19	10.0.1.18	HTTP	345	GET /4.jpg HTTP/1.1
118	0.030942532	10.0.1.19	10.0.1.18	HTTP	345	GET /5.jpg HTTP/1.1
134	0.031289979	10.0.1.19	10.0.1.18	HTTP	345	GET /6.jpg HTTP/1.1
667	0.055427621	10.0.1.18	10.0.1.19	HTTP	33296	HTTP/1.1 200 OK (JPEG JFIF image)
688	0.056137847	10.0.1.18	10.0.1.19	HTTP	29682	HTTP/1.1 200 OK (JPEG JFIF image)
695	0.056324997	10.0.1.19	10.0.1.18	HTTP	345	GET /7.jpg HTTP/1.1
747	0.058711983	10.0.1.19	10.0.1.18	HTTP	345	GET /8.jpg HTTP/1.1
748	0.058735425	10.0.1.18	10.0.1.19	HTTP	390	HTTP/1.1 200 OK (JPEG JFIF image)
769	0.059268840	10.0.1.19	10.0.1.18	HTTP	345	GET /9.jpg HTTP/1.1
1097	0.087909356	10.0.1.18	10.0.1.19	HTTP	8223	HTTP/1.1 200 OK (JPEG JFIF image)
1122	0.090255688	10.0.1.18	10.0.1.19	HTTP	3398	HTTP/1.1 200 OK (JPEG JFIF image)
1139	0.092410029	10.0.1.19	10.0.1.18	HTTP	346	GET /10.jpg HTTP/1.1
1141	0.092611704	10.0.1.18	10.0.1.19	HTTP	33435	HTTP/1.1 200 OK (JPEG JFIF image)
1145	0.093184582	10.0.1.18	10.0.1.19	HTTP	42651	HTTP/1.1 200 OK (JPEG JFIF image)
1163	0.095228326	10.0.1.18	10.0.1.19	HTTP	7644	HTTP/1.1 200 OK (JPEG JFIF image)
1184	0.096905377	10.0.1.18	10.0.1.19	HTTP	6353	HTTP/1.1 200 OK (JPEG JFIF image)
1248	0.116781177	10.0.1.18	10.0.1.19	HTTP	35502	HTTP/1.1 200 OK (JPEG JFIF image)
Frame 4: 402 bytes on wire (3216 bits), 402 bytes captured (3216 bits) on interface any, id 0						
Linux cooked capture						
Internet Protocol Version 4, Src: 10.0.1.19, Dst: 10.0.1.18						
Transmission Control Protocol, Src Port: 49094, Dst Port: 80, Seq: 1, Ack: 1, Len: 334						
Hypertext Transfer Protocol						

