Lab 4: Reference Document

Layer 3 and 2 Addresses

Here are some useful rules to remember about addresses:

- A message's layer 3 (e.g. IP address) and layer 4 port number (e.g. application port) values **do not change** as the message moves from one network to another (there are exceptions but we will not look at these until later in the semester).
    - The destination address value corresponds to the IP address of the device the message is ultimately intended for.
    - The source address value corresponds to the original message sender's IP.
- The message's layer 2 (e.g. MAC address) address values **change** as the message moves from one network to another. Here are the Layer 2 address values as the frame leaves the sender's device.
    - When sending a message to a local device
        - The frame's destination MAC corresponds to the local device's MAC address.
        - The frame's source MAC corresponds to the sending device's MAC address.
    - When sending a message to a remote device
        - The frame's destination MAC corresponds to your default gateway's MAC address.
        - The source MAC corresponds to the sending device's MAC address.

Frames are the PDUs we place on the physical media. They are responsible for carrying our messages from one device to another within the boundaries of the same network segment. If the device we wish to communicate with is on another network segment, then, the frame will be addressed and delivered to the default gateway. It is the default gateway (i.e. router) that performs the complex work of moving the message across the network.

Remember that a frame has no life beyond the network segment on which it was created! The router discards the original frame and encapsulates a message in a new frame when it needs to move the message to another network.

Address Resolution Protocol (ARP)

The ARP protocol operates on Wi-Fi and Ethernet networks and provides the mechanism for obtaining the layer 2 addresses necessary to move frames from one device to another within the same network segment. In short, the purpose of the ARP protocol is to resolve IPv4 addresses to MAC addresses.

Here is a brief and simplified description of how ARP works.

- When sending a message to a local device

  - An ARP request seeking to obtain the local devices MAC address is broadcast to all devices on the network segment as the sender

    - The ARP request is of the form: **Who has a.b.c.d? Tell w.x.y.z**

    - The ARP response is of the form: **w.x.y.z is at aa:bb:cc:dd:ee:ff**

  - The learned MAC address is used to direct the frame to its destination device.

  - The learned MAC address is cached in the sending device's local ARP memory.

- When sending a message to a remote device

  - Remember that you direct all remote communications to your router. You let it do the hard work!

  - An ARP request seeking to obtain your default gateway's MAC address is broadcast to all devices on the network segment

  - The learned MAC address is used to direct the frame to your default gateway device. The default gateway does all the hard work involved in internetwork communications.

  - The learned MAC address is cached in the sending device's local ARP memory.

Note that an ARP broadcast message does not exist/live beyond the network segment it was created on. That is a router will STOP the spread of an ARP message to other networks! Imagine the traffic that would exist if routers allowed ARPs to spread to all networks!

The **arp –a** command allows you to display the ARP table and hence determine the MAC address of devices your device has communicated with (locally). An ARP table ONLY contains MAC entries of other locally connected devices. You will never see or know the MAC address of remote device – the only MAC you need to know to communicate with remote devices is the default gateway's MAC address. Note that the entries in an ARP table have a time limit; they will be deleted from memory after a configurable amount of time!

The figure below shows the output of running **ipconfig** and **arp –a** on a device having IP address **192.168.15.106**.

By examining the output we can tell that default gateway's MAC address for **192.168.15.106** is: **0c-47-3d-a1-88-82**.

We can deduct this information by first determining the Default Gateway address from the ipconfig output. We then take this IPv4 address and attempt to find a matching entry in the **arp –a** output. As there is an entry in the **arp –a** output for **192.168.15.1**, its MAC address is the value that appears under the Physical Address column!

From the output we cannot tell what the MAC address for **192.168.15.106** is.

In this particular case we would need to run **ipconfig/all** in order to obtain the MAC address for **192.168.15.106**.

Note that the output shows multiple interfaces, but as we have learned in class, the interface that provides connectivity with the outside world in this specific configuration is the Ethernet adapter.

```
Ethernet adapter Ethernet:

   Connection-specific DNS Suffix  . :
   IPv4 Address. . . . . . . . . . . : 192.168.15.106
   Subnet Mask . . . . . . . . . . . : 255.255.255.0
   Default Gateway . . . . . . . . . : 192.168.15.1

Ethernet adapter VMware Network Adapter VMnet1:

   Connection-specific DNS Suffix  . :
   IPv4 Address. . . . . . . . . . . : 192.168.29.1
   Subnet Mask . . . . . . . . . . . : 255.255.255.0
   Default Gateway . . . . . . . . . :

Ethernet adapter VMware Network Adapter VMnet8:

   Connection-specific DNS Suffix  . :
   IPv4 Address. . . . . . . . . . . : 192.168.227.1
   Subnet Mask . . . . . . . . . . . : 255.255.255.0
   Default Gateway . . . . . . . . . :

C:\Users\Yvan>arp -a

Interface: 192.168.15.106 --- 0x3
  Internet Address      Physical Address      Type
  192.168.15.1          0c-47-3d-a1-88-82     dynamic
  192.168.15.2          c0-c1-c0-9f-0f-4f     dynamic
  192.168.15.255        ff-ff-ff-ff-ff-ff     static
  224.0.0.22            01-00-5e-00-00-16     static
  224.0.0.251           01-00-5e-00-00-fb     static
  224.0.0.252           01-00-5e-00-00-fc     static
  239.255.255.250       01-00-5e-7f-ff-fa     static
  255.255.255.255       ff-ff-ff-ff-ff-ff     static

Interface: 192.168.29.1 --- 0x13
  Internet Address      Physical Address      Type
  192.168.29.255        ff-ff-ff-ff-ff-ff     static
  224.0.0.22            01-00-5e-00-00-16     static
  224.0.0.251           01-00-5e-00-00-fb     static
  224.0.0.252           01-00-5e-00-00-fc     static
  239.255.255.250       01-00-5e-7f-ff-fa     static

Interface: 192.168.227.1 --- 0x14
  Internet Address      Physical Address      Type
  192.168.227.255       ff-ff-ff-ff-ff-ff     static
  224.0.0.22            01-00-5e-00-00-16     static
  224.0.0.251           01-00-5e-00-00-fb     static
  224.0.0.252           01-00-5e-00-00-fc     static
  239.255.255.250       01-00-5e-7f-ff-fa     static
```