ICT SKILLING FOR SCHOOLS

How Internet Works
&
Introduction to LANs

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Presentation

13th May 2025

Outline

- Introduction to Internet

- How the Internet works?

- OSI model & TCP/IP

- Local Area Network Overview

Knowledge | Community | Solutions

Introduction to Internet

What is Internet?

- A network of computers which links many different types of computers all the world.
- A network of networks worldwide.
- It is a very large wide area network (**WAN**) connecting computers and networks around the world.
- It makes it possible for millions of users to connect to one another via telephone lines, cable lines, satellites.
- Born in late 1960's - Was created by the Advanced Research Project Agency(ARPA) of U.S Department of Defense for scientific and military communications
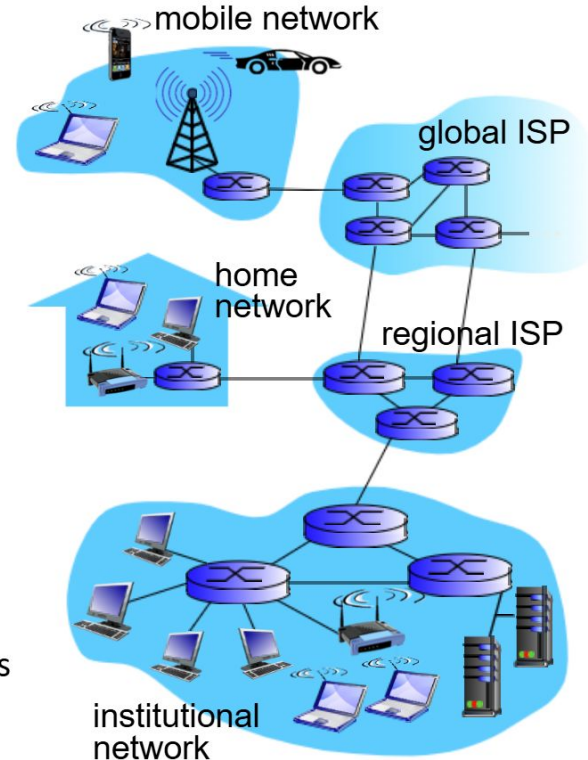
Introduction to Internet: "nuts and bolts" view

PC

server

wireless laptop

smartphone
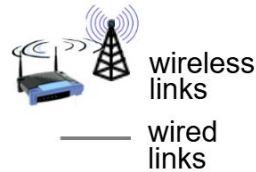
- millions of connected computing devices:
  - *hosts = end systems*
  - running *network apps*

❖ *communication links*
 ▪ fiber, copper, radio, satellite
  ▪ transmission rate: *bandwidth*

wireless links

—— wired links

router

❖ *Packet switches:* forward packets (chunks of data)
  ▪ *routers* and *switches*

mobile network

global ISP

home network

regional ISP

institutional network

# Introduction to Internet: "nuts and bolts" view

- *Internet:* "network of networks"
  - Interconnected ISPs
- *protocols* control sending, receiving of msgs
  - e.g., TCP, IP, HTTP, Skype, 802.11
- *Internet standards*
  - RFC: Request for comments
  - IETF: Internet Engineering Task Force

mobile network

global ISP

home network

regional ISP

institutional network
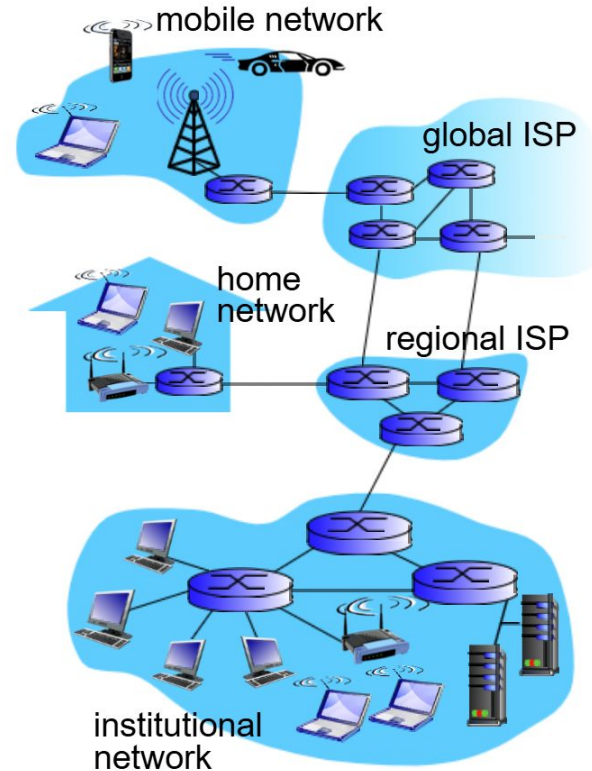
Introduction to Internet: a service view

