Assignment – 2

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Application: GitHub Desktop

Traces: https://bit.ly/3BtEJ81

Question 1

The various protocols used by GitHub Desktop application are explained below in the respective layers that they belong to.

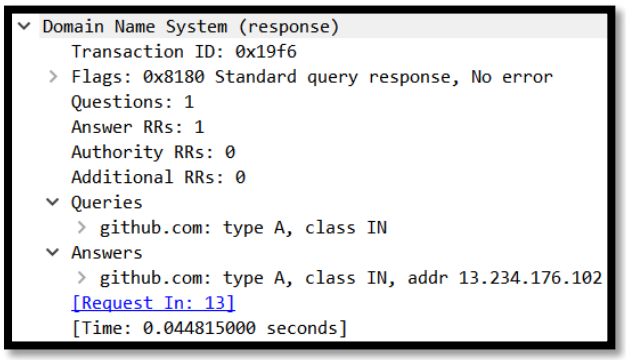
1. **Application Layer (Domain Name System):** The Domain Name System is a host name to IP address translation service. It has following fields –

i) Questions: Queries count

ii) Answer RRs: Answers count

iii) Queries: DNS queries for host name resolution (github.com).

iv) Answers: Answer to DNS queries (13.234.176.102).



2. **Session Layer**: **Secure Socket Layer, TLSv1.2** –

i) Content Type: Type of content whether Application Data, Handshake etc (Application Data).

ii) Version: TLS 1.2

iii) Length: Length of the data.

iv) Encrypted Application data.

3. **Transport Layer**: **UDP, TCP**

=> TCP (Transmission Control Protocol):

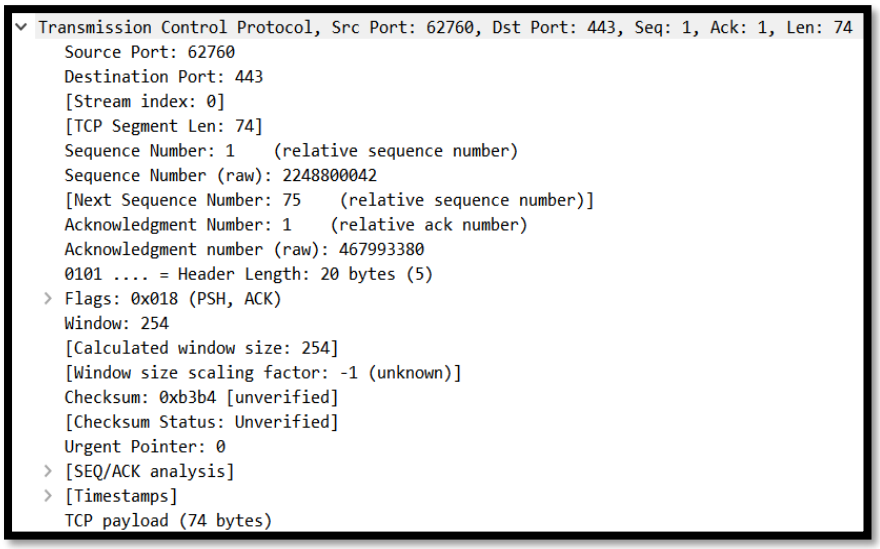
i) Source Port: Port number of the source

ii) Destination Port: Port number of the destination

iii) Sequence Number: byte number of the first byte of data in the TCP packet sent

iv) Acknowledgment number: it is the sequence number of the next byte the receiver expects to receive

v) Checksum: error detection bits of the segment.



=> UDP (User Datagram Protocol):

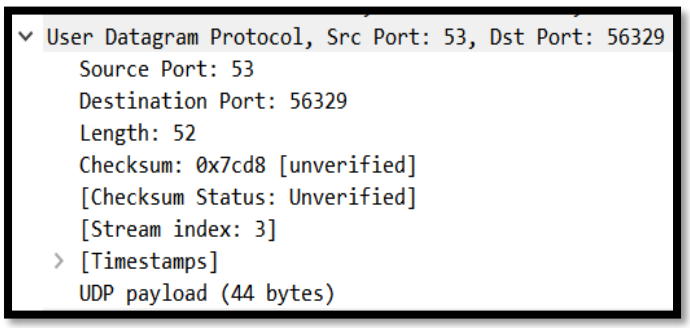
i) Source Port: Port number of the source

ii) Destination Port: Port number of the destination

iii) Length: total length including UDP header and Application

iv) Checksum: It is used to check if data is corrupted or not.

v) Timestamps: Time relative to the last and first frame.



