DALHOUSIE UNIVERSITY

Faculty of Computer Science

CSCI 6704 – Advanced Topics in Networks

Name: Arka Ghosh

Banner ID: B00911033

Assignment: 01

Question no. 1

Evolution of TCP/IP from its predecessor ARPAnet

ARPAnet, a supernetwork built by the Advanced Research Projects Agency (ARPA) in 1969, was the forerunner of today's Internet [1]. ARPAnet's primary task was to offer a quicker, more secure flow of information from one location to another while also protecting systems from potential attacks. Following the establishment of ARPAnet, other organizations began to establish a universal language that would allow the information to be exchange between any two networked computer, regardless of the hardware and the software. Bob Kahn and Vint Cerf, two American computer scientists, invented a new way for transmitting data packets in a digital envelope or 'datagram' in 1974 [2]. They named this method Transmission-Control Protocol (TCP) which made it possible for the computers to operate in the same language. IP stands for Internet Protocol, when paired with TCP, helps in the routing of Internet traffic. ARPANET swiftly expanded after the advent of TCP/IP and became a global linked network of networks, or 'Internet.'

Features of TCP/IP

TCP/IP, which stands for Transmission Control Protocol/Internet Protocol, is a set of communications protocols used to link network devices and exchange messages over the internet [3]. The two protocol suites of TCP/IP serves different functions. TCP outlines how the applications can establish communication channels across a network. It is also responsible for managing how a message is divided into small packets before being transmitted over the internet and reassembled in the right order at the destination address [4]. IP specifies how to address and route each packet to ensure it reaches its intended destination [4]. This IP address is checked by each gateway computer on the network to decide where to send the message. TCP/IP includes many important features which has been described below:

- **Multi-Vendor Support:** TCP/IP is supported by a wide range of hardware and software suppliers which implies that the TCP/IP suite is not limited to any specific vendor [5].
- **Interoperability**: TCP/IP eliminates the barriers of cross-platform or multi vendors which has made it possible for us to to in a heterogeneous networks. A network user using a computer which is Windows Operating System can download files from a Linux workstation, because both Operating Systems support TCP/IP [6].
- **Name resolution:** Although the numeric IP address is more likely convenient for the computer devices rather than the network adapter's pre-defined physical addresses, people might have problem remembering whether a computer's IP address is 198.168.131.145 or 198.168.132.161. TCP/IP enables us to use human-friendly names that are simple to remember i.e. www.google.com. DNS servers are used to convert a human-readable name to an IP address and vice versa [7].
- **Logical Addressing:** A standard addressing technique that allows every TCP/IP device to address any other device in the network uniquely regardless of whether the network is as large as the worldwide Internet [8].
- **Routability:** A router is capable of reading logical addressing information and directing data across the network to its destination. TCP/IP is a routable protocol, which implies that data packets from one network segment can be transported to another [6].

- **Error Check & Flow Control:** The TCP/IP protocol includes features that assure reliable data transport from the source to the destination. Many of these error-checking, flow-control, and acknowledgment functions are defined by TCP [6].

Differences between TCP/IP and OSI

- The biggest difference between the two models is that the OSI model separates different functions into multiple layers, whereas the TCP/IP model assembles them into single layers. For instance, TCP/IP model consists of 4 layers and OSI model consists of 7 seven layer (Appendix A).
- TCP/IP is the client-server model that is used for the data transmission over the internet whereas OSI is a structured model that deals with the operation of a network [9].
- TCP/IP is based on standard protocols developed by the computer network. On the other hand, OSI is protocol independent [10].
- The transport layer of OSI model is only connection-oriented whereas the TCP/IP model provides both connection-oriented and connectionless transmission [11].
- TCP/IP follows horizontal approach whereas OSI model is based on vertical approach [13].
- OSI model provides standardization to devices i.e. router, switches, and other hardware devices. However, TCP/IP provides the connection between various computers [13].
- Most applications use all the layers in the TCP/IP, however not all the layers are used by most of the simple applications in the OSI model. In case of OSI model, only the first three layers are mandatory to enable the data communication [14].