- *Infrastructure that provides services to applications:*
  - Web, VoIP, email, games, e-commerce, social nets, …
- *provides programming interface to apps*
  - hooks that allow sending and receiving app programs to "connect" to Internet
  - provides service options, analogous to postal service

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institutional network
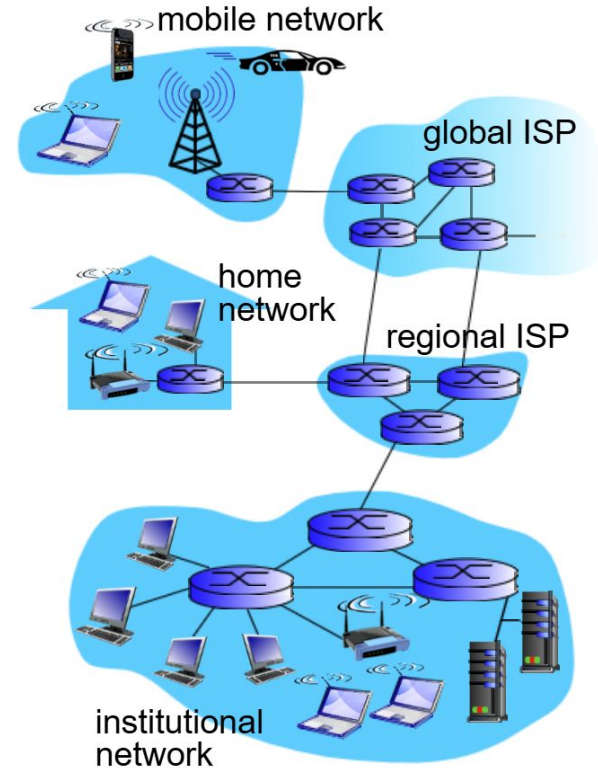
Introduction to Internet: Basic services

- **WWW?**
  - World Wide Web
  - It is a most popular method of accessing the internet
  - Uses Hypertext Transfer Protocol (HTTP) to deliver web pages
  - Web pages created by Hyper Text Markup Language (HTML)
- **Electronic mail; e-mail**
  - Enables sending and receiving of a mail(message)
  - Faster than paper mail
  - Images, audio, video can be sent along with text
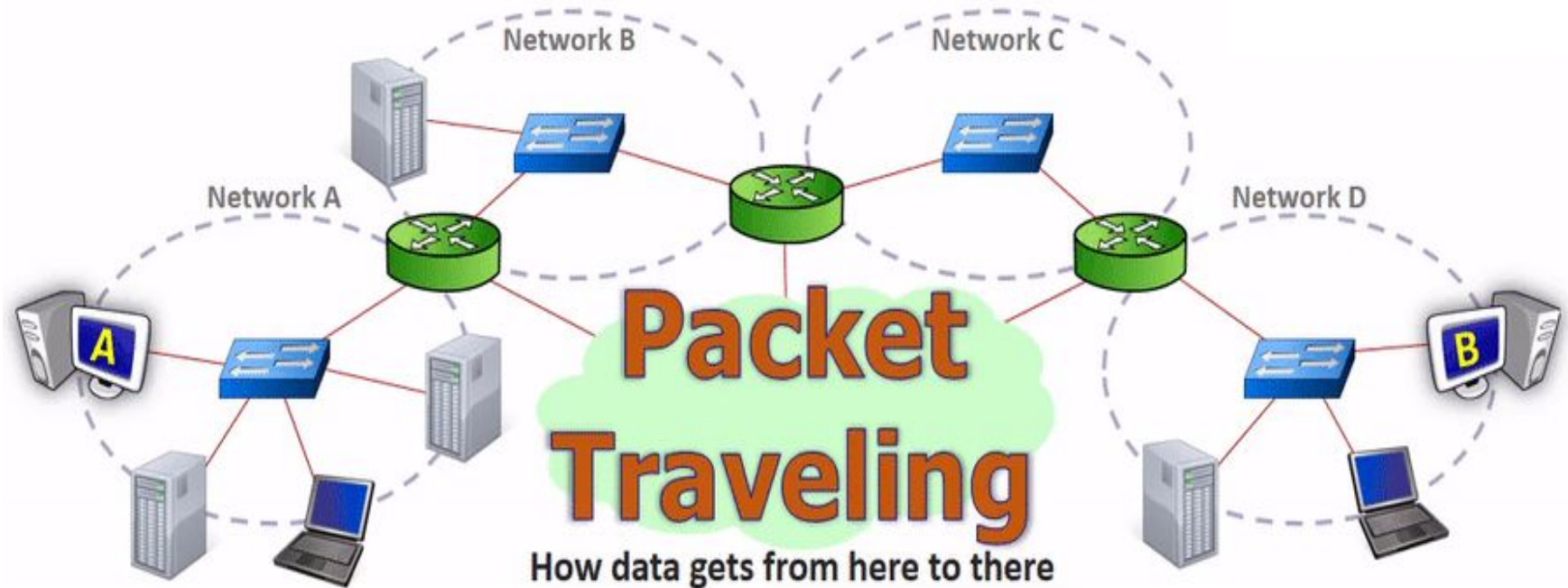- **File transfer protocol (FTP)**
  - Enables users to move a file from one computer to another computer
  - A file may contain; text, image, artwork, movie, sound, software, etc
- Telnet/SSH??