4. Network Layer: IPv4

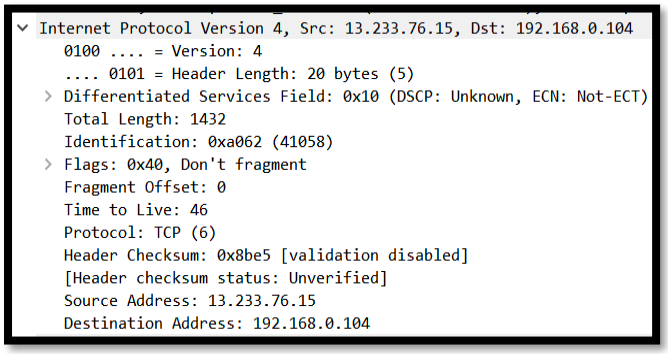
i) Version: Indicates the IP version used

ii) Header Length: contains the length of the IP header

iii) Source: Ip address of the sender.

iv) Destination: Ip address of the receiver.

v) Time to Live: maximum number of hops a datagram can take to reach the destination.

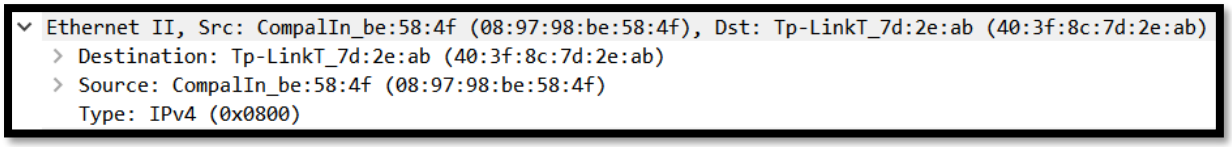


5. Link Layer: Ethernet II

i) Destination: MAC address of the receiving end.

ii) Source: MAC address of the sending end.

iii) Type: Type of Network Layer Protocol.



Question 2

The important functionalities of GitHub Desktop Application are given below:
(i) Cloning a repository from the internet.
(ii) Adding a local repository to GitHub.
(iii) Pushing a repo onto GitHub server.
(iv) Pulling a repo from GitHub server.
(v) Branching a repository

The **TLS protocol** is used by every functionality of GitHub. TLS protocol is used as it encrypts data to and from the site to clients. This also protects the integrity of the website by helping to prevent intruders tampering between the site and client browsing.
The **DNS protocol** is also used by every functionality of GitHub to resolve the IP address for the github.com. DNS uses UDP packets because these are fast and have low overhead.
The **TCP protocol** is used by all functionalities of the GitHub at the transport layer. TCP always guarantees that data reaches its destination and it reaches there without duplication. It guarantees reliable data transfer by having handshaking protocol on connection establishment and connection termination.
The **IPv4 protocol** is also used by all functionalities of GitHub at the network layer. It is a connectionless protocol for use on packet-switched networks. It delivers packets using IP headers from the source to the destination.
The **Ethernet II** is also used by all functionalities of GitHub in the data link layer. This contains information about source and destination MAC address in its header. Ethernet lying in data link layer is also responsible for error detection and correction along with ow control. It exists as a point to point connection.
The **User Datagram Protocol** is a connection-less protocol and provides faster data transfer than TCP but is not very reliable or secure. It is mostly used to transfer small individual packets (like DNS requests). GitHub uses DNS queries to fetch IP addresses, which are made using UDP.