Request for Comments (RFC)

A Request for Comments (RFC) is a formal document created by Internet Engineering Task Force (IETF) and then reviewed by interested parties. The RFC document series contains technical and organizational information authored by individuals or group of computer scientists or engineers regarding the innovations, research and behaviors of the internet and internet-operated systems Internet in the form of a memorandum [15]. They cover a wide range of topics related to computer networking, including protocols, methods, programs, and concepts. Some RFCs are informal, however, the final version of an RFC that is intended to become an Internet standard becomes the standard, and no additional comments or revisions are permitted on it [16].

Role of Internet Engineering Task Force (IETF)

IETF, a global community of network designers, academics, operators and vendors who collaborate in a variety of working group, is a non-profit open standards organization that oversees and develops internet standards [17]. The primary role of IETF is to manage and develop the architecture and implementation of the Internet Protocol Suite which comprises Transmission Control Protocol (TCP) and Internet Protocol (IP) [18]. This role involves allocating IP address ranges for specified reasons such as multicasting, experimental use, documentation and general distribution over the internet. This vital organization seeks to create open technological standards for the global internet through open processes, and to guarantee transparency and accessibility, the IETF makes all Request for Comments (RFC) content publicly available. In simpler words, IETF's primary role is to guarantee that internet operates properly which the organization ensures by creating relevant and high-quality technical documentation.

Question no. 2

VC Table in Switch #1

VCin	In Port	VCout	Out Port
10	1	10	3
10	2	20	3
10	3	10	4
20	3	10	2
10	4	30	3
30	3	10	1

VC Table in Switch #2

VCin	In Port	VCout	Out Port
10	2	10	4
20	2	20	4
10	1	10	2
10	3	30	4
10	4	20	2
20	4	10	3
30	2	10	1
30	4	30	2

VC Table in Switch #3

VCin	In Port	VCout	Out Port
10	1	10	2
10	4	10	3
10	2	20	3
10	3	10	1
20	3	10	4

VC Table in Switch #4

VCin	In Port	VCout	Out Port
10	3	10	4
20	3	20	4
10	1	10	3
20	1	20	3
10	2	30	3
10	4	10	1
30	3	20	1

VC Table in Switch #5

VCin	In Port	VCout	Out Port
10	1	10	4
20	1	10	2
30	1	20	2
10	2	10	3
20	2	10	1
30	2	20	1
10	3	30	2
10	4	30	1

Question no. 3 (A)

Here,

N = number of hops between two end systems = 8

L = length of the message in bits = 4096 bits

B = bandwidth in bits per second, on all links = 1024 bits/sec.

P = packet size in bits = 128 bits

H = overhead for each packet in bits = 32 bits

S = call set up time in seconds = 0.2 sec

R = call release time in seconds = 0.1 sec

D = propagation delay per hop in seconds = 0.001 sec

<u>Circuit Switching</u>

Transmission Delay, Ttrans = L/B = 4096bits / (1024 bits/sec.) = 4 sec.

Propagation Delay, Tprop = D*N (As propagation delay is for the message from node to node)

= 0.001 * 8

= 0.008 sec.

Therefore, the total end-to-end delay = S + R + Ttrans + Tprop

= 0.2 sec. + 0.1 sec. + 0.008 sec. + 4 sec.

= 4.308 sec.

The total end-to-end delay is **4.308 sec.**

Datagram Packet Switching

Here,

Packet Size = 128 – 32 = 96 bits

Number of Packets = 4096/96 = 42.67 = 43 packets

As each packet experiences a transmission delay at every node and there is a propagation delay for each node for each packet from node to node,

Therefore, the total end-to-end delay = Number of Packets * N * (Ttrans + T prop)

= 8 * 43 * (P/B + D)

= 8 * 43 * (128/1024 + 0.001)

= 43.34s

The total end-to-end delay is **43.34s**.

