

CO-223

LABORATORY SESSION 3

NAME : WIMALASIRI KPGP
REG NO : E/14/403
SEMESTER : 3RD
GROUP : 15
DATE : 21/03/2017

Part-1 IP addresses and MAC addresses

a)

IP address	MAC address
Subnet-1: 192.168.2.0/24	PC1: 00-16-35-66-66-03
Subnet-2: 192.168.3.0/24	PC2: 00-16-35-66-6A-CB
PC1: 192.168.2.2	PC3: 00-0B-2B-0E-D9-E1
PC2: 192.168.2.3	MAC addresses associated to the Router: 192.168.2.1 → 00-15-C6-84-A2-58 192.168.3.1 → 00-15-C6-84-A2-59
Router's Interface on subnet-1: 192.168.2.1	
Router's Interface on subnet-2: 192.168.3.1	
PC3: 192.168.3.2	

Table 1

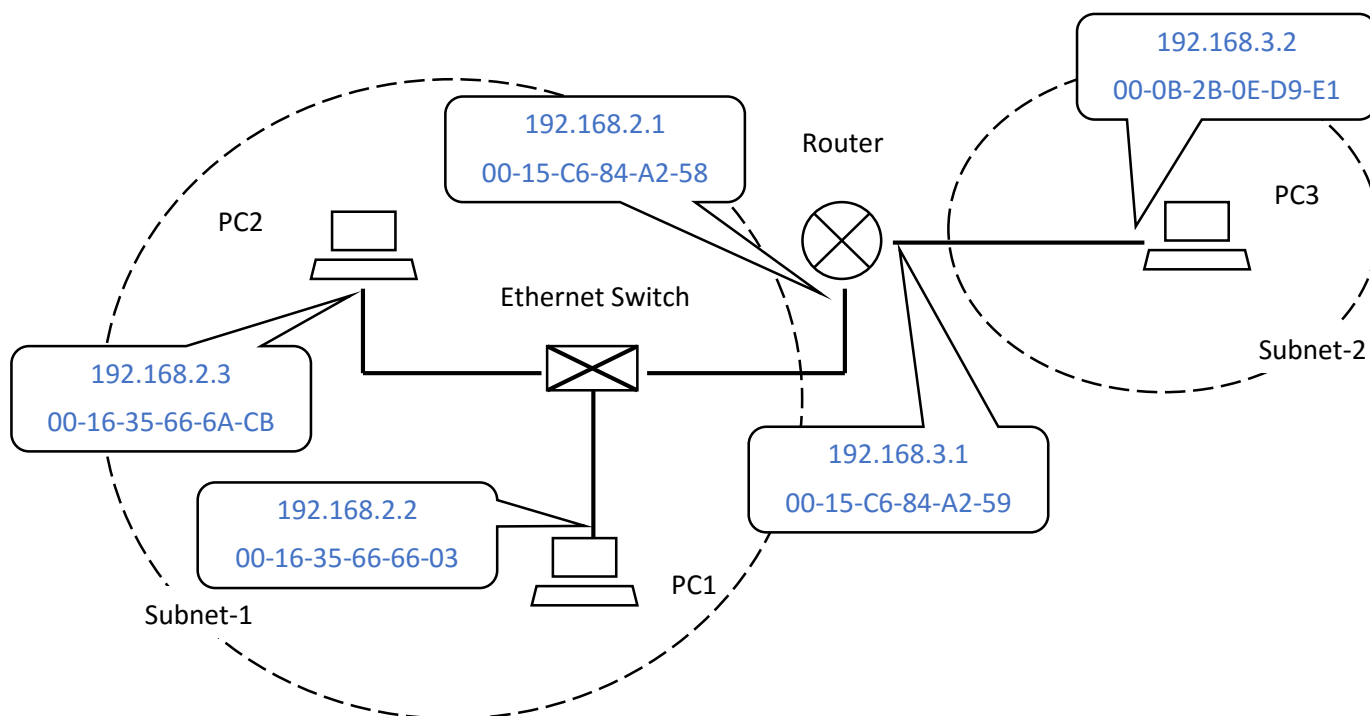


Figure 1A

Part-2: Routing Table (IP tables)