Question 3

Two functionalities of GitHub Desktop application along with the sequence of messages exchanged is given below:

1. Cloning a repository

17	0.431911	fe80::f924:f27a:bd6…	ff02::1:3	LLMNR	84 Standard query 0xd917 A wpad
18	0.431983	192.168.0.104	224.0.0.252	LLMNR	64 Standard query 0xd917 A wpad
19	0.483793	192.168.0.104	192.168.0.1	DNS	70 Standard query 0x380c A github.com
20	0.527458	192.168.0.1	192.168.0.104	DNS	86 Standard query response 0x380c A github.com A 13.234.210.38
21	0.530472	192.168.0.104	13.234.210.38	TCP	66 52639 → 443 [SYN] Seq=0 Win=64240 Len=0 MSS=1460 WS=256 SACK_PERM=1
22	0.555652	13.234.210.38	192.168.0.104	TCP	66 443 → 52639 [SYN, ACK] Seq=0 Ack=1 Win=65535 Len=0 MSS=1436 SACK_PERM=1 WS=1024
23	0.555754	192.168.0.104	13.234.210.38	TCP	54 52639 → 443 [ACK] Seq=1 Ack=1 Win=132096 Len=0
24	0.557586	192.168.0.104	13.234.210.38	TLSv1.2	235 Client Hello
25	0.583030	13.234.210.38	192.168.0.104	TLSv1.2	1490 Server Hello
26	0.583114	13.234.210.38	192.168.0.104	TLSv1.2	1179 Certificate, Server Key Exchange, Server Hello Done
27	0.583136	192.168.0.104	13.234.210.38	TCP	54 52639 → 443 [ACK] Seq=182 Ack=2562 Win=132096 Len=0
28	0.584892	192.168.0.104	13.234.210.38	TLSv1.2	147 Client Key Exchange, Change Cipher Spec, Encrypted Handshake Message
29	0.611402	13.234.210.38	192.168.0.104	TLSv1.2	105 Change Cipher Spec, Encrypted Handshake Message
30	0.613892	192.168.0.104	13.234.210.38	TLSv1.2	312 Application Data
31	0.684182	13.234.210.38	192.168.0.104	TCP	60 443 → 52639 [ACK] Seq=2613 Ack=533 Win=68608 Len=0

Adding a local repository to GitHub

12	0.444394	192.168.0.104	224.0.0.251	MDNS	70 Standard query 0x0000 A wpad.local, "QM" question
13	0.444648	fe80::f924:f27a:bd6…	ff02::fb	MDNS	90 Standard query 0x0000 A wpad.local, "QM" question
14	0.483796	192.168.0.1	192.168.0.104	DNS	90 Standard query response 0x460e A api.github.com A 13.233.76.15
15	0.484410	192.168.0.104	13.233.76.15	TCP	66 59566 → 443 [SYN] Seq=0 Win=64240 Len=0 MSS=1460 WS=256 SACK_PERM=1
16	0.512459	13.233.76.15	192.168.0.104	TCP	66 443 → 59566 [SYN, ACK] Seq=0 Ack=1 Win=65535 Len=0 MSS=1436 SACK_PERM=1 WS=1024
17	0.512594	192.168.0.104	13.233.76.15	TCP	54 59566 → 443 [ACK] Seq=1 Ack=1 Win=132096 Len=0
18	0.512874	192.168.0.104	13.233.76.15	TLSv1.3	571 Client Hello
19	0.542580	13.233.76.15	192.168.0.104	TLSv1.3	1490 Server Hello, Change Cipher Spec, Application Data
20	0.542660	13.233.76.15	192.168.0.104	TLSv1.3	1335 Application Data, Application Data, Application Data
21	0.542681	192.168.0.104	13.233.76.15	TCP	54 59566 → 443 [ACK] Seq=518 Ack=2718 Win=132096 Len=0
22	0.543183	192.168.0.104	13.233.76.15	TLSv1.3	118 Change Cipher Spec, Application Data
23	0.543394	192.168.0.104	13.233.76.15	TLSv1.3	146 Application Data
24	0.543596	192.168.0.104	13.233.76.15	TLSv1.3	477 Application Data

Both the above functionalities of GitHub use 3-way handshake for TCP connection establishment and TLS handshaking for further communication.

