## Solutions to Practice Problems

### Practice Problem 14.1
How can an ARP request be sent to all users in the local network?

Solution: It is placed in the data field of an Ethernet frame, the Ethernet frame is sent to the broadcast address: FF:FF:FF:FF:FF:FF. ARP requests require a hardware broadcast.

### Practice Problem 14.2
The Address Resolution Protocol works at which two layers?

Solution: Network and Data Link

### Practice Problem 14.3
How many bytes are in an ARP Request packet? How many bytes are in an ARP reply packet?

Solution: 28 bytes for both. Note that, at first glance, the figure from Forouzan would appear to be deceptive, since Ethernet addresses are 6 bytes, and the top of the figure indicates a width of 4 bytes.

### Practice Problem 14.4
In the protocol layering model of TCP/IP, how is a host identified:

(a) At the Network Layer  
(b) At the Data Link Layer

Solution:  
(a) IP address  
(b) Ethernet address (also called the MAC address, the hardware address, the data link address and the physical address).

### Practice Problem 14.5
What are the two types of messages used by the Address Resolution Protocol?

Solution: ARP Request and ARP Reply.

### Practice Problem 14.6
When a sender wants to find out what MAC address corresponds to an IP address, to which MAC address would she send an ARP request? (Circle the appropriate answer(s))

(a) 0.0.0.0  
(b) ff:ff:ff:ff:ff:ff  
(c) 255.255.255.255  
(d) 00:00:00:00:00:00

Solution: (b)

### Practice Problem 14.7
Can an ARP Reply be sent without an ARP request?

Solution: Yes
Practice Problem 14.8

One of your crewmembers has downloaded ARP-spoofing software.

(a) What does ARP spoofing software do?
(b) What is one malevolent purpose he could use this for?

Solution: 
(a) Sends an ARP Reply with an incorrect IP address–Ethernet address pairing with the intent to misdirect traffic.
(b) Steal someone else's traffic (breach of confidentiality) and stop someone else from receiving their traffic (breach of availability).

Practice Problem 14.9

Your IP Address is 10.16.58.92/27. Can you use direct delivery to send messages to the host 10.16.58.129?

Solution: Using your IP address and mask, you determine your network ID is 10.16.58.64

If we apply the same mask to the user with IP address 10.16.58.129, we see that he would be on the network 10.16.58.128.

10.16.58.128 ≠ 10.16.58.64. He is not on the same network, so direct delivery cannot be used.

Practice Problem 14.10

Your IP Address is 10.226.58.15/24. Could you use direct delivery to send messages to the host 10.226.58.229?

Solution: Source IP – 10.226.58.15/24 yields the network address – 10.226.58.0

Destination IP – 10.226.58.15/24 yields the network address – 10.226.58.0

Both hosts on same network, so we use direct delivery within the LAN.
Practice Problem 14.11

The router R1 in the figure below connects the four different networks shown. The four networks connect to the router’s four interfaces, labeled m0, m1, m2 and m3.

![Configuration for Example 22.1](image)

(a) Why does the router R1 have 4 different IP addresses?

Solution: It is connected to four different networks.

(b) How would you verify that the router address 180.70.65.135/26 on the m0 interface is indeed on the network 180.70.65.128/26?

Solution: Bitwise-ANDing the router address 180.70.65.135/26 with its mask yields 180.70.65.128/26.

(c) Your friend says: "Wait just a minute! The two different networks 180.70.65.128/26 and 180.70.65.192/26 look very similar. Are these really two different networks...i.e., are these really two non-overlapping blocks of addresses?" How would you reply?

Solution: Yes, the range of addresses are:

- 180.70.65.128/26: 180.70.65.129 to 180.70.65.190
- 180.70.65.192/26: 180.70.65.193 to 180.70.65.254

(d) Construct the routing table.

<table>
<thead>
<tr>
<th>Mask</th>
<th>Network Address</th>
<th>Next Hop</th>
<th>Interface</th>
</tr>
</thead>
<tbody>
<tr>
<td>/26</td>
<td>180.70.65.192</td>
<td>—</td>
<td>m2</td>
</tr>
<tr>
<td>/26</td>
<td>180.70.65.128</td>
<td>—</td>
<td>m0</td>
</tr>
<tr>
<td>/24</td>
<td>201.4.22.0</td>
<td>—</td>
<td>m3</td>
</tr>
<tr>
<td>/22</td>
<td>201.4.16.0</td>
<td>....</td>
<td>m1</td>
</tr>
<tr>
<td>Any</td>
<td>Any</td>
<td>180.70.65.200</td>
<td>m2</td>
</tr>
</tbody>
</table>

We will see later that it is best to order the table by decreasing mask value...but let's proceed.
(e) Suppose an IP packet with destination IP address 180.70.65.140 arrives at router R1. Explain how the routing table is used to make a routing decision.

Solution: R1 looks at the first line in the routing table and applies the mask, yielding the result:

180.70.65.128

This does **not** match the network address on the first line (180.70.65.192).

R1 looks at the second line in the routing table and applies the mask, yielding the result:

180.70.65.128

This **does** match the network address on the second line (180.70.65.128).

R1 places this IP packet on interface m0 using ARP.

(f) Suppose an IP packet with destination IP address 201.4.22.35 arrives at router R1. What does it do?

Solution: It looks at the first line in the routing table and applies the mask, yielding the result:

201.4.22.0

This does **not** match the network address on the first line (180.70.65.192).

It looks at the second line in the routing table and applies the mask, yielding the result:

201.4.22.0

This **does not** match the network address on the second line (180.70.65.128).

It looks at the third line in the routing table and applies the mask, yielding the result:

201.4.22.0

This **does** match the network address on the third line (201.4.22.0).

R1 places IP packet on interface m3 using ARP.
Practice Problem 14.12

Given the following diagram:

Use the technique of address aggregation to create the routing table for Router R2 with the minimum number of entries.

Solution:

Let’s look at the third octet of each of the two networks shown

\[
\begin{align*}
172.16.0.0 & \quad \text{third octet: } 0 \ 0 \ 0 \ 0 \ 0 \ 0 \ 0 \ 0 \\
172.16.128.0 & \quad \text{third octet: } 1 \ 0 \ 0 \ 0 \ 0 \ 0 \ 0 \ 0
\end{align*}
\]

The first bit in the third octet is irrelevant—it can be 0 or 1. So, we can aggregate these two entries as

\[172.16.0.0 /16\]

The routing table is:

<table>
<thead>
<tr>
<th>Mask</th>
<th>Network Address</th>
<th>Next Hop</th>
<th>Interface</th>
</tr>
</thead>
<tbody>
<tr>
<td>/16</td>
<td>172.16.0.0</td>
<td>R1</td>
<td>m0</td>
</tr>
<tr>
<td>/0</td>
<td>0.0.0.0</td>
<td>---</td>
<td>m1</td>
</tr>
</tbody>
</table>