Virtual Circuit Packet Switching

As there is no overhead, so the packet size will remain 128 bits.

Number of Packets = 4096/128 = 32 packets

As each packet experiences a transmission delay at every node and there is a propagation delay for each node for each packet from node to node,

Therefore, the total end-to-end delay = S+ R + (Number of Packets * N (Ttrans + T prop))

= 0.2 + 0.1 + (8 * 32 * (P/B + D))

= 0.2 + 0.1 + (8 * 32 * (128/1024 + 0.001))

= 32.556s

Therefore, the total end-to-end is **32.556s.**

Question no. 3 (B)

Here,

Propagation Speed, s = 2.5 * 10^8 meters/sec.

Length of the Packet, L = 100 bits

Bandwidth of Link, R = 28 kbps = 28 * 10^3 bits/sec.

We need do compute the distance m meters.

Given,

Ttrans = Tprop

- ⇨ L/R = m/s
- ⇨ m = (L * S) / R
- ⇨ m = (100 * 2.5 * 10^8) / 28 * 10^3
- ⇨ m = (2.5 * 10^10) / (28 * 10^3)
- ⇨ m = 892857.142857 meters

So, the distance m = **892857.142857 meters or 892.857 kilometers**.

Question no. 3 (C)

Part A

Here,

Distance, d = 20000 kilometers = 2 * 10^7 meters

Bandwidth of Link, R = 2 Mbps = 2 * 10^6 bits/sec.

Propagation Speed, s = 2.5 * 10^8 meters/sec

Packet Size, L = 800,000 bits

Therefore,

Ttrans = L/R

= 800000 bits / (2 * 10^6 bits/sec.)

= 0.4 sec.

Tprop = d/s

= (2 * 10^7 meters) / (2.5 * 10^8 meters/sec)

= 0.08 sec.

So, Total time = Ttrans + Tprop

= 0.4 sec. + 0.08 sec.

= 0.48 sec.

So, the total time needed to send the file is **0.48 sec**.

Part B

Here,

Distance, d = 20000 kilometers = 2 * 10^7 meters

Bandwidth of Link, R = 2 Mbps = 2 * 10^6 bits/sec.

Propagation Speed, s = 2.5 * 10^8 meters/sec

Total Packets = 20

Packet Size, L = 40,000 bits

Ttrans of acknowledgment packet, Ttrans' = 100 ms = 0.1 sec.

Each packet will be sent with a Ttrans + Tprop + Ttrans' delay. The acknowledgement packet must first reach the sender before the following packet can be sent, which adds an additional Ttrop delay.

Therefore,

Total time needed for 20 packets to send = 20 * (Ttrans + 2Tprop + Ttrans')

= 20 * (40000 bits / (2 * 10^6 bits/sec.) + 2*((2 * 10^7 meters) / (2.5 * 10^8 meters/sec)) + 0.1sec.)

= 20 * (0.02+ 2 * 0.08 + 0.1)

= 5.6 sec.