a) Routing table @ PC1:

```
Administrator: C:\Windows\system32\cmd.exe

C:\Users\Administrator>netstat -r

=====
Interface List
11...00 16 35 66 66 03 .....Broadcom NetXtreme Gigabit Ethernet
1.....Software Loopback Interface 1
12...00 00 00 00 00 00 e0 Microsoft ISATAP Adapter
=====

IPv4 Route Table
=====
Active Routes:
Network Destination        Netmask          Gateway          Interface        Metric
0.0.0.0                    0.0.0.0          192.168.2.1      192.168.2.2      266
127.0.0.0                  255.0.0.0        On-link          127.0.0.1        306
127.0.0.1                  255.255.255.255  On-link          127.0.0.1        306
127.255.255.255            255.255.255.255  On-link          127.0.0.1        306
192.168.2.0                255.255.255.0    On-link          192.168.2.2      266
192.168.2.2                255.255.255.255  On-link          192.168.2.2      266
192.168.2.255              255.255.255.255  On-link          192.168.2.2      266
224.0.0.0                  240.0.0.0        On-link          127.0.0.1        306
224.0.0.0                  240.0.0.0        On-link          192.168.2.2      266
255.255.255.255            255.255.255.255  On-link          127.0.0.1        306
255.255.255.255            255.255.255.255  On-link          192.168.2.2      266

Persistent Routes:
Network Address          Netmask  Gateway Address  Metric
0.0.0.0                  0.0.0.0  192.168.4.1      Default
0.0.0.0                  0.0.0.0  192.168.2.1      Default

IPv6 Route Table
=====
Active Routes:
If Metric Network Destination      Gateway
1 306 ::1/128 On-link
11 266 fe80::/64 On-link
11 266 fe80::e04e:fc20:7389:8f52/128 On-link
1 306 ff00::/8 On-link
11 266 ff00::/8 On-link

Persistent Routes:
None

C:\Users\Administrator>
```

Figure 2A : Routing table PC1

b) Routing table @ PC2:

```
Administrator: Command Prompt
C:\Users\Administrator>netstat -r

=====
Interface List
11...00 16 35 66 6a cb .....Broadcom NetXtreme Gigabit Ethernet
1.....Software Loopback Interface 1
13...00 00 00 00 00 00 00 e0 Microsoft ISATAP Adapter
=====

IPv4 Route Table
=====
Active Routes:
Network Destination        Netmask          Gateway          Interface        Metric
0.0.0.0                    0.0.0.0          192.168.2.1      192.168.2.3      266
127.0.0.0                  255.0.0.0        On-link          127.0.0.1        306
127.0.0.1                  255.255.255.255  On-link          127.0.0.1        306
127.255.255.255           255.255.255.255  On-link          127.0.0.1        306
192.168.2.0                255.255.255.0    On-link          192.168.2.3      266
192.168.2.3                255.255.255.255  On-link          192.168.2.3      266
192.168.2.255             255.255.255.255  On-link          192.168.2.3      266
224.0.0.0                  240.0.0.0        On-link          127.0.0.1        306
224.0.0.0                  240.0.0.0        On-link          192.168.2.3      266
255.255.255.255           255.255.255.255  On-link          127.0.0.1        306
255.255.255.255           255.255.255.255  On-link          192.168.2.3      266
=====
Persistent Routes:
Network Address            Netmask          Gateway Address  Metric
0.0.0.0                    0.0.0.0          192.168.2.1      Default
=====

IPv6 Route Table
=====
Active Routes:
If Metric Network Destination      Gateway
1 306 ::1/128 On-link
11 266 fe80::/64 On-link
11 266 fe80::88c2:dc5:57df:88ac/128 On-link
1 306 ff00::/8 On-link
11 266 ff00::/8 On-link
=====
Persistent Routes:
None
C:\Users\Administrator>
```

