

Computer Networks Lab – Week 2

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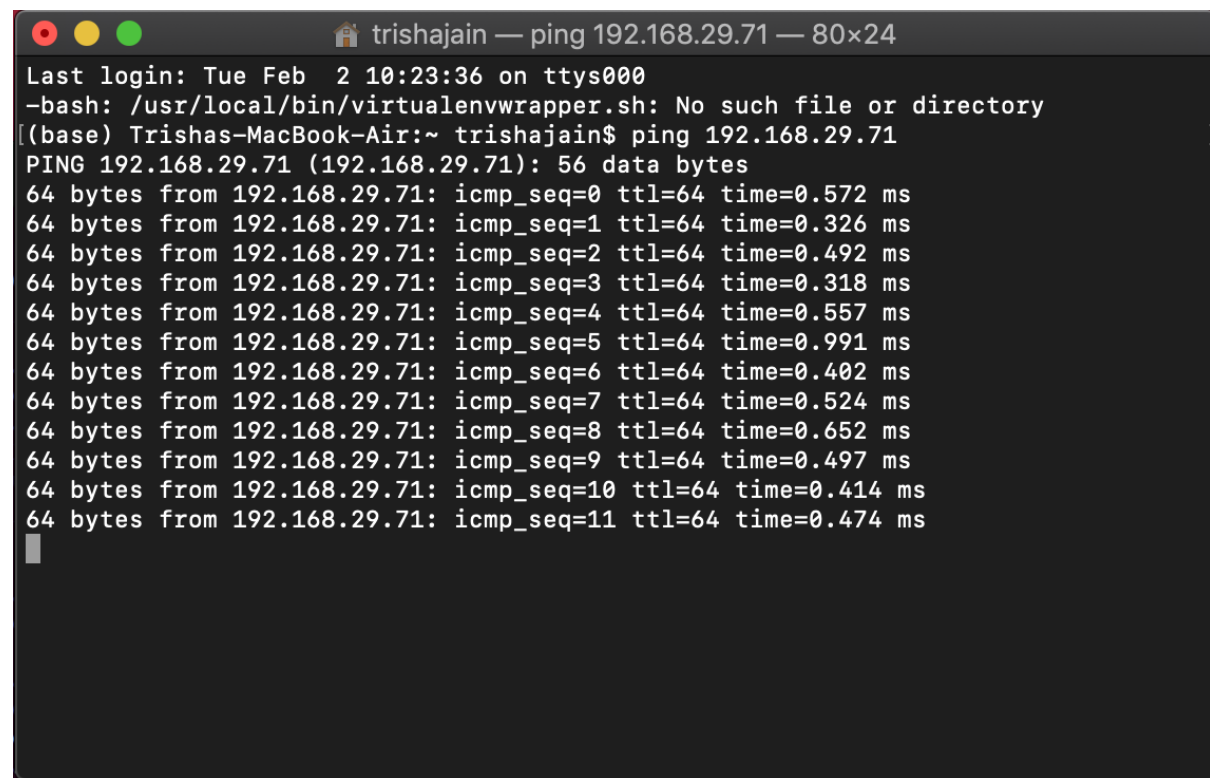
Understanding Persistent and Non-Persistent HTTP Connections

I. Setting up the client and server environments

1. The client is the host system and the server is the Virtual Machine.
2. Apache Server was installed on the (server machine) Virtual Machine and a webpage consisting of 10 objects was created.
3. Then the effect of the number of persistent connections on the load time of the webpage was observed.

Client Server Setup :-

CLIENT MACHINE PINGING SERVER MACHINE



```
trishajain — ping 192.168.29.71 — 80x24
Last login: Tue Feb  2 10:23:36 on ttys000
-bash: /usr/local/bin/virtualenvwrapper.sh: No such file or directory
[(base) Trishas-MacBook-Air:~ trishajain$ ping 192.168.29.71
PING 192.168.29.71 (192.168.29.71): 56 data bytes
64 bytes from 192.168.29.71: icmp_seq=0 ttl=64 time=0.572 ms
64 bytes from 192.168.29.71: icmp_seq=1 ttl=64 time=0.326 ms
64 bytes from 192.168.29.71: icmp_seq=2 ttl=64 time=0.492 ms
64 bytes from 192.168.29.71: icmp_seq=3 ttl=64 time=0.318 ms
64 bytes from 192.168.29.71: icmp_seq=4 ttl=64 time=0.557 ms
64 bytes from 192.168.29.71: icmp_seq=5 ttl=64 time=0.991 ms
64 bytes from 192.168.29.71: icmp_seq=6 ttl=64 time=0.402 ms
64 bytes from 192.168.29.71: icmp_seq=7 ttl=64 time=0.524 ms
64 bytes from 192.168.29.71: icmp_seq=8 ttl=64 time=0.652 ms
64 bytes from 192.168.29.71: icmp_seq=9 ttl=64 time=0.497 ms
64 bytes from 192.168.29.71: icmp_seq=10 ttl=64 time=0.414 ms
64 bytes from 192.168.29.71: icmp_seq=11 ttl=64 time=0.474 ms
```

SERVER MACHINE PINGING CLIENT MACHINE

```
trisha@trisha-VirtualBox: ~  
trisha@trisha-VirtualBox:~$ ping 192.168.29.131  
PING 192.168.29.131 (192.168.29.131) 56(84) bytes of data.  
64 bytes from 192.168.29.131: icmp_seq=1 ttl=64 time=0.363 ms  
64 bytes from 192.168.29.131: icmp_seq=2 ttl=64 time=0.481 ms  
64 bytes from 192.168.29.131: icmp_seq=3 ttl=64 time=0.319 ms  
64 bytes from 192.168.29.131: icmp_seq=4 ttl=64 time=0.351 ms  
64 bytes from 192.168.29.131: icmp_seq=5 ttl=64 time=0.214 ms  
64 bytes from 192.168.29.131: icmp_seq=6 ttl=64 time=0.222 ms  
64 bytes from 192.168.29.131: icmp_seq=7 ttl=64 time=0.300 ms  
64 bytes from 192.168.29.131: icmp_seq=8 ttl=64 time=0.341 ms  
64 bytes from 192.168.29.131: icmp_seq=9 ttl=64 time=0.346 ms  
64 bytes from 192.168.29.131: icmp_seq=10 ttl=64 time=0.542 ms  
64 bytes from 192.168.29.131: icmp_seq=11 ttl=64 time=0.227 ms  
64 bytes from 192.168.29.131: icmp_seq=12 ttl=64 time=0.412 ms  
64 bytes from 192.168.29.131: icmp_seq=13 ttl=64 time=0.299 ms  
64 bytes from 192.168.29.131: icmp_seq=14 ttl=64 time=0.750 ms  
64 bytes from 192.168.29.131: icmp_seq=15 ttl=64 time=0.564 ms  
64 bytes from 192.168.29.131: icmp_seq=16 ttl=64 time=0.455 ms  
64 bytes from 192.168.29.131: icmp_seq=17 ttl=64 time=0.300 ms  
64 bytes from 192.168.29.131: icmp_seq=18 ttl=64 time=0.368 ms  
64 bytes from 192.168.29.131: icmp_seq=19 ttl=64 time=0.348 ms  
64 bytes from 192.168.29.131: icmp_seq=20 ttl=64 time=0.478 ms  
64 bytes from 192.168.29.131: icmp_seq=21 ttl=64 time=0.317 ms
```

