ET0730

Chapter 4
Dynamic and Static IP Addresses

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Objectives

- Describe the difference between Static and Dynamic IP Addresses.
- Describe the advantages and disadvantages of static and dynamic IP addresses.
- Determine the range of valid host address.
- Describe the function of DHCP service.

Outline

- Static IP Addresses
  - What are static IP addresses?
  - Advantages?
  - Disadvantages?
- Dynamic IP Addresses
  - What are Dynamic IP addresses?
  - Advantages?
  - Disadvantages?
- Types of IP Addresses
  - Network Address
  - Broadcast Address
  - Host Address
- Dynamic Host Configuration Protocol (DHCP)

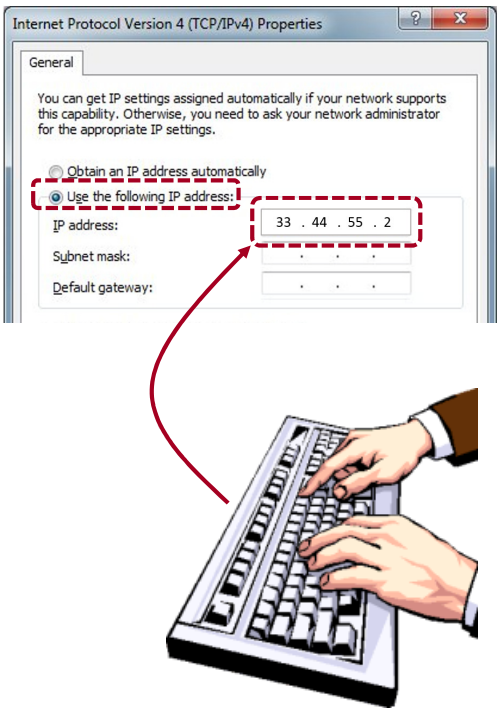
Static and Dynamic IP Addresses

- IP addresses can be "static" or "dynamic".

- **Static IP Addresses**
  - Fixed, always the same IP address even if the host reboots.
- **Dynamic IP Addresses**
  - Is not fixed. IP address of a host may change after the host reboots.

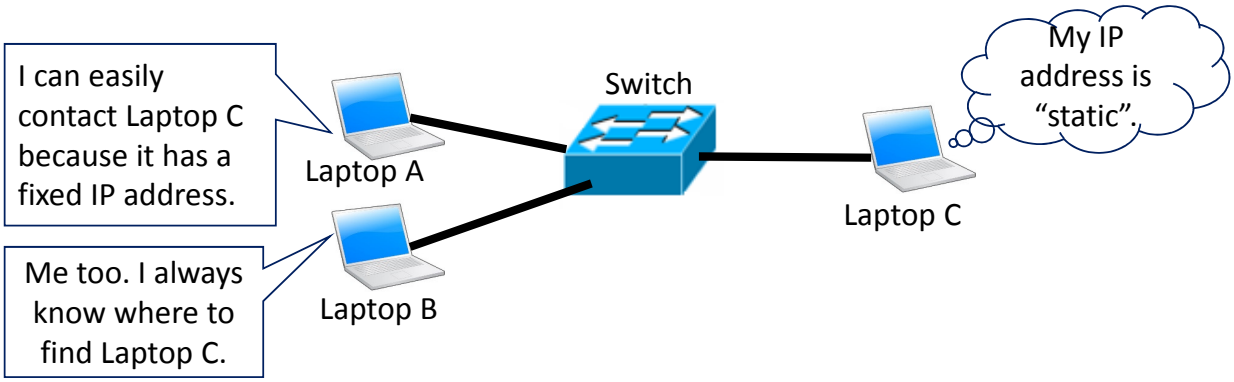
What are “Static” IP Addresses?

- “Static” = “unchanging”.
  - Therefore “Static IP Addresses” are IP addresses that remain unchanged.
- Static IP Addresses are often “manually” allocated and configured on hosts, but can be done automatically too.
- Even if the host is rebooted, the configured IP address is preserved.
  - The host always has the same IP address.



Why do we use “Static IP Addresses”?

- Deterministic IP address – always the same IP address, conveniently contactable from other hosts.



