Lecture 14: DHCP and NAT

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IPv4 Address Shortage

- Classless IP addressing solved IPv4 address shortage temporarily, but the exponential growth of the Internet presented yet again the challenge of running out of IP addresses.
- Solutions:
- *Future*: migrating from IPv4 (with 32 bit IP address) to IPv6 (with 128 bit IP address).
- DHCP (Dynamic Host Configuration Protocol).
- NAT (Network Address Translation).

Dynamic Host Configuration Protocol (DHCP)

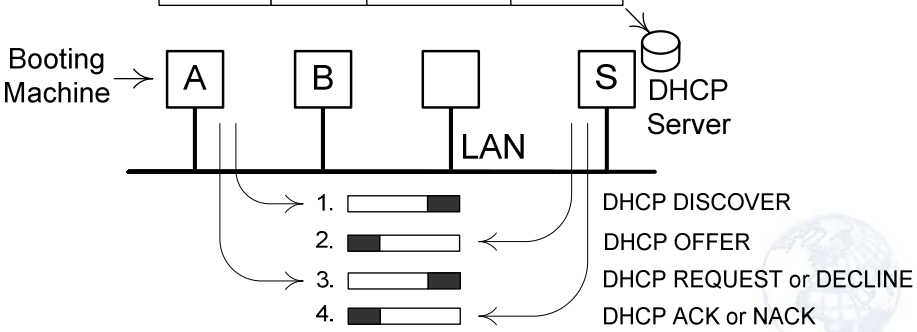
- DHCP is described in RFC 2131, RFC 2132 and others.
- Was extremely helpful for ISPs with dial-up subscribers. An ISP with /16 (formerly class B) addresses dynamically assigns an IP address (through a DHCP server) to a computer when it calls up and logs in, then takes back that IP address when the session ends.
- This way, a single /16 address space serves few hundred thousand customers, since less than 65,534 are active users at any time.
- With ADSL modems, fiber connections and business customers (i.e., always-on Internet), DHCP is now seen as a tool to simplify the job of the administrator.

Dynamic Host Configuration Protocol (DHCP)

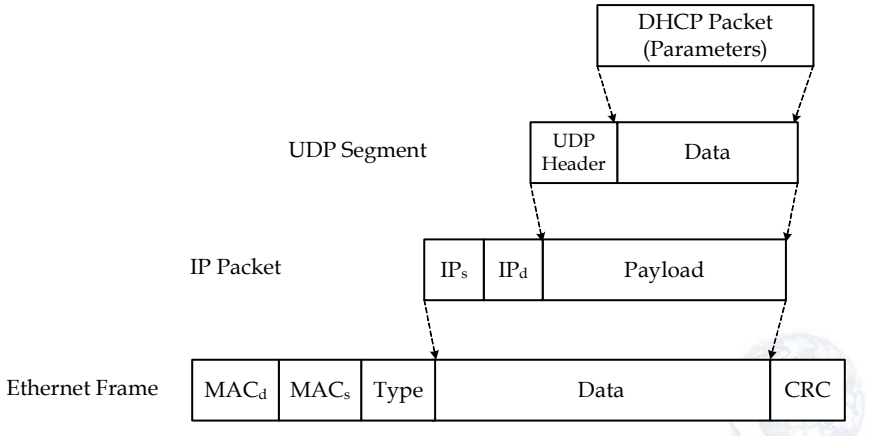
- A DHCP server supplies clients with the following IP configuration information:
  - A unique IP address for the host
  - Subnet mask
  - Default gateway
  - Other IP configuration parameters, such as the domain name.
- This happens through 4 sequence message exchange between the DHCP client and the DHCP server.

DHCP Messages

IP Address	Available	Lease Expires At	Options
30.0.0.1	Used	2015/3/13, 12:05	
30.0.0.2	Used	2015/3/14, 18:43	
30.0.0.3	Available	N/A	
…….	…….	…….	



DHCP runs on top of UDP



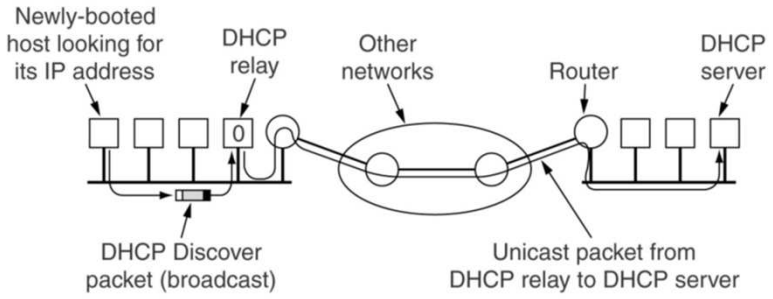
DHCP Messages

	DHCP DISCOVER	DHCP OFFER
MAC_d	FF:FF:FF:FF:FF:FF	FF:FF:FF:FF:FF:FF
MAC_s	MAC of Host	MAC of DHCP Server
Type	0800h	0800h
IP_d	255.255.255.255	255.255.255.255
IP_s	0.0.0.0	IP of DHCP Server
$Port_d$	67 (UDP)	68 (BOOTP)
$Port_s$	68 (BOOTP)	67 (UDP)

	DHCP REQUEST	DHCP ACK
MAC_d	FF:FF:FF:FF:FF:FF	FF:FF:FF:FF:FF:FF
MAC_s	MAC of Host	MAC of DHCP Server
Type	0800h	0800h
IP_d	255.255.255.255	255.255.255.255
IP_s	0.0.0.0	IP of DHCP Server
$Port_d$	67 (UDP)	68 (BOOTP)
$Port_s$	68 (BOOTP)	67 (UDP)

DHCP Agents

- To be reachable through broadcasting, the DHCP server must be on the same LAN as the requesting host. Otherwise, a DHCP relay agent is needed on each LAN.



NAT (Network Address Translation)

- You need multiple IP addresses for your PC or laptop (one for Ethernet NIC, another for Bluetooth NIC, another for Wi-Fi NIC, etc).
- Enterprises and Universities have thousands of PCs to be connected to the Internet.
- Everyone wants to connect to the Internet, including billions of smart phones and now Internet-of-Things (IoT).
- NAT is an *ugly* solution to the IPv4 address exhaustion problem because it violates OSI rules of separating the layers, and limits any one-to-any one communications on the Internet.
- But it was a *very effective* solution that prolonged the life of IPv4. So, it is now widely available.
- It was supposed to be abandoned once IPv6 is deployed, but now we have Carrier-grade NAT (CGN) and NAT for IPv6.

NAT: Private vs. Public

- All devices in your home are assigned **private IP addresses**.
- Other homes and business can re-use those private IP addresses. Everyone can.
- But none of these private IP addresses are allowed to communicate over the global Internet because address uniqueness will be destroyed.
- Rather, these private IP addresses are translated into **one** (or a few) **public IP addresses** when they leave your home.
- All devices in your home look like one device (using that public IP address) to the outside world. They *share* the address.
- NAT was never meant to be a security feature. However, in most cases (not all), when a machine is behind a NAT box, the machine is *somewhat protected*, because even if one of its ports is left open by mistake (say a Web server on port 80), people from the outside cannot connect to it directly.

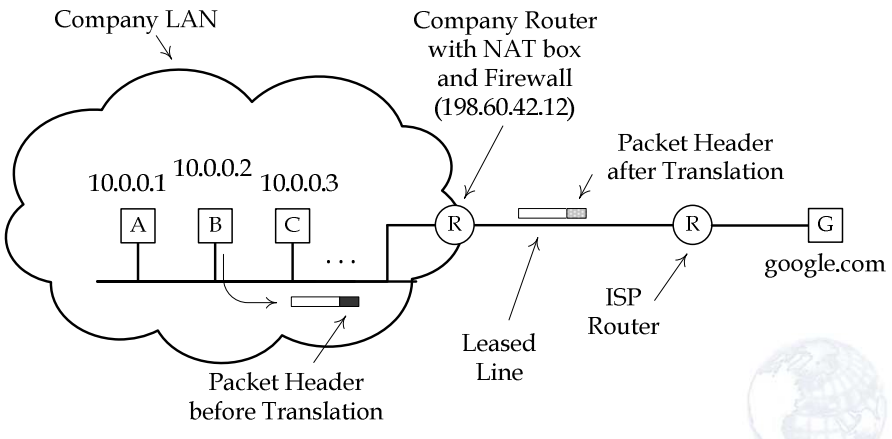
Private IP Addresses

The three **reserved** ranges for **NAT** are:

Address Range	Private IP Addresses	Number of Addresses
10.0.0.0/8	10.0.0.1 – 10.255.255.254	16,777,216 – 2
172.16.0.0/12	172.16.0.1 – 172.31.255.254	1,048,576 – 2
192.168.0.0/16	192.168.0.1 – 192.168.255.254	65,536 – 2

The range 10.0.0.0/8 is used by Windows machines by default.
The range 192.168.0.0/16 is used by default for many routers (*inside* the same box for Ethernet switches and Wi-Fi access points).

Example



Example (*Cont.*)

Original Source IP Address	Original Source TCP Port	New Source IP Address	New Source TCP Port
10.0.0.1	1088	198.60.42.12	4096
10.0.0.1	1023	198.60.42.12	4097
10.0.0.1	500	198.60.42.12	4098
10.0.0.2	1088	198.60.42.12	4099
10.0.0.3	950	198.60.42.12	4100
10.0.0.3	1023	198.60.42.12	4101
10.0.0.4	950	198.60.42.12	4102
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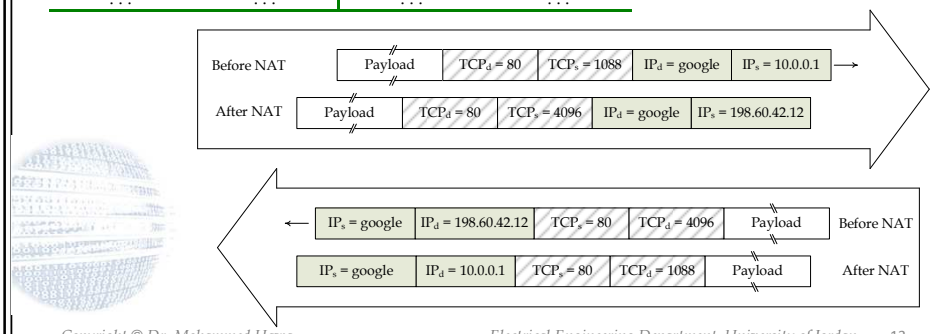

Example: JU Network