IPv4 Address Architecture

• Addresses are 32-bits, interpreted as:

| network | host |

• Unicast, multicast, and broadcast addresses
  ◦ Address is unicast if it's not broadcast or multicast
  ◦ Broadcast
    ▪ 255.255.255.255 – all hosts on this IP network
      • Relies on link layer broadcast (e.g., MAC address FF.FF.FF.FF.FF)
    ▪ [network | 11...1 | – all hosts on the named network
      • E.g., 172.19.255.255 is all hosts on 172.19.0.0/16
      • I wouldn't count on this being implemented...
  ◦ Multicast
    ▪ 224.0.0.0/4 are multicast addresses
      • Probably implemented only within the local IP network or perhaps the administrative domain (i.e., not the wide area)
    ▪ Some are well known...
      • 224.0.0.5 – OSPF (Open Shortest Path First link state implementation)
      • 224.0.0.9 – RIP (Routing Information Protocol distance vector implementation)
      • 224.0.1.1 – NTP (Network Time Protocol clock synchronization)
      • 239.255.255.250 – SSDP (Simple Service Discovery Protocol (UpnP))
  ◦ Address scope
    ◦ Private networks
      ▪ Don't need to ask anyone to use these addresses
      ▪ Addresses are non-routable on Internet – can't be used to cross Internet
      ▪ 10.0.0.0/8, 172.16.0.0/12, 192.168.0.0/16
    ◦ Link local
      ▪ Addresses won't pass through any routers
      ▪ Used for auto-configuration (talked about later)
      ▪ 169.254.0.0/16
    ◦ Host only
      ▪ 10.0.0.0/8 – loopback (“localhost”)
IPv4 Supporting Protocols

- **DHCP** (Dynamic Host Configuration Protocol)
  - Machine boots, needs an IP address and possibly config parameters. This is one way to obtain them.
  - UDP packets are sent to broadcast IP address: 255.255.255.255
    - Uses ports 67 (server) and 68 (client)
  - DHCP header contains a transaction ID
    - Random 32-bit int
  - Client identifier is (by default) [IP subnet number, MAC address].
  - DHCP Discover →
    - ← DHCP Offer
    - ← DHCP Offer
  - DHCP Request →
    - ← DHCP ACK
  - Addresses are “leased”
    - Must issue a DHCP Request to renew lease before it expires
  - DHCP server can also supply other configuration information
    - Host name
    - Name server
    - Time server
    - Gateway

- **ARP** (Address resolution protocol)
  - Suppose a host wants to send an IP packet to a destination on the same network it is on
    - For example, a router receives a packet intended for a destination on a network it is connected to
  - The IP packet must be encapsulated in a link layer frame whose destination MAC address is that of the host with the destination IP address
  - How do we determine a MAC address given an IP address?
    - ARP
  - ARP Request
    - Sent to link layer broadcast addresses
    - Contains senders MAC and IP addresses
    - Contains 00:00:00:00:00:00 for destination's MAC and the destination IP we want to query
  - ARP response
    - Sent to requester's MAC
    - Contains requester's IP and MAC
    - Contains responder's IP and MAC
  - All nodes maintain an ARP cache
- Harvest information from the broadcast packets, plus responses to their own requests

**DHCP + ARP**
- DHCP server wants to be sure that IP addresses it thinks are free are in fact free
- A host assigned a new address by a DHCP server wants to make sure it isn't already in use
- They can use ARP to check if any node thinks it currently has an IP
  - "Gratuitous ARP"
- If there is no DHCP server, eventually give up and pick a random link-local address
  - Use ARP to verify that you haven't created a collision
  - (You should be able to talk to other nodes on the same network.)

**NAT (Network Address Translation)**
- Problem: running out of IPv4 addresses
- Solution:
  - use private network addresses, because an unlimited number of hosts can use the same private address (but only one inside a single private network)
  - new problem: if you send a packet into the Internet with a private IP as the source address, you can't receive a reply
    - Solution: translate the source address from the host's private IP to the public IP of the gateway/router that connects the private network to the Internet