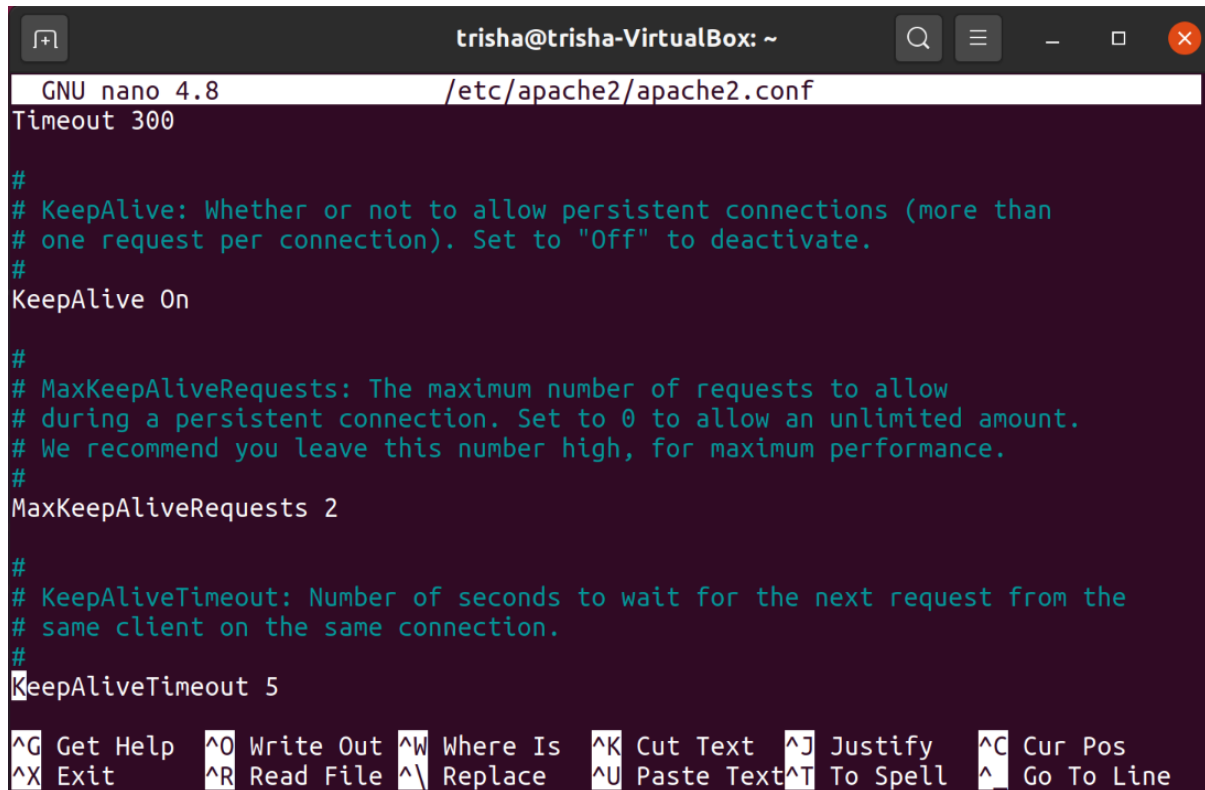
Apache Server Setup:-

The status of the server can be viewed using the command :

systemctl status apache2

```
trisha@trisha-VirtualBox: ~  
trisha@trisha-VirtualBox:~$ systemctl status apache2  
Unit apache2.service could not be found.  
trisha@trisha-VirtualBox:~$ systemctl status apache2  
● apache2.service - The Apache HTTP Server  
   Loaded: loaded (/lib/systemd/system/apache2.service; enabled; vendor prese  
   Active: active (running) since Tue 2021-02-02 13:59:03 IST; 2min 23s ago  
     Docs: https://httpd.apache.org/docs/2.4/  
   Process: 685 ExecStart=/usr/sbin/apachectl start (code=exited, status=0/SUC  
   Main PID: 741 (apache2)  
     Tasks: 55 (limit: 4655)  
    Memory: 8.0M  
   CGroup: /system.slice/apache2.service  
           └─741 /usr/sbin/apache2 -k start  
             └─742 /usr/sbin/apache2 -k start  
               └─743 /usr/sbin/apache2 -k start  
  
Feb 02 13:59:01 trisha-VirtualBox systemd[1]: Starting The Apache HTTP Server...  
Feb 02 13:59:03 trisha-VirtualBox apachectl[716]: AH00558: apache2: Could not r  
Feb 02 13:59:03 trisha-VirtualBox systemd[1]: Started The Apache HTTP Server.  
lines 1-16/16 (END)
```

Apache server needs to be configured to allow persistent connections. For achieving this, the apache2.conf configuration file is edited : **KeepAlive** to **On** and **MaxKeepAliveRequests** to **2**



```
trisha@trisha-VirtualBox: ~  
GNU nano 4.8 /etc/apache2/apache2.conf  
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  
  
^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
```