- Example: A file server using static IP address is easy for the clients to find it.

Disadvantages of Static IP Addresses (1)

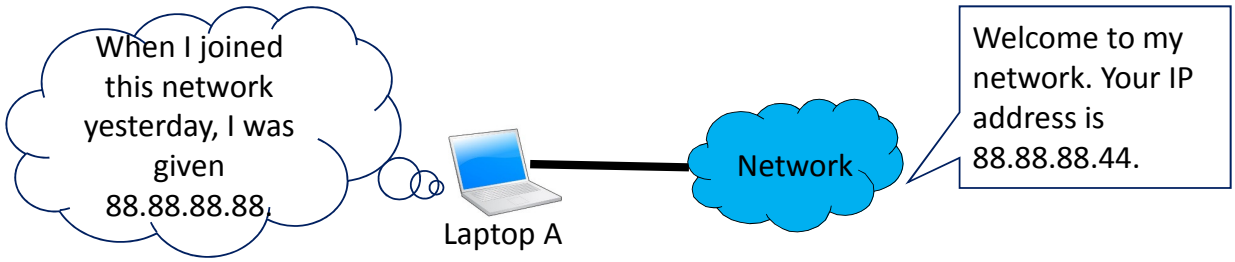
- Static IP addresses are convenient (easy to contact), but they do come with problems:
  - Not scalable
    - Very often static IP addresses are configured manually. This approach works well for small number of hosts, but it is too laborious for large number of hosts.
  - Conflict of IP addresses
    - There is high chance of configuring two or more hosts with same IP address, causing "IP address conflict". Recall that each host must have an unique IP address.

Disadvantages of Static IP Addresses (2)

- Inconvenience for mobile devices
  - For wireless networks, mobile devices are joining and leaving the wireless network frequently in and out of network frequently. It will be too much trouble to configure and release IP addresses.
- Insufficient IP addresses
  - Each static IP address is dedicated to a particular host, hence cannot be relocated to other hosts when it is not in use.
  - May not have enough IP addresses for every host.

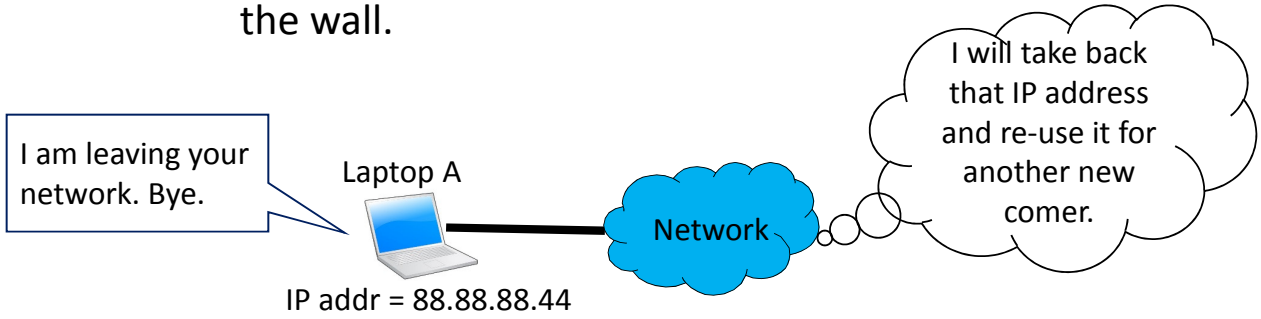
Dynamic IP Addresses (1)

- Dynamic IP addresses are assigned by the network when a host is connected to the network.
- The dynamic IP address allocated to a host may be different each time the host is connected to the network (not a fixed IP address).



Dynamic IP Addresses (2)

- Dynamic IP addresses are temporarily allocated to a device. It is taken back when no longer needed.
  - Examples:
    - a mobile phone leaves a Wi-Fi network.
    - A laptop is disconnected from the Ethernet port on the wall.



Why do we use "Dynamic IP Addresses"?

- More efficient (less network administration works)
  - Automatic IP address allocation and configuration (less human intervention).
- Eliminate the problem of IP address conflict faced by manually configured static IP addresses.
- IP addresses can be re-allocated, solving the IP address scarcity problem.
  - A small number of IP addresses can be shared by a large group of users, as long as not too many of the users need the IP address at the same.