Time taken to capture images

$$0.116781177 - 0.000542428 = 0.116238749$$

3.4 8 Persistent Connections

Packet Capture Screenshot

http						
No.	Time	Source	Destination	Protocol	Length	Info
4	0.000557596	10.0.1.19	10.0.1.18	HTTP	402	GET /a.html HTTP/1.1
6	0.001232359	10.0.1.18	10.0.1.19	HTTP	562	HTTP/1.1 200 OK (text/html)
8	0.022076902	10.0.1.19	10.0.1.18	HTTP	345	GET /1.jpg HTTP/1.1
27	0.023710049	10.0.1.19	10.0.1.18	HTTP	345	GET /2.jpg HTTP/1.1
57	0.025428616	10.0.1.19	10.0.1.18	HTTP	345	GET /3.jpg HTTP/1.1
59	0.025538968	10.0.1.19	10.0.1.18	HTTP	345	GET /4.jpg HTTP/1.1
99	0.027390964	10.0.1.19	10.0.1.18	HTTP	345	GET /5.jpg HTTP/1.1
118	0.028072690	10.0.1.19	10.0.1.18	HTTP	345	GET /6.jpg HTTP/1.1
208	0.030743862	10.0.1.19	10.0.1.18	HTTP	345	GET /7.jpg HTTP/1.1
214	0.030968267	10.0.1.19	10.0.1.18	HTTP	345	GET /8.jpg HTTP/1.1
616	0.043161929	10.0.1.18	10.0.1.19	HTTP	18098	HTTP/1.1 200 OK (JPEG JFIF image)
1085	0.069404907	10.0.1.18	10.0.1.19	HTTP	9078	HTTP/1.1 200 OK (JPEG JFIF image)
1144	0.079479354	10.0.1.19	10.0.1.18	HTTP	345	GET /9.jpg HTTP/1.1
1201	0.082016978	10.0.1.18	10.0.1.19	HTTP	16430	HTTP/1.1 200 OK (JPEG JFIF image)
1301	0.087326365	10.0.1.18	10.0.1.19	HTTP	166	HTTP/1.1 200 OK (JPEG JFIF image)
1310	0.087632421	10.0.1.19	10.0.1.18	HTTP	346	GET /10.jpg HTTP/1.1
1429	0.099722254	10.0.1.18	10.0.1.19	HTTP	33296	HTTP/1.1 200 OK (JPEG JFIF image)
1449	0.112363912	10.0.1.18	10.0.1.19	HTTP	659	HTTP/1.1 200 OK (JPEG JFIF image)
1539	0.121959923	10.0.1.18	10.0.1.19	HTTP	6476	HTTP/1.1 200 OK (JPEG JFIF image)
1541	0.121959955	10.0.1.18	10.0.1.19	HTTP	34287	HTTP/1.1 200 OK (JPEG JFIF image)
1561	0.128419066	10.0.1.18	10.0.1.19	HTTP	16454	HTTP/1.1 200 OK (JPEG JFIF image)
1602	0.138007696	10.0.1.18	10.0.1.19	HTTP	49982	HTTP/1.1 200 OK (JPEG JFIF image)
1604	0.156740000	10.0.1.19	10.0.1.18	HTTP	351	GET /11.jpg HTTP/1.1
Frame 4: 402 bytes on wire (3216 bits), 402 bytes captured (3216 bits) on interface any, id 0						
Linux cooked capture						
Internet Protocol Version 4, Src: 10.0.1.19, Dst: 10.0.1.18						
Transmission Control Protocol, Src Port: 49190, Dst Port: 80, Seq: 1, Ack: 1, Len: 334						
Hypertext Transfer Protocol						

Time taken to capture images

$$0.138007696 - 0.000557596 = 0.1374501$$

3.5 10 Persistent Connections

Packet Capture Screenshot

No.	Time	Source	Destination	Protocol	Length	Info
4	0.000648789	10.0.1.19	10.0.1.18	HTTP	402	GET /a.html HTTP/1.1
6	0.001403723	10.0.1.18	10.0.1.19	HTTP	562	HTTP/1.1 200 OK (text/html)
8	0.024777225	10.0.1.19	10.0.1.18	HTTP	345	GET /1.jpg HTTP/1.1
17	0.025877556	10.0.1.19	10.0.1.18	HTTP	345	GET /2.jpg HTTP/1.1
42	0.026770041	10.0.1.19	10.0.1.18	HTTP	345	GET /3.jpg HTTP/1.1
57	0.027493022	10.0.1.19	10.0.1.18	HTTP	345	GET /4.jpg HTTP/1.1
78	0.028349852	10.0.1.19	10.0.1.18	HTTP	345	GET /5.jpg HTTP/1.1
130	0.030103084	10.0.1.19	10.0.1.18	HTTP	345	GET /6.jpg HTTP/1.1
146	0.030672161	10.0.1.19	10.0.1.18	HTTP	345	GET /7.jpg HTTP/1.1
206	0.032313099	10.0.1.19	10.0.1.18	HTTP	345	GET /8.jpg HTTP/1.1
244	0.033479627	10.0.1.19	10.0.1.18	HTTP	345	GET /9.jpg HTTP/1.1
270	0.034096931	10.0.1.19	10.0.1.18	HTTP	346	GET /10.jpg HTTP/1.1
1129	0.064974151	10.0.1.18	10.0.1.19	HTTP	390	HTTP/1.1 200 OK (JPEG JFIF image)
1225	0.069843305	10.0.1.18	10.0.1.19	HTTP	35474	HTTP/1.1 200 OK (JPEG JFIF image)
1315	0.073145811	10.0.1.18	10.0.1.19	HTTP	41302	HTTP/1.1 200 OK (JPEG JFIF image)
1440	0.078846089	10.0.1.18	10.0.1.19	HTTP	750	HTTP/1.1 200 OK (JPEG JFIF image)
1595	0.088896647	10.0.1.18	10.0.1.19	HTTP	7801	HTTP/1.1 200 OK (JPEG JFIF image)
1632	0.099141435	10.0.1.18	10.0.1.19	HTTP	10795	HTTP/1.1 200 OK (JPEG JFIF image)
1736	0.108152378	10.0.1.18	10.0.1.19	HTTP	16094	HTTP/1.1 200 OK (JPEG JFIF image)
1775	0.114649756	10.0.1.18	10.0.1.19	HTTP	1440	HTTP/1.1 200 OK (JPEG JFIF image)
1787	0.133801119	10.0.1.18	10.0.1.19	HTTP	5327	HTTP/1.1 200 OK (JPEG JFIF image)
1794	0.140670109	10.0.1.18	10.0.1.19	HTTP	5028	HTTP/1.1 200 OK (JPEG JFIF image)