So, the total time needed to send the file is **5.6 sec.**

Question no. 4

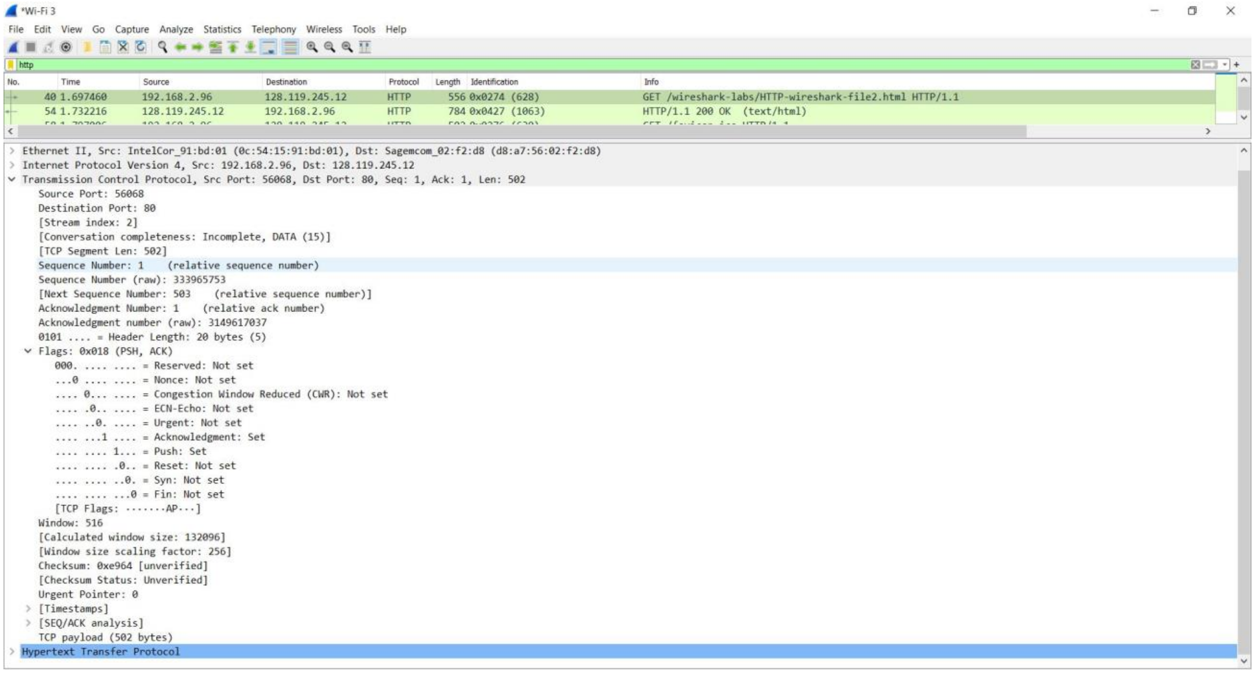

Figure: Wireshark Capture of TCP Segment

The components for the TCP header has been mentioned in the following diagram:

<table>
<tr><td colspan="8">0 15</td><td>16 32</td></tr>
<tr><td colspan="8">16- bit source port number
(56068)</td><td>16- bit source destination number
(80)</td></tr>
<tr><td colspan="9">32-bit sequence number **(1)**</td></tr>
<tr><td colspan="9">32-bit acknowledgement number **(1)**</td></tr>
<tr><td>6-bit Header Length
(0101)</td><td>Reserved
(000)</td><td>U R G
(0)</td><td>A C K
(1)</td><td>P S H
(1)</td><td>R S T
(0)</td><td>S Y N
(0)</td><td>F I N
(0)</td><td>16- bit window size
(516)</td></tr>
<tr><td colspan="8">16-bit TCP Checksum
(0xe964)</td><td>16-bit urgent pointer
(0)</td></tr>
<tr><td colspan="9">options (if any)</td></tr>
<tr><td colspan="9">data **(502 bytes)**</td></tr>
</table>