Figure 2B : Routing table PC2

c) Routing table @ PC3:

```

C:\Users\Administrator>netstat -r

Interface List
15...00 0b 2b 0e d9 e1 .....Realtek RTL8139/810x Family Fast Ethernet NIC #2
11...00 16 35 66 72 31 .....Broadcom NetXtreme Gigabit Ethernet
1.....Software Loopback Interface 1
16...00 00 00 00 00 00 e0 Microsoft ISATAP Adapter
14...00 00 00 00 00 00 e0 Microsoft ISATAP Adapter #2

IPv4 Route Table

Active Routes:
Network Destination        Netmask          Gateway          Interface        Metric
0.0.0.0                    0.0.0.0          192.168.3.1      192.168.3.2      276
127.0.0.0                  255.0.0.0        On-link          127.0.0.1        306
127.0.0.1                  255.255.255.255  On-link          127.0.0.1        306
127.255.255.255            255.255.255.255  On-link          127.0.0.1        306
192.168.3.0                255.255.255.0    On-link          192.168.3.2      276
192.168.3.2                255.255.255.255  On-link          192.168.3.2      276
192.168.3.255              255.255.255.255  On-link          192.168.3.2      276
224.0.0.0                  240.0.0.0        On-link          127.0.0.1        306
224.0.0.0                  240.0.0.0        On-link          192.168.3.2      276
255.255.255.255            255.255.255.255  On-link          127.0.0.1        306
255.255.255.255            255.255.255.255  On-link          192.168.3.2      276

Persistent Routes:
Network Address            Netmask          Gateway Address  Metric
0.0.0.0                    0.0.0.0          192.168.3.1      Default
0.0.0.0                    0.0.0.0          192.168.4.1      Default
0.0.0.0                    0.0.0.0          192.168.4.1      Default

IPv6 Route Table

Active Routes:
If Metric Network Destination      Gateway
1 306 ::1/128 On-link
15 276 fe80::/64 On-link
15 276 fe80::8d55:a75b:9dda:2869/128 On-link
1 306 ff00::/8 On-link
15 276 ff00::/8 On-link

Persistent Routes:
None

C:\Users\Administrator>

```

Figure 2C : Routing table PC3

When considering about columns in IPv4 routing tables on PCs there are 5 main columns.

- Network destination – Destination IP which the packets are to be forwarded.
- Netmask – in this column it shows whether packets are to be broadcast or send in default route. Ex: 0.0.0.0 is the default netmask address
255.255.255.255 is the broadcast address
- Gateway – gateways shows whether the next destination is within the subnet or if not what is the way out towards the final destination

- Interface – this column shows the interfaces which are locally available in order to reach the gateway.
- Metric – when multiple routes are available this metric is used to choose the route. Lowest metric valued route will always be chosen.

First row in the table indicates the default situation, which have the router's interface on the subnet as the gateway. Except this situation there are no any specified gateways as all are linked.

Fifth row indicates the route for packets that are to be transferred within the subnet.

Sixth row shows the packets received to the pc itself. They are directed towards their own IP.

Last row shows packets that are to be broadcast. They should be return to the router in order to broadcast.

d) Routing table @ Router:

```
COM1 - PuTTY
Internet address is 192.168.3.1/24
MTU 1500 bytes, BW 1000000 Kbit, DLY 100 usec,
    reliability 255/255, txload 1/255, rxload 1/255
Encapsulation ARPA, loopback not set
Keepalive set (10 sec)
Full-duplex, 100Mb/s, media type is T
output flow-control is XON, input flow-control is XON
ARP type: ARPA, ARP Timeout 04:00:00
Last input 00:00:04, output 00:00:01, output hang never
Last clearing of "show interface" counters never
Input queue: 0/75/0/0 (size/max/drops/flushes); Total output drops: 0
Queueing strategy: fifo
Output queue: 0/40 (size/max)
5 minute input rate 0 bits/sec, 0 packets/sec
5 minute output rate 0 bits/sec, 0 packets/sec
  838 packets input, 75809 bytes, 0 no buffer
    Received 618 broadcasts, 0 runts, 0 giants, 0 throttles
    0 input errors, 0 CRC, 0 frame, 0 overrun, 0 ignored
    0 watchdog, 0 multicast, 0 pause input
    0 input packets with dribble condition detected
  617 packets output, 55002 bytes, 0 underruns
    0 output errors, 0 collisions, 0 interface resets
    0 babbles, 0 late collision, 0 deferred
    0 lost carrier, 0 no carrier, 0 pause output
    0 output buffer failures, 0 output buffers swapped out
Router#
Router#
Router#
Router#show ip ro
Router#show ip route
Codes: C - connected, S - static, R - RIP, M - mobile, B - BGP
       D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2
       I - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2
       ia - IS-IS inter area, * - candidate default, U - per-user static route
       o - ODR, P - periodic downloaded static route

Gateway of last resort is not set

S    192.168.4.0/24 [1/0] via 192.168.2.2
C    192.168.2.0/24 is directly connected, GigabitEthernet0/0
C    192.168.3.0/24 is directly connected, GigabitEthernet0/1
Router#
```

Figure 2D : Routing table Router

In the routing table of router in the beginning and in mid part packets status and many other information related to packet transferring are shown.
At the end connected subnets and their status are shown.