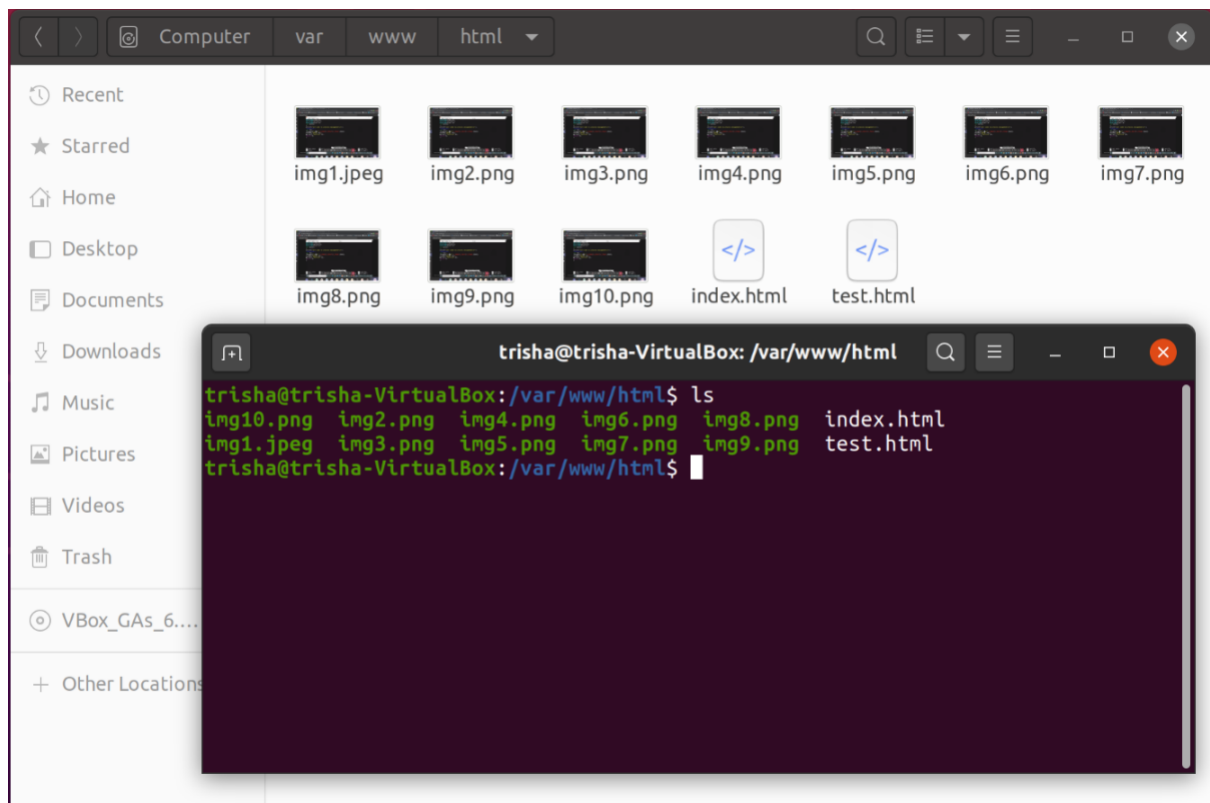
The file was edited using the command:

sudo nano etc/apache2/apache2.conf

Hosting the webpage :-

The webpage is named test.html and has ten images in it. The webpage along with the images are moved to the server path which is /var/www/html/.

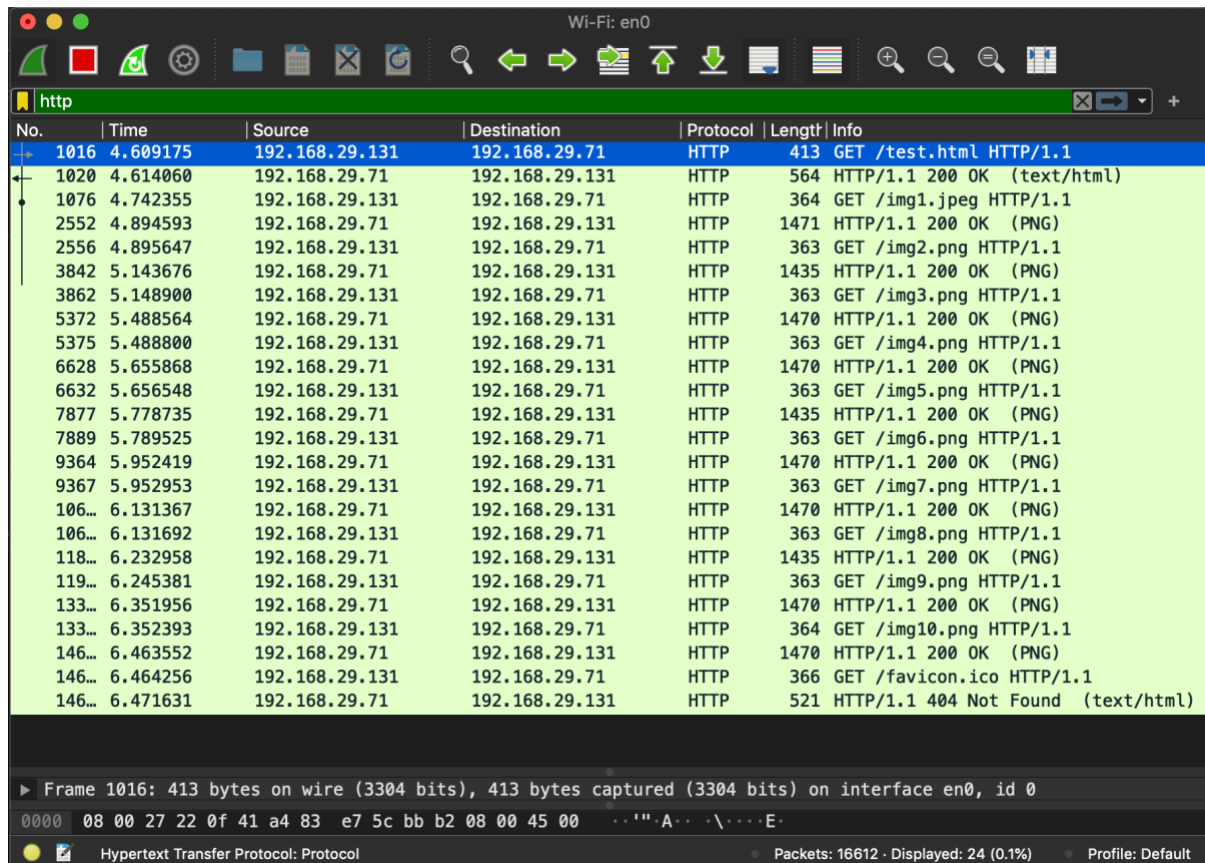
The screenshot below shows the images and the html file present in the path : /var/www/html/.



