Chit-Chat in Lab (CCL)

Part1

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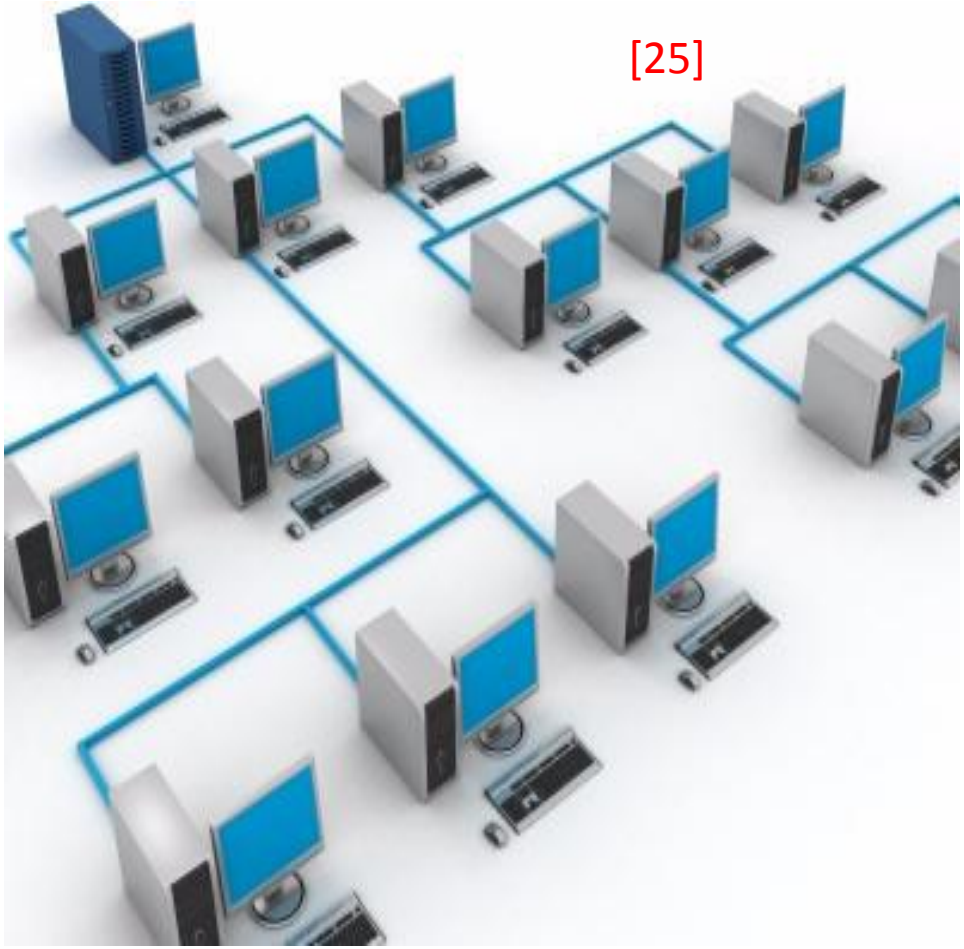
Computer Network

A computer network is a group of computer [1] systems and other computing hardware devices that are linked together through communication channels **to facilitate communication and resource-sharing** among a wide range of users.


[25]

Usage of Computer Network

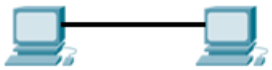
Networks are used to:

- Facilitate communication via email, video conferencing, instant messaging, etc.
- Enable multiple users to share a single hardware device like a printer or scanner
- Enable file sharing across the network
- Allow for the sharing of software or operating programs on remote systems
- Make information easier to access and maintain among network users

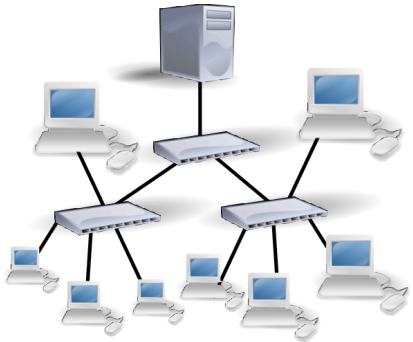
Different Kinds of Network [1]

There are many types of networks, including:

- Local Area Networks (LAN)
- Personal Area Networks (PAN)
- Home Area Networks (HAN)
- Wide Area Networks (WAN)
- Campus Networks
- Metropolitan Area Networks (MAN)
- Enterprise Private Networks
- Internetworks ***(internet)***
- Backbone Networks (BBN)
- Global Area Networks (GAN)
- ***The Internet***



(a) Simplest Network



[2]

(b) A bit Complicated Network

[3]

(c) Complicated Network

Hardware of a Network

- Computing Hardware Devices
  - Computer, Printer, Scanner
- Communication Channels
  - Copper straight-through cable, Copper cross-over cable, optical fiber, Wireless channel
- Network Interface Card
- Connecting Points or Ports
  - Physical port
- Interconnecting devices
  - Repeater, **Hub, Switch**, Bridge, **Router**

PC

Copper Cable

NIC

Switch

Hub

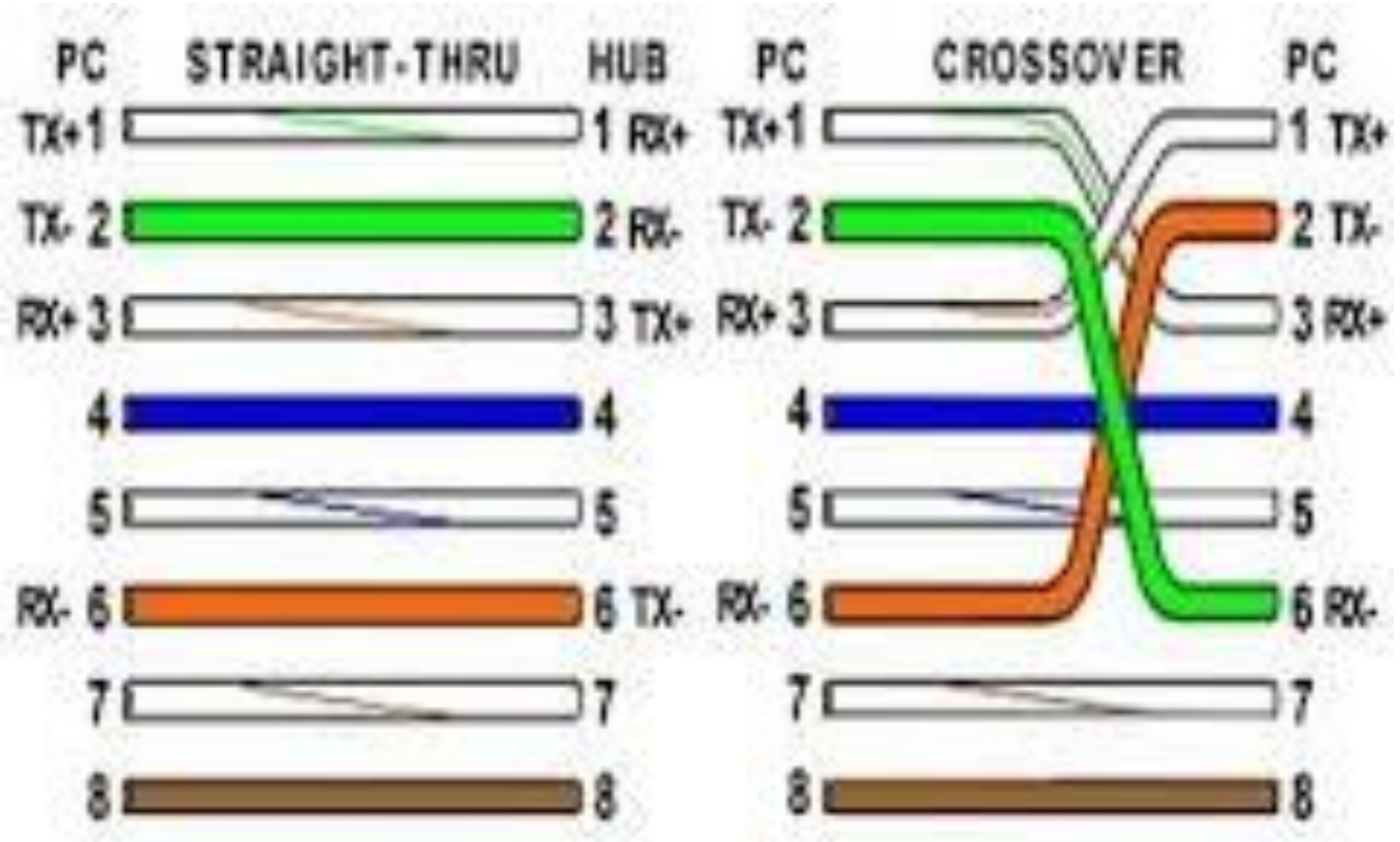
Physical port

Communication Channel

- Communication channels are pathways to convey data from source to destination.
- Communication channels use two media
  1. Cable [e.g., Copper Cable, Fiber Optic cable] for Ethernet
  2. Broadcast [e.g., microwave, radio, infrared] for WiFi
- **Copper cable or Category 5 cable** :
  commonly referred to as **cat 5**,
  is a twisted pair cable for carrying data in an Ethernet.
  - ❖Straight-through cable and Crossover cable


[Copper Cable]

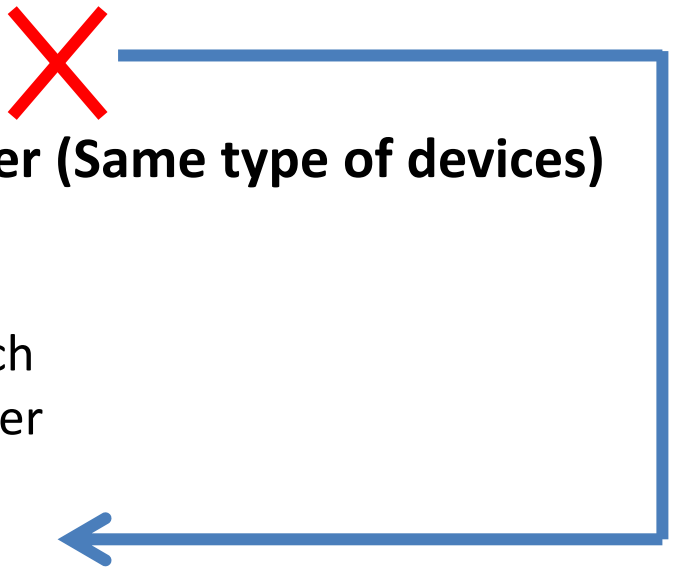
Connection: Straight-Through vs. Cross-Over



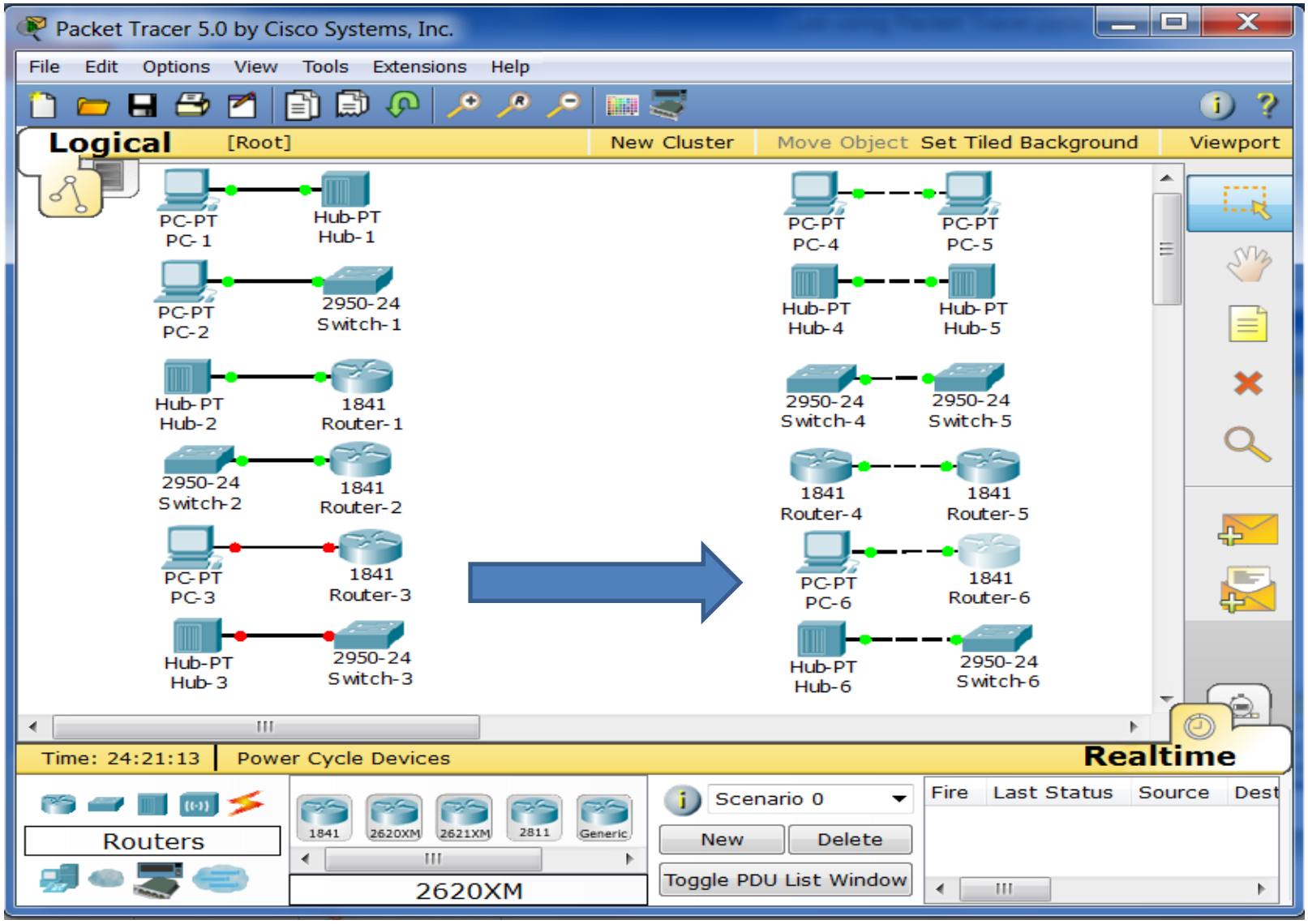
*** In Cross-over connection, only (1&3) and (2&6) are crossed

End-points: Straight-Through vs. Cross-Over

- **Straight-Through (Different type of devices)**
  - PC-to-Hub
  - PC-to-Switch
  - Switch-to-Router
  - Hub-to-Router
  - **PC-to-Router**
  - **Hub-to-Switch**
- **Copper Cross-Over (Same type of devices)**
  - PC-to-PC
  - Hub-to-Hub
  - Switch-to-Switch
  - Router-to-Router
  - **PC-to-Router**
  - **Hub-to-Switch**

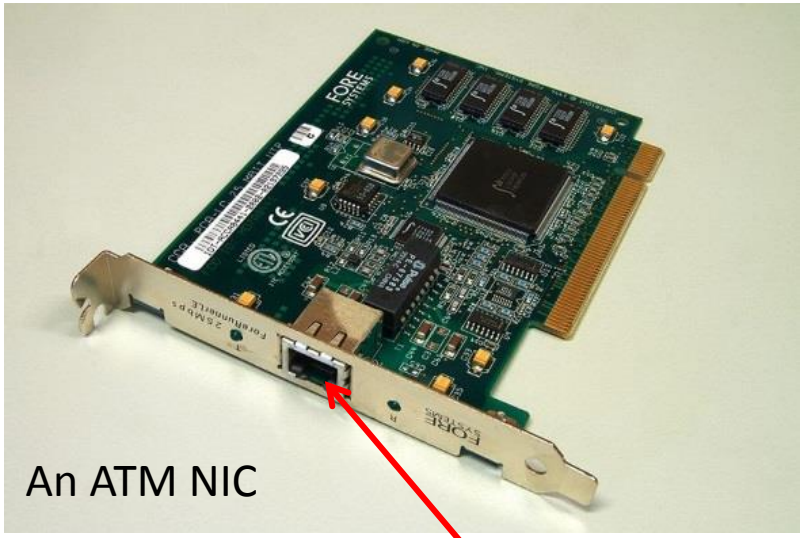


Copper Straight-Through vs. Cross-Over



NIC

- NIC: Network Interface Controller
- It connects a device to a computer network
  - A device, e.g., a computer must have an NIC in order to connect to a network
- It is also known as
  - Network Interface Card
  - Network Adapter
  - LAN Adapter
  - Physical Network Interface
- Common manufacturers:
  - Intel, Realtek, Broadcom, Qlogic, Group,



An ATM NIC

NIC Address

- In order to communicate with other devices, each NIC needs two kinds of addresses
  - Physical Address
  - Logical Address
- Physical Address
  - One NIC can have only one Physical address
  - This is a lifetime address
  - **MAC Address**
- Logical Address
  - One NIC may have multiple logical addresses at the same time (rare use)
  - This is changeable by *Administrator* or *OS* or *DHCP server*
  - **IP Address**

MAC Address

- MAC: Medium Access Control
- Each NIC has a **unique** physical address known as MAC address.
- It is 48 bit long written in either of these formats:
  - MM:MM:MM:SS:SS:SS
  - MM-MM-MM-SS-SS-SS