TCP connection establishment (3-way handshake)

3-way handshake enables both ends to initiate and negotiate separate TCP socket connections at the same time. It has following three steps:

Step1(SYN): Client sends a segment with SYN (Synchronize Sequence Number) which informs the server that the client is likely to start communication and with what sequence number it starts segments with.

Step2([SYN, ACK]): Server responds to the client request with SYN-ACK signal bits set. The ACK signifies that the connection request has been acknowledged and SYN signifies the sequence number it is likely to start the segments with.

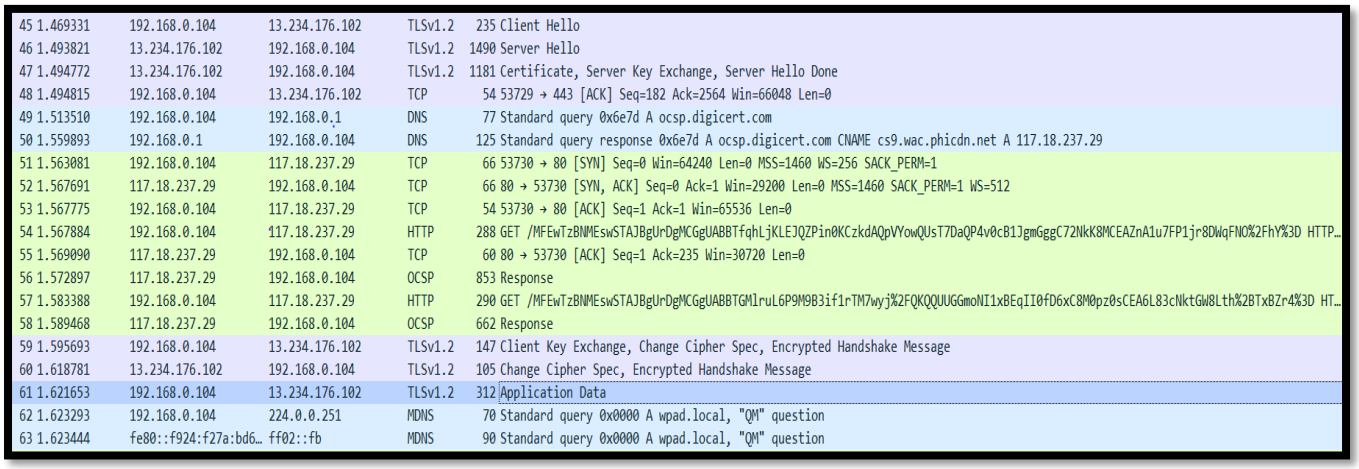
Step3(ACK): The client acknowledges the response of the server and thus establishes a reliable connection with which they start the actual data transfer.

21	0.530472	192.168.0.104	13.234.210.38	TCP	66 52639 → 443 [SYN] Seq=0 Win=64240 Len=0 MSS=1460 WS=256 SACK_PERM=1
22	0.555652	13.234.210.38	192.168.0.104	TCP	66 443 → 52639 [SYN, ACK] Seq=0 Ack=1 Win=65535 Len=0 MSS=1436 SACK_PERM=1 WS=1024
23	0.555754	192.168.0.104	13.234.210.38	TCP	54 52639 → 443 [ACK] Seq=1 Ack=1 Win=132096 Len=0

TLS handshaking

A TLS handshake starts a communication session that uses TLS encryption. During a TLS handshake, the two communicating sides exchange messages to verify each other, establish the encryption algorithms they will use, and **agree on session keys**. The first message in the TLS Handshake is the **Client Hello** which is sent by the client to initiate a session with the server. In return, the server responds with **Server Hello** and the Server Certificate (for authentication) along with a Server Key, which is used by the client to encrypt Client Key Exchange later in the process**.** Server Hello Done is an indication that the server is now

waiting for the client's response. The client responds with the Client Key and is issued a New Session Ticket. The TLS session is now established, and application data can be exchanged between the server and the client.