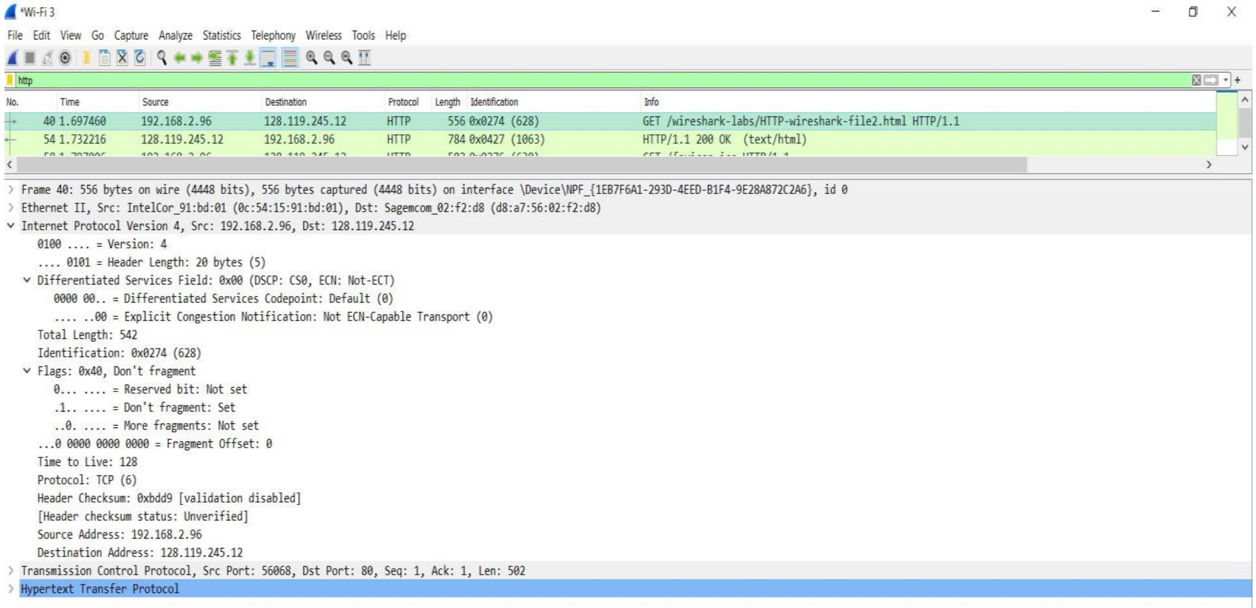

Figure: Wireshark Capture of IP Segment

The components for the IP header has been mentioned in the following diagram:

<table>
<tr><td>4 bits IP version
(4)</td><td>4 bits header length
(20)</td><td>8 bits Type of Service
(0)</td><td colspan="4">16 bits Total Length
(542)</td></tr>
<tr><td colspan="3">16 bits Identification Fragment
(0x0274)</td><td>R
(0)</td><td>D
F
(1)</td><td>M
F
(0)</td><td>13 bits Fragment Offset
(0)</td></tr>
<tr><td colspan="2">8 bits Time-to-Live (TTL)
(128)</td><td>8 bits Protocol
(6)</td><td colspan="4">16 bits Header Checksum
(0xbdd9)</td></tr>
<tr><td colspan="7">32 bits Source IP Address
(192.168.2.96)</td></tr>
<tr><td colspan="7">32 bits Destination IP Address
(128.119.245.12)</td></tr>
<tr><td colspan="7">Options</td></tr>
<tr><td colspan="7">Data</td></tr>
</table>