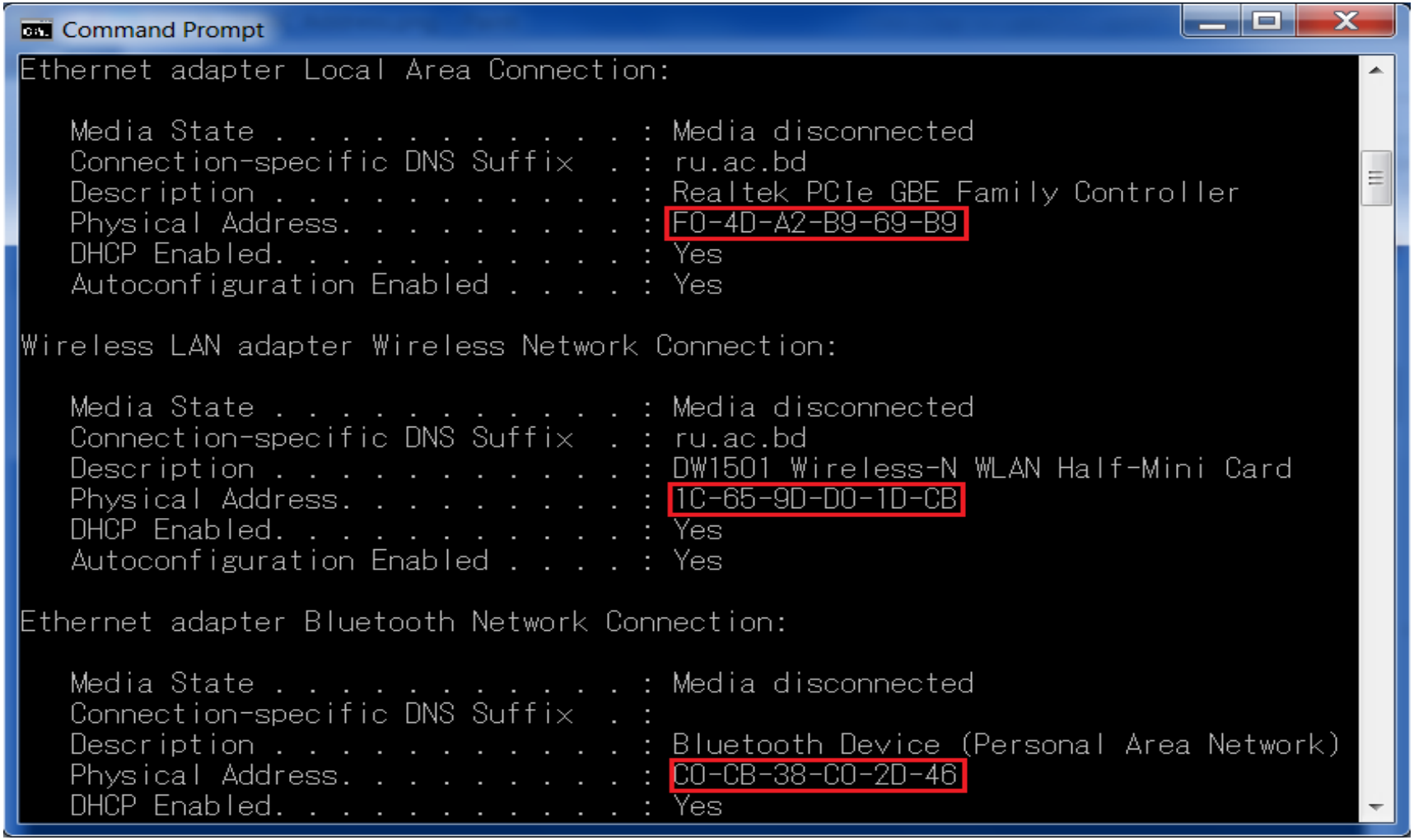
*OUI: Organizationally Unique Identifier

- It is assigned by the manufacturer of NIC
  - Inside a read-only memory
  - firmware

How to Know MAC Address

- In Windows OS
  - Go to the Command prompt
    - Click on Start button, select Run
    - Type ‘cmd’ and press ENTER
  - In the Command prompt, type **ipconfig /all** and press ENTER
- In Linux OS
  - Go to a terminal
  - In the terminal, type **ifconfig** and press ENTER

Example: A Laptop having 3 MAC Addresses



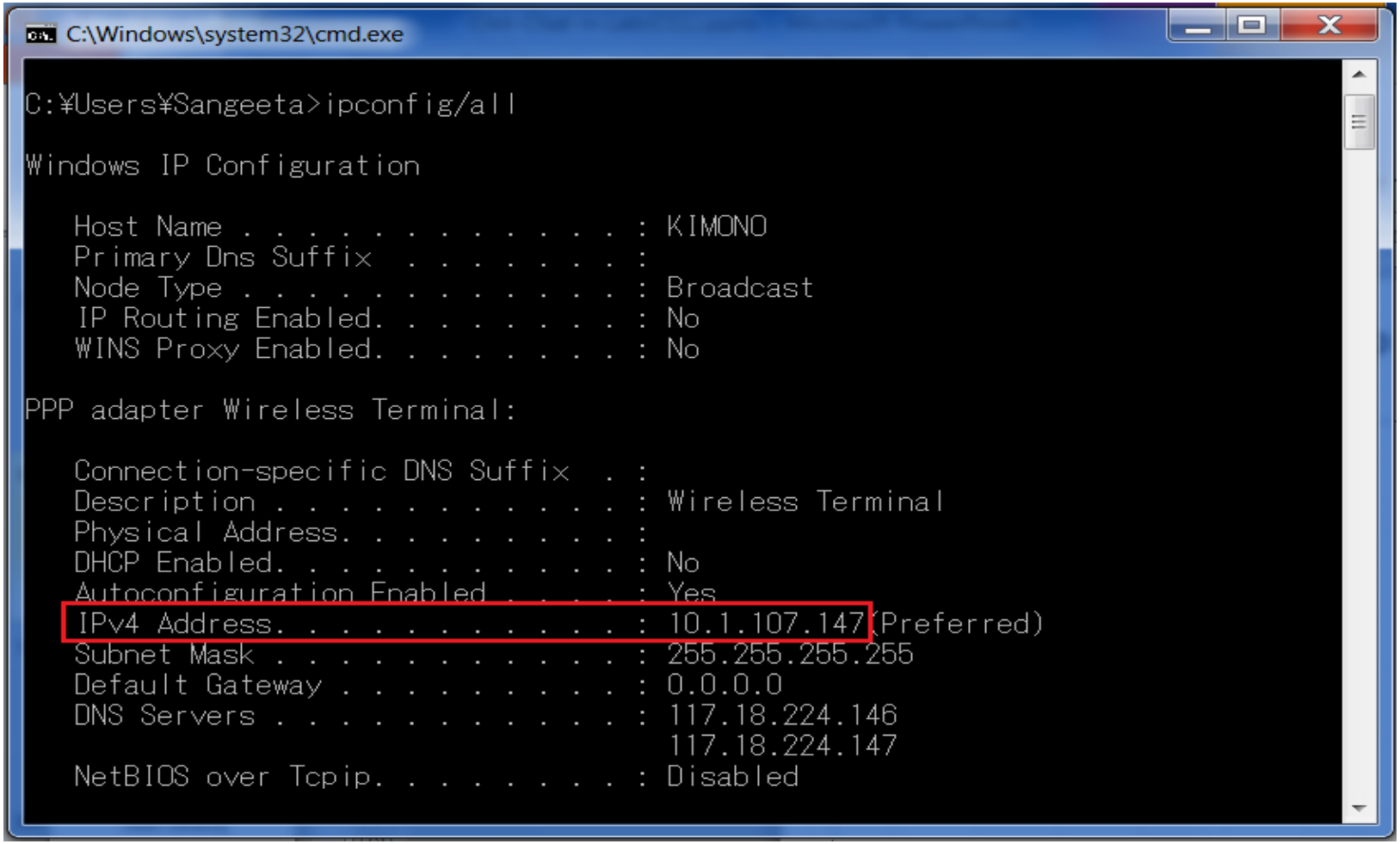
IP Address

- In order to communicate with other machines in the network based on Internet Protocol, each machine must have an IP (Internet Protocol) address.
- An IPv4(IP version 4) or IP (in short) address is 32 bit long.
  - $\mathbf{2^{32}}$ or **4,29,49,67,296** IP addresses.
- An IP address is written by 4 numbers separated by 3 dots.
  - $a.b.c.d$ where $\{0 \leq \{a, b, c, d\} \leq 255\}$
  - Example: 172.16.0.1

How to Know IP Address

- In Command Prompt of Windows OS
  - Type ipconfig/all and Enter
- In GUI of Windows OS
  - Go to 'Control Panel'
  - Click on 'Network and Internet→ View network status and tasks'
  - Click on 'Connections: '
  - Click on 'Details' Tab
- In Linux
  - Open a terminal
  - Type 'ip addr show' to see all IP addresses
  - Type 'ip addr show eth0' to see IP information about eth0

Example: IP Address in Command Prompt



Setting IP Address

- An IP address can be assigned to a device by
  - Root User/ Network Administrator
  - Operating system
  - Internet Service Provider (ISP)
- Depending on how frequently an IP address is assigned to a device, there are two kinds of IP addresses
  - **Static** : It is not changed as long as network administrator or root user do not change it
  - **Dynamic** : It is changed by either operating system or a DHCP server because of disconnection or lease time expiration.
- A user needs to pay more money for a static **real** IP address than a dynamic **real** IP address.

Static vs Dynamic IP Address

- Dynamic IP Addresses:
  - They can be changed each time a user connects to the Internet
  - Residential Internet connections, whether broadband or dialup usually use dynamic IP addresses.
  - The need for dynamic IP addresses arises from the limited number of 32bit IP (IPv4) addresses are not sufficient
- Static IP Addresses:
  - They are reserved for a user statically and does not be changed over time.
  - Commercial leased lines and servers have static IPs, so they can always be reached at the same address.
  - Every device will have static address when 128 bit IP address (IPv6) will be widely implemented.

How to Set IP Address

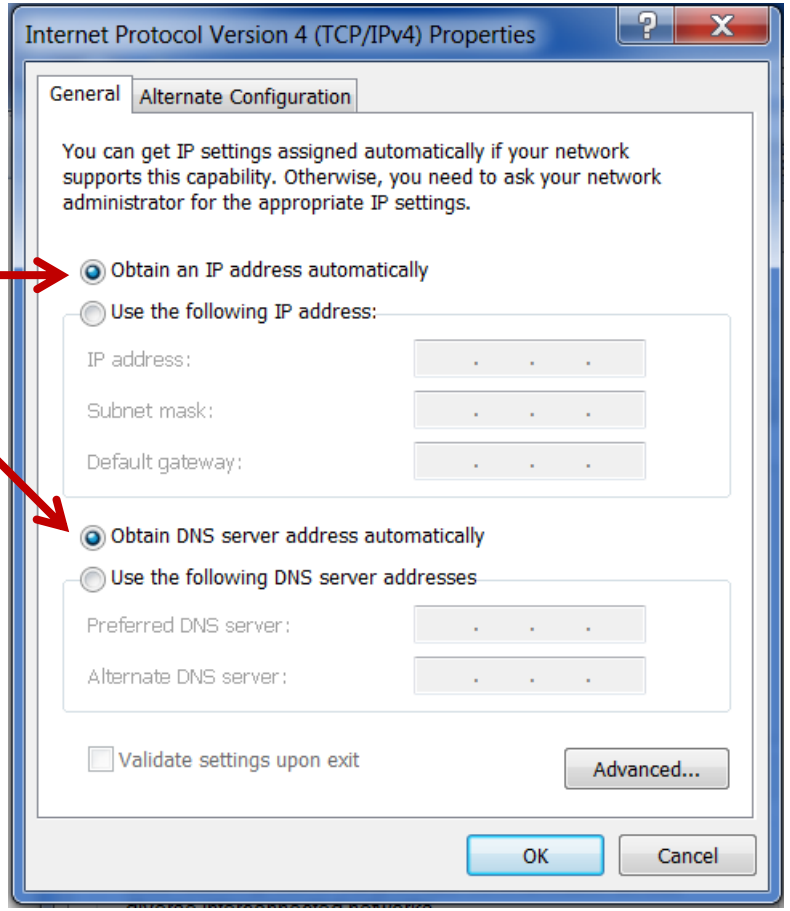
- Root User / Network Administrator can set **static IP** address.
- Operating System (OS)/ ISP can provide **dynamic IP** address
  - OS provides only APIPA address
    - **169.254.0.0 to 169.254.255.255**
  - ISP via DHCP server provides IP address in any range

What to Do for Dynamic IP Address

- In Windows OS , we do not need to do anything, for getting dynamic IP address.
- It is a by-default setting.

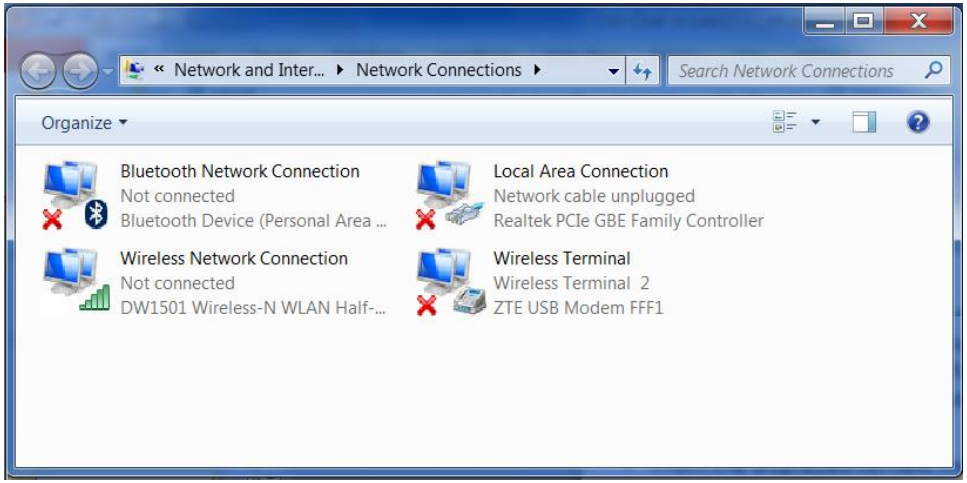
- In order to see this window we need to go to

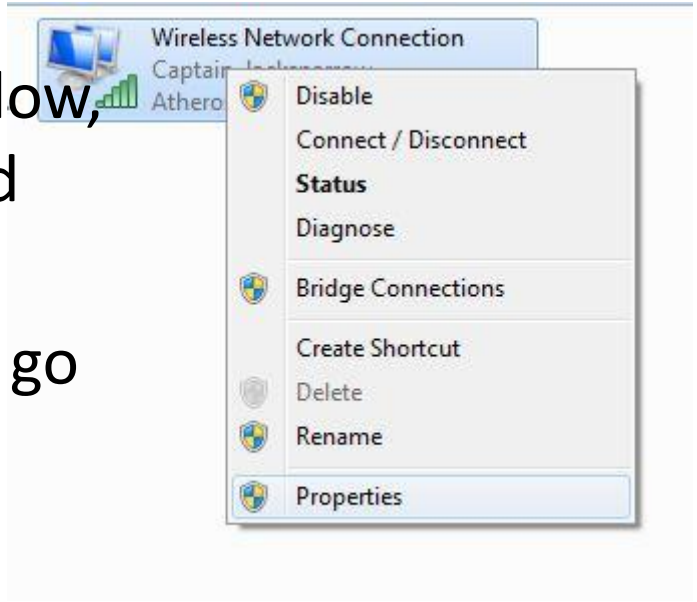
Control Panel→Network and Internet →Network Connections →[Any Network Connection] →Properties → Internet Protocol Version 4 (TCP/IP) Properties



How to Set Static IP Address (1)

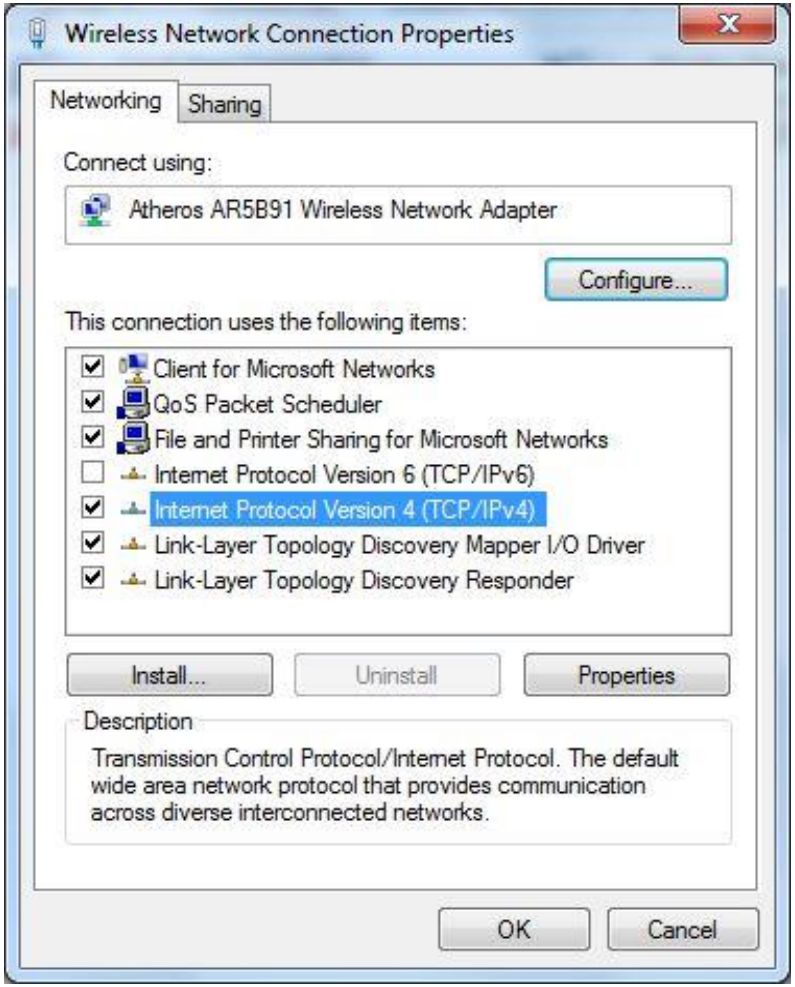
1. Log on to the computer as an administrator.
2. Open command prompt window and type NCPA.CPL
3. On the Network Connections window, right-click the icon of the preferred network interface card
4. From the displayed context menu, go to the Properties option.





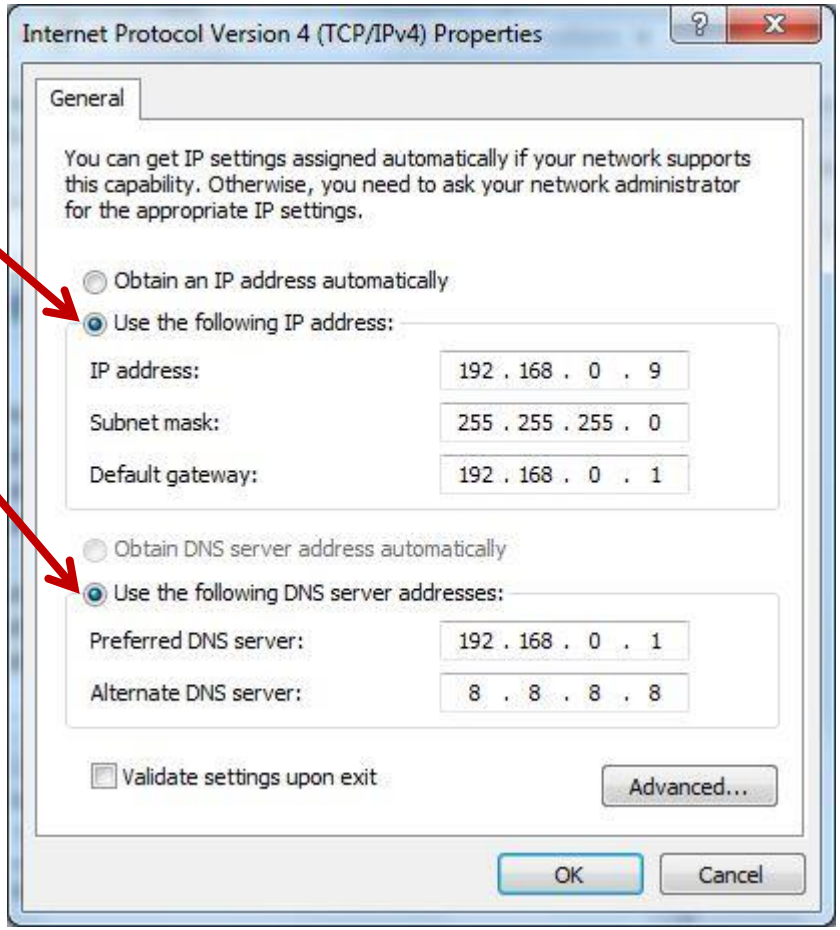
How to Set Static IP Address(2)

5. On the opened NIC properties box, from the displayed list, double-click on the ‘Internet Protocol Version 4 (TCP/IPv4)’ option.