II. Establishing a non - persistent connection

To establish a non-persistent connection we need to set the **max – persistent – connections – per – server** to **0** and **persistent – settings** to **false**

Capturing packets using wireshark for a non-persistent connection :-



No.	Time	Source	Destination	Protocol	Length	Info
1016	4.609175	192.168.29.131	192.168.29.71	HTTP	413	GET /test.html HTTP/1.1
1020	4.614060	192.168.29.71	192.168.29.131	HTTP	564	HTTP/1.1 200 OK (text/html)
1076	4.742355	192.168.29.131	192.168.29.71	HTTP	364	GET /img1.jpeg HTTP/1.1
2552	4.894593	192.168.29.71	192.168.29.131	HTTP	1471	HTTP/1.1 200 OK (PNG)
2556	4.895647	192.168.29.131	192.168.29.71	HTTP	363	GET /img2.png HTTP/1.1
3842	5.143676	192.168.29.71	192.168.29.131	HTTP	1435	HTTP/1.1 200 OK (PNG)
3862	5.148900	192.168.29.131	192.168.29.71	HTTP	363	GET /img3.png HTTP/1.1
5372	5.488564	192.168.29.71	192.168.29.131	HTTP	1470	HTTP/1.1 200 OK (PNG)
5375	5.488800	192.168.29.131	192.168.29.71	HTTP	363	GET /img4.png HTTP/1.1
6628	5.655868	192.168.29.71	192.168.29.131	HTTP	1470	HTTP/1.1 200 OK (PNG)
6632	5.656548	192.168.29.131	192.168.29.71	HTTP	363	GET /img5.png HTTP/1.1
7877	5.778735	192.168.29.71	192.168.29.131	HTTP	1435	HTTP/1.1 200 OK (PNG)
7889	5.789525	192.168.29.131	192.168.29.71	HTTP	363	GET /img6.png HTTP/1.1
9364	5.952419	192.168.29.71	192.168.29.131	HTTP	1470	HTTP/1.1 200 OK (PNG)
9367	5.952953	192.168.29.131	192.168.29.71	HTTP	363	GET /img7.png HTTP/1.1
106...	6.131367	192.168.29.71	192.168.29.131	HTTP	1470	HTTP/1.1 200 OK (PNG)
106...	6.131692	192.168.29.131	192.168.29.71	HTTP	363	GET /img8.png HTTP/1.1
118...	6.232958	192.168.29.71	192.168.29.131	HTTP	1435	HTTP/1.1 200 OK (PNG)
119...	6.245381	192.168.29.131	192.168.29.71	HTTP	363	GET /img9.png HTTP/1.1
133...	6.351956	192.168.29.71	192.168.29.131	HTTP	1470	HTTP/1.1 200 OK (PNG)
133...	6.352393	192.168.29.131	192.168.29.71	HTTP	364	GET /img10.png HTTP/1.1
146...	6.463552	192.168.29.71	192.168.29.131	HTTP	1470	HTTP/1.1 200 OK (PNG)
146...	6.464256	192.168.29.131	192.168.29.71	HTTP	366	GET /favicon.ico HTTP/1.1
146...	6.471631	192.168.29.71	192.168.29.131	HTTP	521	HTTP/1.1 404 Not Found (text/html)

► Frame 1016: 413 bytes on wire (3304 bits), 413 bytes captured (3304 bits) on interface en0, id 0

0000 08 00 27 22 0f 41 a4 83 e7 5c bb b2 08 00 45 00 ...".A... \....E.

Hypertext Transfer Protocol: Protocol

Packets: 16612 · Displayed: 24 (0.1%) · Profile: Default

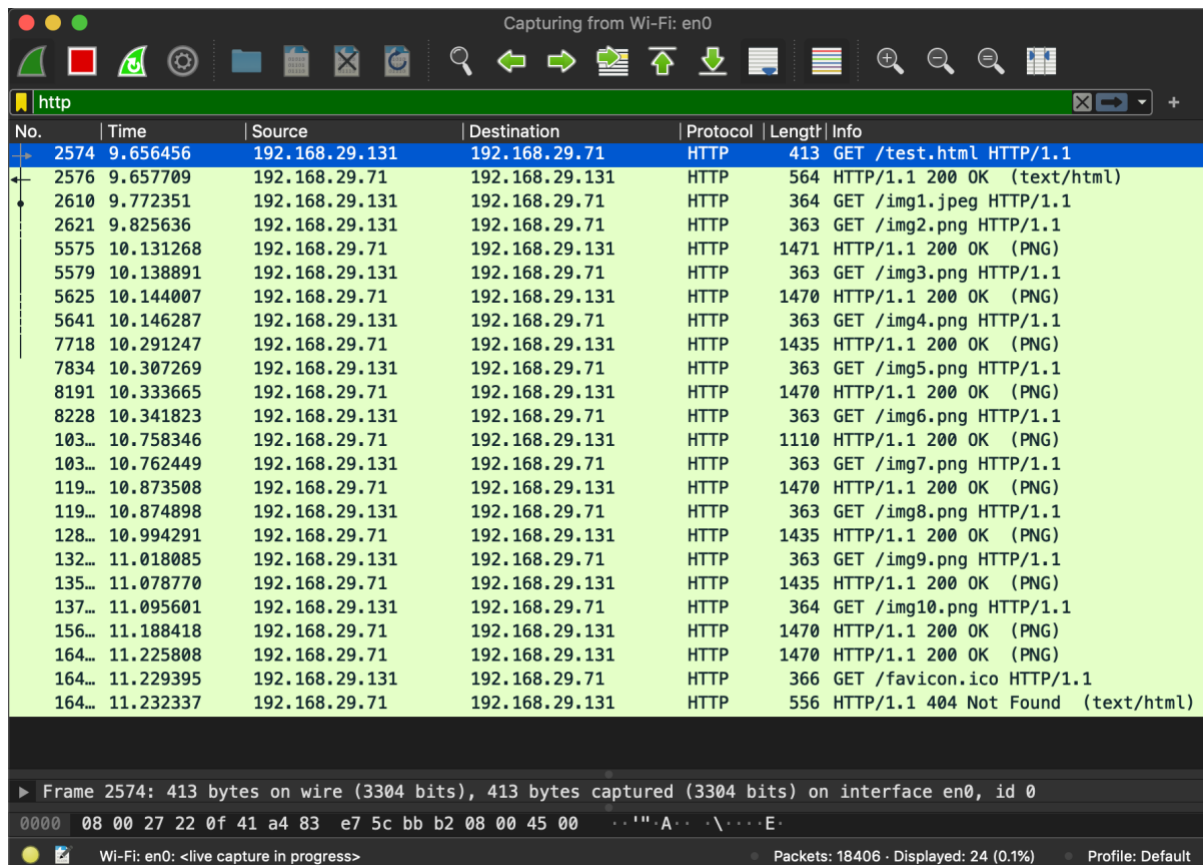
$$\begin{aligned} \text{Total load time} &= \text{Last response time} - \text{First GET time} \\ &= 6.463552 - 4.609175 \\ &= 1.854377 \end{aligned}$$