Part-3 Encapsulation, the use of routing tables and Layers working together

b)

No.	Time	Source	Destination	Protocol	Length	Info
1	0.000000	Cisco_c8:49:81	Cisco_c8:49:81	LOOP	00	Reply
2	0.150518	0.0.0.0	255.255.255.255	DHCP	320	DHCP Discover - Transaction ID 0x1b21
3	0.506209	Cisco_c8:49:81	Spawning-tree-1(192.168.2.255)	STP	88	Conf. Root = 32768/1/00:00:00:00:00:00 Cost = 0 Port = 0x0001
4	1.555298	Cisco_c8:49:81	Spawning-tree-1(192.168.2.255)	STP	88	Conf. Root = 32768/1/00:00:00:00:00:00 Cost = 0 Port = 0x0001
5	3.221694	192.168.2.4	192.168.2.255	NBNS	92	Name query NB GOOGLE.COM<00>
6	3.971002	192.168.2.4	192.168.2.255	NBNS	92	Name query NB GOOGLE.COM<00>
7	4.456367	192.168.2.2	192.168.3.2	TCP	60	49165 → 80 [SYN] Seq=0 Win=65535 Len=0 MSS=1460 JS=0 SACK_PERM=1
8	4.456718	192.168.3.2	192.168.2.2	TCP	62	80 → 49165 [SYN, ACK] Seq=0 Ack=1 Win=65535 Len=0 MSS=1460 SACK_PERM=1
9	4.456760	192.168.2.2	192.168.3.2	TCP	54	49165 → 80 [ACK] Seq=1 Ack=1 Win=65535 Len=0
10	4.457499	192.168.2.2	192.168.3.2	HTTP	515	GET /met/Heteosat7-full-scan.jpg HTTP/1.1
11	4.458873	192.168.3.2	192.168.2.2	TCP	1514	[TCP segment of a reassembled PDU]
12	4.459021	192.168.3.2	192.168.2.2	TCP	1514	[TCP segment of a reassembled PDU]
13	4.459080	192.168.2.2	192.168.3.2	TCP	54	49165 → 80 [ACK] Seq=462 Ack=2921 Win=65535 Len=0
14	4.459437	192.168.3.2	192.168.2.2	TCP	1514	[TCP segment of a reassembled PDU]
15	4.459583	192.168.3.2	192.168.2.2	TCP	1514	[TCP segment of a reassembled PDU]
16	4.459610	192.168.3.2	192.168.2.2	TCP	54	49165 → 80 [ACK] Seq=462 Ack=2921 Win=65535 Len=0

Frame 10: 515 bytes on wire (4120 bits), 515 bytes captured (4120 bits) on interface 0
 Ethernet II, Src: HewlettP_66:66:03 (00:16:35:66:66:03), Dst: Cisco_84:a2:58 (00:15:c6:84:a2:58)
 Internet Protocol Version 4, Src: 192.168.2.2, Dst: 192.168.3.2
 Transmission Control Protocol, Src Port: 49165, Dst Port: 80, Seq: 1, Ack: 1, Len: 461
 Hypertext Transfer Protocol

0000 00 15 c6 84 a2 58 00 10 35 66 66 03 00 00 45 00X..5ff...E.
 0010 01 75 1a d8 40 00 80 06 00 00 c8 a8 02 02 c8 a8@... ..
 0020 03 02 c8 0d 00 50 19 9c 21 9e 0a 98 b7 c1 50 18P..!....P.
 0030 fa f0 88 3c 00 00 47 45 54 20 2f 6d 65 74 2f 4d ...<..GE T /met/H
 0040 65 74 65 6f 73 61 74 37 2d 06 75 6c 6c 2d 73 63 eteosat7 -full-sc
 0050 61 6e 2e 6a 70 67 20 48 54 54 50 2f 31 2e 31 0d an.jpg H TTP/1.1.
 0060 0a 41 63 63 65 70 74 3a 20 2a 2f 2a 0d 0a 52 65 .Accept: /*..Re
 0070 66 65 72 65 72 3a 20 68 74 74 70 3a 2f 2f 31 39 ferer: h ttp://19
 0080 32 2e 31 36 58 2e 33 2e 32 2f 6d 65 74 2f 0d 0a 2.168.3. 2/met/..
 0090 41 63 63 65 70 74 2d 4c 61 6e 67 75 61 67 65 3a Accept-L language!