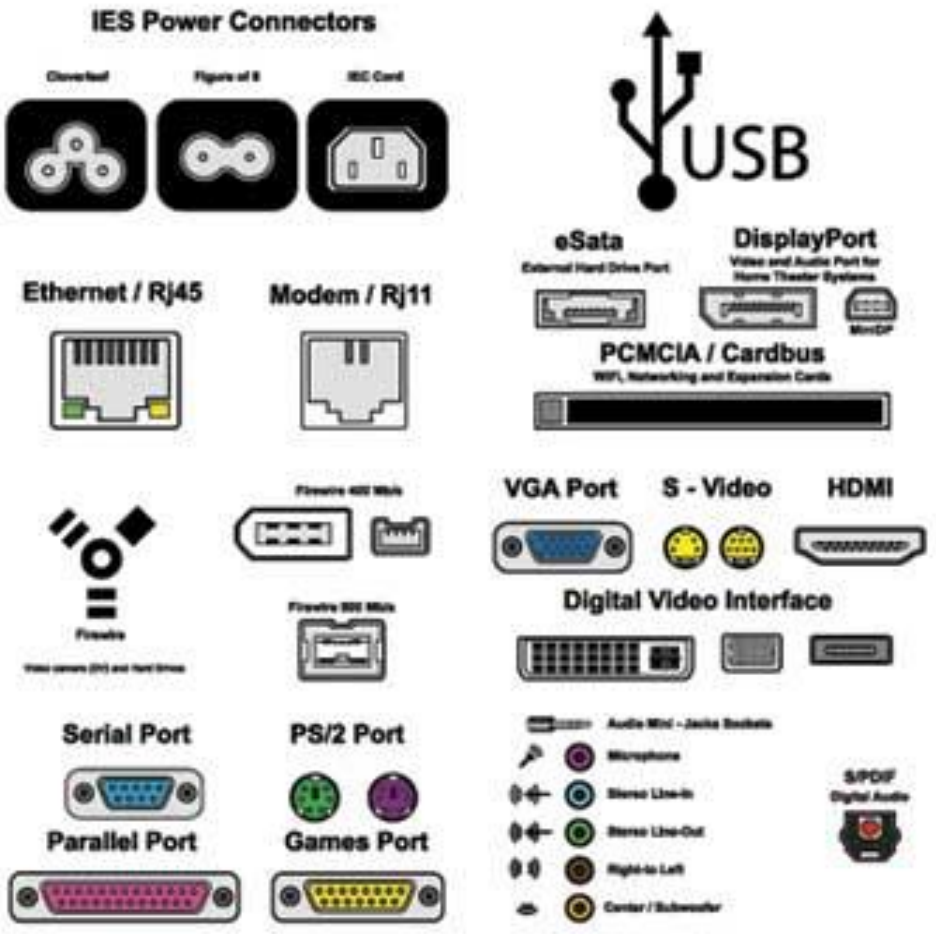
How to Set Static IP Address(3)

6. Choose “Use the following IP address” for setting Static IP address. “Use the following DNS server address” for setting DNS server will be automatically selected.
7. Set IP address and DNS server address



Port

- In computer networking ‘port’ refers to connection points.
- There are two kinds of ports
    1. Physical port
    2. Logical port
- Physical Port:
    - ❖ an interface on a device into which user can insert a connector for that device



Different kinds of Physical Ports

Logical Port

- A port is an end-point of a logical connection and the way where a client program specifies a particular server program on a computer in a network.
- It is always associated with an IP address of a host and the protocol type of the communication.
- A logical port number is 16-bit long.
  - There are 0-65535 logical port numbers.
  - 0-1024 numbers are used for well-known services.
  - Well-known port numbers are assigned by IANA.
- Some well-known ports

  20 → FTP data 21 → FTP control

  53 → DNS service 80 → HTTP

  546 → DHCP Client 547 → DHCP Server

Simplest Network

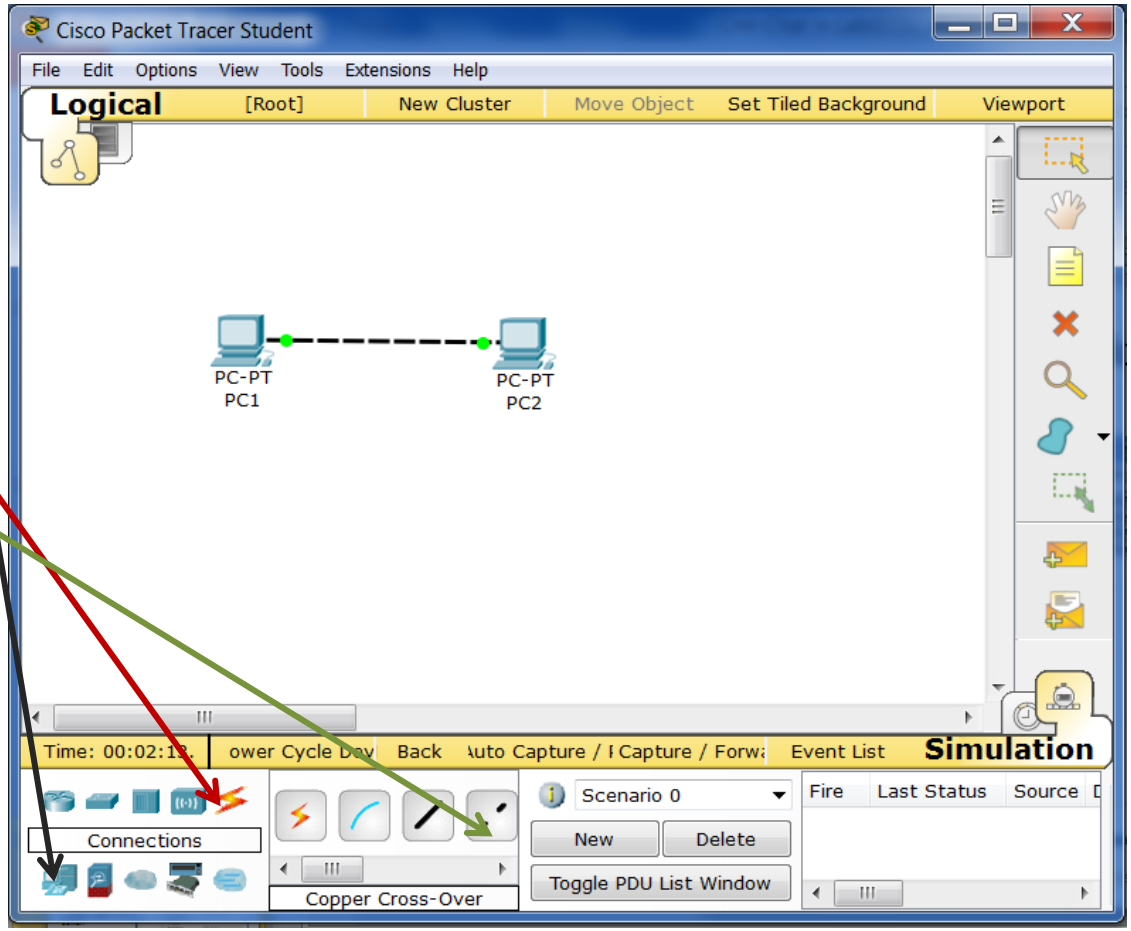
Simplest Network

- The simplest network can be established by:
  1. connecting NICs of two machines (e.g., two PCs, one PC and one printer etc.,) by a twisted pair cable.
  2. Setting **consecutive** two static IP addresses into those two machines
- For example:
  - IP address of PC1: 172.16.0.1
  - IP address of PC2: 172.16.0.2

- **Without IP addresses, two machines cannot share data.**
- We do not need to bother about MAC addresses, since they are provided by manufacturers of NICs inside NICs.

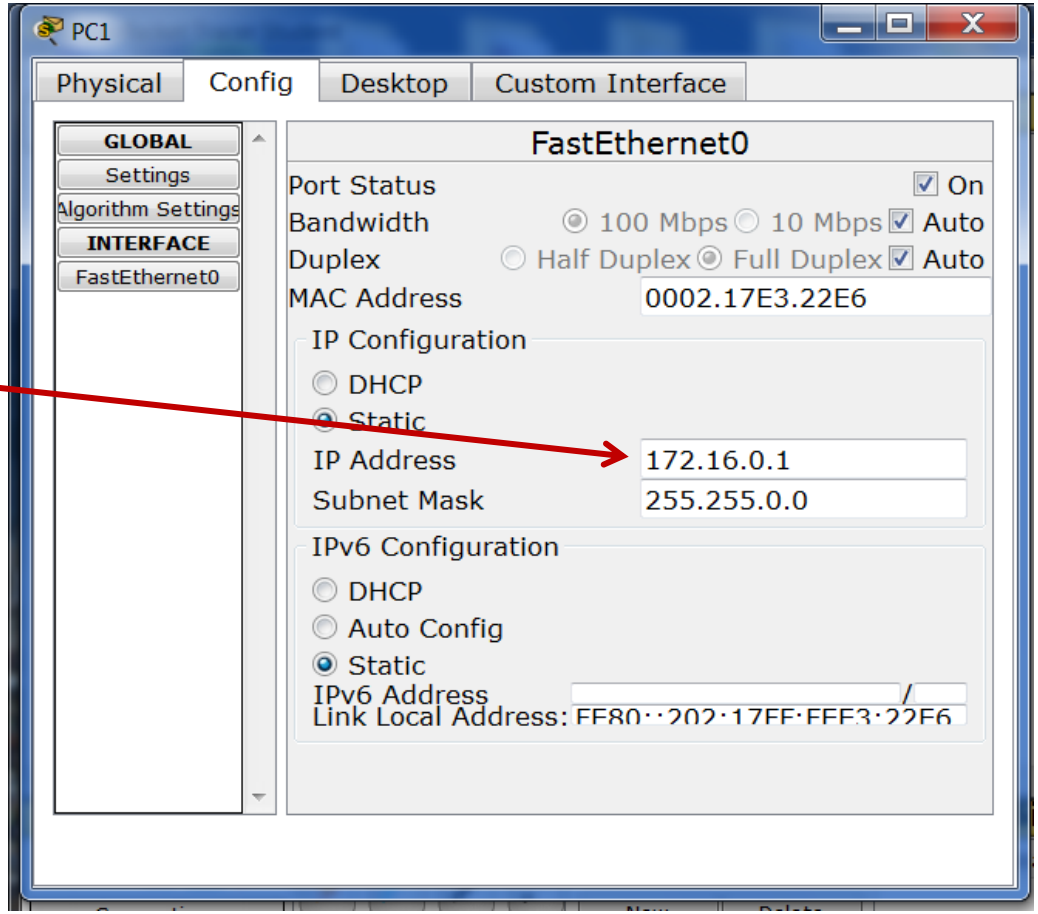
Simplest Network in Packet Tracer (1)

1. Click on ‘End Devices’ in the bottom tool bar
2. Drag two PCs
3. Click on ‘Connections’
4. Click on ‘Copper Cross-Over’
5. Click on PC1 and choose ‘fastEthernet0’.
6. Click on PC2 and choose ‘fastEthernet0’



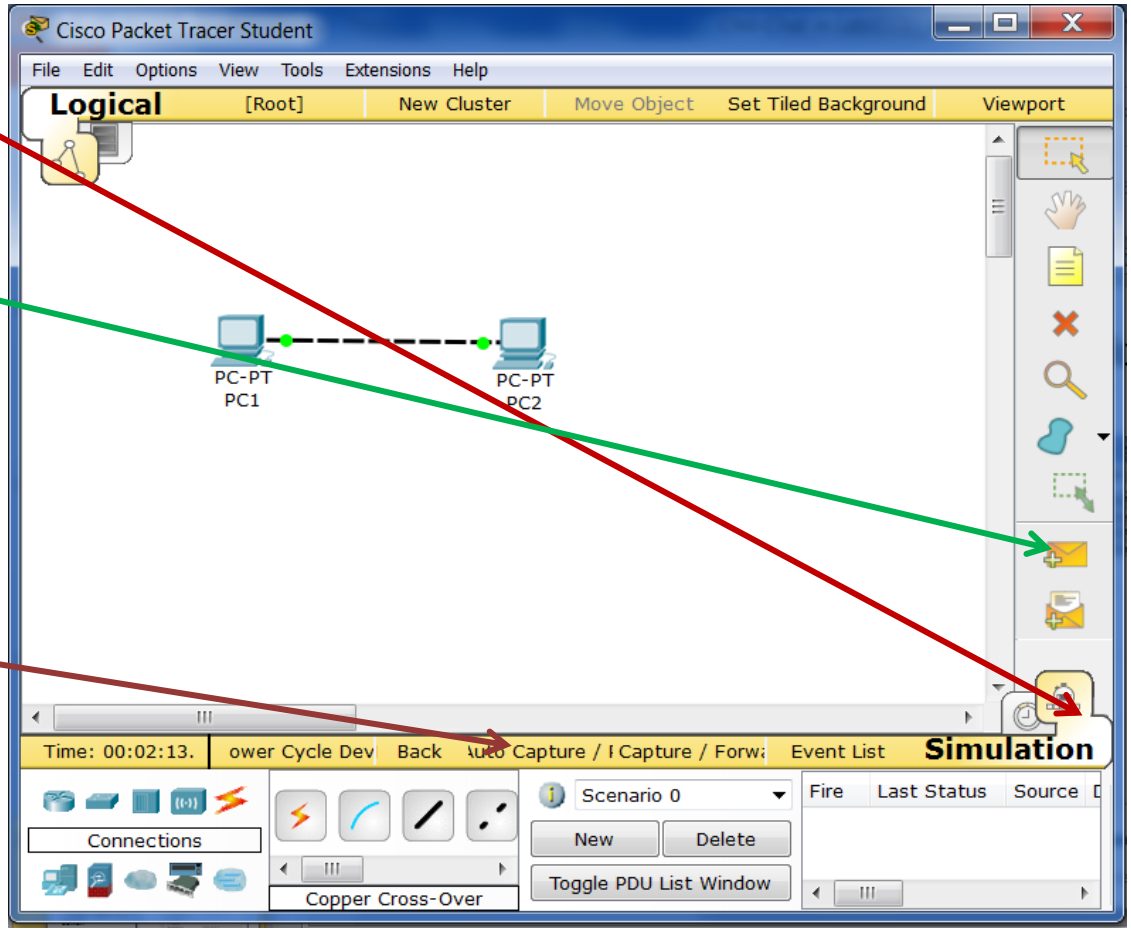
Simplest Network in Packet Tracer (2)

7. Double click on PC1
8. Click on ‘Config’ tab
9. Click on ‘FastEtnernet0’ tab
10. Set IP address
11. Subnet Mask will be automatically set, which does not need to be changed
12. Do the same thing for PC2 to set 172.16.0.2



Simplest Network in Packet Tracer (3)

13. Click on ‘Simulation’ tab
14. Click on ‘Add Simple PDU (P)’ and drag a packet
15. Click on PC1 and PC2
16. Click on ‘Auto Capture/Play’ tab
17. See **ARP** packet transfer between PC1 and PC2



ARP

- ARP: Address Resolution Protocol
- It is a network layer protocol used to convert network layer addresses (e.g., IPv4 addresses) into MAC address.

- In order to send a packet to a machine, a host needs to know the MAC address of destination machine. ARP helps host in such situation.

How Does ARP Work

1. **Host-A** wishing to obtain a physical address corresponding to an IP address , asks its ARP program.
2. The ARP program looks in the ARP table and, if it finds the address, provides it to **Host-A**.
3. Otherwise, the ARP program broadcasts an ARP request packet onto the TCP/IP network.
4. The machine on the network that has the IP address in the request then replies with its physical hardware address to the ARP program of **Host-A**.
5. ARP program saves IP address and corresponding IP address in the ARP table of **Host-A** for future reference.

ARP Table

- It is used to maintain a correlation between each MAC address and its corresponding IP address.
- It is also known as ARP cache.
- In order to reduce ARP traffic in a network this table/cache is stored in a PC or a switch for future use.
- To view ARP cache:
  - Open Command Prompt.
  - At the command prompt, type **arp -a**.
- To delete ARP cache:
  - Open Command Prompt.
  - At the command prompt, type **arp -d**.

Example of ARP Table

- Steps:
  1. Double click on PC1
  2. Go to 'Desktop → Command Prompt'
  3. Type 'arp -a' to see ARP table

- Example:

```
PC> arp -a
Internet Address      Physical Address      Type
172.16.0.2            0003.e4b9.158e        dynamic
```

- Same kind of ARP Cache or Table can be seen in our PC.

Command: ping [17]

- 'ping' command is a Command Prompt command.
- It is used to test the ability of the source computer to reach a specified destination computer.
- It operates by sending **Internet Control Message Protocol (ICMP)** Echo Request messages to the destination computer and waiting for a response.
- It provides following information
  - how many of those responses are returned, and
  - how long it takes for them to return
- Example:
  - **ping** www.mail.yahoo.com
- Just type 'ping' in the command window of Windows machine in order to see other options.

