ECE 461 – Internetworking

Problem Set 3

Solutions

Problem 1. Consider the network shown in Figure 1 with three hosts (HostA, HostB, HostC), one router (Router1), and two Ethernet segments. The figure includes the network configuration, the IP addresses, the netmasks, and the MAC addresses.

The routing table entries for HostA, HostB, HostC, and Router1 are provided to you below in Figure 1. Assume that the ARP tables of all hosts and the router are initially empty.

Note:

- For each packet, you need to specify the source, the destination, and a description of the packet type. For ARP packets, provide enough detail so that the address translation can be traced.
- Recall that a successful ping involves two ICMP packets: an ICMP echo request from the host that issues the ping, and an ICMP echo reply from the host which is queried.

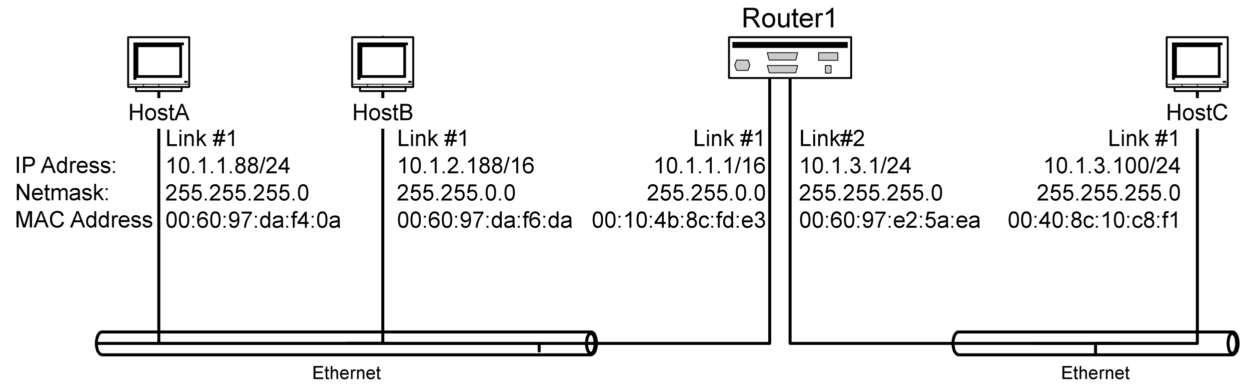

Figure 1.

Routing Table at Router1

Destination	Gateway
10.1.0.0/16	Link #1
10.1.1.0/24	Link #1
10.1.3.0/24	Link #2

Routing Table at HostA

Destination	Gateway
Default	10.1.1.1
10.1.1.0/24	Link#1

Routing Table at HostB

Destination	Gateway
Default	10.1.1.1
10.1.0.0/16	Link#1

Routing Table at HostC

Destination	Gateway
Default	10.1.3.1
10.1.3.0/24	Link#1

a) Describe in detail the ARP and ICMP packets which are transmitted on the Ethernet segments when HostA executes the command "ping 10.1.2.188".

1. Ethernet Header(Src=HostA, Dest=broadcast) ARP who-has 10.1.1.1 tell 10.1.1.88
2. Ethernet Header (Src= Router1, Dest = HostA), ARP reply 10.1.1.1 is-at 00:10:4b:8c:fd:e3
3. Ethernet Header (Src= HostA, Dest = Router1), IP Header (Src= HostA, Dest = HostB), ICMP Echo Request
4. Ethernet Header(Src=Router1, Dest=broadcast) ARP who-has 10.1.2.188 tell 10.1.1.1
5. Ethernet Header (Src= HostB, Dest = Router1), ARP reply 10.1.2.188 is-at 00:60:97:da:f6:da
6. Ethernet Header (Src= Router1, Dest = HostB), IP Header (Src= HostA, Dest = HostB), ICMP Echo Request
7. Ethernet Header(Src=HostB, Dest=broadcast) ARP who-has 10.1.1.88 tell 10.1.2.188
   /* Note that HostB believes that Host A is on the same subnetwork.
   Therefore, it will try to send the packet directly to HostA*/
8. Ethernet Header (Src= HostA, Dest = HostB), ARP reply 10.1.1.88 is-at 00:60:97:da:f4:0a
9. Ethernet Header (Src= HostB, Dest = HostA), IP Header (Src= HostB, Dest = HostA), ICMP Echo Reply

b) Describe in detail the ARP and ICMP packets which are transmitted on the Ethernet segments when HostB executes the command "ping 10.1.3.100". ***Assume that "proxy ARP" is enabled on Router1***.