Figure 3A : HTTP Request PC2

Frame no. of the http request is 10.

c)

- The HTTP request data is specified by adding commands 'GET/met/'.
- 515 bytes in size

d)

	1 st level encapsulation	2 nd level encapsulation	3 rd level encapsulation
What is the payload of this layer?	Data + header-1	Data + header-1 + header-2	Data + header-1 + header-2 + header-3
State where this encapsulation is done:			
Where in PC1?	In Operating system	In Operating system	In Network Interface Card
At Which layer?	At transport layer	At network layer	At physical layer
Details of the control information (header fields) added by this layer:			
Associated Protocol in this layer:	TCP	IP	Ethernet
Source port no:	49165	-	-
Destination port no:	80	-	-
Protocol type:	Connection oriented There is a fixed path to transfer the packets.	Connection-less There is no fixed path to transfer packets.	Connection-less There is no fixed path to transfer packets.
Source address:	-	192.168.2.2	00:16:35:66:66:03
Destination address:	-	192.168.3.2	00:15:C6:84:A2:58
State whether the above addresses are IP addresses or MAC addresses:	-	IP addresses	MAC addresses
Other control information:	TCP segment length : 461	Total length:501 TTL = 128	-
What is the size (in bits/bytes) of the control information (header fields) added by this layer?	20 bytes	20 bytes	14 bytes
How do you call the payload+header?	Segment	Datagram	Frame

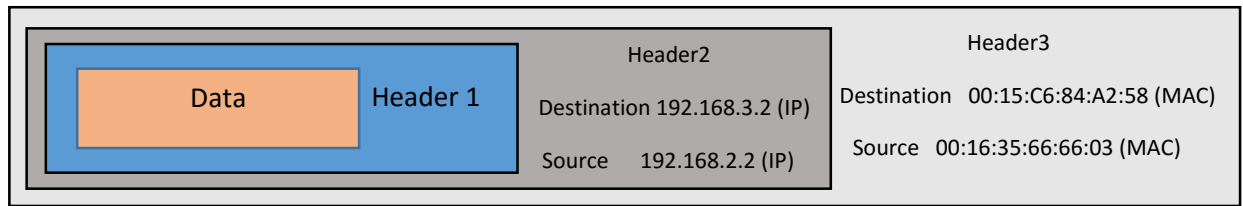
e)

$$\text{Percentage} = \frac{\text{size of header1} + \text{size of header2} + \text{size of header3}}{\text{frame size}} \times 100\%$$

$$\text{Percentage} = \frac{20 + 20 + 14}{515} \times 100\%$$

$$\text{Percentage} = 10.49\%$$

f)



g)

Part 1) a)		Part 3) f)	
Source	192.168.2.2 (IP)	Source	192.168.2.2 (IP)
Destination	192.168.3.2 (IP)	Destination	192.168.3.2 (IP)
Source	00:16:35:66:66:03 (MAC)	Source	00:16:35:66:66:03 (MAC)
Destination	00:15:C6:84:A2:58 (MAC) (MAC address of the router)	Destination	00:15:C6:84:A2:58 (MAC)

Table 2

Destination IP address is not in the same subnet of PC1. According to the routing table of PC1, it makes its decision to forward the packet to the default gateway (192.168.2.1). In order to send the packet to the particular IP, frame should be sent to the particular MAC address. Which is 00:15:C6:84:A2:58

PC1 contains a directory of MAC addresses and IP addresses of devices within the same subnet. PC1 can refer the particular IP and find the MAC address of certain device.

- h) When the frame is received by the router, Ethernet header, which was put by the physical layer is processed and router recovers that the frame was sent by the physical layer of PC1 and its destination is physical layer of router.

```
> Frame 10: 515 bytes on wire (4120 bits), 515 bytes captured (4120 bits) on interface 0
▼ Ethernet II, Src: HewlettP_66:66:03 (00:16:35:66:66:03), Dst: Cisco_84:a2:58 (00:15:c6:84:a2:58)
  ▼ Destination: Cisco_84:a2:58 (00:15:c6:84:a2:58)
    Address: Cisco_84:a2:58 (00:15:c6:84:a2:58)
    .... 0. .... = LG bit: Globally unique address (factory default)
    .... 0. .... = IG bit: Individual address (unicast)
  ▼ Source: HewlettP_66:66:03 (00:16:35:66:66:03)
    Address: HewlettP_66:66:03 (00:16:35:66:66:03)
    .... 0. .... = LG bit: Globally unique address (factory default)
    .... 0. .... = IG bit: Individual address (unicast)
  Type: IPv4 (0x0800)
> Internet Protocol Version 4, Src: 192.168.2.2, Dst: 192.168.3.2
> Transmission Control Protocol, Src Port: 49165, Dst Port: 80, Seq: 1, Ack: 1, Len: 461
> Hypertext Transfer Protocol
```