How the Internet Works

The OSI model & TCP/IP

The Internet's architecture;

- Primarily based on the TCP/IP model, not directly on the OSI model,
- We use the OSI model to conceptually understand network communication

Layers & Encapsulation;

- Each layer provides services to the layer above
- Each layer makes use of the layer below
- Data from one higher layers is encapsulated(wrapped) in headers of the layer below

How the Internet Works

- **TCP/IP and OSI Model**
  - Universal protocols
  - Allows all devices to communicate in the same language regardless of type
- **Routers**
  - Guide data packets across different networks
  - Choose the best available path to the destination
- **Client-Server Model**
  - Client (e.g. your laptop) requests data
 - Server (e.g. YouTube) sends the response
- **Data Packets**
  - Information is broken into small chunks
  - Packets travel separately and are reassembled at the destination
- **Network Layers**
  - Layers handle different tasks (physical, addressing, transport, etc.)
  - Work together to move data from sender to receiver
  - Why Layers? Easy to understand and troubleshoot, Easy to program (change one layer without changing others)

The OSI Model: "Encapsulation in action"

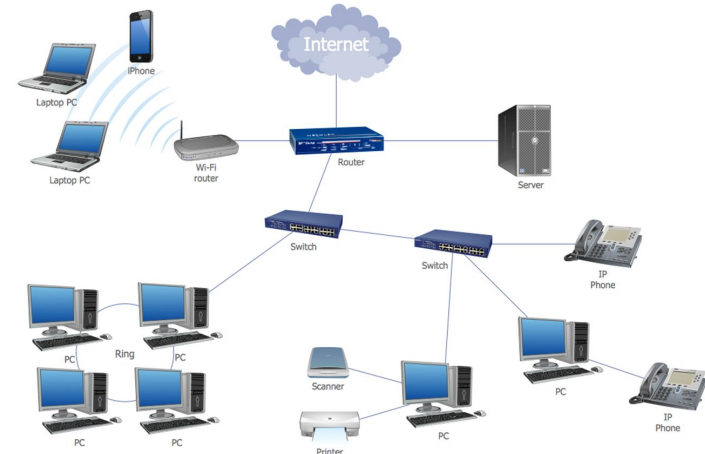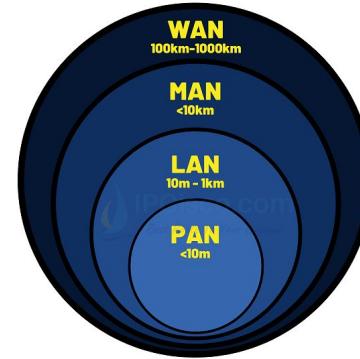Device A — Data → Device B

Encapsulation

De-encapsulation
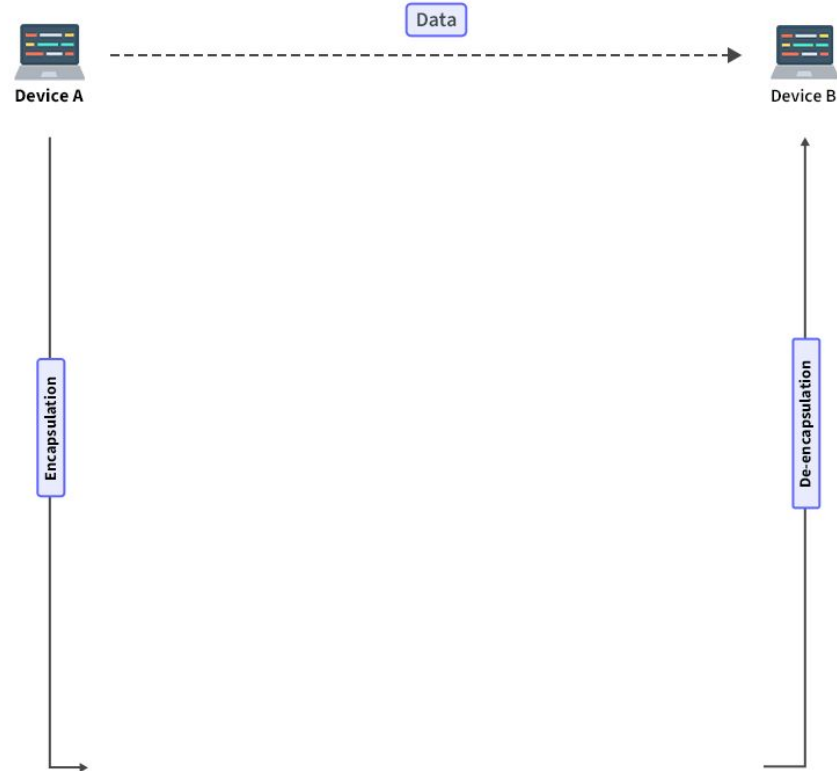
* PH : Presentation Header