Ping www.mail.yahoo.com

[using Wi-Fi of CityCell]

- **Go to command prompt and type**

C:\Users\Sangeeta>ping www.mail.yahoo.com

Pinging src.g03.yahoodns.net [106.10.212.150] with 32 bytes of data:
Reply from 106.10.212.150: bytes=32 time=297ms TTL=53
Reply from 106.10.212.150: bytes=32 time=350ms TTL=53
Reply from 106.10.212.150: bytes=32 time=1896ms TTL=53
Reply from 106.10.212.150: bytes=32 time=637ms TTL=53

Ping statistics for 106.10.212.150:
Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),
Approximate round trip times in milli-seconds:
Minimum = 297ms, Maximum = 1896ms, Average = 795ms

Analysis of Previous Output of ‘ping’

- *4* **ICMP Echo Requests** were sent.
- Packet’s size was 32 bytes.
- TTL : Time To Live
  - is a value that tells a network router whether or not the packet should be discarded.
- The *0% loss* reported under *Ping statistics for* 106.10.212.150 tells that each ICMP Echo Request message sent to *www.mail.yahoo.com* was returned.
  - This means that, as far as network connection is Okay, user can communicate with yahoo’s mail server.
- By ‘n’ and ‘l’ options user can change default values of packet number and packet’s size.
  - Example : ping –n 300 –l 1500 www.mail.yahoo.com

A Bit Complicated Network

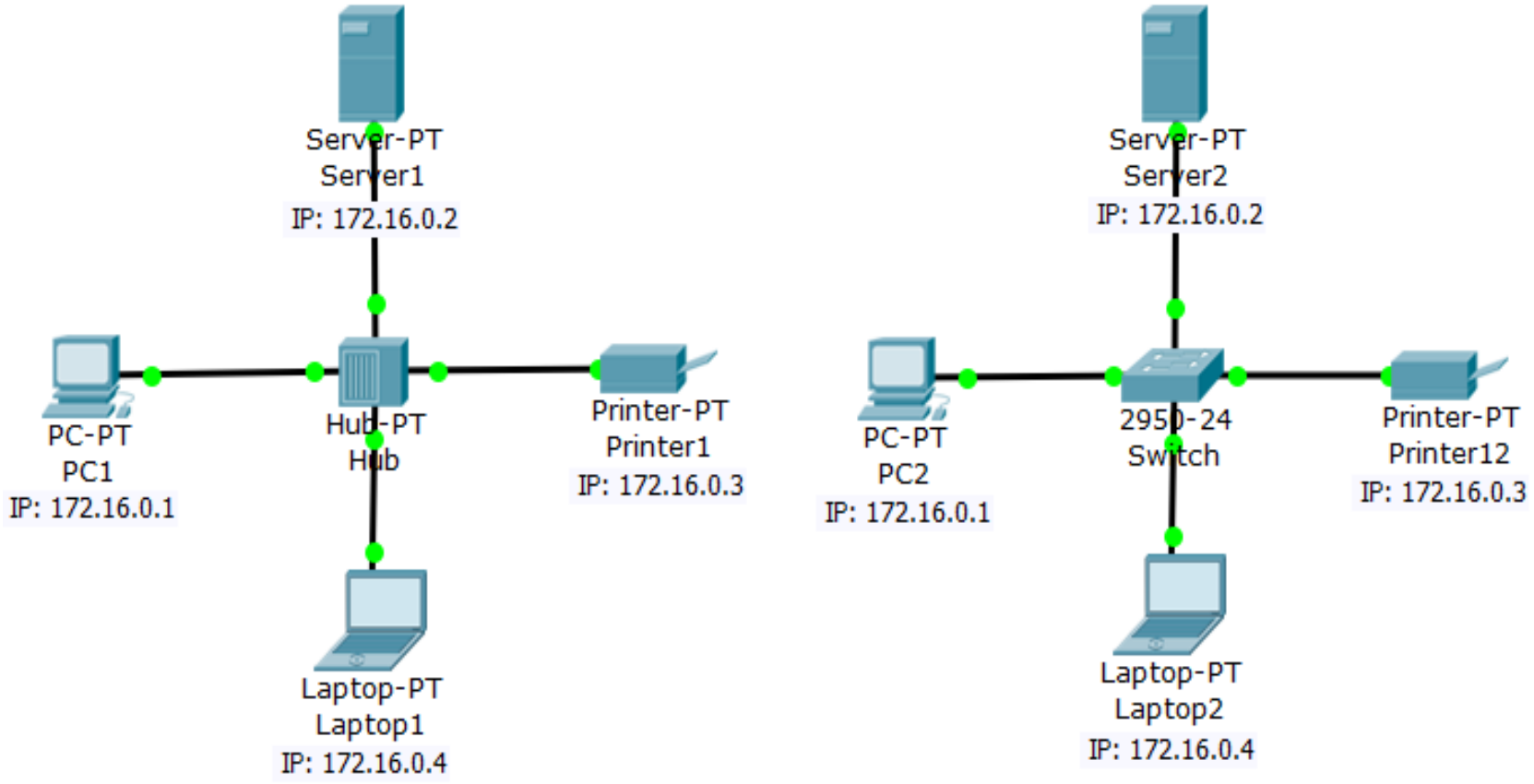
Interconnecting Devices

- In order to establish a network with more than two devices, interconnecting devices are necessary, such as
  - Hub, Switch

- Hubs and Switches are used to connect together a number of end-user devices such as workstations, printer, etc.
  - Hub and Switch can be considered as a multi-plug.
- Network segments that employ hubs or switches are often described as having a star topology, in which the hub or switch forms the wiring center of the star.

Star Topology

- Switch can be used as the same way as Hub.



Exercise (1)

- Design four networks as shown in Fig-1, where $P: PC; H: Hub$ and $S: Switch$.

  (i) What will happen in each case when:

  – P1 and P2 send packets to P3

  – at the same time

  – P1, P2 and P3 send packets to P4 at the same time.

  – P1 sends to P3 and P6 sends to P4.

  (ii) Which design will you choose? Justify your answer by mentioning the drawbacks of the rejected designs.

Exercise (2)

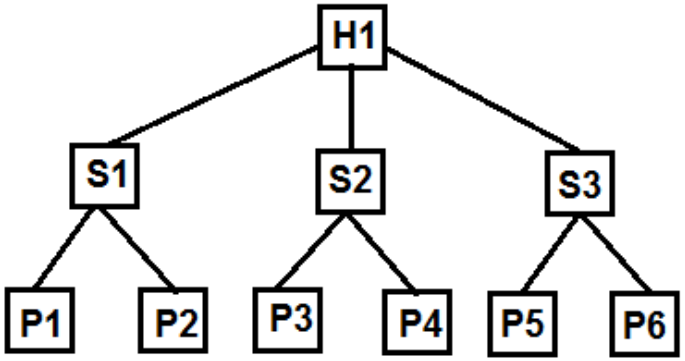


Fig-1(a)

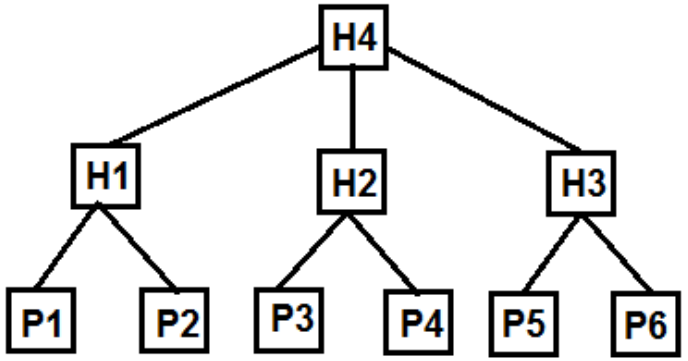


Fig-1(b)

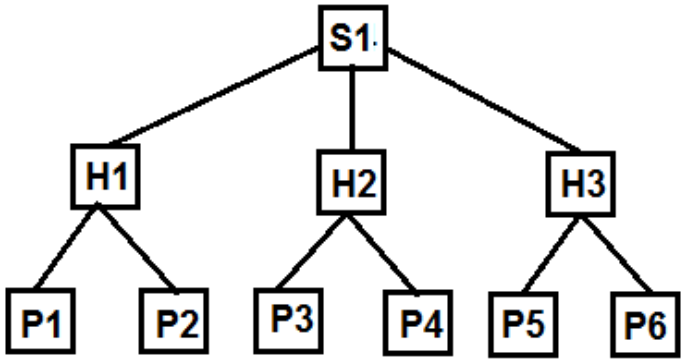


Fig-1(c)

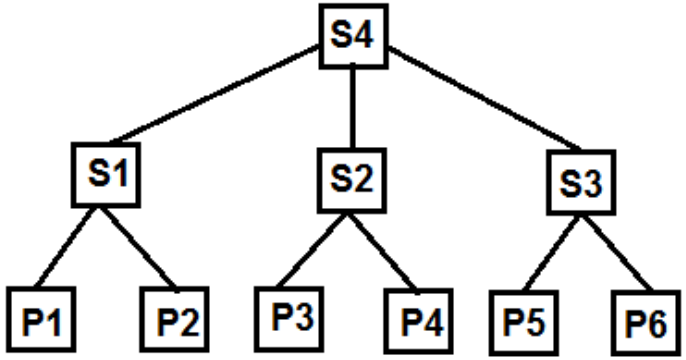


Fig-1(d)

Switch vs. Hub (1)

- Collision:
  - Frame collision occurs in a network using a **hub** when multiple devices send frames to the same/multiple destinations.
  - Frame collision never occurs in a network using a switch. Switch stores frames when any channel is busy.
- Address Table:
  - A hub does not have any address table.
  - A switch uses an internal address table to route incoming frames via the port associated with their destination MAC address.

Switch vs. Hub (2)

- Frame Forwarding:
  - A frame received at any port on the hub is retransmitted on all other ports except the incoming port.
  - A switch forward a frame only to the port specified for the destination in its internal table. If there is no entry for the destination and its port, the switch broadcast that frame to all ports except the incoming port.
- Speed:
  - A hub is assumed to be faster than a switch since it does not spend time for address checking.
  - However, frequent collision of frames demand huge number of retransmission of frames, which ultimately demolish the advantage of a hub over a switch

Unicast vs. Broadcast

- Unicast:
  - a packet is sent from a single source to a specified destination
- Broadcast:
  - a packet is sent from one point to all other points.
  - a packet could reach all hosts on the subnet, all subnets, or all hosts on all subnets.
  - broadcast packets have the host (and/or subnet) portion of the address set to all ones.
  - by design, most modern routers will block IP broadcast traffic and restrict it to the local subnet

MAC Address Table

- A MAC address table is used on Ethernet switches to determine where to forward traffic on a LAN.
- Sometimes it is called a *Content Addressable Memory* (CAM) table.
- When a switch receives a frame, it associates the Mac address of the sending network device with the LAN port on which it was received.
- The switch generally dynamically builds the address table.
- The switch uses an aging mechanism in order to remove inactive addresses from the address table.

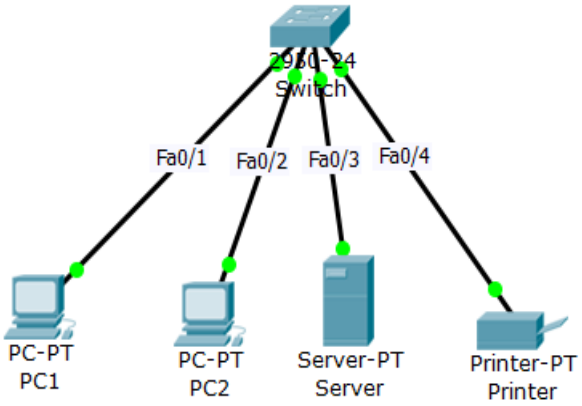
How is MAC Address Table Used

- At first MAC address table of a switch is empty.
- Switch gradually fills up the MAC address table.
- When the switch receives a frame
  - if the MAC address of the destination is in the MAC table, then the switch forwards that frame to the port(s) specified in the MAC address table.
  - otherwise,
    - the switch floods the frame to all LAN ports of the same VLAN except the port that received the frame.
    - when the destination station replies, the switch adds its relevant MAC source address and port ID to the address table.
    - The switch then forwards subsequent frames to a single LAN port without flooding all LAN ports.

Example: MAC Address Table

- To see MAC address table of a Cisco switch, type ‘show mac-address-table’ in the CLI (command line interface).
- For example, after sending a packet from PC1 to printer the MAC table of switch in packet tracer will look like

```
Switch>enable
Switch#show mac-address-table
          Mac Address Table
-------------------------------------------------------
Vlan    Mac Address       Type        Ports
-----   --------------------   ------------   -------
 1      0001.969d.74c3   DYNAMIC    Fa0/1
 1      0007.ec4d.5c13   DYNAMIC    Fa0/4
```



Static MAC Address

- A network administrator can enter a MAC address, which is termed a static MAC address, into the table.
- These static MAC entries are retained across a reboot of the switch.
- Configuring a static MAC address

Step1: switch# **configure terminal**

Step2: switch(config)# **mac-address-table static** *mac_address* **vlan** *vlan-id* { **drop** | **interface** { *type slot / port* } | **port-channel** *number* } [**auto-learn**]

Example: Static MAC Addressing

- Send a packet from PC1 to printer the MAC table of switch in packet tracer
- Type in the CLI of the switch

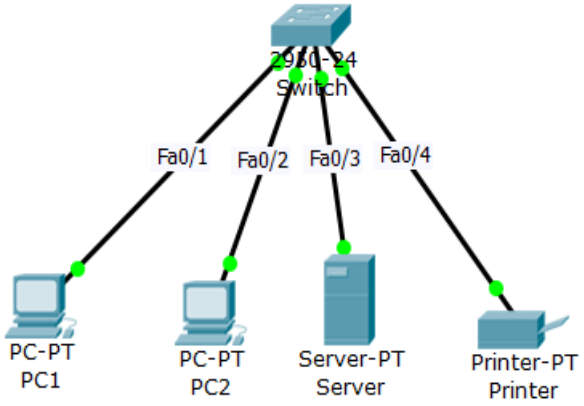
  Switch>enable

  Switch#configure terminal

  Switch(config)# mac-address-table static 0001.c728.13DE vlan 1 interface fa0/2

Mac Address Table

Vlan	Mac Address	Type	Ports
1	0001.969d.74c3	DYNAMIC	Fa0/1
1	0007.ec4d.5c13	DYNAMIC	Fa0/4
1	0001.c728.13de	STATIC	Fa0/2

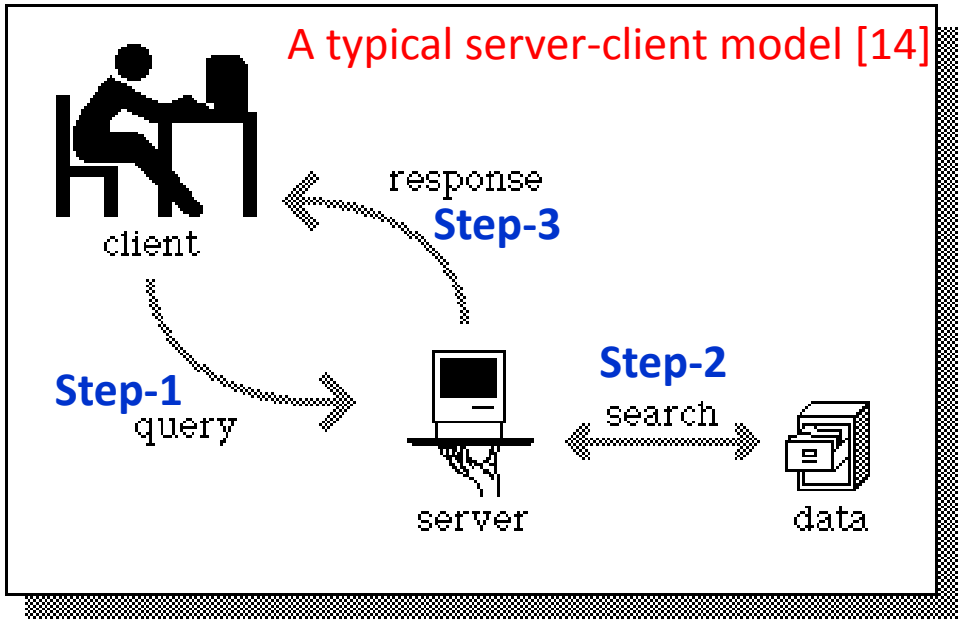


DHCP Server

Server

- A server is a computer program that provides services to other computer programs (and their users) in the same or other computers.
- The device that a server program runs in is also frequently referred to as a server.
- In the client/server programming model:
  - a server is a program that awaits and fulfills requests from client programs
  - a client is a program that requests for services

- Some popular servers
  - DHCP server
  - DNS server
  - File server
  - Mail server
  - Web server
  - Proxy server
  - Database server
  - Printer server



DHCP

- DHCP : Dynamic Host Configuration Protocol
- It is a protocol used to **automatically/dynamically provide network configuration information** to devices connected to an IP network.
- DHCP usually provides:
  - **IP Address**
  - Subnet mask
  - Gateway address
  - Name server address

Advantages of DHCP(1)

- **Reduced time to configure and deploy:** When the number of hosts is large in a network, DHCP is faster than human engineer especially than inexperienced/ non-technical administrator to allocate unique IP addresses.

- **Reliable IP address configuration:** DHCP minimizes configuration errors caused by manual IP address configuration, such as typographical errors, or address conflicts caused by the assignment of an IP address to more than one computer at the same time.

Advantages of DHCP(2)

- **Reduced network administration:** DHCP includes features to efficiently handle the IP address changes for clients that must be updated frequently, such as those for portable computers that move to different locations on a wireless network. This feature reduces operational overhead of network administrator.

- **Centralized management:** The DHCP Server maintains configurations for several networks. Therefore, an administrator only needs to update a single, central server when configuration parameters change.

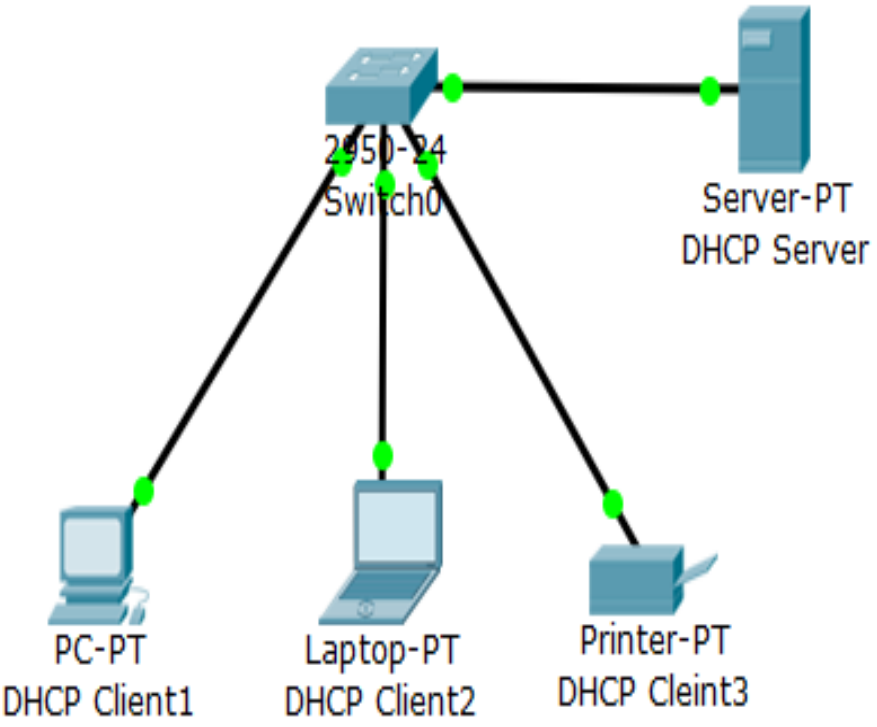
Advantages of DHCP(3)

- **Reduced costs:**
  - Using automatic IP address assignment at each remote site substantially reduces Internet access costs. Static IP addresses are considerably more expensive to purchase than are automatically allocated IP addresses.
  - Because DHCP is easy to configure, it minimizes costs associated with device configuration tasks and eases deployment by nontechnical users.

DHCP Server-Client Model

DHCP is based on a server-client model.

- **DHCP Server**: maintains TCP/IP configuration information and provide address configuration to DHCP-enabled clients in the form of a lease offer.
- **DHCP Client**: obtains an IP address from a DHCP Server dynamically using the DHCP protocol.