1st Ethernet Segment:

1. Ethernet Header(Src=HostB, Dest=broadcast) ARP who-has 10.1.3.100 tell 10.1.2.188
2. Ethernet Header (Src= Router1, Dest = HostB), ARP reply 10.1.3.100 is-at 00:10:4b:8c:fd:e3
   /* This was a Proxy ARP */
3. Ethernet Header (Src= HostB, Dest = Router1), IP Header (Src= HostB, Dest = HostC), ICMP Echo Request

2nd Ethernet Segment:

4. Ethernet Header(Src=Router1, Dest=broadcast) ARP who-has 10.1.3.100 tell 10.1.3.1
5. Ethernet Header (Src= HostC, Dest = Router1), ARP reply 10.1.3.100 is-at 00:40:8c:10:c8:f1
6. Ethernet Header (Src= Router1, Dest = HostC), IP Header (Src= HostB, Dest = HostC), ICMP Echo Request
7. Ethernet Header (Src= HostC, Dest = Router1), IP Header (Src= HostC, Dest = HostB), ICMP Echo Reply

1st Ethernet Segment:

/* The next two are not needed if (4a) was run */

8. Ethernet Header (Src= Router1, Dest = HostB), IP Header (Src= HostC, Dest = HostB), ICMP Echo Reply

c) Repeat (b), assuming that "proxy ARP" is not enabled on Router1.

Compare to (b). Since Router1 does not respond to the ARP request, Host B can never resolve the MAC address for 10.1.3.100. ARP will give up after several attempts, and a "host not reachable" or "host down" notification will be given.

Problem 2. *(15 points)* **Encapsulation**

Below *is* the traffic capture of an ICMP Echo Request packet in hexadecimal notation, The capture consists of an Ethernet II header, followed by an IP header, followed by an ICMP message. (Hint: Each digit corresponds to 4 bits.)

```
00 0a e4 37 f8 36 00 12 3f 61 d7 ac 08 00 45 00
00 54 4a 25 00 00 80 01 d8 c5 80 64 0b f0 80 64
0b 06^08 00 6d 02 44 0d 06 00 cf 1c 15 47 68 89
09 00 08 09 0a 0b 0c 0d 0e 0f 10 11 12 13 14 15
16 17 18 19 1a 1b 1c 1d 1e 1f 20 21 22 23 24 25
26 27 28 29 2a 2b 2c 2d 2e 2f 30 31 32 33 34 35
36 37
```

a. Use the description of the packet format provided on a separate page to answer and provide the value of the following fields:
   - (a1) *(3 Points)* Source MAC address, Destination MAC address (as a hexadecimal number)
   - (a2) *(3 Points)* Source IP Address, Destination IP address (Use dotted decimal notation !)
   - (a3) *(3 Points)* Value of the protocol field in the IP header (as a decimal number)
   - (a4) *(3 Points)* Total length of IP datagram (as a decimal number)
   - (a5) *(3 Points)* Header length of IP datagram (as a decimal number)

Note: The solution of all fields is given on the next page.

(a1) Source MAC: 00:12:3f:61:d7:ac
Destination MAC: 00:0a:e4:37:f8:36
(a2) Source IP address: 128.100.11.240
Destination IP address: 128.100.11.6
(a3) 1 (for ICMP)
(a4) 84
(a5) 5 (Note that the size of the IP header is the value of this field multiplied by 4 → IP header is 20 bytes long)

b. *(3 Points)* In the traffic capture above, mark the end of the IP header. Provide the number of bytes of the IP header (in bytes). Provide the number of bytes of the ICMP message following the IP header (in bytes).