Local Area Network

- A collection of devices connected together in one small physical location.

- Other networks–PAN,MAN,WAN

- Cable or Wireless connections.

- Cable – Ethernet, Optical Fiber, Serial.

- Wireless (WLAN) – WiFi, Microwave links.

Common Network Devices

1. Router

- A Layer 3 device that routes and forwards data between networks

- Uses IP addresses.

- Determines the best path for data to travel.

- Sometimes includes firewall, and DHCP functions

- Does NAT
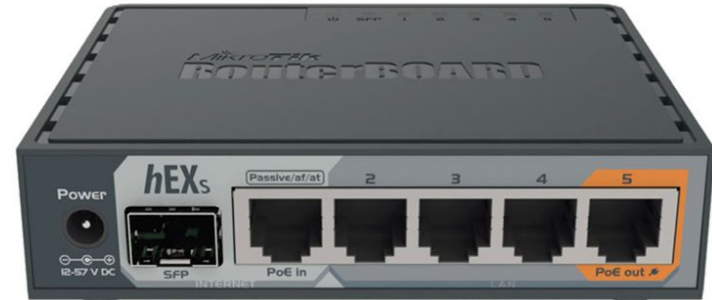
Selecting Routers

Minimum features:

- Routing (layer 3 forwarding)

  - IPv4 and IPv6, static routes

- Powerful CPU, Large Memory

- Management: SSH, SNMP

- OSPF (v2 and v3) or IS-IS

- Traffic growths

- NAT (if using internal private IPv4 address space)

- Cost

Common Network Devices

2. Switch

- Connects devices on a computer network.

- Can be managed or unmanaged

- Can be Layer 2 or Layer 3.

- Layer 2 – uses MAC addresses.

- Layer 3 – Has IP functionality such as basic routing.

Selecting Switches

Minimum features:

- Standards compliance– Encrypted management (SSH/HTTPS)

- VLAN trunking

- Spanning Tree (RSTP at least)

- SNMP

  - At least v2 (v3 has better security)

- Remote management and configuration backup

  - CLI preferred, also serial console desirable

- DHCP Snooping

  - Prevent end-users from running a rogue DHCP server

- Port density– Copper Vs Fiber ports

- Low Cost

  - D-Link DGS-1510 series,DGS-1210,MikroTik devices

Common Network Devices

3. Firewall

- A firewall acts as a security barrier between trusted internal and untrusted external networks.

- Controls traffic based on predefined rules to block unauthorized access and cyber threats
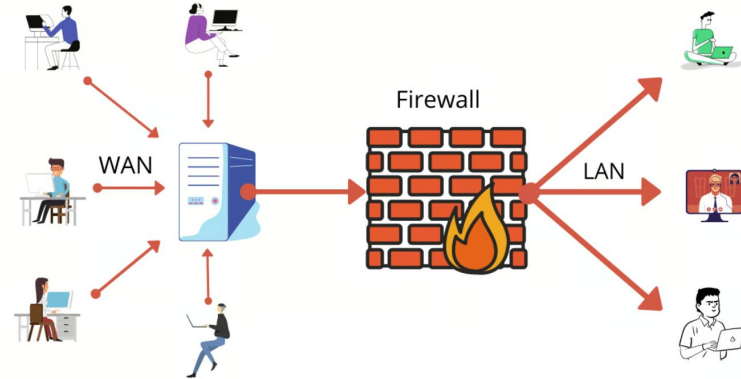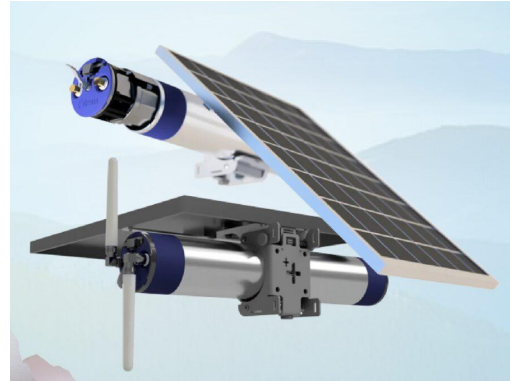
Common Network Devices

4. Access Points

- Creates a WLAN

- Allows Wi-Fi devices to connect to a LAN.