Disadvantages of Dynamic IP Addresses

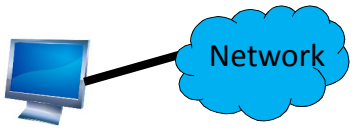
- IP address is not fixed.
  - This is bad for servers. The clients need to know the IP address of the server in order to initiate the connection.
- There are other problems to be discussed later (see slide #30).

How to choose IP address for manual/auto IP address setting? (1)

- Regardless of manual or automatic configuration of IP address, we need to select the correct range of IP addresses.
- **Manual configuration**
  - Pick a valid IP address and configure the host accordingly.
- **Automatic Configuration**
  - Define a pool of usable IP addresses, and let the network decide which is to be allocated to a host.

How to choose IP address for manual/auto IP address setting? (2)

Example of valid IP addresses:
192.168.1.5
192.168.1.99
192.168.1.234



Network = 192.168.1.x
Subnet mask = 255.255.255.0

- When choosing an IP address for manual or automatic configuration, the network portion is always fixed (defined by the network).
- Host portion can be anything between 00…001 and 11…110.
  - Note: Host portion = 00…000 (all zeros) and host portion = 11…111 (all ones) cannot be used. See next few slides for the reason.

Types of IP Addresses

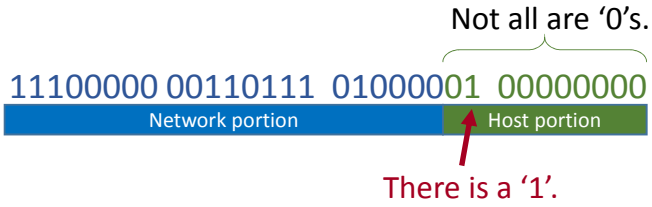
- There are 3 types of IP addresses:
  - Network address
    - The address by which we refer to the network.
  - Broadcast address
    - A special address used to send data to all hosts in the network.
  - Host addresses
    - The addresses assigned to the end devices in the network.

Type 1: Network Address

- Network Address is an address in which all the bits in the Host portion are '0's.
- An address by which we refer to a network. This can be considered as Network ID or Subnetwork Identifier.
- Example:
  - 192.168.88.0/24 is a network address.
  - Proof:
    - 192.168.88.0 = 11000000 10101000 01011000 00000000
    - Since the prefix length is 24 (given by "/24"), the IP address has 24 bits for Network portion, and 8 bits for Host portion.
    - Since all the 8 bits in the Host portion are '0's, this is a Network Address.

Exercise: Is this a Network Address?

- Given an IP address 224.55.65.0/22. Is this a Network Address?
- Answer:
  - 224.55.65.0 = 11100000 00110111 01000001 00000000
  - Prefix length = 22, hence 22 bits belong to Network portion and 10 bits belong to Host portion:
    - 11100000 00110111 01000001 00000000
  - Since one of the 10 bits in the Host portion is not '0', this is not a Network Address.



Type 2: Broadcast Address

- Broadcast Address is an address in which all the bits in the Host portion are '1's.
- Broadcast Address is a special address that allows communication to all the hosts in that network.
- Example:
  - For network 100.88.99.0 /24, the broadcast address would be 100.88.99.255.
  - Proof:
    - 100.88.99.0 = 01100100 01011000 01100011 00000000
    - Prefix Length = 24, hence the IP address has 24 bits for Network portion, and 8 bits for Host portion.
    - For a Broadcast Address, all the 8 bits in the Host portion are '1's.
    - Therefore, Broadcast Address is:
      - 01100100 01011000 01100011 11111111
      - 100 88 99 255 (proved)

Exercise: Find the Broadcast Address

- Given an IP address 224.55.65.0/22. Find the Broadcast Address for this network.
- Answer:
  - 224.55.65.0 = 11100000 00110111 01000001 00000000
  - Prefix length = 22, hence 22 bits belong to Network portion and 10 bits belong to Host portion:
    - 11100000 00110111 01000001 00000000
  - Making all the 10 bits in the Host portion to '1's, the Broadcast Address is:
    - 11100000 00110111 01000011 11111111
    - 224 55 67 255
  - Therefore, the Broadcast Address is 224.55.67.255 (answer).