DHCP Address Pool

- Address pool is a set of IP addresses decided by a Network engineer for allocating to DHCP clients by the DHCP server.
- The nature of IP addresses received by DHCP clients will depend on the nature of IP addresses in the pool.
  - For example, if 192.167.23.0 255.255.255.0 is assigned to a pool, DHCP clients will dynamically get **254 real IP** addresses in the range 192.167.23.1-192.167.23.254.
  - On the other hand, if 192.168.23.0 255.255.255.0 is assigned to a pool, DHCP clients will dynamically get **254 private IP** addresses in the range 192.168.23.1-192.168.23.254.

Allocation of IP Addresses

1. Based on availability and usage policies set on the DHCP server, it chooses an appropriate address (if any) from its pool to give to the client.
2. The DHCP Server pings chosen address a certain times before assigning that address to the requesting client.
3. If the ping is unanswered, the DHCP Server assumes (with a high probability) that
   - the address is not in use and
   - reserves the address to the requesting client.

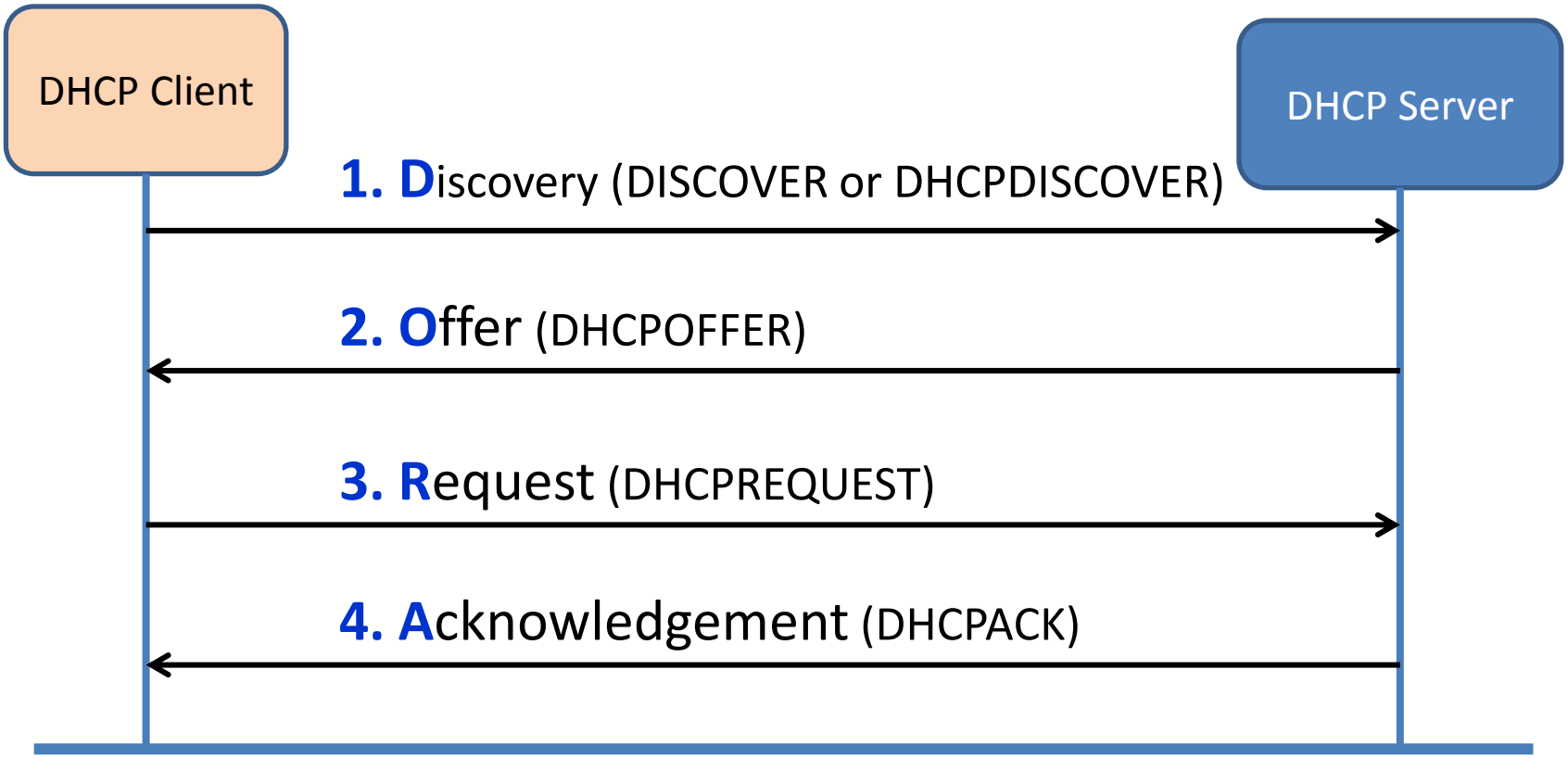
Steps for Getting an IP Address

When a machine connected in the network is turned on with a DHCP client:

1. The **client sends a broadcast request** (called a DISCOVER or DHCPDISCOVER), looking for a DHCP server to answer.
2. The **DHCP server** temporarily reserves an IP address for the client and **sends back to the client an OFFER (or DHCPOFFER) packet**, with that address information.
3. The **client sends a REQUEST (or DHCPREQUEST) packet**, letting the server know that it intends to use the address.
4. The **server sends an ACK (or DHCPACK) packet**, confirming that the client has a been given a lease on the address for a server-specified period of time.

DORA

DHCP's steps are abbreviated as DORA



DHCP Configuration using Packet Tracer 6.2

Recommended PDF :

Chapter : Configuring DHCP

Cisco IOS IP Configuration Guide Release 12.2

Example

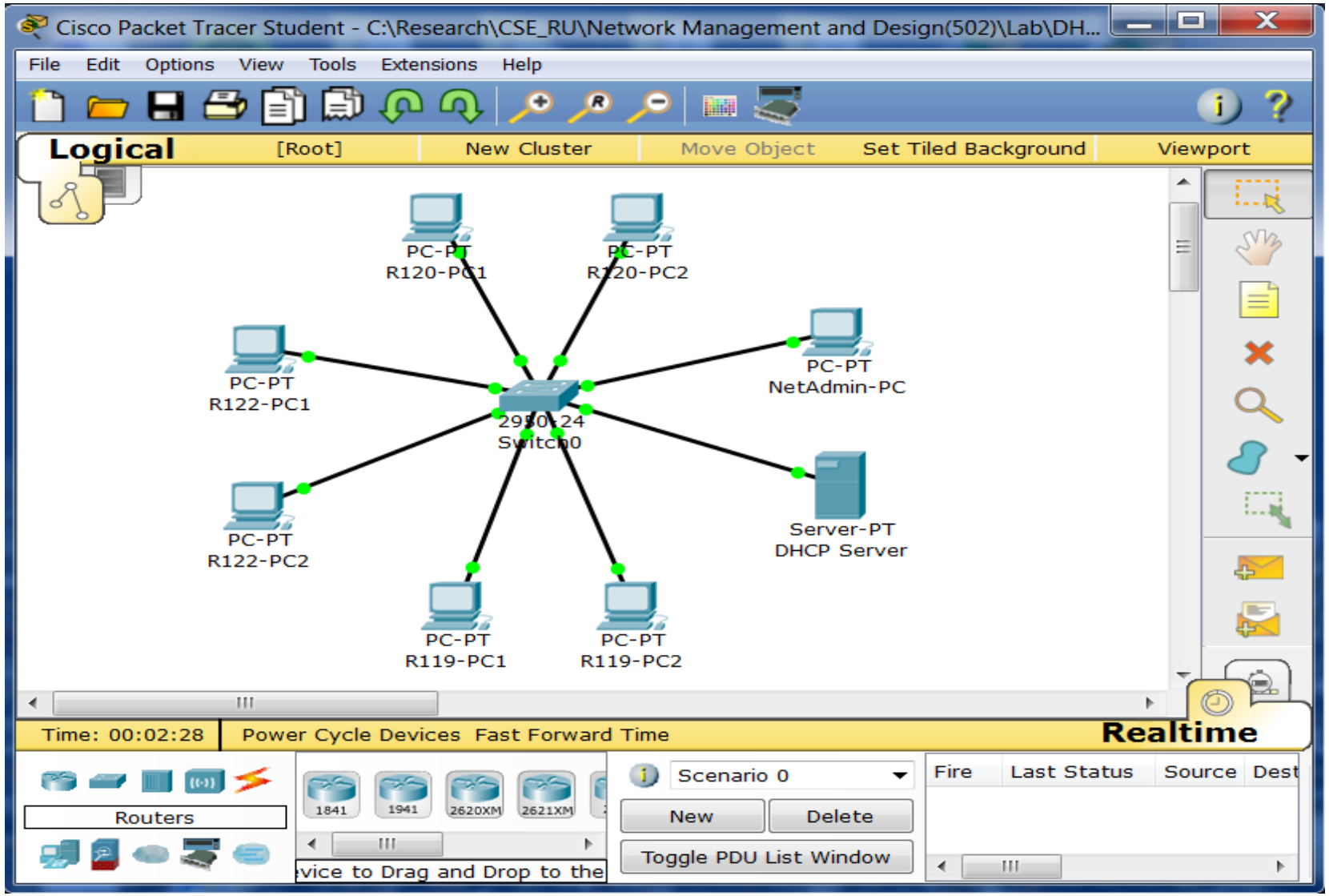
Problem: Configure a DHCP server for a simple LAN of 8 machines covering four rooms of our CSE department

- Rooms: admin, R122, R120 and R119
- At most 30 machines can be attached to this LAN
- Start IP address: 172.16.0.0
- DHCP Server's IP address: 172.16.0.1
- Other machines will get IP addresses from DHCP server according to booting order. Say if PC-1 of R122 is booted earlier than PC-1 of R119, then R122-PC1 will get lower IP address.

Steps for Building CSE Network

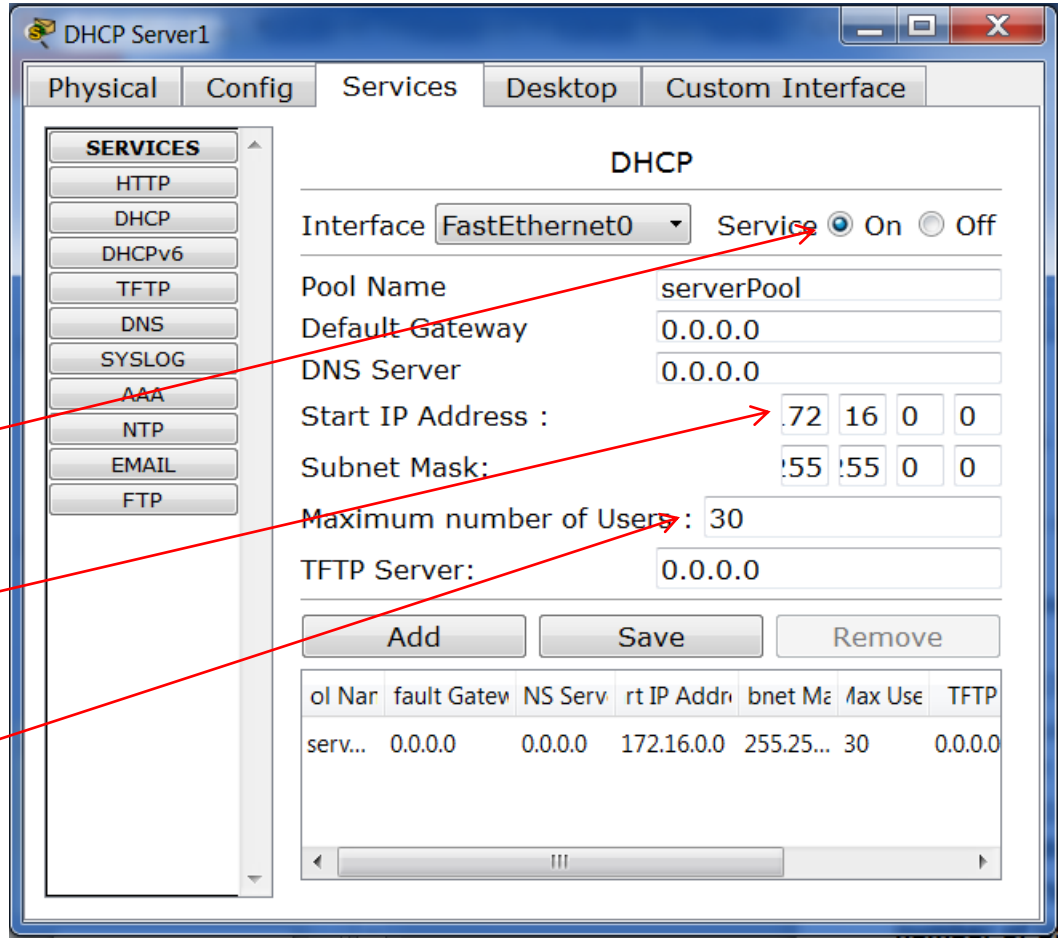
1. Take one Server and one PC for Admin's room(say, admin).
2. For other three rooms (say R122,R120 and R119), take 2 PCs.
3. Connect all machines to a Switch using **Copper Straight-Through** connector.
4. Wait for a while so that all connections will have green boxes indicating that all machines are connected to Switch.
5. Change name of all machines, eg., R122-PC1, R119-PC1 or NetAdmin-PC, etc. [Figure in next slide]
6. Assign an static IP, say 172.16.0.1, to DHCP server.
7. Rest of the 7 machines will get IP addresses dynamically from the server after DHCP server configuration completed.

DHCP Server Configured in a Server Machine



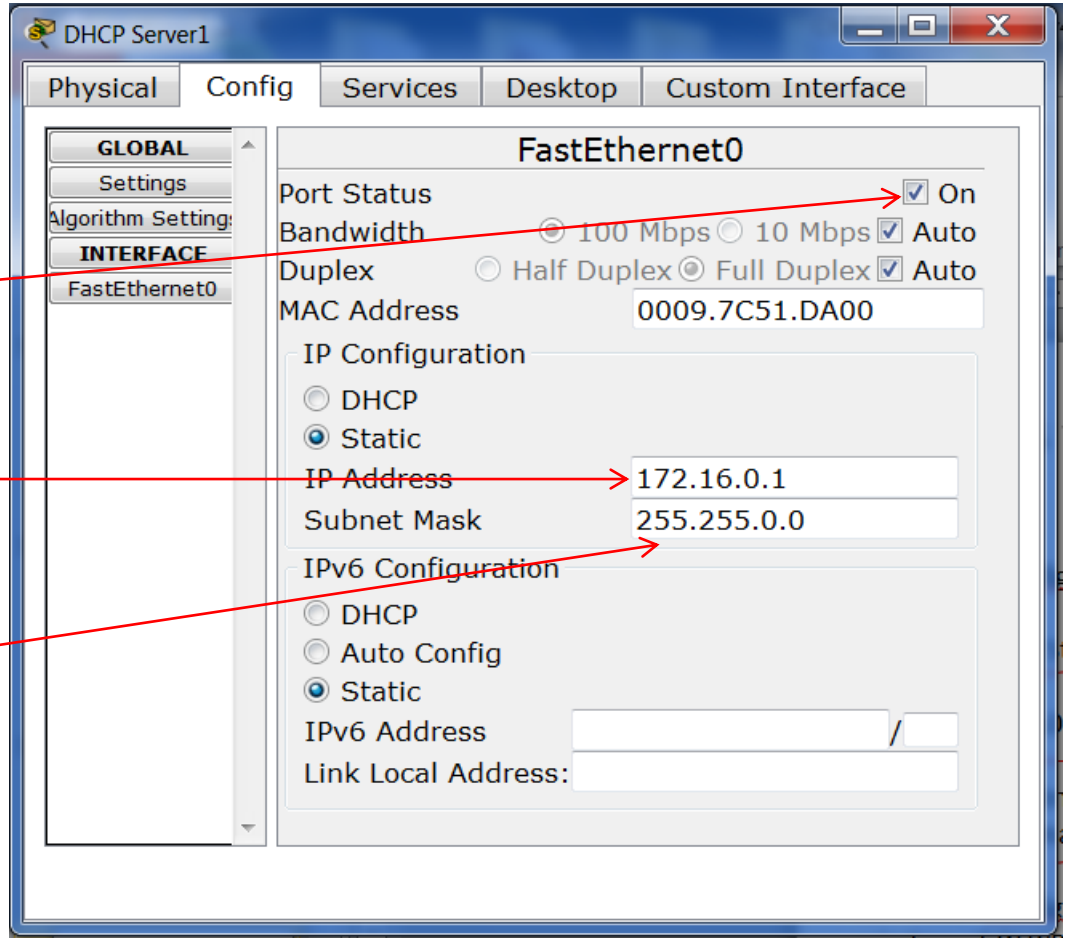
Steps for DHCP Configuration(1)

1. Double click on DHCP server.
2. Open '**Services**' window
3. Click on DHCP
4. Click on Service (On) radio button
5. Put 172.16.0.0 into **'Start IP Address'.**
6. Put 30 into **'Maximum number of Users'** box.
7. Click on '**Save**' button



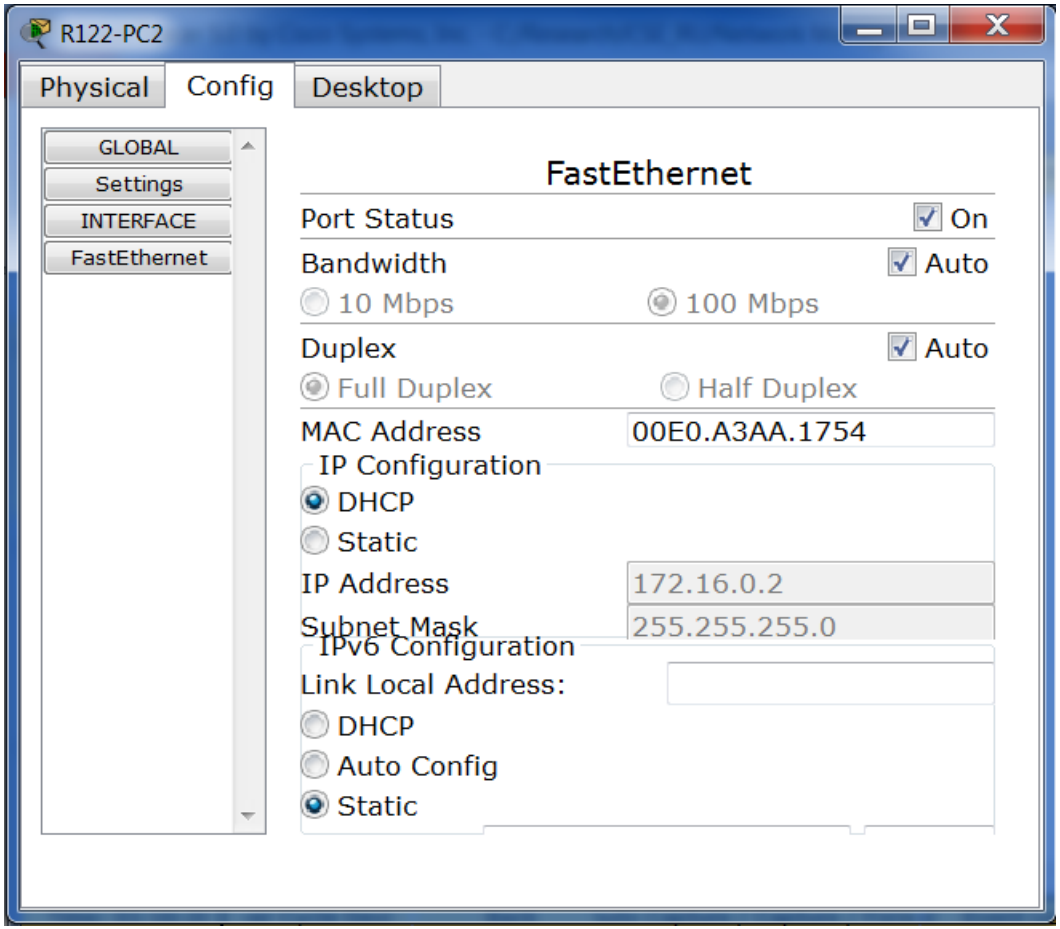
Steps for DHCP Configuration(2)

8. Click on Config → FastEthernet
9. Ensure ‘Port Status’ is checked.
10. Put 172.16.0.1 into **‘IP Address’.**
11. Click on Subnet Mask (it will be automatically changed)
12. Close ‘Config’ window of DHCP Server.