- Typically connected to LAN through ethernet.

- Outdoor or Indoor.

- Layer 2 device.

Transcription Media

1. Ethernet cable - Copper cores.

- Standardisations: CAT 6>CAT 5E>CAT 5

- Connector – RJ45 – into ethernet port.

Cable Type	Speed	Max Distance
Category 5**	100Mbps	100m
Category 5e	1,000Mbps	100m
Category 5e	2,500Mbps	100m
Category 6	5,000Mbps	100m
Category 6	10,000Mbps	55m
Category 6A	10,000Mbps	100m
Category 8	40,000Mbps	30m

2. Optical fiber cable/ patch cord

- Optical fiber core.

- Connectors – LC (Into SFP), SC, and FC

- Types – LC-LC, LC-SC, LC-FC
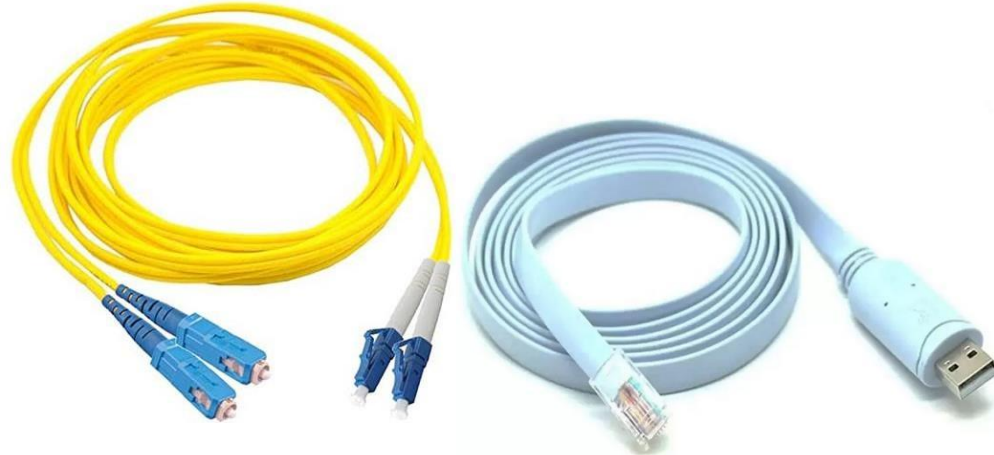
3. Console cable – Access to devices

Network Terminologies

1. IP Addresses

- A numerical layer 3 address that identifies a device and the network to which it is connected. eg.

- Prefix length– A range of IP addresses

- Internet connected networks use two types of IP Addressing

  - IPv4 – "legacy" Internet protocol– 137.63.189.3/24.

    - Only 4,294,967,296 addresses– **depleted**

  - IPv6 – new Internet protocol– 2c0f:f6d0:2b:13::/64.

Dual stack

network

IP Addresses cont….

- Private IPs Vs Public IPs

- NAT

  - Static NAT

  - Dynamic NAT

  - PAT (NAT Overload)

- Drawbacks of NAT

  - Performance issues

 - Troubleshooting Issues

  - Application Use

IPv4 Addresses

- 32-bit binary number

- Represented as four dotted decimal octet

- Two parts

  - Network/prefix portion & Host portion

- Netmask– alternative (old) way of writing the prefix length

  - A '1' for a prefix bit and '0' for a host bit

  - Hence N x 1's followed by (32-N) x 0's

- Classes Vs CIDR

  - Class A :**1 to 127**

  - Class B :**128 to 191**

  - Class C :**192 to 223**

11111111 **11111111** **11111111** **11111111**

255 . 255 . 255 . 255

Can you explain why 11111111 = 255 in decimal?

	8bits	8bits	8bits	8bits
Class A	Network	Host	Host	Host
Class B	Network	Network	Host	Host
Class C	Network	Network	Network	Host

IPv4 Addresses cont…

- Special IP addresses

- Subnetting

  • Dividing a large network into

  smaller ones(subnets)
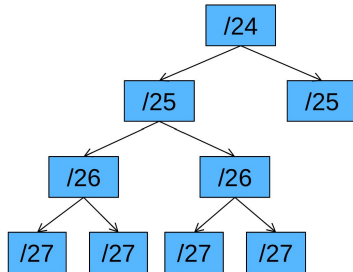
Range	Purpose
10.0.0.0 - 10.255.255.255	Private networks (Class A)
172.16.0.0 - 172.31.255.255	Private networks (Class B)
192.168.0.0 - 192.168.255.255	Private networks (Class C)
127.0.0.0 - 127.255.255.255	Loopback (localhost)
169.254.0.0 - 169.254.255.255	Link-local (automatic assignment)
224.0.0.0 - 239.255.255.255	Multicast

Network Terminologies

2. MAC Address - A unique layer 2 address that identifies devices network devices.

- Assigned to Network Interface Card (NIC) – Identifies device + Vendor eg. **28:b8:29:43:29:93**.