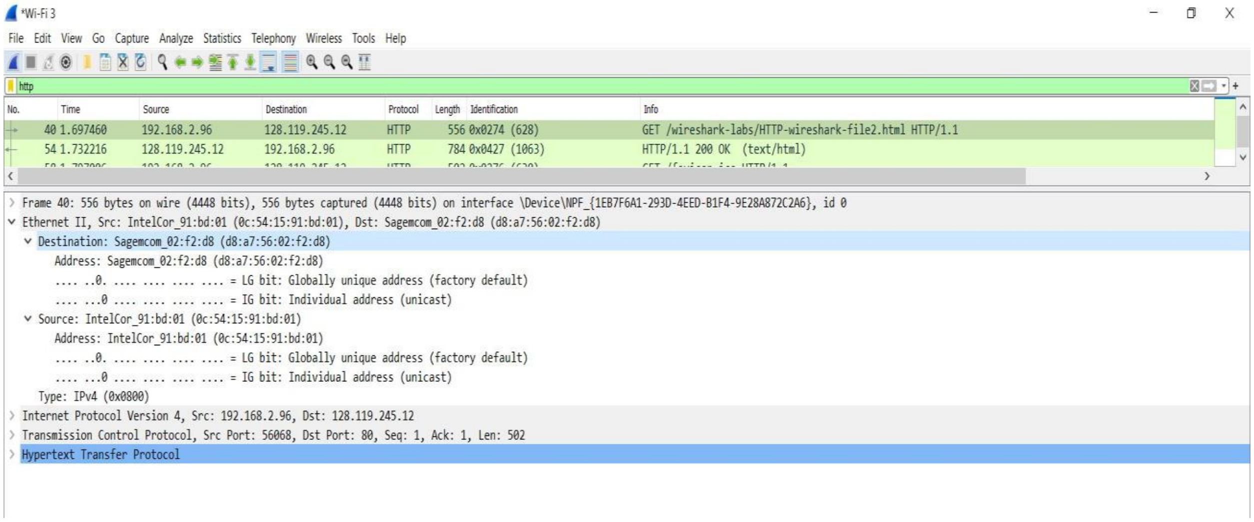

Figure: Wireshark Capture of Ethernet Segment

I have used a wireless network for capturing the packets using Wireshark. There's only source and destination address in the Wireshark capture for the Ethernet header which has been mentioned below. Other fields of the Ethernet header isn't visible in the Wireshark capture.

Source Address: 0c:54:15:91:bd:01

Destination Address: d8:a7:56:02:f2:d8

Notes on Data Link Trailer

No, I have not been able to find the Data Link Trailer in the Ethernet Frame Capture in Wireshark. The majority of the Ethernet either don't supply the FCS to the Wireshark or other applications, or their drivers aren't set up to do so [19]. With the FCS shortened, Wireshark only displays the data that is provided to it by the Network Interface Controller driver.

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Appendix

Appendix A

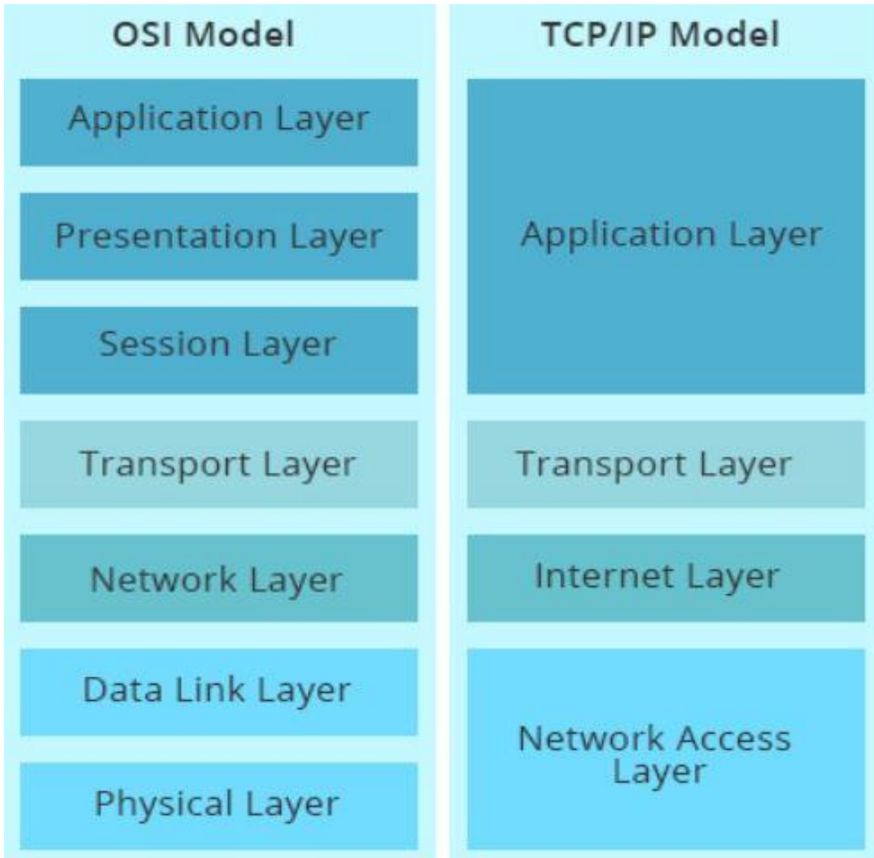

Figure: Layers of OSI and TCP/IP Model [12]