Figure 3B

Then, router's physical layer removes the 3rd level encapsulation and recover the IP address which the packet to be sent and send the packet to the IP layer.

```
> Frame 10: 515 bytes on wire (4120 bits), 515 bytes captured (4120 bits) on interface 0
> Ethernet II, Src: HewlettP_66:66:03 (00:16:35:66:66:03), Dst: Cisco_84:a2:58 (00:15:c6:84:a2:58)
▼ Internet Protocol Version 4, Src: 192.168.2.2, Dst: 192.168.3.2
  0100 .... = Version: 4
  .... 0101 = Header Length: 20 bytes (5)
  > Differentiated Services Field: 0x00 (DSCP: CS0, ECN: Not-ECT)
    Total Length: 501
    Identification: 0x1ad8 (6872)
  > Flags: 0x02 (Don't Fragment)
    Fragment offset: 0
    Time to live: 128
    Protocol: TCP (6)
    Header checksum: 0x0000 [validation disabled]
    [Header checksum status: Unverified]
    Source: 192.168.2.2
    Destination: 192.168.3.2
    [Source GeoIP: Unknown]
    [Destination GeoIP: Unknown]
  > Transmission Control Protocol, Src Port: 49165, Dst Port: 80, Seq: 1, Ack: 1, Len: 461
  > Hypertext Transfer Protocol
```

Figure 3C

- i) Destination IP address that the IP layer of the router reads is 192.168.3.2
According to the routing table, IP layer of the router check whether to which subnet, 192.168.3.2 is referred to.

```

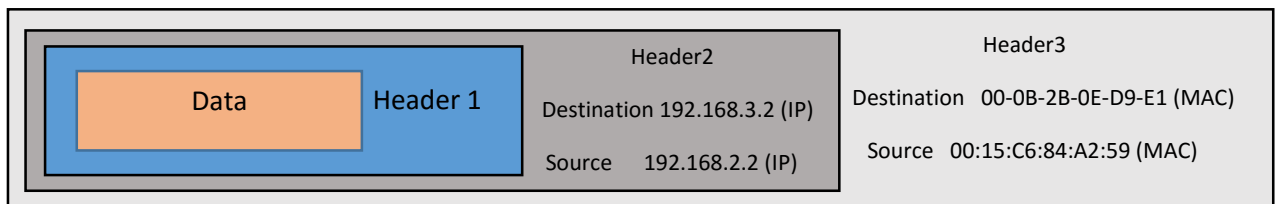
S    192.168.4.0/24 [1/0] via 192.168.2.2
C    192.168.2.0/24 is directly connected, GigabitEthernet0/0
C    192.168.3.0/24 is directly connected, GigabitEthernet0/1
Router#

```

Figure 3D

Then, IP layer of the router identifies the subnet which 192.168.3.2 belongs to, and send the packet to the particular Ethernet interface. In this case it is GigabitEthernet0/1.

j)



k)