Network Terminologies

3. DHCP

- A system that automatically assigns a unique IP address to each device on a network.

- A device may fail to get an IP (**169.254.x.x/16**) due to;
    - A weak Wi-Fi signal
    - Network cable problems
    - DHCP server malfunctioning
    - Static IP address configuration
    - No available IP addresses

DHCP client — DHCP server

1. DCHP Discover →
2. DHCP Offer ←
3. DHCP Request →
4. DHCP Ack ←
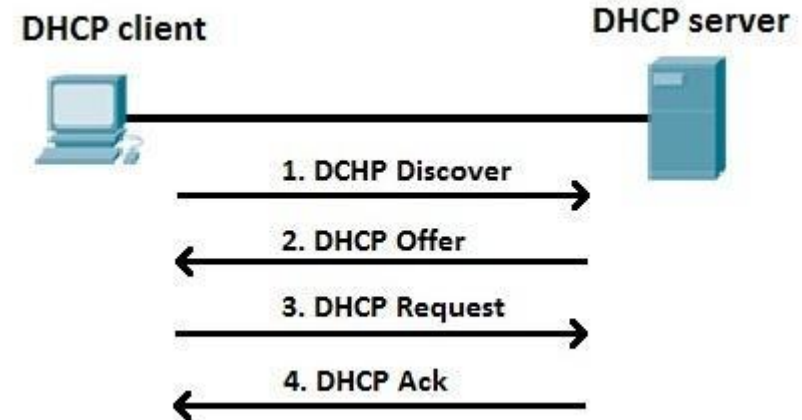
Network Terminologies

4. DNS

- DNS translates domain names into IP addresses, allowing users to access websites without typing numeric addresses.

- Without DNS, users would need to remember complex numerical IP addresses for every website they visit.
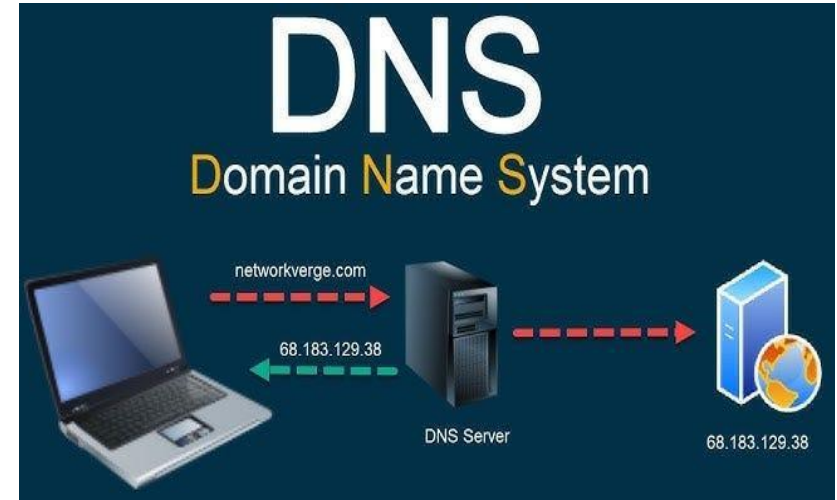
Network Performance

Bandwidth

- Network bandwidth defines how much data can possibly travel in a network in a period of time.

- Measured in Mbps.

- Analogy - Bandwidth (Water pipe); Data (Water)

    - The bigger the pipe, the more water can flow through in a given amount of time.

Latency - Speed at which data travels across the network to its destination and back to the source.

Common Network Bottlenecks

✔ **Slow and Unreliable Connectivity**

- Outdated routers, switches, and access points.

✔ **Inadequate Bandwidth**

- As number of devices and high-bandwidth applications increases, the internet bandwidth needs to be upgraded proportionally.