III. Establishing a persistent connection

To establish a non-persistent connection we need to set the **max – persistent – connections – per – server** to anything greater than 0 and **persistent – settings** to true

1) 2 Persistent Connections

Capturing packets using wireshark for 2 persistent connections :-



The image shows a Wireshark packet capture window. The top bar indicates 'Capturing from Wi-Fi: en0'. The packet list pane shows a series of HTTP requests and responses. The first request is for '/test.html' at 9.656456s. Subsequent requests are for various image files (img1.jpg, img2.png, etc.) at later times. The packet details pane shows the selected packet (No. 2574) with its structure: Ethernet II, Internet Protocol Version 4, and Hypertext Transfer Protocol. The packet bytes pane shows the raw data of the selected packet.

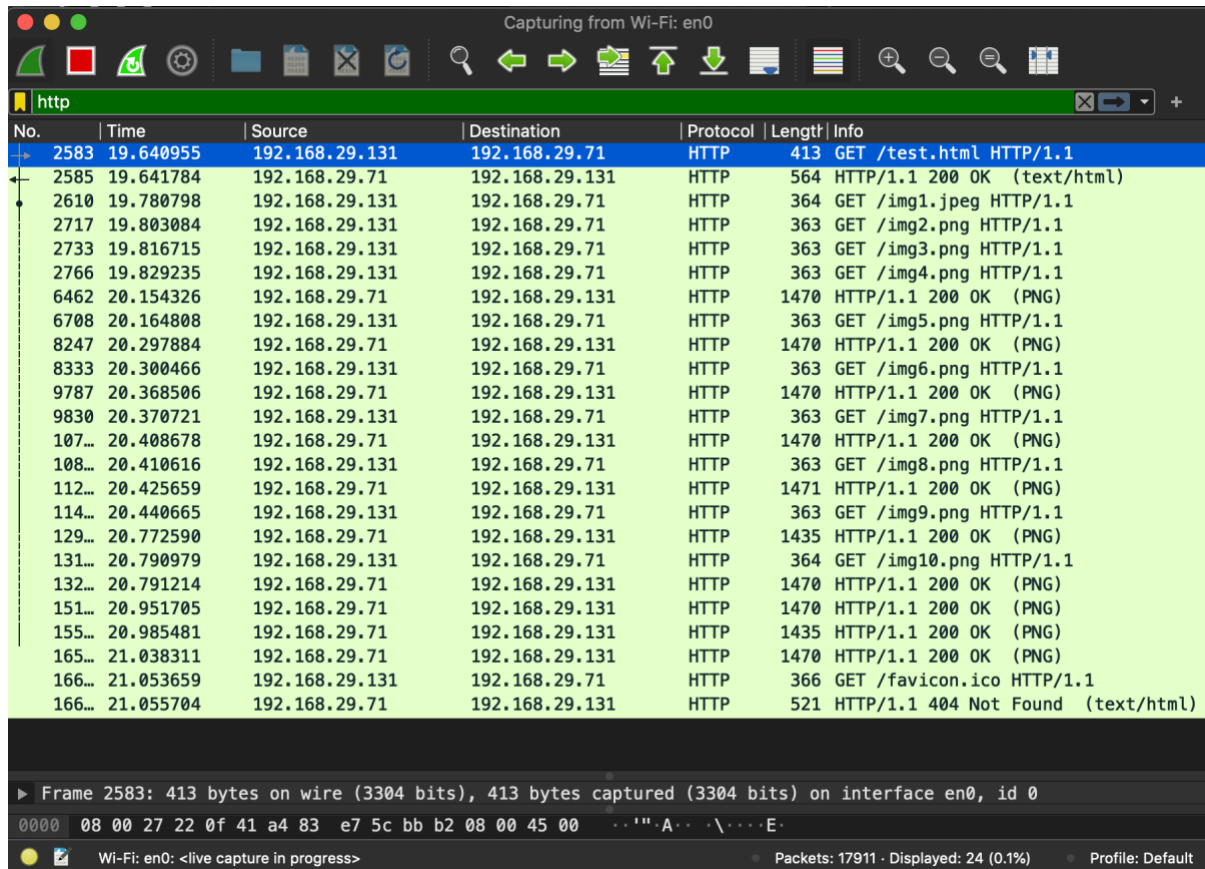
No.	Time	Source	Destination	Protocol	Length	Info
2574	9.656456	192.168.29.131	192.168.29.71	HTTP	413	GET /test.html HTTP/1.1
2576	9.657709	192.168.29.71	192.168.29.131	HTTP	564	HTTP/1.1 200 OK (text/html)
2610	9.772351	192.168.29.131	192.168.29.71	HTTP	364	GET /img1.jpeg HTTP/1.1
2621	9.825636	192.168.29.131	192.168.29.71	HTTP	363	GET /img2.png HTTP/1.1
5575	10.131268	192.168.29.71	192.168.29.131	HTTP	1471	HTTP/1.1 200 OK (PNG)
5579	10.138891	192.168.29.131	192.168.29.71	HTTP	363	GET /img3.png HTTP/1.1
5625	10.144007	192.168.29.71	192.168.29.131	HTTP	1470	HTTP/1.1 200 OK (PNG)
5641	10.146287	192.168.29.131	192.168.29.71	HTTP	363	GET /img4.png HTTP/1.1
7718	10.291247	192.168.29.71	192.168.29.131	HTTP	1435	HTTP/1.1 200 OK (PNG)
7834	10.307269	192.168.29.131	192.168.29.71	HTTP	363	GET /img5.png HTTP/1.1
8191	10.333665	192.168.29.71	192.168.29.131	HTTP	1470	HTTP/1.1 200 OK (PNG)
8228	10.341823	192.168.29.131	192.168.29.71	HTTP	363	GET /img6.png HTTP/1.1
103...	10.758346	192.168.29.71	192.168.29.131	HTTP	1110	HTTP/1.1 200 OK (PNG)
103...	10.762449	192.168.29.131	192.168.29.71	HTTP	363	GET /img7.png HTTP/1.1
119...	10.873508	192.168.29.71	192.168.29.131	HTTP	1470	HTTP/1.1 200 OK (PNG)
119...	10.874898	192.168.29.131	192.168.29.71	HTTP	363	GET /img8.png HTTP/1.1
128...	10.994291	192.168.29.71	192.168.29.131	HTTP	1435	HTTP/1.1 200 OK (PNG)
132...	11.018085	192.168.29.131	192.168.29.71	HTTP	363	GET /img9.png HTTP/1.1
135...	11.078770	192.168.29.71	192.168.29.131	HTTP	1435	HTTP/1.1 200 OK (PNG)
137...	11.095601	192.168.29.131	192.168.29.71	HTTP	364	GET /img10.png HTTP/1.1
156...	11.188418	192.168.29.71	192.168.29.131	HTTP	1470	HTTP/1.1 200 OK (PNG)
164...	11.225808	192.168.29.71	192.168.29.131	HTTP	1470	HTTP/1.1 200 OK (PNG)
164...	11.229395	192.168.29.131	192.168.29.71	HTTP	366	GET /favicon.ico HTTP/1.1
164...	11.232337	192.168.29.71	192.168.29.131	HTTP	556	HTTP/1.1 404 Not Found (text/html)