Frame 4: 402 bytes on wire (3216 bits), 402 bytes captured (3216 bits) on interface any, id 0
 Linux cooked capture
 Internet Protocol Version 4, Src: 10.0.1.19, Dst: 10.0.1.18
 Transmission Control Protocol, Src Port: 49288, Dst Port: 80, Seq: 1, Ack: 1, Len: 334
 Hypertext Transfer Protocol

Time taken to capture images

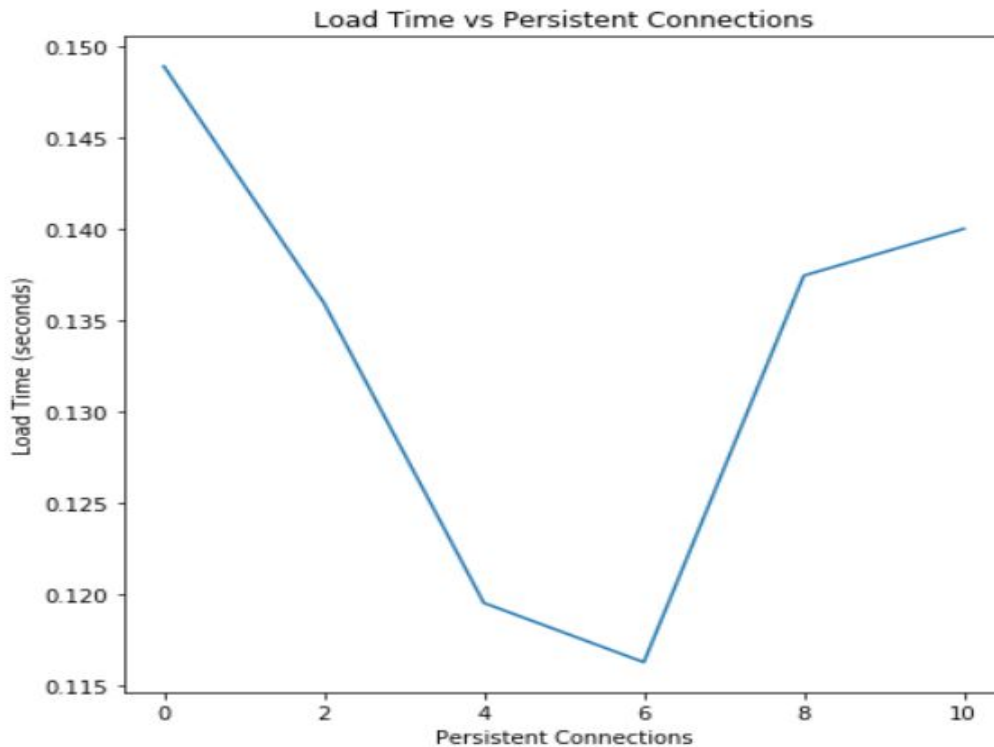
$$0.140670109 - 0.000648789 = 0.14002132$$

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	0.000652321	0.149593941	0.14894162
2	0.208051154	0.344012056	0.135960902
4	0.000605450	0.120098302	0.119492852
6	0.000542428	0.116781177	0.116238749
8	0.000557596	0.138007696	0.1374501
10	0.000648789	0.140670109	0.14002132

- We can also plot the values of Load Time against the number of Persistent Connections to obtain the following visualisation.



- 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 increases, we can observe that the load time decreases 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.