✔ **Unreliable Power**

✔ **DNS Issues**

✔ **Packet Loss**

✔ **Security Threats**

How to spot Bottlenecks

- Monitor Internet Speeds Regularly
- Track User Complaints
- Ping and Traceroute Tools
- Power Monitoring - frequent outages or unstable power affecting network uptime.
- Test DNS Resolution Times

Recommended Network Design
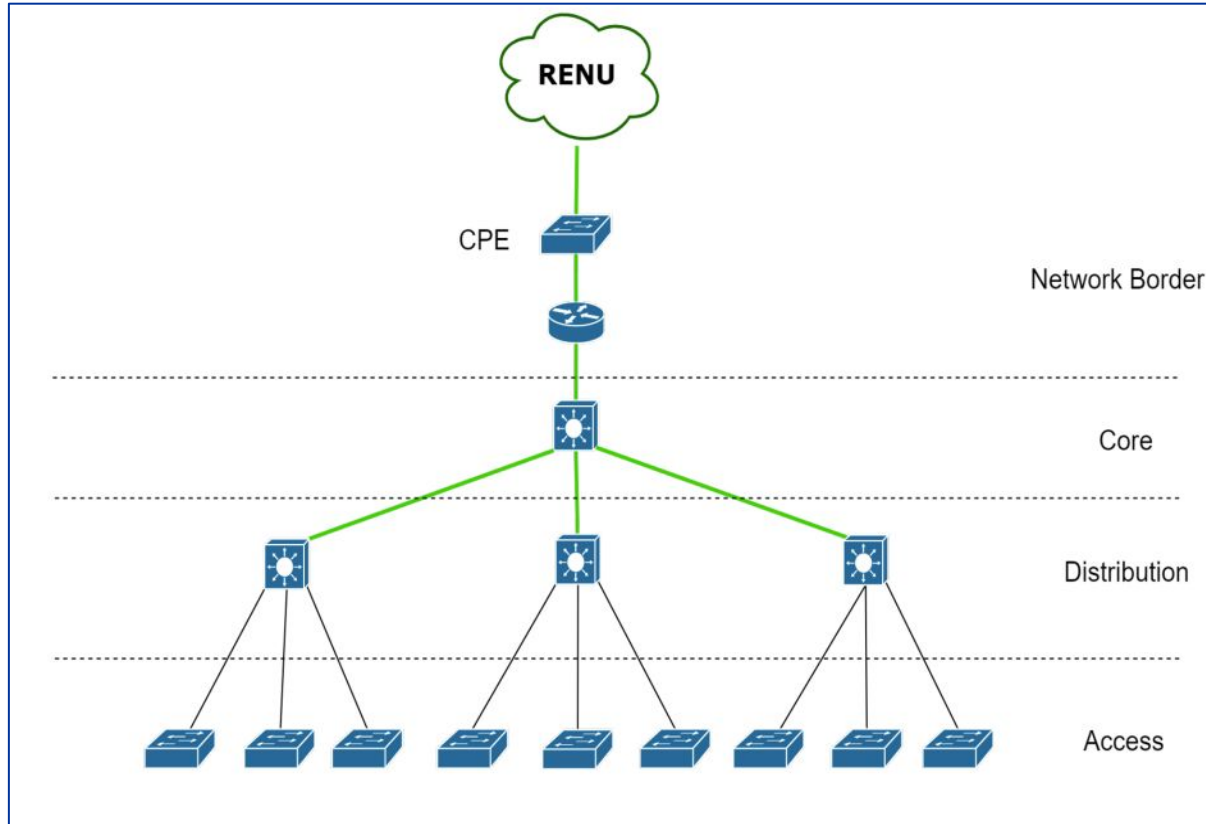
# Recommended Network Design Practices

Hierarchical network design model

Using a hierarchical network design model that consists of three layers: core, distribution and access with separation of functions.

This model provides;

- Modularity

- Resilience

- Flexibility

- Scalability

Recommended Network Design Practices

✔ Minimize number of network devices in the path

✔ Build hub and spoke (sometimes called star) networks

✔ Not daisy chained (sometimes called cascaded) networks
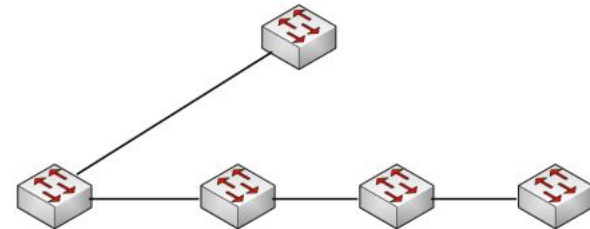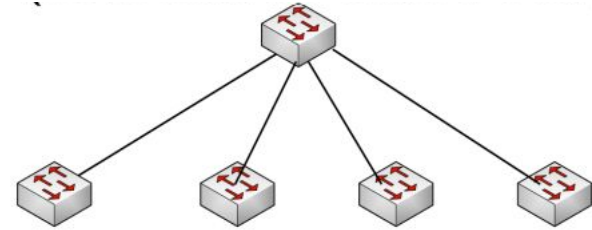
Cabling Best Practices