Take note of the difference.

All are '1's.

11100000 00110111 01000011 11111111

Network portion | Host portion

Type 3: Host Address (1)

- Host Addresses are addresses assigned to the end devices in the network.
- For a network with prefix length of m bits, there are:
  - m bits in the Network portion, and
  - (32-m)=n bits in the Host portion.
- With n bits in the Host portion, there are 2^n possible patterns, from 000…00 to 111…11.
- The first pattern, where all bits in the Host portion are '0's (000…00) is reserved as the Network Address.
- The last pattern, where all bits in the Host portion are '1's (111…11) is reserved as the Broadcast Address.

Type 3: Host Address (2)

- Using 8-bit Host portion as a example, the patterns of the host portion are:
  - 00000000 (Cannot be used!!! Reserved for Network Address.)
  - 00000001 (Can be used as Host Address – First valid Host Address)
  - 00000010 (Can be used as Host Address)
  - 00000011 (Can be used as Host Address)
  - ..... (Can be used as Host Address)
  - 11111100 (Can be used as Host Address)
  - 11111101 (Can be used as Host Address)
  - 11111110 (Can be used as Host Address – Last valid Host Address)
  - 11111111 (Cannot be used!!! Reserved for Broadcast Address.)

- Out of the 2^n patterns, two patterns cannot be used as Host Addresses:
  - "000…00" and "111…11" are reserved as Network Address and Broadcast Address respectively.
- Therefore, for a network with n bits in the Host portion, the number of valid Host Addresses = $2^n - 2$.

No. of valid Host Addresses = $2^n - 2$

Exercise:

- Given an IP address 192.168.33.0/19, determine:
  - (i) the Network Address of the network that this IP address belongs to,
  - (ii) the number of valid Host Addresses in this network,
  - (iii) first valid IP address for this network,
  - (iv) last valid IP address for this network,
  - (v) the Broadcast Address for this network.

Answer

- (i)
  - IP address = 192.168.33.0/19, therefore
    Binary format = 11000000 10101000 00100001 00000000
  - Prefix length = 19, hence Network portion is
    11000000 10101000 001 (19 bits)
  - No. of bits in Host portion, n = 32 – 19 = 13 bits
  - For Network Addresses, all Host portion bits are '0's.
    - 00000 00000000
  - Therefore, Network Address =
    11000000 10101000 00100000 00000000
  - 192 168 32 0
  - Network Address = 192.168.32.0

Answer (cont'd)

- (ii)
  - No. of bits in Host portion, n = 32 – 19 = 13 bits
  - Number of valid Host Addresses = $2^n - 2 = 2^{13} - 2 = 8190$

- (iii)
  - First valid IP address is
    11000000 10101000 00100000 00000001
  - 192 168 32 1
  - First valid Host Address = 192.168.32.1

Answer (cont'd)

- (iv)
  - Last valid IP address is
    11000000 10101000 00111111 11111110
  - 192 168 63 254
  - Last valid Host Address = 192.168.63.254

- (v)
  - Broadcast Address is
    11000000 10101000 00111111 11111111
  - 192 168 63 255
  - Broadcast Address = 192.168.63.255

Dynamic Host Configuration Protocol (DHCP)

- In automatic IP address configuration, the network allocates IP address to a host.