Frame 2574: 413 bytes on wire (3304 bits), 413 bytes captured (3304 bits) on interface en0, id 0
0000 08 00 27 22 0f 41 a4 83 e7 5c bb b2 08 00 45 00 ...A...E
Wi-Fi: en0: <live capture in progress> Packets: 18406 · Displayed: 24 (0.1%) Profile: Default

$$\begin{aligned} \text{Total load time} &= \text{Last response time} - \text{First GET time} \\ &= 11.225808 - 9.656456 \\ &= 1.569352 \end{aligned}$$

2) 4 Persistent Connections

Capturing packets using wireshark for 4 persistent connections :-



The image shows a Wireshark packet capture of an HTTP session. The top toolbar indicates 'Capturing from Wi-Fi: en0'. The packet list table below shows 24 packets, all of which are GET requests from 192.168.29.131 to 192.168.29.71. The first packet (No. 2583) is a GET request for /test.html. The subsequent 23 packets are GET requests for various image files (img1.jpg through img10.png) and a favicon.ico. The status of the requests is shown in the 'Info' column: 200 OK for the HTML and PNG files, and 404 Not Found for the favicon. The bottom status bar shows 'Frame 2583: 413 bytes on wire (3304 bits), 413 bytes captured (3304 bits) on interface en0, id 0' and 'Packets: 17911 · Displayed: 24 (0.1%)'.

No.	Time	Source	Destination	Protocol	Length	Info
2583	19.640955	192.168.29.131	192.168.29.71	HTTP	413	GET /test.html HTTP/1.1
2585	19.641784	192.168.29.71	192.168.29.131	HTTP	564	HTTP/1.1 200 OK (text/html)
2610	19.780798	192.168.29.131	192.168.29.71	HTTP	364	GET /img1.jpeg HTTP/1.1
2717	19.803084	192.168.29.131	192.168.29.71	HTTP	363	GET /img2.png HTTP/1.1
2733	19.816715	192.168.29.131	192.168.29.71	HTTP	363	GET /img3.png HTTP/1.1
2766	19.829235	192.168.29.131	192.168.29.71	HTTP	363	GET /img4.png HTTP/1.1
6462	20.154326	192.168.29.71	192.168.29.131	HTTP	1470	HTTP/1.1 200 OK (PNG)
6708	20.164808	192.168.29.131	192.168.29.71	HTTP	363	GET /img5.png HTTP/1.1
8247	20.297884	192.168.29.71	192.168.29.131	HTTP	1470	HTTP/1.1 200 OK (PNG)
8333	20.300466	192.168.29.131	192.168.29.71	HTTP	363	GET /img6.png HTTP/1.1
9787	20.368506	192.168.29.71	192.168.29.131	HTTP	1470	HTTP/1.1 200 OK (PNG)
9830	20.370721	192.168.29.131	192.168.29.71	HTTP	363	GET /img7.png HTTP/1.1
107...	20.408678	192.168.29.71	192.168.29.131	HTTP	1470	HTTP/1.1 200 OK (PNG)
108...	20.410616	192.168.29.131	192.168.29.71	HTTP	363	GET /img8.png HTTP/1.1
112...	20.425659	192.168.29.71	192.168.29.131	HTTP	1471	HTTP/1.1 200 OK (PNG)
114...	20.440665	192.168.29.131	192.168.29.71	HTTP	363	GET /img9.png HTTP/1.1
129...	20.772590	192.168.29.71	192.168.29.131	HTTP	1435	HTTP/1.1 200 OK (PNG)
131...	20.790979	192.168.29.131	192.168.29.71	HTTP	364	GET /img10.png HTTP/1.1
132...	20.791214	192.168.29.71	192.168.29.131	HTTP	1470	HTTP/1.1 200 OK (PNG)
151...	20.951705	192.168.29.71	192.168.29.131	HTTP	1470	HTTP/1.1 200 OK (PNG)
155...	20.985481	192.168.29.71	192.168.29.131	HTTP	1435	HTTP/1.1 200 OK (PNG)
165...	21.038311	192.168.29.71	192.168.29.131	HTTP	1470	HTTP/1.1 200 OK (PNG)
166...	21.053659	192.168.29.131	192.168.29.71	HTTP	366	GET /favicon.ico HTTP/1.1
166...	21.055704	192.168.29.71	192.168.29.131	HTTP	521	HTTP/1.1 404 Not Found (text/html)

