

More on the Network Layer in the Internet

CS158a

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Outline

Today's menu acronym soup:

- NAT
- ICMP
- ARP
- RARP, BOOTP, and DHCP

NAT

- With a 4 byte IP address there are a maximum of 4 billionish possible addresses and these are quickly running out.
- NAT (Network Address Translation) is a stop-gap method aimed at temporarily solving this problem.
- The idea is that each company has a single IP address for internet traffic.
- Within the company each machine gets a unique IP address, which can be used to route traffic within the companies network.
- When a packet exits the company to go to an ISP, an address translation takes place.
- Three ranges of IP address are declared as private and no packets with these addresses are allowed on the internet:
 - 10.0.0.0 -- 10.255.255.255/8 (16millionish hosts)
 - 172.16.0.0 -- 172.31.255.255/12 (1millionish hosts)
 - 192.168.0.0 -- 192.168.255.255/16 (65thousandish hosts)
- Remember 0 refers to the current network, and -1 (255) is used to broadcast to all hosts, so not all these addresses are usable.

More on NAT

- When a packet is sent through a **NAT box** the internal source IP address is converted to the companies IP address.
- The source port address of the packet is replaced by a new source port. The NAT box has a table consisting of entries (internal IP, internal source port, external source port).
- When a packet comes into the NAT Box from outside the company the reverse conversion is done.
- NAT has many problems: (1) each IP no longer corresponds to a unique machine, (2) makes internet less connectionless, (3) network and transport layer no longer independent, (4) some apps insert the IP address into the data and these will fail if NAT is used (for example, FTP).

ICMP

- The operations of the internet are closely watched by its router.
- When an error occurs the event is reported by the ICMP protocol (Internet Control Message Protocol).
- The most important of these messages are listed below:

Message type	Description
Destination unreachable	Packet could not be delivered
Time exceeded	Time to live field hit 0
Parameter problem	Invalid header field
Source quench	Choke packet
Redirect	Teach a router about geography
Echo request	Ask a machine if it is alive
Echo reply	Yes, I am alive
Timestamp request	Same as Echo request, but with timestamp
Timestamp reply	Same as Echo reply, but with timestamp

ARP

- ARP stands for the Address Resolution Protocol.
- It is used to map IP addresses to MAC addresses so that packets can be sent to the correct machine at the data link layer.
- If a host A on Ethernet 192.31.65.0 is looking for another host B with IP address 192.31.65.5 on the Ethernet, it first broadcasts 192.31.65.5.
- The machine with this address responds with its Ethernet (MAC) address. Then host A can make a data link frame to send to host B.
- Caching can be used to prevent machines from having to run ARP twice for the same machine. The cache is usually only for a few minutes.
- Typically, host A send its MAC address as well as its IP address in its initial frame to avoid host B also having to do ARP on Host A.
- If two machines live on different Ethernets, the initial broadcast will be responded to usually by a router which does a **proxy ARP**. Alternatively, Host A might realize the traffic is on a different Ethernet and then send to a default address.

RARP, BOOTP, DHCP

- Sometimes one also needs to solve the problem given an Ethernet address find the IP address.
- For example you might have a workstation that gets the binary image of its OS from a remote server.
- RARP (Reverse Address Resolution Protocol) solves this problem by allowing the newly booted machine to broadcast its Ethernet address and ask does anyone know its IP address. The RARP server responds with the IP based on the Ethernet address in its tables.
- It uses the destination address of all 1's (broadcast) to get to the server. Such requests are not forwarded by routers which limits the scope of RARP.
- BOOTP solves this problem by using a UDP message to send the initial broadcast. This is forwarded over routers. It also sends back the IP address of the fileserver and router masks.
- BOOTP require manual configurations of tables mapping IP to Ethernet addresses.
- This is solve by DHCP (dynamic Host configuration protocol).Here after the machine sends out a request for an IP address the server sends back an IP dynamically for a lease period. When this period is about to expire the lease must be renewed or the IP address is lost.