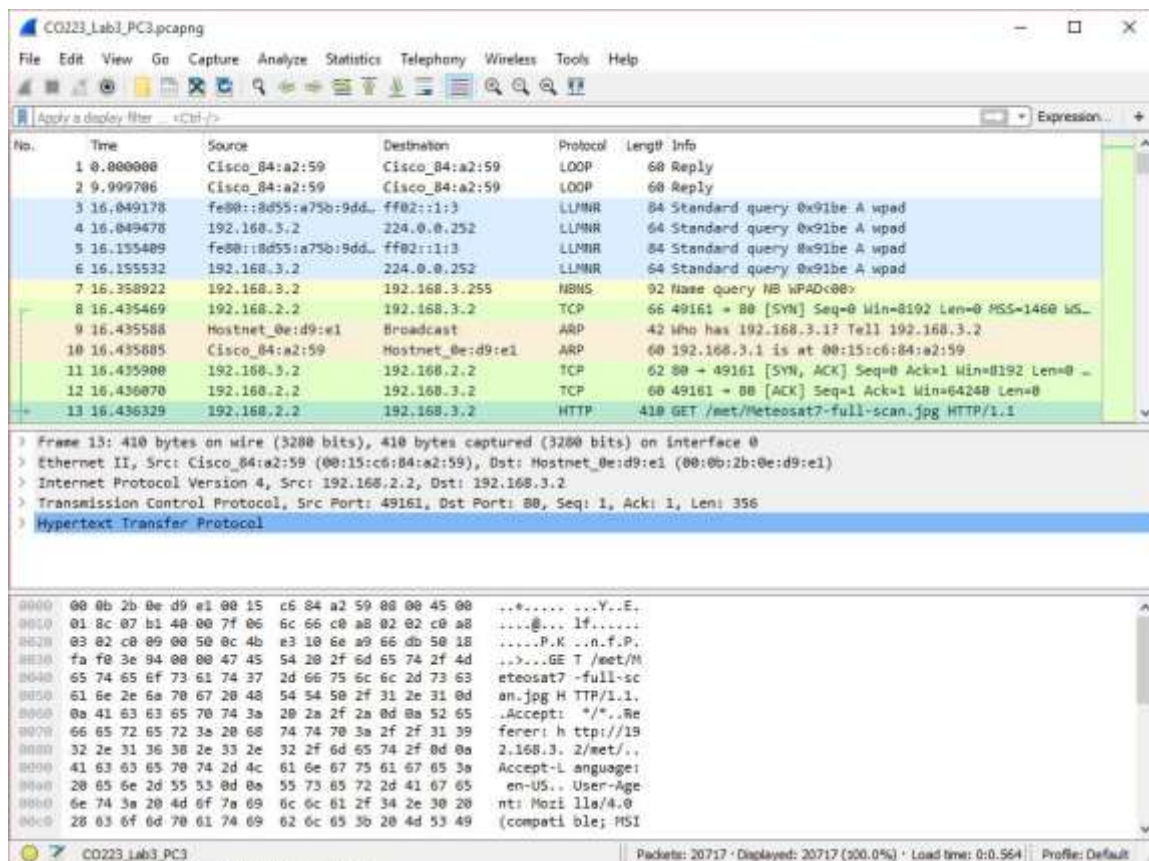


Figure 3E

Frame no. 13 is the frame which have sent from PC1

According to Figure 3E		According to question j)	
Source	192.168.2.2 (IP)	Source	192.168.2.2 (IP)
Destination	192.168.3.2 (IP)	Destination	192.168.3.2 (IP)
Source	00:15:C6:84:A2:59 (MAC)	Source	00:15:C6:84:A2:59 (MAC)
Destination	00:0B:2B:0E:D9:E1 (MAC)	Destination	00:0B:2B:0E:D9:E1 (MAC)

Table 3

l)

Sending data from PC1 to router	Sending data from router to PC3
Component associated to the 'Source IP address' : PC1	Component associated to the 'Source IP address' : Router-NIC2
Component associated to the 'Destination IP address' : Router-NIC1,PC1,PC3	Component associated to the 'Destination IP address' : Router-NIC2,PC3
Component associated to the 'Source MAC address' : PC1	Component associated to the 'Source MAC address' : Router-NIC2
Component associated to the 'Destination IP address' : Router-NIC1,PC1	Component associated to the 'Destination IP address' : Router-NIC2,PC3

Table 4

m)

- Consider an incident where PC1 is transferring a packet to PC3 which is not within the same subnet. In PC1, according to the destination IP address, destination MAC address is chosen. If IP is within the same subnet MAC address of particular IP can be obtained. If IP is referred to somewhere else, packet is forwarded towards the gateways so that packet can be directed to the subnet it belongs. In order to do that, MAC address of gateway interface should be obtain. MAC addresses are used locally within the subnet.

Always gateway interfaces are belongs to a router. Router then obtain the MAC address of particular router interface which is connected to the PC3 by IP address. Then segment is forwarded to the physical interface of PC3. Then the packet is directed to the particular IP address.

- When network layer send the packet to the physical layer in PC1, it obtained the destination MAC address by referring the destination IP address. If the destination IP address is not within the same subnet MAC address would be the gateway interface (Router) MAC address. This process is done by the combination of both network layer and the physical layer. After forwarding the frame to the physical layer of the router, it process the header put by the PC1 and decide IP address that the segment to be forwarded. Then in the network layer of router packet is send to the connected physical layer in order to send to the particular IP address. Physical layer decides the physical interface that the segment to be forwarded with the help of network layer. At the end, physical layer of PC3 receives the frame and remove the header 3 and forward it to the particular IP address in network layer.

n)