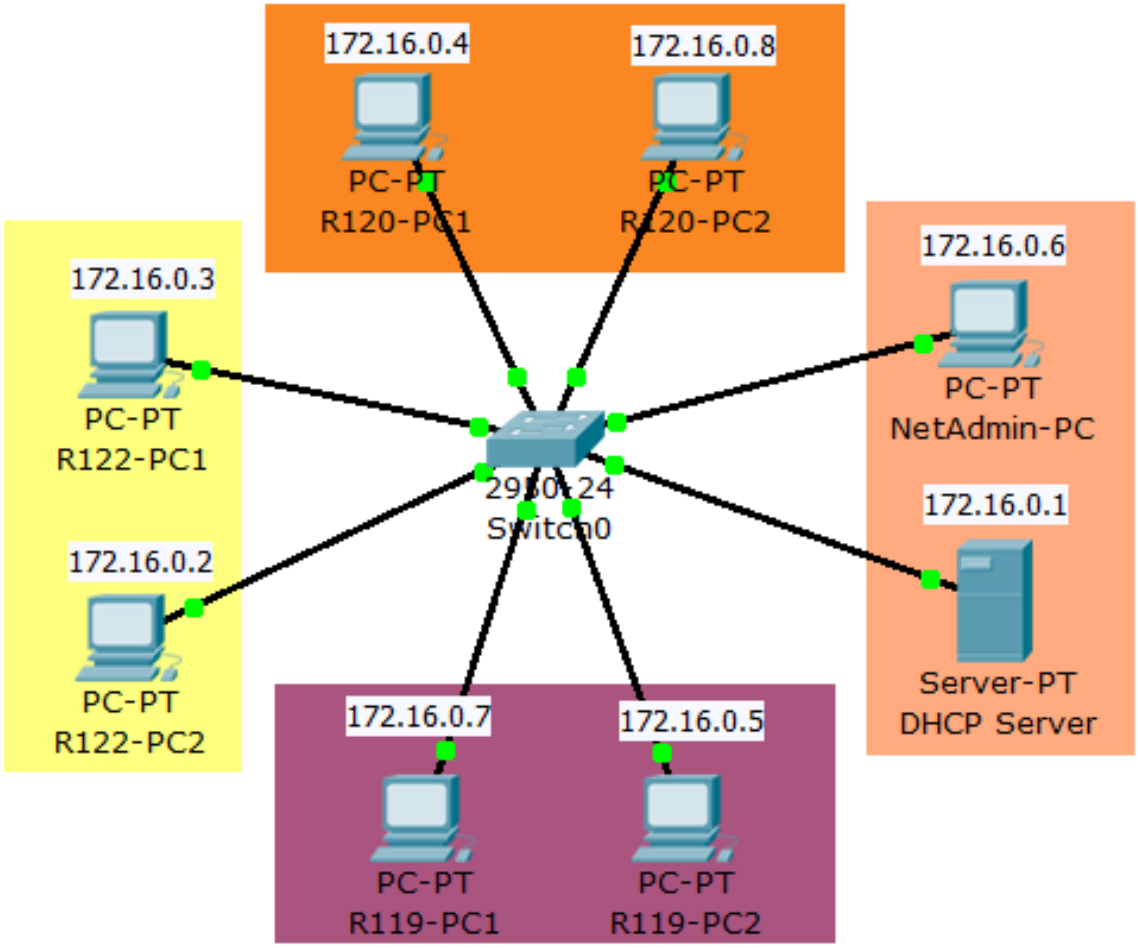
Steps for IP Address Allocation to PC

1. Open ‘Config’ window of a client, e.g., PC.
2. Click on FastEthernet.
3. Ensure ‘Port Status’ is checked.
4. Click on **‘DHCP’** radio button
5. Wait for a while
6. Close ‘Config’ window of PC.



Final Look of CSE Network

- PCs of R122 got sequential IP addresses while PCs of other rooms got discontinuous addresses.
- Allocation of IP addresses was dependent on the clients' booting sequence.

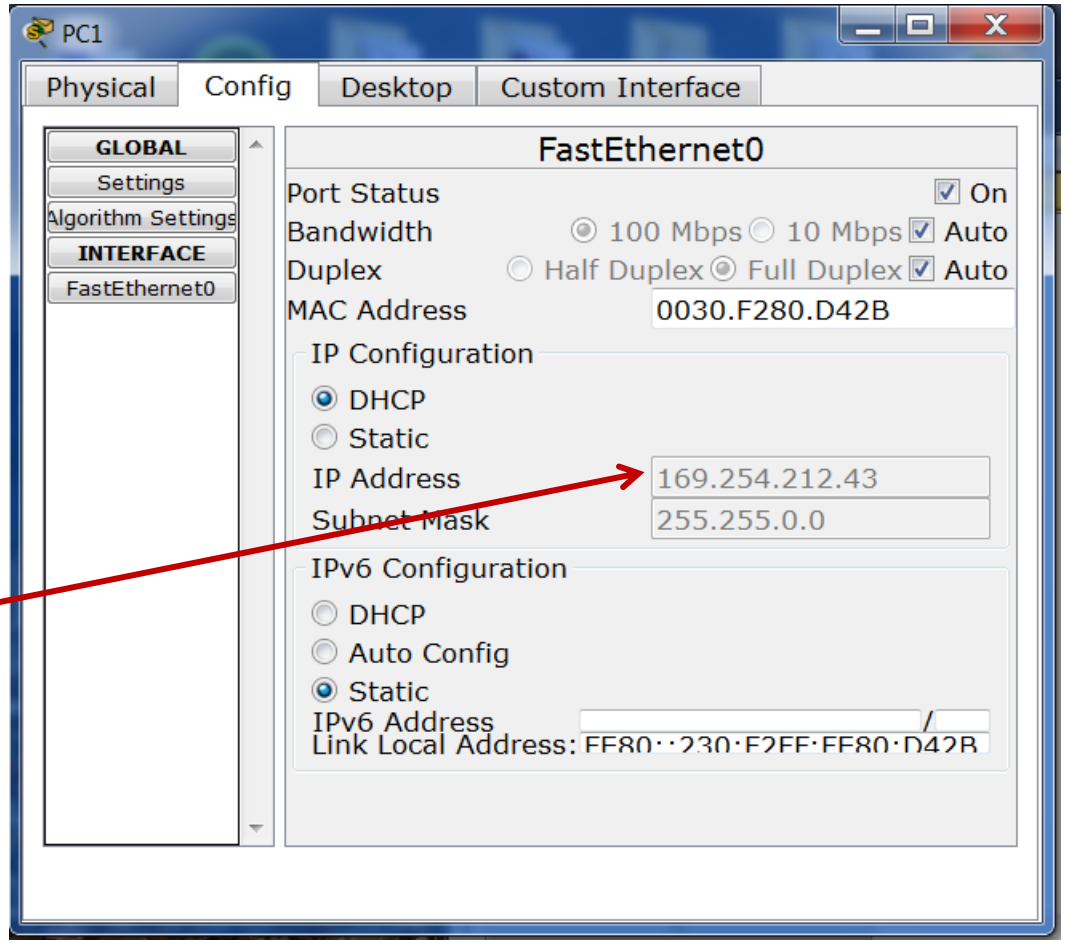


APIPA

- **APIPA** (Automatic Private IP Addressing) is a mechanism to assign IP addresses dynamically to DHCP clients when DHCP servers are temporarily / permanently unavailable.
- It could occur on a network
  - without a DHCP server, or
  - if a DHCP server is temporarily down for maintenance
- It is enabled by default in Microsoft Windows OS.
- **Internet Assigned Numbers Authority (**IANA) has reserved IP addresses from **169.254.0.0 to 169.254.255.255** for APIPA.
- A client get an IP address in the range of **169.254.0.1 - 169.254.255.254** by it's OS
  - It verifies the uniqueness of IP addresses by ARP

Example: APIPA

- When there is no DHCP server and ‘DHCP’ IP configuration option is selected for a PC, it gets an IP address by operating system (OS).



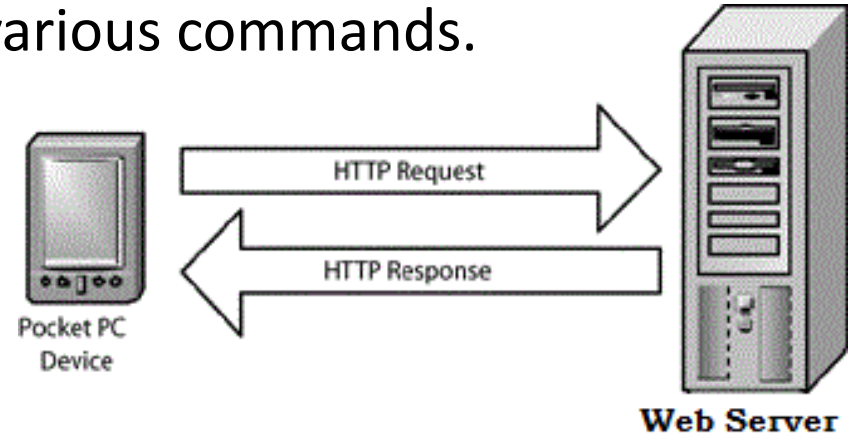
Limited Access

- Computer with an APIPA address has **'Limited Access'**
- In the limited access mode, the computer can use TCP/IP to communicate with any other computer that is:
  - connected to the same LAN and that is also configured for APIPA or
  - has the IP address manually set to the 169.254.x.y (where x.y is the client's unique identifier) address range
- The computer cannot communicate with
  - computers on other subnets, or
  - computers that do not use APIPA, i.e., that got IP addresses from DHCP servers, or that have static IP rather than 169.254.x.y series.

Web Server

HTTP

- HTTP: Hypertext Transfer Protocol
- World Wide Web (WWW) uses HTTP.
- HTTP defines how messages are formatted and transmitted, and what actions Web servers and browsers should take in response to various commands.



[24]

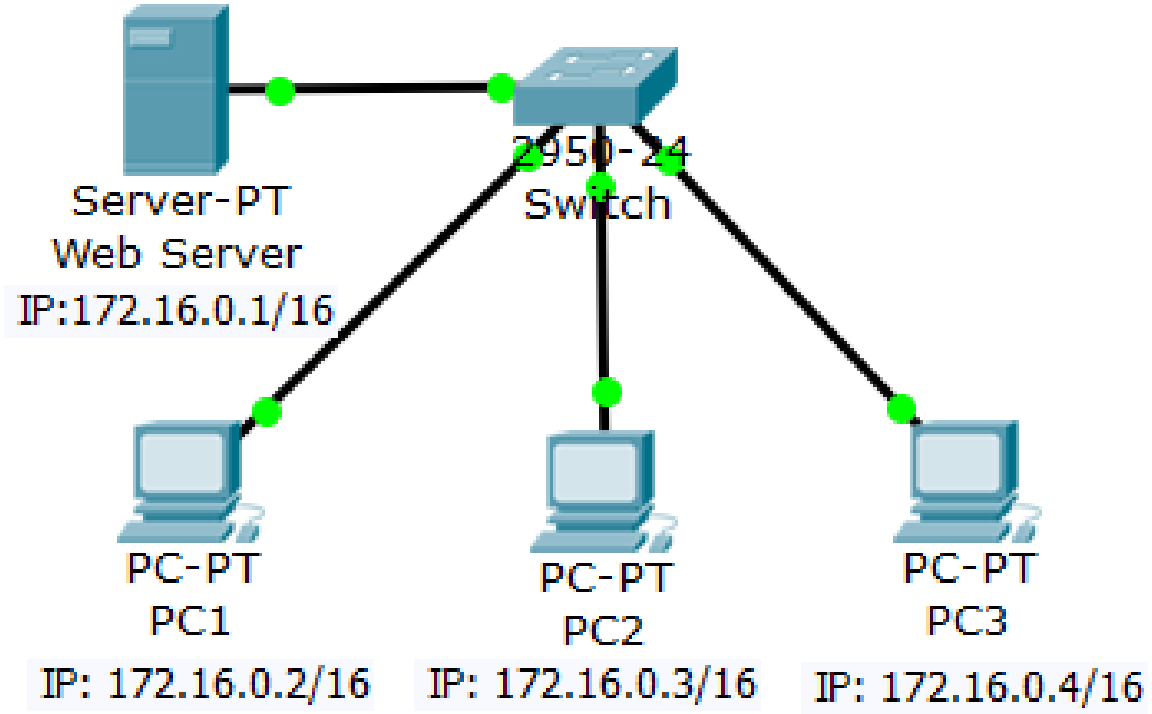
For example, when we enter a URL in our browser, this actually sends an HTTP command to the Web server directing it to fetch and transmit the requested Web page.

Web Server

- A web server is a program which delivers Web pages to browsers as well as other data files to Web-based applications using HTTP.
- Sometimes dedicated machines are also referred to as web servers.
- A machine running as a web server has a unique IP address and possibly a domain name.
  - Example: www.google.com, www.yahoo.com
- One common web server software is Apache.

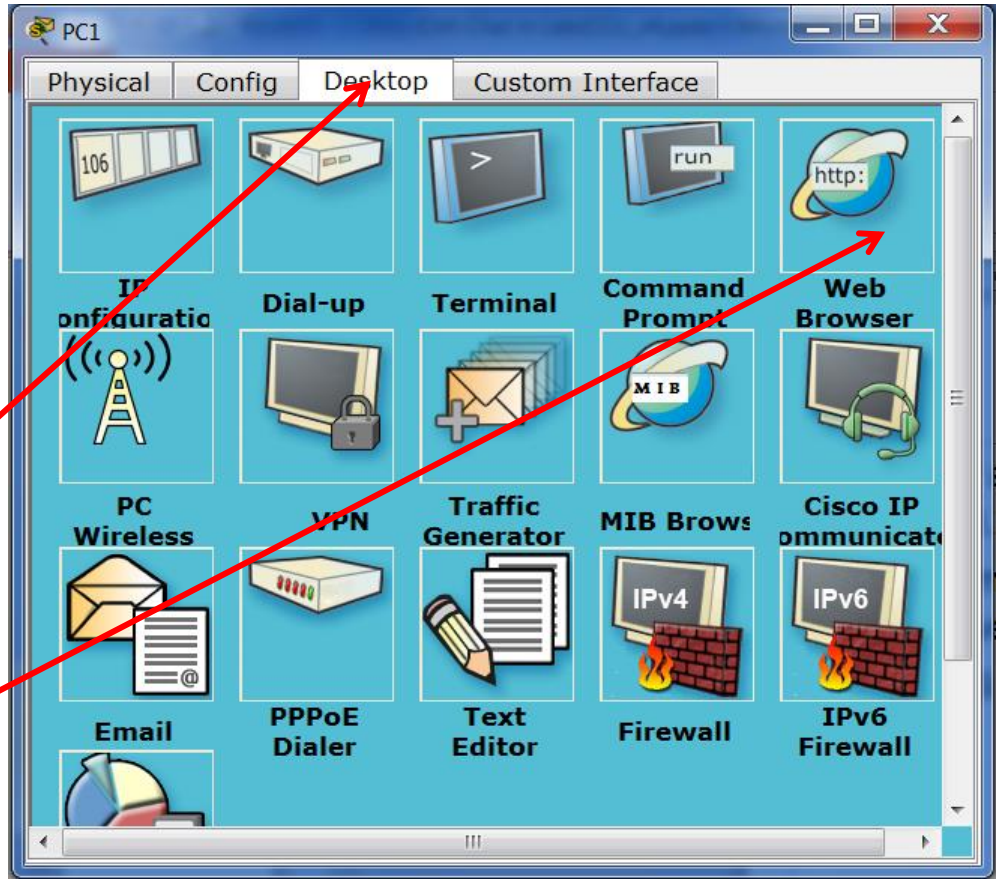
Example

Problem: Design a network like the following Figure and check what would happen if you type 172.16.0.1 in the URL box of the web browser of any PC.