Frame 2583: 413 bytes on wire (3304 bits), 413 bytes captured (3304 bits) on interface en0, id 0

0000 08 00 27 22 0f 41 a4 83 e7 5c bb b2 08 00 45 00 ...".A... \...E

Wi-Fi: en0: <live capture in progress> Packets: 17911 · Displayed: 24 (0.1%) Profile: Default

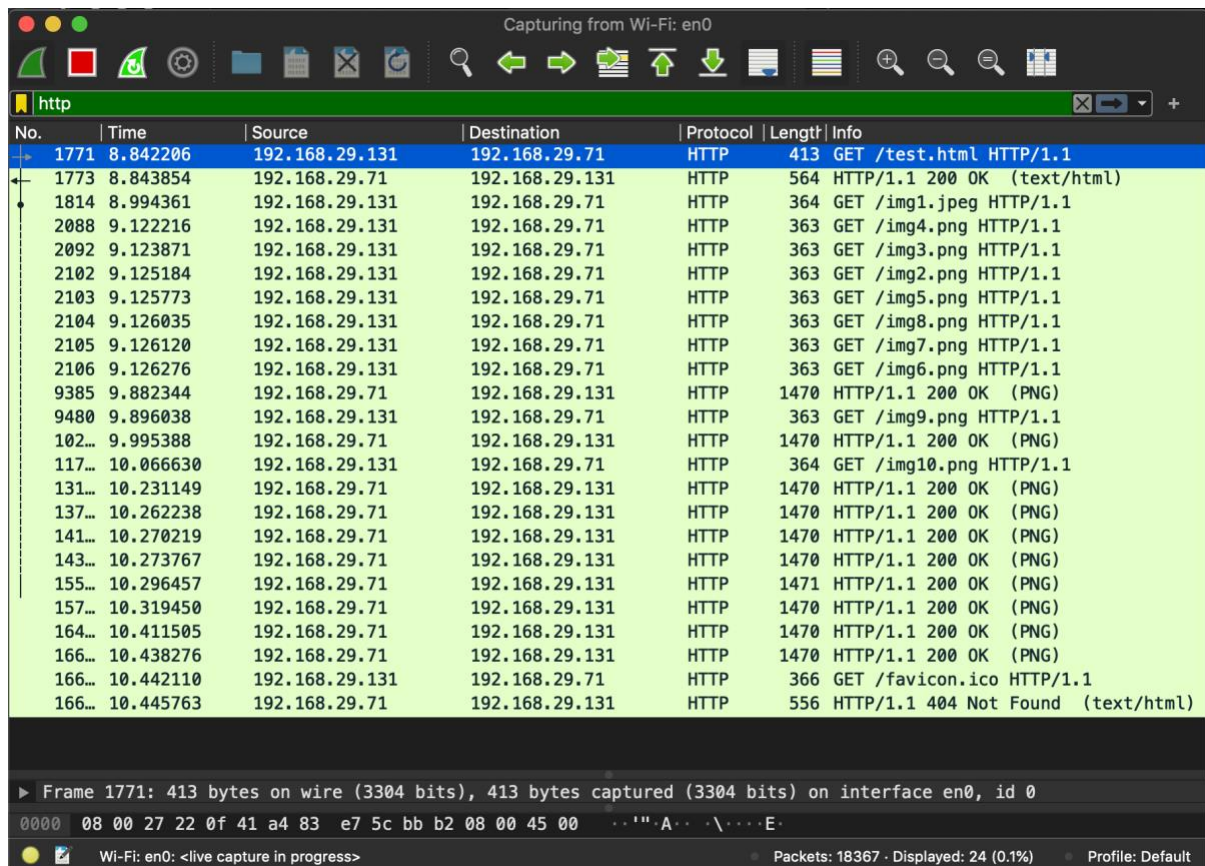
$$\begin{aligned}\text{Total load time} &= \text{Last response time} - \text{First GET time} \\ &= 21.038311 - 19.640955 \\ &= 1.397356\end{aligned}$$

3) 6 Persistent Connections

Capturing packets using wireshark for 6 persistent connections :-

4) 8 Persistent Connections

Capturing packets using wireshark for 8 persistent connections :-



No.	Time	Source	Destination	Protocol	Length	Info
1771	8.842206	192.168.29.131	192.168.29.71	HTTP	413	GET /test.html HTTP/1.1
1773	8.843854	192.168.29.71	192.168.29.131	HTTP	564	HTTP/1.1 200 OK (text/html)
1814	8.994361	192.168.29.131	192.168.29.71	HTTP	364	GET /img1.jpeg HTTP/1.1
2088	9.122216	192.168.29.131	192.168.29.71	HTTP	363	GET /img4.png HTTP/1.1
2092	9.123871	192.168.29.131	192.168.29.71	HTTP	363	GET /img3.png HTTP/1.1
2102	9.125184	192.168.29.131	192.168.29.71	HTTP	363	GET /img2.png HTTP/1.1
2103	9.125773	192.168.29.131	192.168.29.71	HTTP	363	GET /img5.png HTTP/1.1
2104	9.126035	192.168.29.131	192.168.29.71	HTTP	363	GET /img8.png HTTP/1.1
2105	9.126120	192.168.29.131	192.168.29.71	HTTP	363	GET /img7.png HTTP/1.1
2106	9.126276	192.168.29.131	192.168.29.71	HTTP	363	GET /img6.png HTTP/1.1
9385	9.882344	192.168.29.71	192.168.29.131	HTTP	1470	HTTP/1.1 200 OK (PNG)
9480	9.896038	192.168.29.131	192.168.29.71	HTTP	363	GET /img9.png HTTP/1.1
102...	9.995388	192.168.29.71	192.168.29.131	HTTP	1470	HTTP/1.1 200 OK (PNG)
117...	10.066630	192.168.29.131	192.168.29.71	HTTP	364	GET /img10.png HTTP/1.1
131...	10.231149	192.168.29.71	192.168.29.131	HTTP	1470	HTTP/1.1 200 OK (PNG)
137...	10.262238	192.168.29.71	192.168.29.131	HTTP	1470	HTTP/1.1 200 OK (PNG)
141...	10.270219	192.168.29.71	192.168.29.131	HTTP	1470	HTTP/1.1 200 OK (PNG)
143...	10.273767	192.168.29.71	192.168.29.131	HTTP	1470	HTTP/1.1 200 OK (PNG)
155...	10.296457	192.168.29.71	192.168.29.131	HTTP	1471	HTTP/1.1 200 OK (PNG)
157...	10.319450	192.168.29.71	192.168.29.131	HTTP	1470	HTTP/1.1 200 OK (PNG)
164...	10.411505	192.168.29.71	192.168.29.131	HTTP	1470	HTTP/1.1 200 OK (PNG)
166...	10.438276	192.168.29.71	192.168.29.131	HTTP	1470	HTTP/1.1 200 OK (PNG)
166...	10.442110	192.168.29.131	192.168.29.71	HTTP	366	GET /favicon.ico HTTP/1.1
166...	10.445763	192.168.29.71	192.168.29.131	HTTP	556	HTTP/1.1 404 Not Found (text/html)