✔ 90 Meters maximum installed cable distance– No copper cable

✔ No more than 1 cm unsheathed cable at terminations

✔ Labeling is a key to reducing work later

✔ Use Conduits

No

Yes
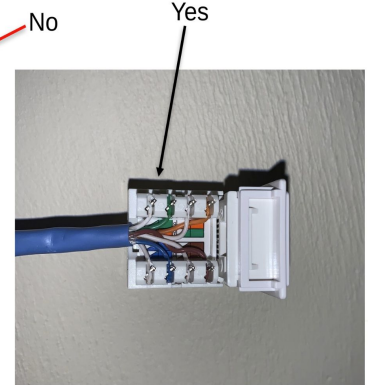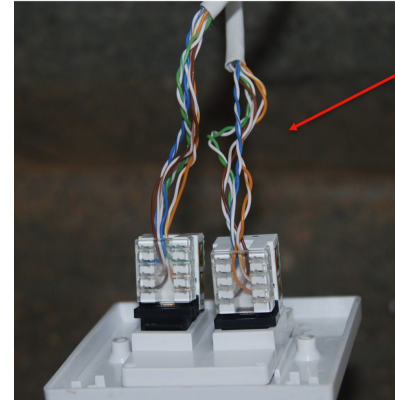
Practical Session
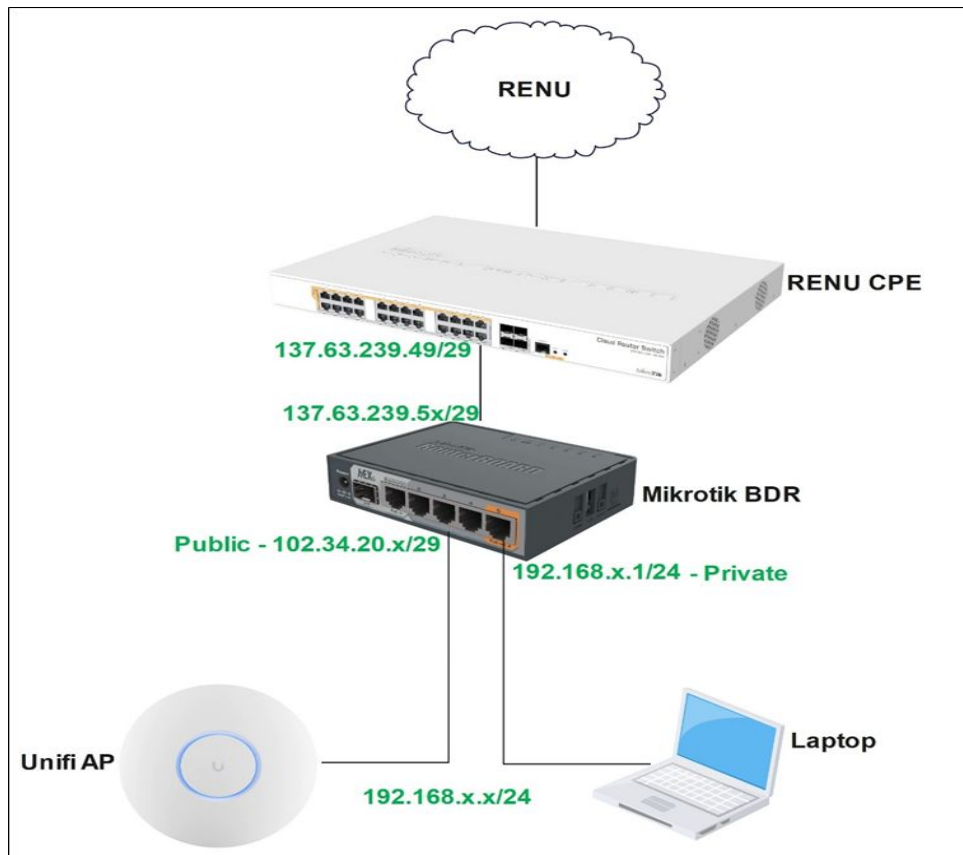
Necessary Equipment

- A Mikrotik heX Router
- A Unifi U6 Access point
- Ethernet Cables
- A computer

Guidelines

- Form 6 groups
- Each group will have access to a Mikrotik router, Unifi AP, and some Ethernet cables
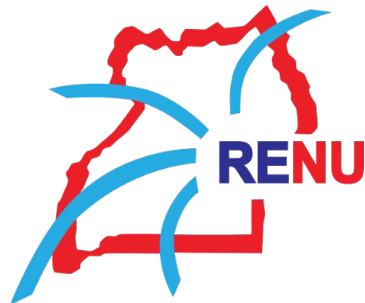- Follow the documentation provided to complete the setup

Lab Topology

IP Requirements

1. P2P to CPE: 137.63.239.48/29
   - ❖   Gateway: 137.63.239.49
   - ❖   BDR IP: 137.63.239.5x/29

1. Private Subnet: 192.168.x.0/24

2. Public Subnet: 102.34.20.x/29

THANK YOU

Knowledge | Community | