

Lecture 14: DHCP and NAT

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EE426: Communication Networks

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).



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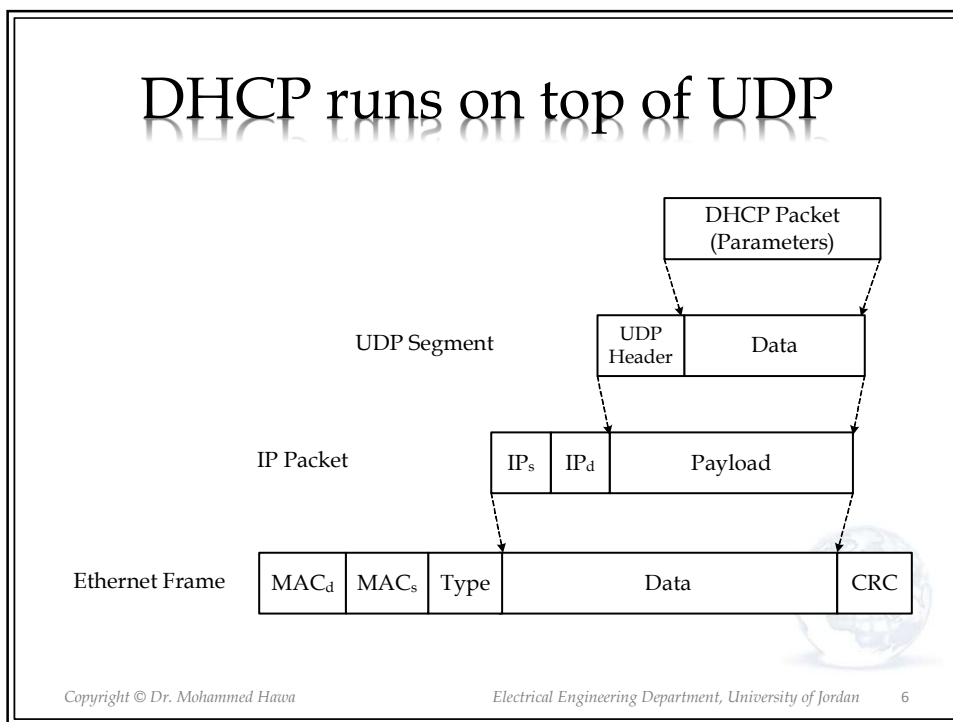
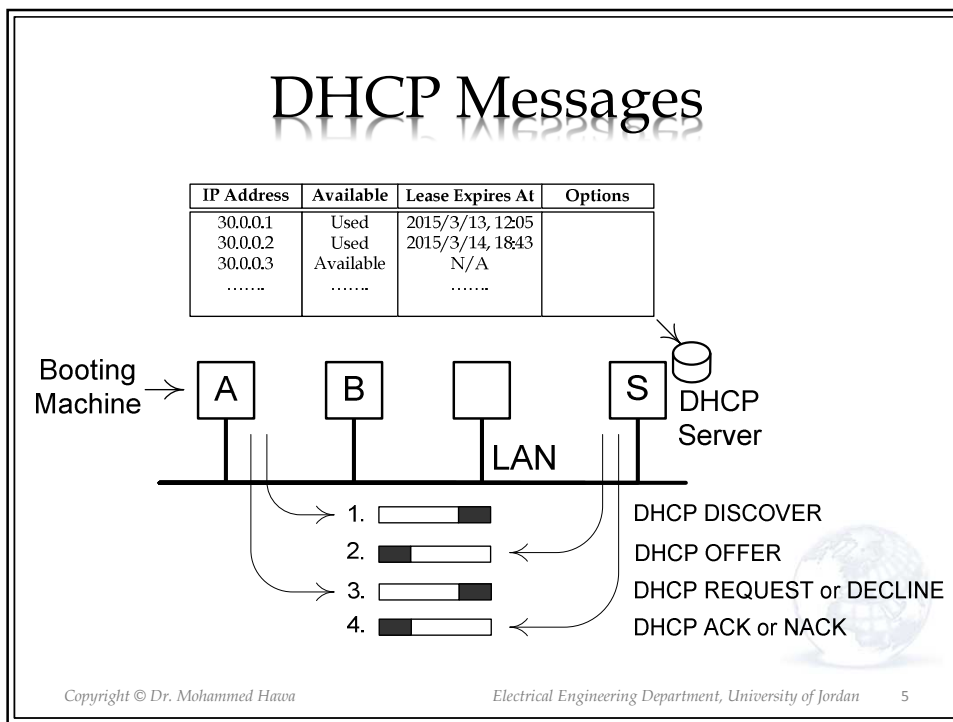
2

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)

- DHCP server supplies clients with IP configuration information:
 - A unique IP address for the host, subnet mask, default gateway information, and other IP configuration parameters (e.g., domain name).
- This happens through 4 sequence message exchange between the DHCP client and the DHCP server.
- Performed after the machine boots.
- The IP address is leased to the client. Lease must be renewed periodically.
- DHCP replaces the old practice of statically configuring IP address information in the OS (say in control panel of MS Windows).



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) |

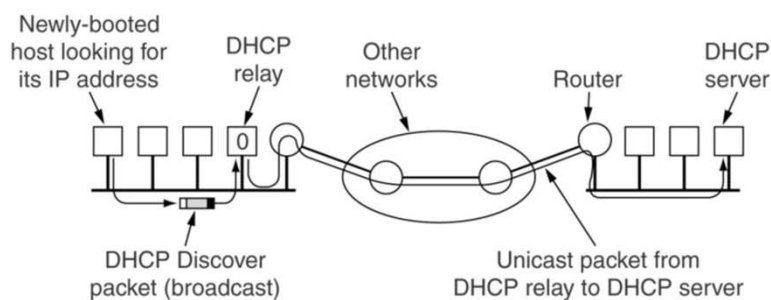
| | DHCP REQUEST | DHCP ACK |
|-------------------------|-------------------|--------------------|
| MAC_d | FF:FF:FF:FF:FF:FF | FF:FF:FF:FF:FF:FF |
| MAC_s | MAC of Host | MAC of DHCP Server |
| Type | 0800h | 0800h |
| IP_d | 255.255.255.255 | 255.255.255.255 |
| IP_s | 0.0.0.0 | IP of DHCP Server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

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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.



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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:

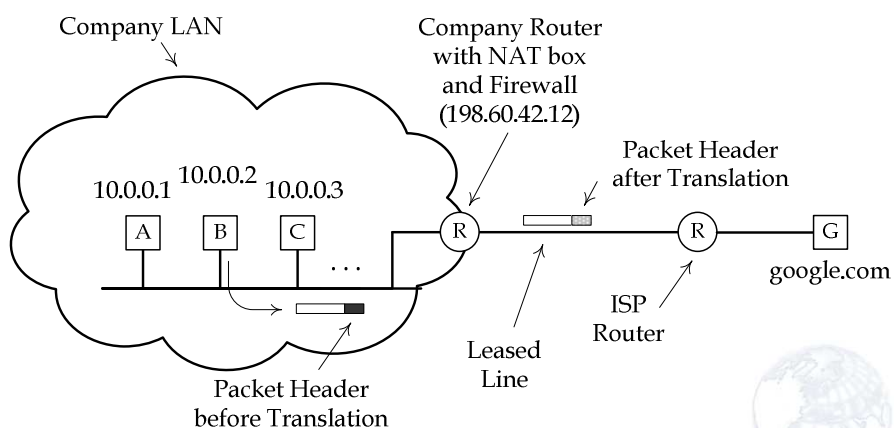
| Address Range | Private IP Addresses | Number of Addresses |
|---------------|-------------------------------|---------------------|
| 10.0.0/8 | 10.0.0.1 – 10.255.255.254 | 16,777,216 – 2 |
| 172.16.0/12 | 172.16.0.1 – 172.31.255.254 | 1,048,576 – 2 |
| 192.168.0/16 | 192.168.0.1 – 192.168.255.254 | 65,536 – 2 |

The range 10.0.0/8 is used by Windows machines by default.

The range 192.168.0/16 is used by default for many routers (*inside* the same box for Ethernet switches and Wi-Fi access points).

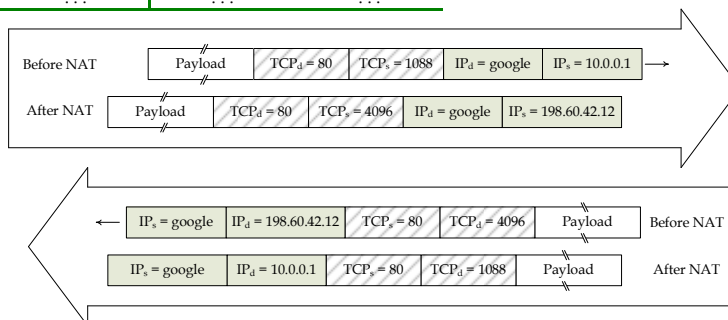


Example



Example (Cont.)

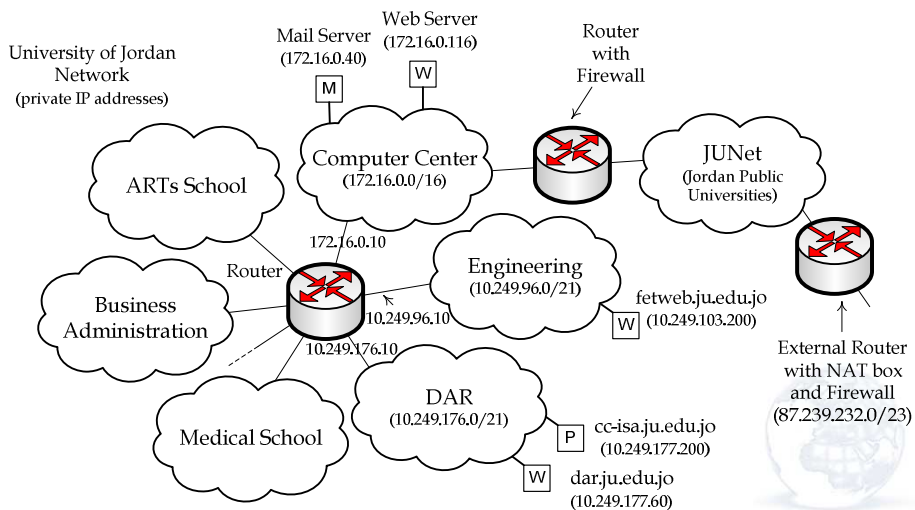
| Original Source IP Address | Original Source TCP Port | New Source IP Address | New Source TCP Port |
|----------------------------|--------------------------|-----------------------|---------------------|
| 10.0.0.1 | 1088 | 198.60.42.12 | 4096 |
| 10.0.0.1 | 1023 | 198.60.42.12 | 4097 |
| 10.0.0.1 | 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



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