Frame 1771: 413 bytes on wire (3304 bits), 413 bytes captured (3304 bits) on interface en0, id 0

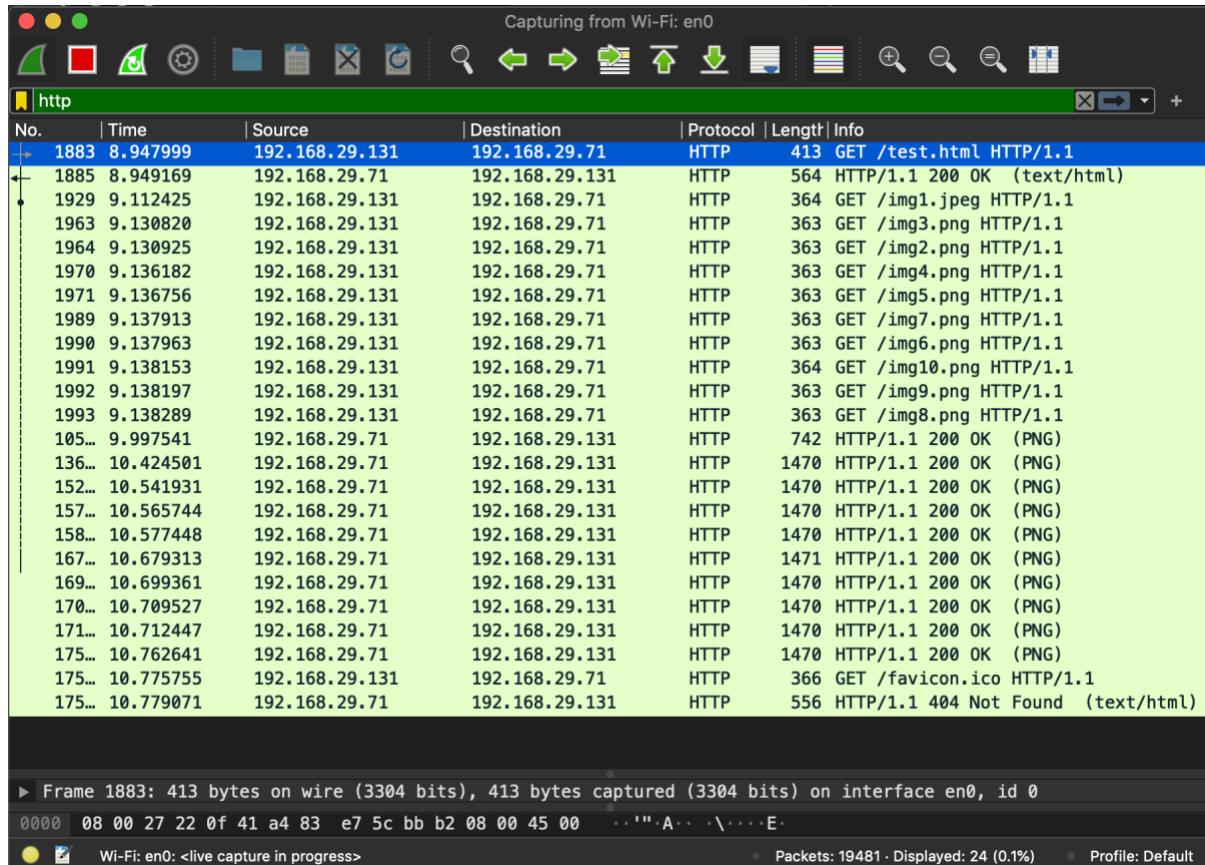
0000 08 00 27 22 0f 41 a4 83 e7 5c bb b2 08 00 45 00 ...''A... \....E.

Wi-Fi: en0: <live capture in progress> Packets: 18367 · Displayed: 24 (0.1%) Profile: Default

$$\begin{aligned} \text{Total load time} &= \text{Last response time} - \text{First GET time} \\ &= 10.438276 - 8.842206 \\ &= 1.59607 \end{aligned}$$

5) 10 Persistent Connections

Capturing packets using wireshark for 10 persistent connections :-



$$\begin{aligned}
 \text{Total load time} &= \text{Last response time} - \text{First GET time} \\
 &= 10.762641 - 8.947999 \\
 &= 1.81462
 \end{aligned}$$

Load time for different persistent connections :-

Number of persistent connections	Load Time
0	1.854377
2	1.569352
4	1.397356
6	1.370056
8	1.59607
10	1.814642

Observations:-

From the table above we observe that the *load time decreases as we increase the number of persistent connections*.

This is because persistent connections enable *pipelining* the HTTP requests and response in a connection which in turn *allows a client to make requests without waiting for a response*.

Therefore persistent connections allow the clients to make *multiple image requests without having to wait for the response*.

But as we increase the number of persistent connections at a point the load time increases in spite of having multiple persistent connections. This happens because of *decrease in throughput*. Many persistent connections cause the server to become *overloaded*.

Therefore it is not advisable to increase the number of persistent connections by a large number.

From the table shown above it is clear that the *load time is minimum when the number of persistent connections are 6*. Therefore the *optimal number of persistent connections is 6*.

And the time taken to load images for 2, 4, 6 persistent connections is lesser than 10 persistent connections.