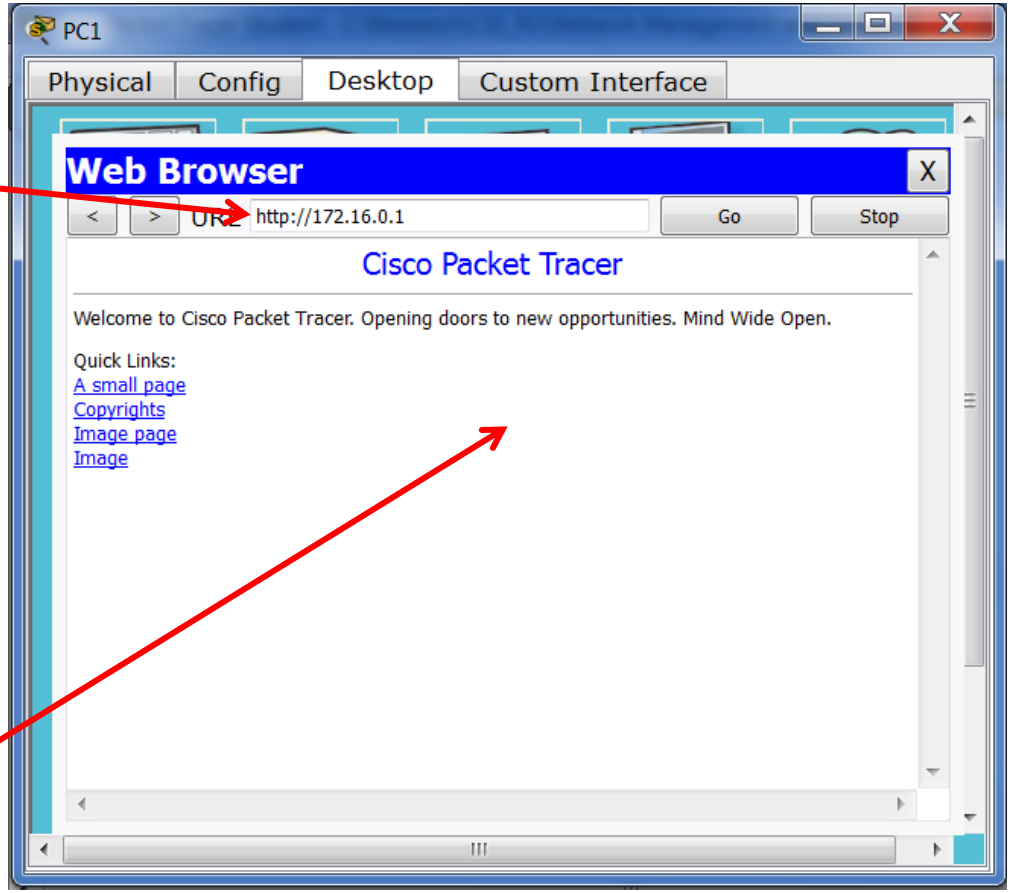
Steps (1)

1. Assign IP address to each machine.
2. Select Simulation mode and chose ‘ARP’ and ‘HTTP’ event.
3. Click on any PC and click on Desktop tab.
4. Click on web browser which is a simple version of Internet Explorer/Google Chrome/Mozilla Firefox



Steps (2)

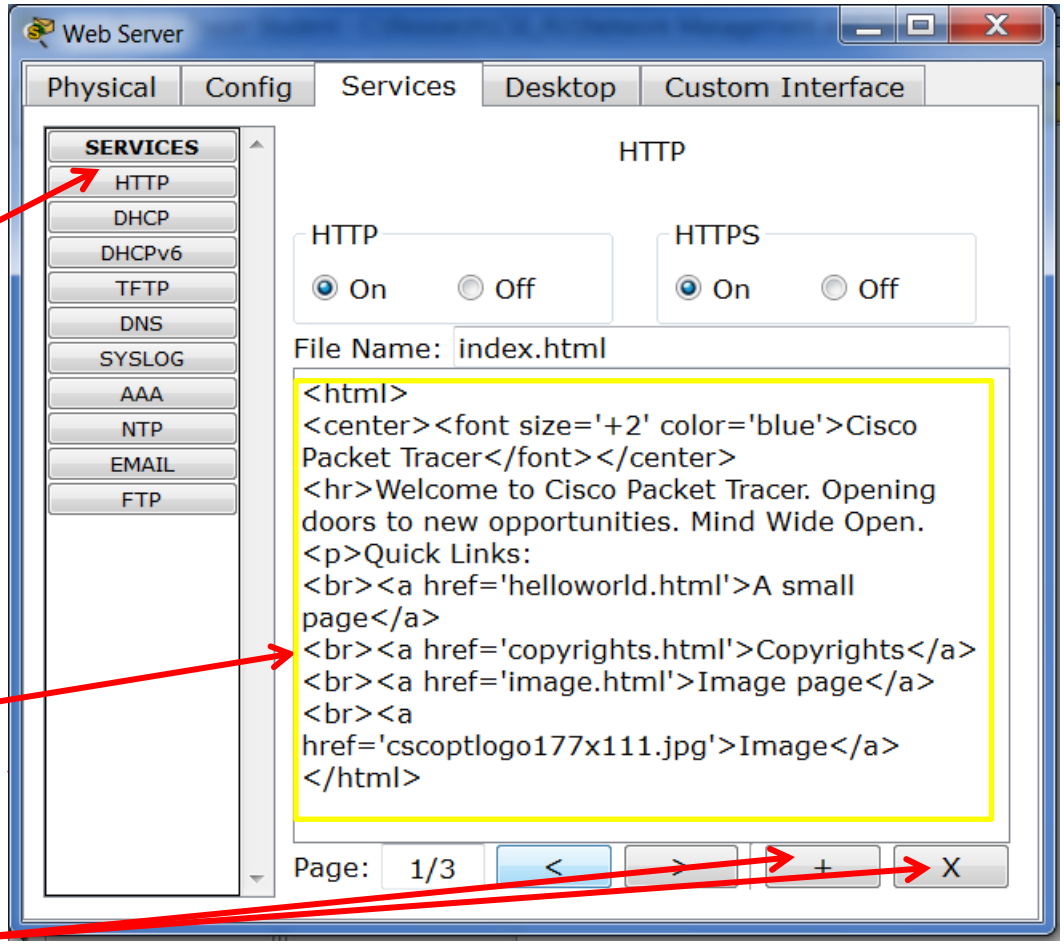
5. Type 172.16.0.1 in the URL box and click on ‘Go’.
6. Check Packet Transferring by clicking on ‘Auto capture/play’ on the simulation window.
7. After successfully transferring HTTP packet, a default web (Cisco Packet Tracer) page will be displayed.



Steps (3)

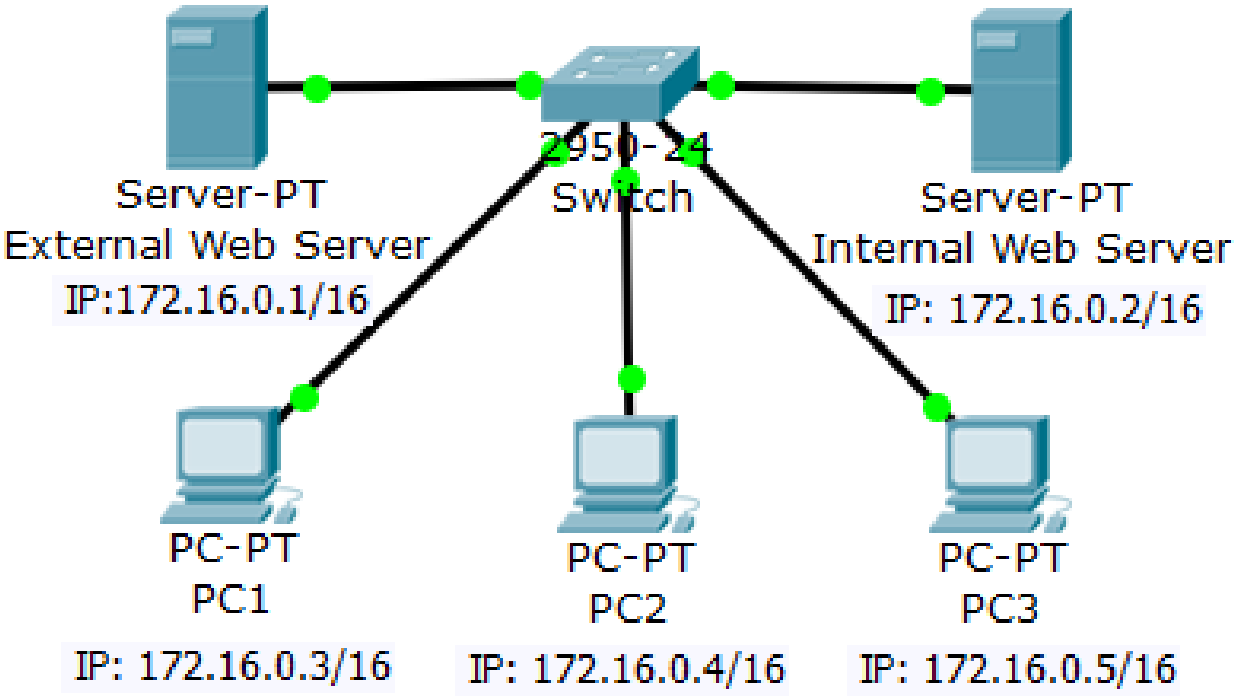
How to change default web pages:

1. Double Click on Web Server.
2. Select ‘Services’→ ‘HTTP’.
3. See ‘HTTP’ service is already on.
4. Change index.html page.
5. Add or delete pages by using those buttons.



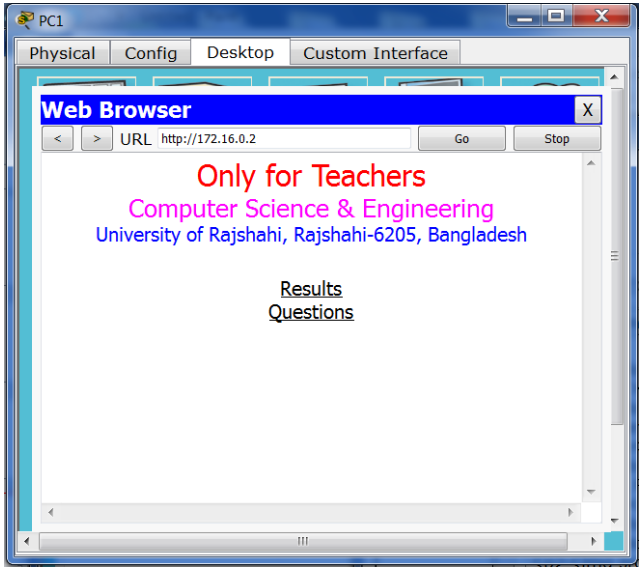
Exercise (1)

Design a network with two web servers with the home pages shown in the next page. Investigate what happens when you try to access these servers via a computer (say PC1).



Exercise (2)

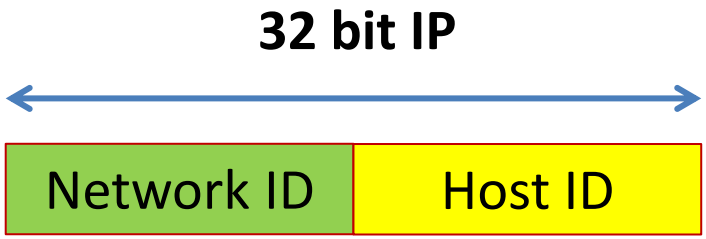
- Tips:
  - Download RU-Logo.png from web.
  - Store RU-Logo.png file in C:\Program Files\Cisco Packet Tracer 6.1sv\saves directory as an administrator(root user).
  - Learn simple HTML code and Change index.html file.



Types of IP Addresses

Parts of IP Address

- An IP address does not actually refer to a device. It refers to a network interface.
- If a device, e.g., router, is on two networks, it must have two IP addresses.
- An IP address has two parts
  1. Network ID
  2. Host ID



- There are two ways to decide the boundary of each part:
  - Classful Addressing
  - Classless InterDomain Routing (CIDR)

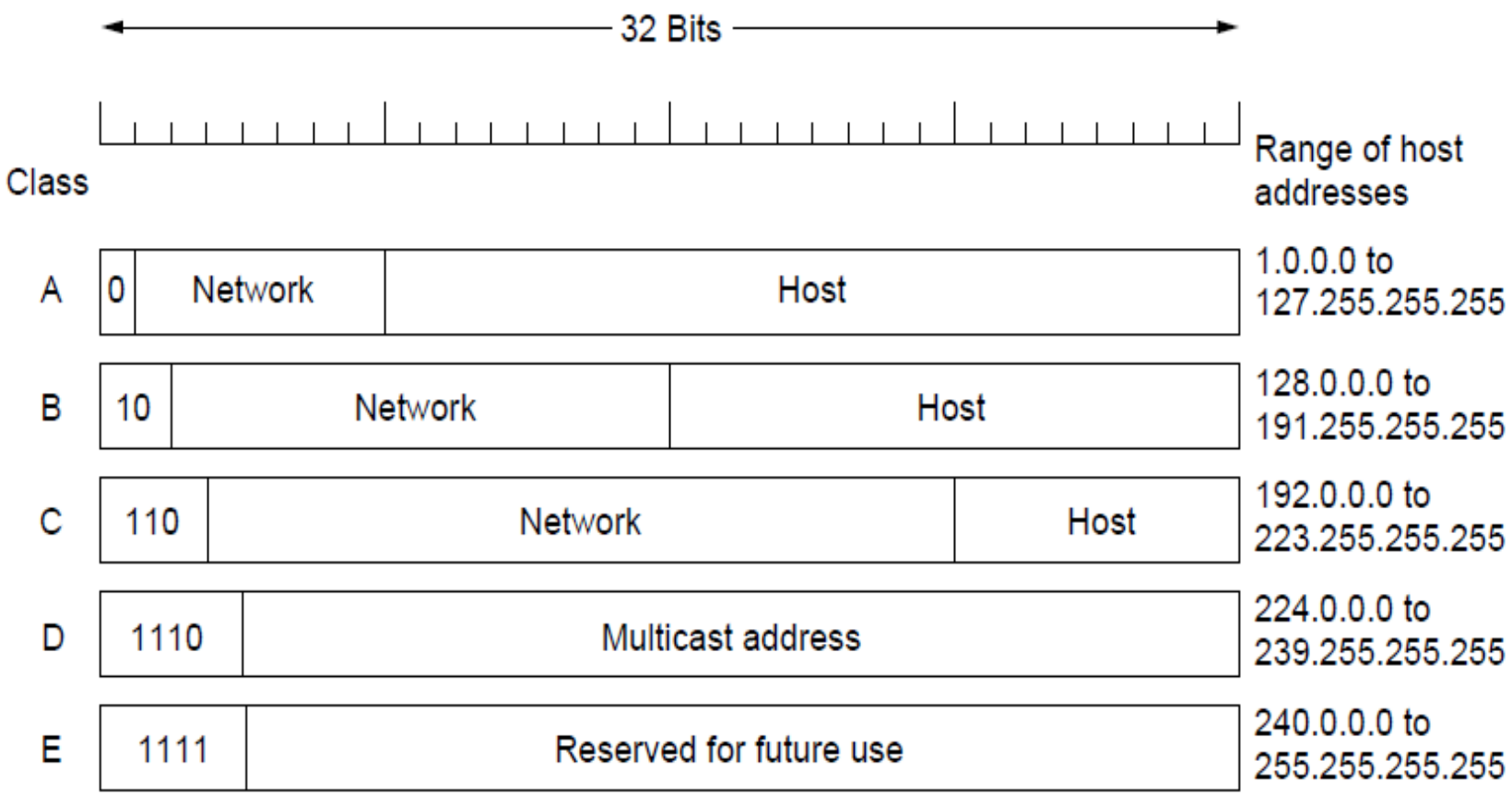
Classful Addressing

- For several decades, IP addresses were divided into 5 classes
  - Class A, B, C, D and E
- **Class A:** 128 networks with 16 million hosts

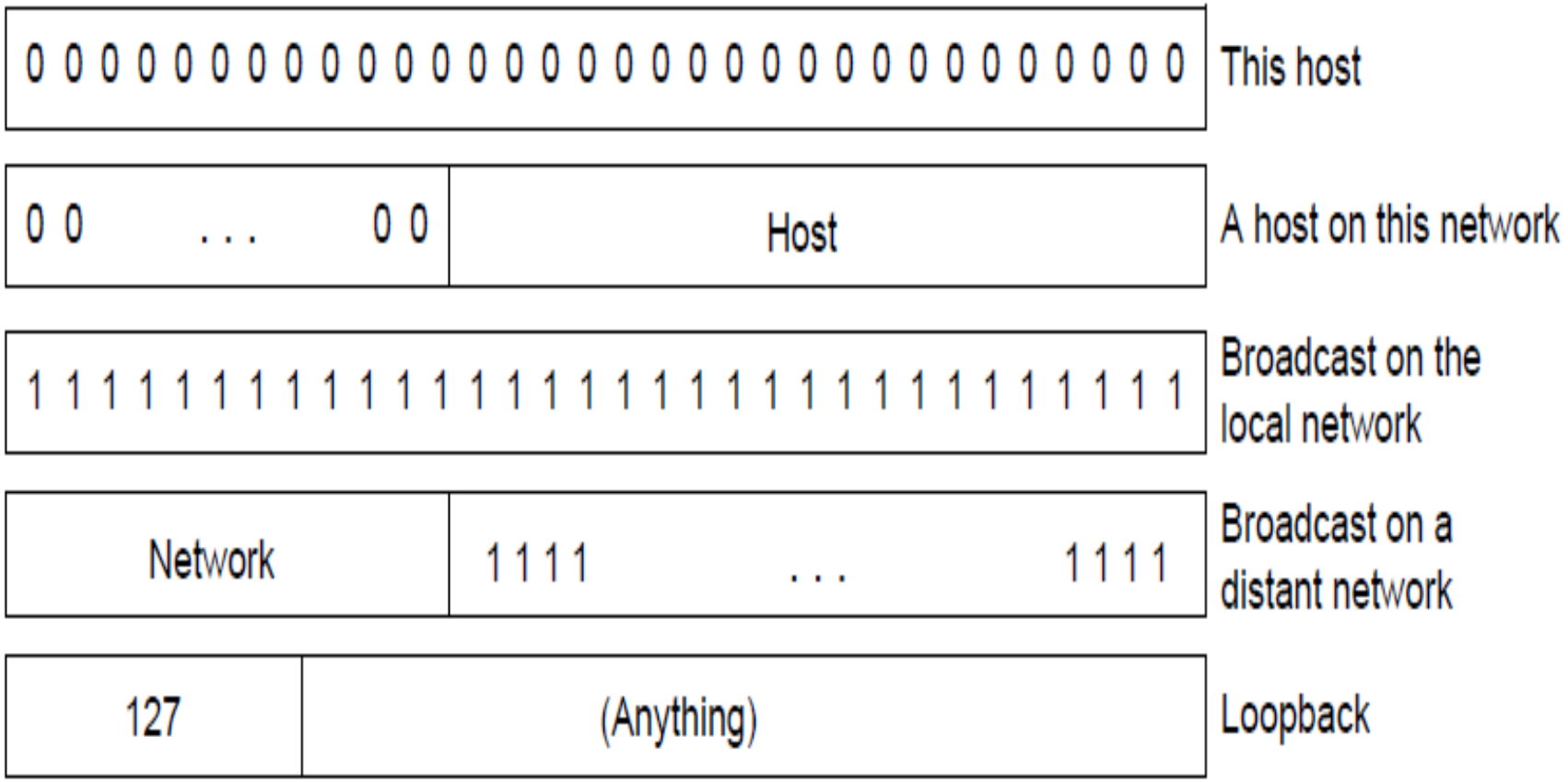
  Class B: 16,384 networks with up to 64,000 hosts

  Class C: 2 million networks with p to 256 hosts
- This concept is no longer used, only found in literature, because
  - The number of networks connected to the Internet is growing every year. Classful addressing cannot support this growth.

IP Address Range in Classful Addressing



Special IP Address



Private vs Public IP Address

- Uniqueness:
  - Private IP addresses could be duplicate in different home/office/enterprise networks, e.g., LAN, as long as they are not interconnected.
  - Public IP addresses cannot be duplicate. In order to communicate on Internet, each machine must have **a unique global/public/real IP** address.
- Responsible:
  - Network administrator is responsible for deciding private IP addresses for a private network
  - IANA and 5 RIRs(APNIC, AfriNIC, ARIN, LACNIC & RIPE NCC) are responsible for managing real IP addresses.