45	1.469331	192.168.0.104	13.234.176.102	TLSv1.2	235 Client Hello
46	1.493821	13.234.176.102	192.168.0.104	TLSv1.2	1490 Server Hello
47	1.494772	13.234.176.102	192.168.0.104	TLSv1.2	1181 Certificate, Server Key Exchange, Server Hello Done
48	1.494815	192.168.0.104	13.234.176.102	TCP	54 53729 → 443 [ACK] Seq=182 Ack=2564 Win=66048 Len=0
49	1.513510	192.168.0.104	192.168.0.1	DNS	77 Standard query 0x6e7d A ocsp.digicert.com
50	1.559893	192.168.0.1	192.168.0.104	DNS	125 Standard query response 0x6e7d A ocsp.digicert.com CNAME cs9.wac.phicdn.net A 117.18.237.29
51	1.563081	192.168.0.104	117.18.237.29	TCP	66 53730 → 80 [SYN] Seq=0 Win=64240 Len=0 MSS=1460 WS=256 SACK_PERM=1
52	1.567691	117.18.237.29	192.168.0.104	TCP	66 80 → 53730 [SYN, ACK] Seq=0 Ack=1 Win=29200 Len=0 MSS=1460 SACK_PERM=1 WS=512
53	1.567775	192.168.0.104	117.18.237.29	TCP	54 53730 → 80 [ACK] Seq=1 Ack=1 Win=65536 Len=0
54	1.567884	192.168.0.104	117.18.237.29	HTTP	288 GET /MFEwTzBNMEswSTAJBgUrDgMCGgUABBTfqhLjKLEJQZPin0KCzkdAQpVYowQUsT7DaQP4v0cB1JgmGggC72NkK8MCEAZnA1u7FP1jr8DWqFNO%2FhY%3D HTTP…
55	1.569090	117.18.237.29	192.168.0.104	TCP	60 80 → 53730 [ACK] Seq=1 Ack=235 Win=30720 Len=0
56	1.572897	117.18.237.29	192.168.0.104	OCSP	853 Response
57	1.583388	192.168.0.104	117.18.237.29	HTTP	290 GET /MFEwTzBNMEswSTAJBgUrDgMCGgUABBTGMlruL6P9M9B3if1rTM7wyj%2FQKQQUUGGmoNI1xBEqII0fD6xC8M0pz0sCEA6L83cNktGW8Lth%2BTxBZr4%3D HT…
58	1.589468	117.18.237.29	192.168.0.104	OCSP	662 Response
59	1.595693	192.168.0.104	13.234.176.102	TLSv1.2	147 Client Key Exchange, Change Cipher Spec, Encrypted Handshake Message
60	1.618781	13.234.176.102	192.168.0.104	TLSv1.2	105 Change Cipher Spec, Encrypted Handshake Message
61	1.621653	192.168.0.104	13.234.176.102	TLSv1.2	312 Application Data
62	1.623293	192.168.0.104	224.0.0.251	MDNS	70 Standard query 0x0000 A wpad.local, "QM" question
63	1.623444	fe80::f924:f27a:bd6…	ff02::fb	MDNS	90 Standard query 0x0000 A wpad.local, "QM" question

Question 4:

I have done the cloning operation at three different times of the day.

Time	Throughput (in KB/s)	RTT (in ms)	Avg. Packet Size (Bytes)	Packet Lost	UDP Packets	TCP Packets	Number of responses per request
2:00pm	80	23.62	833	0	42	438	1.8152
6:30pm	109	25.28	870	0	17	422	1.8648
11:00pm	59	28.20	855	0	21	441	1.821

Question 5:

2:00 pm: 13.234.176.102

6:30 pm: 13.234.210.38

11 pm: 13.234.176.102

IP address of GitHub observed at 2pm and 11pm is same but different from one at 6:30 pm. Difference is there because GitHub uses many servers around the world. When a request is sent to GitHub, one of the servers depending on network traffic and congestion a server is assigned for that request. More than one server is used for load balancing and increasing the reliability of the system i.e. even if some server fails traffic can be diverted to other servers.