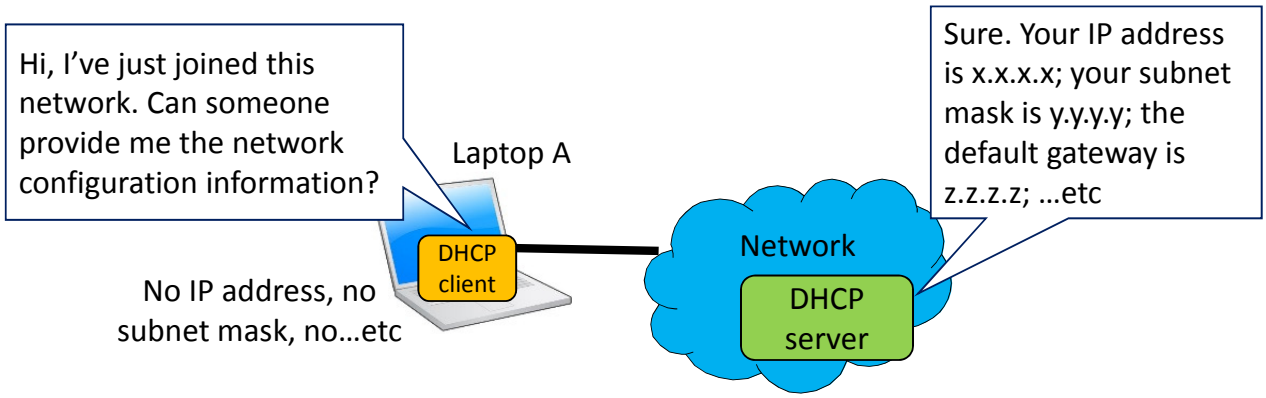
- The process of auto-configuration of IP address (and other parameters) follows the Dynamic Host Configuration Protocol (DHCP).

- DHCP is a client-server protocol that automatically provides an host with an IP address and other related configuration information (e.g. subnet mask, default gateway, DNS server).

How does DHCP work?

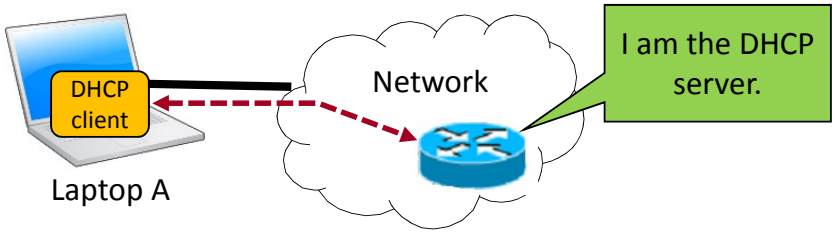
DHCP client i
Laptop A

- When a host is connected to a network, the "DHCP client" service in the host makes a request (known as "DHCP Discovery") with the DHCP server in the network for the network configuration information (IP address, subnet mask, …etc).

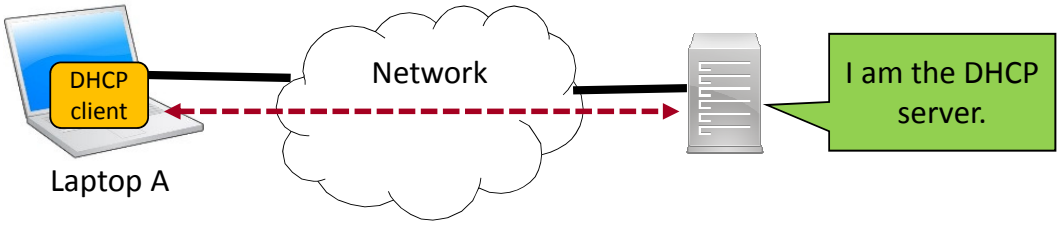


Where is the DHCP Server?