The boundary is marked above (ICMP payload is marked in red).
The IP header has a length of 20 bytes (see comment in (a5).
The length of the ICMP message is 64 bytes. (This can be obtained by counting, or by taking the total length field ("84 bytes") and subtracting the length of the IP header ("20 bytes")

c. *(2 Points)* The problem statement gives away that the Ethernet frame is of type Ethernet II (as opposed to type IEEE 802.3). Suppose this information was not given, describe how you can still determine the type of frame.

In Ethernet II, bytes 13 and 14 of the Ethernet header indicate the type field. In 802.3, these bytes indicate the length of the frame. The value of these bytes is 0x0800, which is (2048)10. Since the maximum Ethernet frame size is limited to 1500 bytes, this value is not a valid value for the frame size. We can conclude that this is an Ethernet II frame.

ADDENDUM TO PROBLEM 3: This is the wireshark output for the packet

```
No.     Time         Source          Destination            Protocol Info
1328 107.822459  128.100.11.240   128.100.11.6     ICMP     Echo (ping) request

    Packet Length: 98 bytes
    Capture Length: 98 bytes
    Protocols in frame: eth:ip:icmp:data
```

Ethernet II,

```
    Destination: 00:0a:e4:37:f8:36
    Source: 00:12:3f:61:d7:ac
    Type: IP (0x0800)
```

Internet Protocol

```
    Version: 4
    Header length: 20 bytes
    Differentiated Services Field: 0x00
    Total Length: 84
    Identification: 0x4a1b (18971)
    Flags: 0x00
    Fragment offset: 0
    Time to live: 128
    Protocol: ICMP (0x01)
    Header checksum: 0xd8cf
    Source: 128.100.11.240
    Destination: 128.100.11.6
```

Internet Control Message Protocol

```
    Type: 8 (Echo (ping) request)
    Code: 0
    Checksum: 0x7902 [correct]
    Identifier: 0x440d
    Sequence number: 0x0000
    Data (56 bytes)

0000  00 0a e4 37 f8 36 00 12 3f 61 d7 ac 08 00 45 00   ...7.6..?a....E.
0010  00 54 4a 1b 00 00 80 01 d8 cf 80 64 0b f0 80 64   .TJ........d...d
0020  0b 06 08 00 79 02 44 0d 00 00 c9 1c 15 47 68 89   ....y.D......Gh.
0030  09 00 08 09 0a 0b 0c 0d 0e 0f 10 11 12 13 14 15   ................
0040  16 17 18 19 1a 1b 1c 1d 1e 1f 20 21 22 23 24 25   .......... !"#$%
0050  26 27 28 29 2a 2b 2c 2d 2e 2f 30 31 32 33 34 35   &'()*+,-./012345
0060  36 37                                             67
```

Problem 3. *(10 points)* **IP Routing Tables**

Consider the following routing table:

Network Destination	Next Hop
142.150.64.0/20	A
142.150.71.128/28	B
142.150.71.128/30	D
142.150.0.0/16	C

a. *(5 Points)* Assume that a router receives an IP datagram with destination 142.150.71.132. Determine the next hop of the IP datagram that is selected by the router? Explain you answer.

b. *(3 Points)* Add a routing table entry to the table above which enforces that all IP datagrams with destination 142.150.71.132 have "A" as Next Hop. For all other IP destination addresses, the Next Hop should not change.

c. *(2 Points)* Add a routing table entry to the table above which enforces that all IP datagrams whose destination address does not match any of the entries in the table, are forwarded to next hop "C". (The network destination for this entry must be provided as an network prefix)

(a)

```
142.150.71.132    = 1000 1110.1001 0110.0100 0111.1000 0100
-------------------------------------------------------------
142.150.64.0/20   = 1000 1110.1001 0110.0100 0000.0000 0000
142.150.71.128/28 = 1000 1110.1001 0110.0100 0111.1000 0000
142.150.71.128/30 = 1000 1110.1001 0110.0100 0111.1000 0000
142.150.0.0/16    = 1000 1110.1001 0110.0000 0000.0000 0000
```

The bold digits show the bits of the prefix that need to match the destination address. The first, second and fourth entry match. The second entry has the longest matching prefix, so the next hop is **B.**

(b)

The routing table to be added is:

Network Destination	Next Hop
142.150.71.132/32	A

(c)

The routing table to be added is:

Network Destination	Next Hop
0.0.0.0/0	C