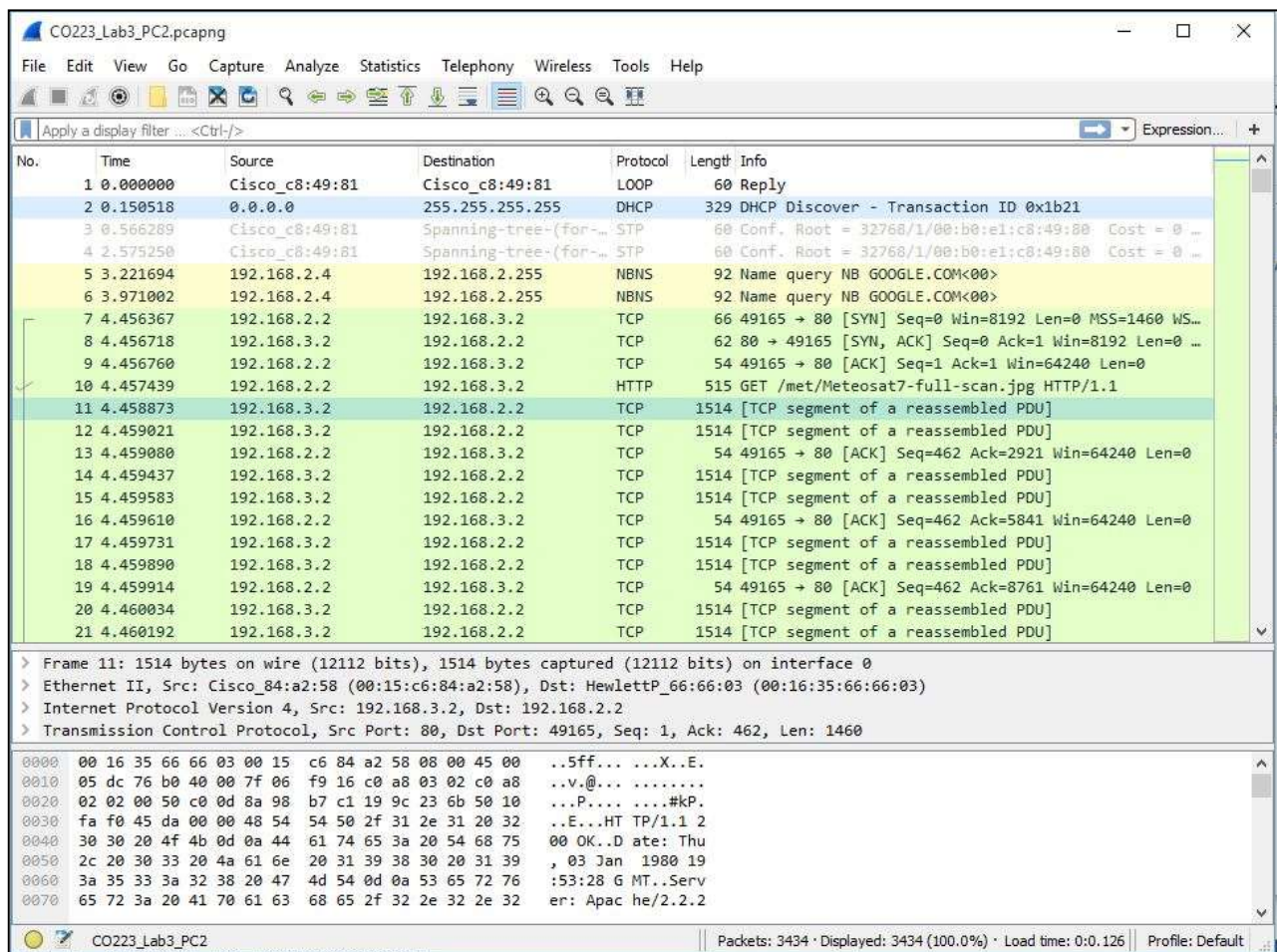


Figure 3F

TCP packets those are 1514 in length, are the packets which carry the contents.
Destination is 192.168.2.2 and source is 192.168.3.2

o)

$$\text{Percentage} = \frac{\text{size of header1} + \text{size of header2} + \text{size of header3}}{\text{frame size}} \times 100\%$$

$$\text{Percentage} = \frac{20 + 20 + 14}{1514} \times 100\%$$

$$\text{Percentage} = 3.66\%$$

In question e. percentage was 10.49% and now the percentage is 3.66%.
Reason for this difference is the different size of each datagram. Except that all the header sizes are same.