- DHCP Server is a service (software) that may be running on:
  - a router

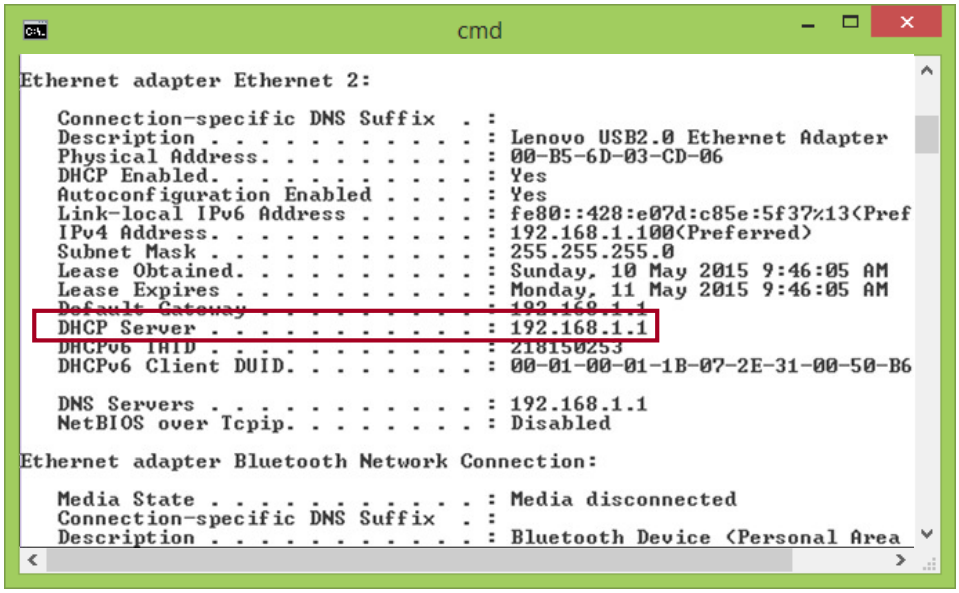


  - a computer



Try this: Find out your DHCP Server

- Launch a DOS prompt window.
- Key in "IPCONFIG /ALL" <ENTER>

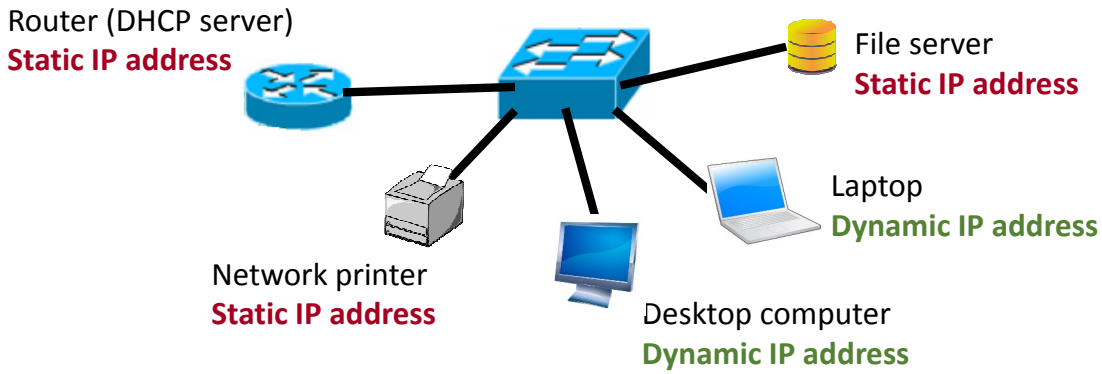


Disadvantages of using DHCP

- IP address is not fixed (discussed earlier).
- If the DHCP server fails, any host joining the network will not be able to obtain an IP address.
- Security risk
  - An unauthorised DHCP server may offer IP addresses to users connecting to the network, and hence intercepting information sent over that connection. This can lead to "man in the middle attack".
    - See http://en.wikipedia.org/wiki/Man-in-the-middle_attack for definition of "man in the middle attack".

Can you mix Static and Dynamic IP addresses?

- In a network, it is quite common to mix static and dynamic IP addresses.
- Example: use static IP addresses for servers; use dynamic IP addresses for user computers.



How to mix Static and Dynamic IP Addresses? (1)

- **Dynamic IP Addresses**
  - In the DHCP server, define a pool of IP addresses (for example, 192.168.1.100 to 192.168.1.149) for dynamic IP address allocation.
    - Make sure that the pool of IP addresses is large enough to serve the maximum possible number of hosts to connected to the network.
  - When a new connecting host requests for an IP address, the DCHP server will pick one IP address from the pool and makes the offers.
  - The IP address that a host gets is not fixed. It depends on what IP addresses are available when the request is made.

How to mix Static and Dynamic IP Addresses? (2)

- **Static IP Addresses**
  - Allocate IP addresses outside the dynamic IP addresses pool (for example, 192.168.1.70 to 192.168.1.99) to a list of hosts that require static IP addresses.
  - For each host, reserve a fixed IP address for it.
  - Based on the MAC address (physical address) of the hosts, the DHCP server will offer a particular IP address to the host when it makes the request.
  - You may also manually configure the host with that reserved IP address (i.e. not making request to the DHCP server).

Questions & Answers