Range of Private IP Addresses

- Private IP assigned by network administrator:
  - ❖ 10.0.0.0 - 10.255.255.255
  - ❖ 172.16.0.0 - 172.31.255.255
  - ❖ 192.168.0.0 - 192.168.255.255
- Private IP assigned by Operating System
  - 169.254.0.0 -169.254.255.255
  - It is enabled by default in Microsoft Windows OS.
  - It could occur on a network
    - without a DHCP server, or
    - if a DHCP server is temporarily down for maintenance

Authority for Managing Public IP

- **IANA: Internet Assigned Numbers Authority**
- **IANA** is responsible for the global coordination of
  - the DNS Root,
  - **Internet number**
  - other Internet protocol resources.
- Internet number resources include:
  - **IP addresses**
  - autonomous system (AS) numbers
- **RIR: Regional Internet Registry**
- RIR is an organization that manages the allocation and registration of Internet number resources (e.g., **IP addresses**) within a particular region of the world.

Division of World into RIRs

1. AfriNIC (African Network Information Centre): Africa
2. ARIN (American Registry for Internet Numbers): the United States, Canada, several parts of the Caribbean region, and Antarctica.
3. APNIC (Asia-Pacific Network Information Centre): Asia, Australia, New Zealand, and neighboring countries
4. LACNIC (Latin America and Caribbean Network Information Centre): Latin America and parts of the Caribbean region
5. RIPE NCC(Réseaux IP Européens Network Coordination Centre): Europe, Russia, the Middle East, and Central Asia

Fig: Service regions of five RIRs nowadays

Fig: Service regions of three RIRs in 2002-2005

Fig: Service regions of three RIRs in 2002

APNIC

- Founded: 13 January, 1993
- Focus:
  - **allocating IPv4** and IPv6 address space, and Autonomous System Numbers,
  - maintaining the public Whois Database for the Asia Pacific region,
  - representing the interests of the Asia Pacific Internet community on the global stage.
- Location: Brisbane, Queensland, Australia
- Website: www.apnic.net
- Members: 4,737 from 56 economies
  - **Bangladesh has 207 members** of APNIC [checked on 20.3.2015]

Membership Tier

- APNIC's membership structure is divided into seven tiers.

Membership tier	IPv4 prefix	IPv6 prefix
Associate	None	None
Very small	Up to and including /22	Up to and including /35
Small	Greater than /22, up to and including /19	Greater than /35, up to and including /32
Medium	Greater than /19, up to and including /16	Greater than /32, up to and including /29
Large	Greater than /16, up to and including /13	Greater than /29, up to and including /26
Very large	Greater than /13, up to and including /10	Greater than /26, up to and including /23
Extra large	>/10	>/23

APNIC's BD Members

[checked on 20.3.2015]

- 207 members, e.g.,

Member	Membership Tier
Bangladesh Computer Council	Associate
Apple Network Ltd.	Very Small
Banglalink GSM	Small
Grameenphone limited	Small
Bangladesh Telegraph & Telephone Board	Medium
Banglalion Communication Ltd.	Medium
Augere Wireless Broadband Bangladesh Limited	Large
Mango Teleservices Limited.	Large

❖Tier: rank/one of several layers or levels

APNIC Whois Search(1)

- http://wq.apnic.net/whois-search/static/search.html

inetnum:	180.211.128.0 - 180.211.255.255
netname:	BTTB-BD
descr:	Bangladesh Telegraph & Telephone Board
country:	BD

128 × 256 = 32,768 IP addresses
*** RU rent 32 IP addresses

inetnum:	117.18.224.0 - 117.18.231.255
netname:	citycell
descr:	service provider
country:	BD

8 × 256 = 2,048 IP addresses

APNIC Whois Search(2)

- http://wq.apnic.net/whois-search/static/search.html

inetnum:	114.130.0.0 - 114.130.255.255
netname:	MANGOTELESERVICE-BD
descr:	Mango Teleservices, IIG of Bangladesh
country:	BD

256 × 256 = 65,536 IP addresses

inetnum:	202.56.4.0 - 202.56.7.255
netname:	GRAMEENPHONEIT
descr:	Grameenphone is the largest telecommunication Organisation
country:	BD

4 × 256 = 1,024 IP addresses

Command: tracert

- 'tracert' is a computer network diagnostic tool to:
  - display the route (path) and
  - measure transit delays of packets across an IP network.
- 'tracert' sends out three packets per TTL increment. Column 2, 3 and 4 correspond to the round-trip-time of three packets.
- * * * means tracert packets have been dropped.
- The maximum hop count number can be changed using '-h' option, e.g.,:
  - tracert –h 34 www.titech.ac.jp
- Just type 'tracert' in the command window of windows machine in order to see other options.

Route to www.apinc.net

[from our Department]

C:\Users\Sangeeta>tracert www.apnic.net

Tracing route to www.apnic.net [203.119.102.244] over a maximum of 30 hops:

1	1 ms	6 ms	4 ms	172.16.0.1
2	<1 ms	<1 ms	1 ms	180.211.185.200
3	1 ms	12 ms	1 ms	180.211.183.137
4	2 ms	16 ms	1 ms	180.211.182.73
5	7 ms	9 ms	7 ms	180.211.182.61
6	10 ms	10 ms	15 ms	180.211.130.33
7	5 ms	5 ms	5 ms	180.211.130.6
8	10 ms	10 ms	66 ms	180.211.200.1
9	5 ms	5 ms	5 ms	123.49.13.94
10	221 ms	221 ms	221 ms	103.9.137.237
11	*	*	*	Request timed out.
12	341 ms	341 ms	341 ms	182.79.245.149
13	*	*	*	Request timed out.
14	513 ms	513 ms	513 ms	203-29-129-209.static.tpgi.com.au [203.29.129.209]
15	505 ms	505 ms	505 ms	ve2034.rn-639gardeners-cer-01.tpg-telecom.net [203.161.139.241]
16	520 ms	520 ms	520 ms	ve2011.rq-127creek-cer-01.tpg-telecom.net [121.101.138.70]
17	506 ms	506 ms	506 ms	ip-34-129-161-203.static.pipenetworks.com [203.161.129.34]
18	510 ms	510 ms	510 ms	squiz-proxy.apnic.net [203.119.102.244]

Trace complete.

Route to www.apnic.net

[using Wi-Fi of CityCell]

C:\Users\Sangeeta>tracert www.apnic.net

Tracing route to www.apnic.net [203.119.102.244] over a maximum of 30 hops:

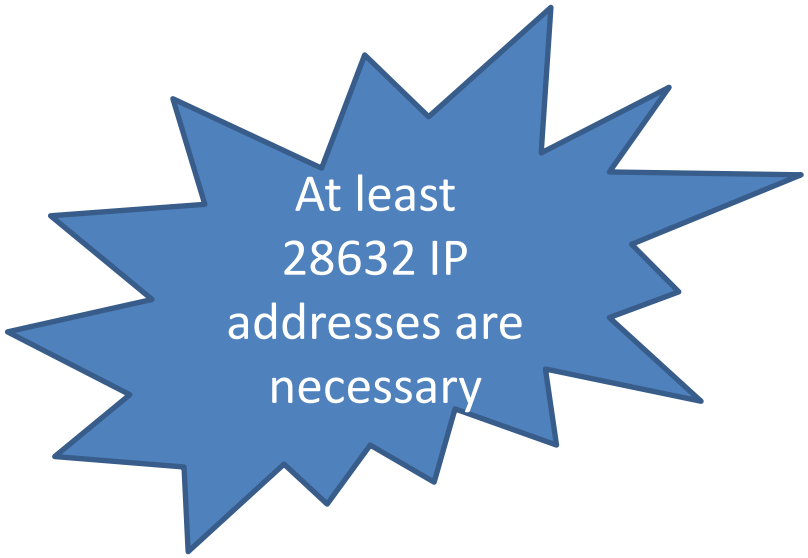
1	*	*	*	Request timed out.
2	328 ms	179 ms	159 ms	192.168.4.54
3	159 ms	159 ms	460 ms	192.168.101.6
4	279 ms	259 ms	320 ms	85.dhk-peer.mango.com.bd [114.130.3.85]
5	280 ms	*	1084 ms	114.130.1.57
6	198 ms	219 ms	199 ms	if-3-1-0.core1.CFO-Chennai.as6453.net [116.0.79.45]
7	624 ms	919 ms	539 ms	if-0-1-2-0.tcore2.CXR-Chennai.as6453.net [180.87.36.17]
8	440 ms	397 ms	519 ms	if-6-2.tcore2.SVW-Singapore.as6453.net [180.87.37.14]
9	1294 ms	505 ms	458 ms	if-1-2.tcore1.HK2-Hong-Kong.as6453.net [180.87.112.1]
10	650 ms	767 ms	604 ms	116.0.67.34
11	400 ms	399 ms	398 ms	203-29-129-145.static.tpgi.com.au [203.29.129.145]
12	444 ms	459 ms	699 ms	ve2034.rn-639gardeners-cer-01.tpg-telecom.net [203.161.139.241]
13	415 ms	399 ms	674 ms	ve2011.rq-127creek-cer-01.tpg-telecom.net [121.101.138.70]
14	676 ms	679 ms	678 ms	ip-34-129-161-203.static.pipenetworks.com [203.161.129.34]
15	736 ms	899 ms	719 ms	squiz-proxy.apnic.net [203.119.102.244]

Trace complete.

Wide Area Network (WAN) of University of Rajshahi

About University of Rajshahi (RU)

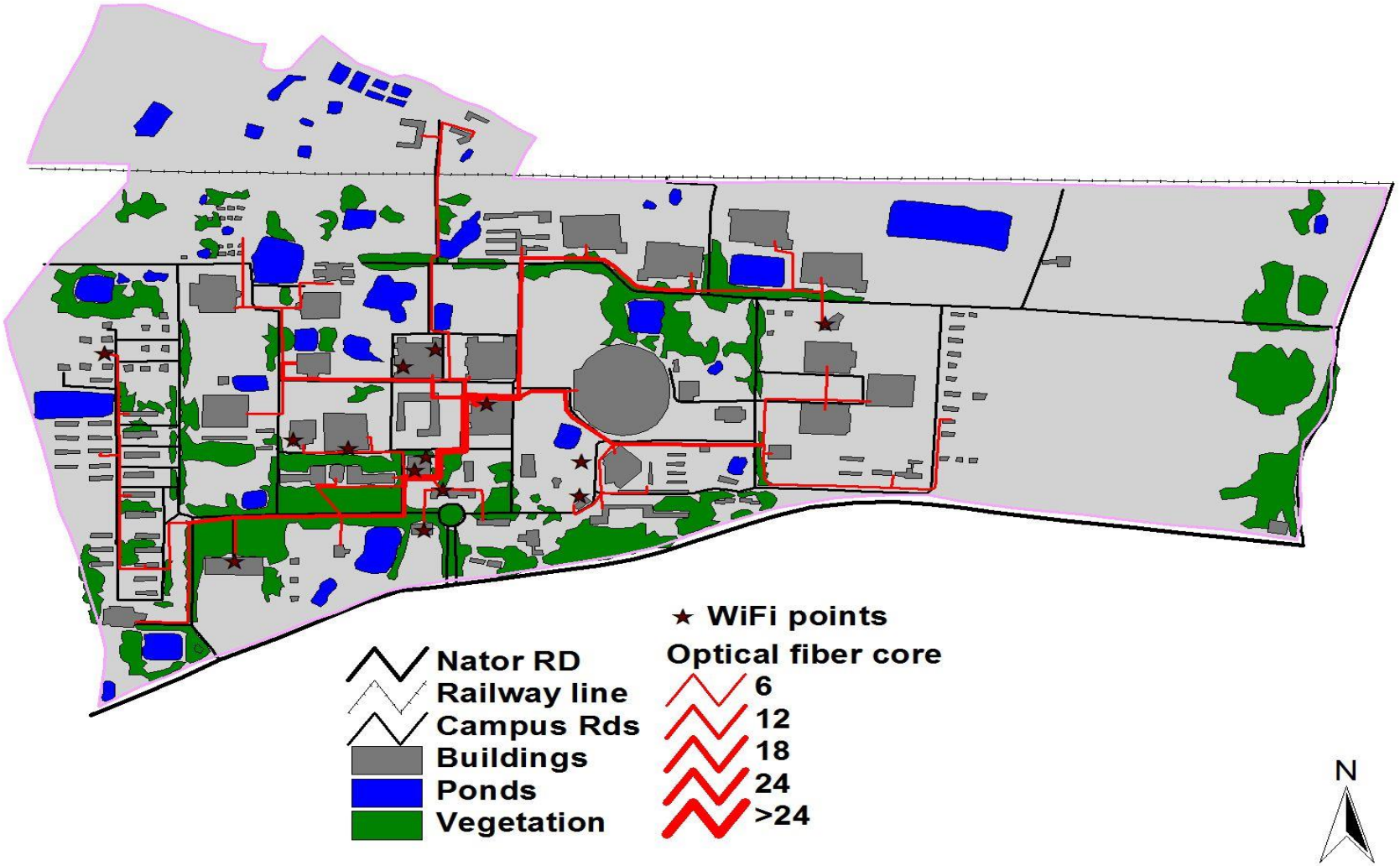
- Infrastructure
  - Total area: 303.80 Hectors
  - 9 Faculties with 50 Departments and 5 Institutes
  - 10 Academic Buildings and 2 Administrative Buildings
  - 17 Residential Halls and Dormitory
- University Personnel
  - Students: Around 25,000
  - Faculty members: 1,131
  - Officers: 575
  - Supporting Staffs: 643
  - General Staffs: 1,283



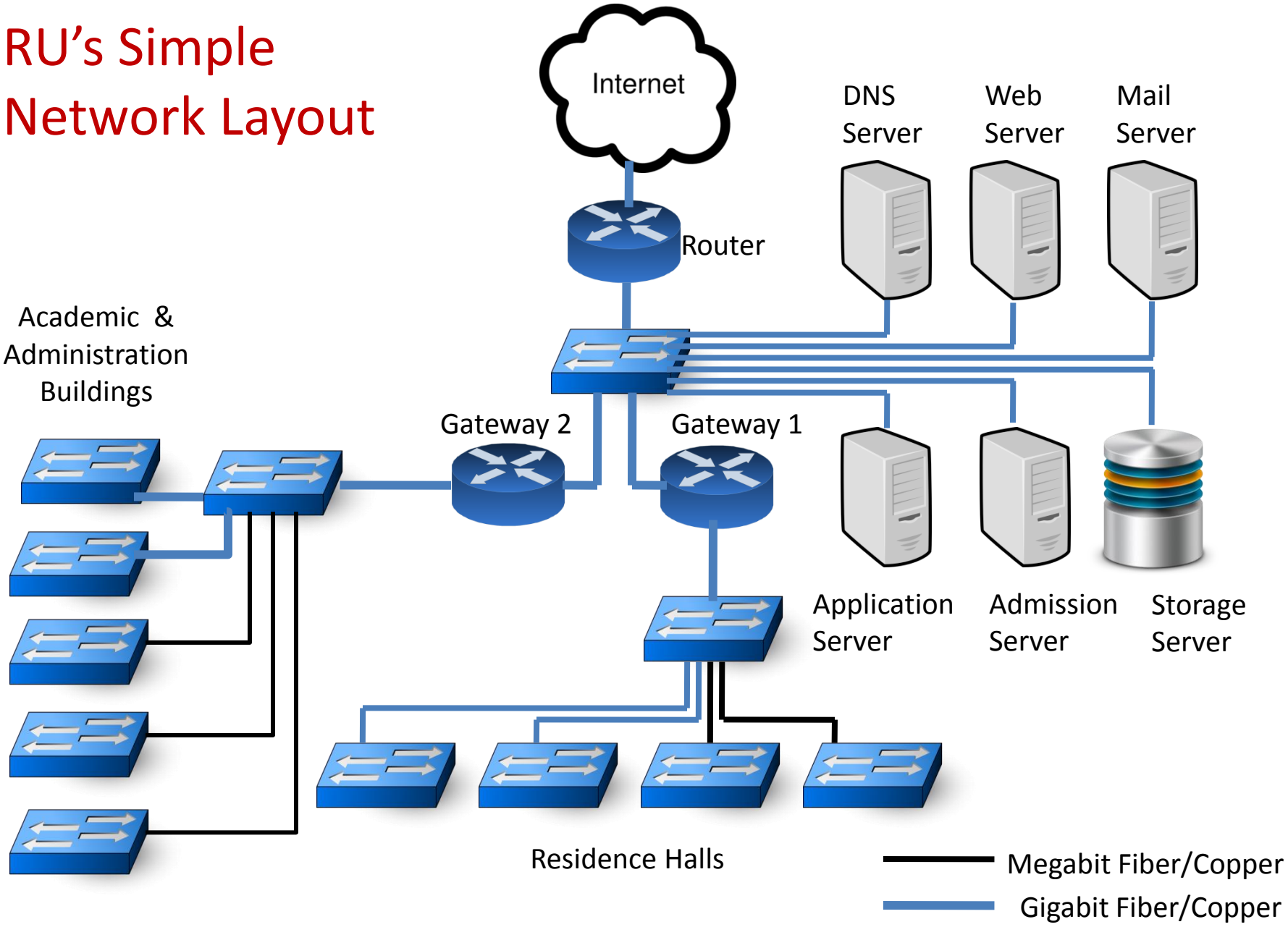
Network Infrastructure

- Optical Fiber LAN.
  - Length and Coverage–25 Km LAN
  - Coverage Area–everywhere within campus
- Wireless Network
  - Central library, Senate building and some parts of academic and administration buildings
  - Most parts of all the residence hall.
- Internet – 200 Mbps bandwidth from BTCL
  - 32 Real IP from BTCL

Optical Fiber Network Layout



RU's Simple Network Layout



RU's Some Global IP Addresses

- RU rent 32 Real IP from BTCL
  1. Name: dns.arun-hpcc.ru.ac.bd Address: 180.211.185.243
  2. Name: dueo.ru.ac.bd Address: 180.211.185.242
  3. Name: cse.ru.ac.bd Address: 180.211.185.241
  4. Name: dept1.ru.ac.bd Address: 180.211.185.219
  5. Name: apps1.ru.ac.bd Address: 180.211.185.206
  6. Name: gwdhcp.ru.ac.bd Address: 180.211.185.205
  7. Name: web1.ru.ac.bd Address: 180.211.185.196
  8. Name: ns1.ru.ac.bd Address: 180.211.185.195
  9. Name: ns2.ru.ac.bd Address: 180.211.185.194
  10. Name: mail.ru.ac.bd Address: 180.211.185.193

Exercise: Try to find out rest of the 22 addresses.

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Confession

- It is possible that some sentences or some information were included in these slides without mentioning exact references. I am sorry for violating rules of intellectual property. When I will have a bit more time, I will try my best to avoid such things.
- These slides are only for students in order to give them very basic concepts about the giant, “Networking”, not for experts.
- Since I am not a network expert, these slides could have wrong/inconsistent information…I am sorry for that.
- Students are requested to check references and Books, or to talk to Network engineers.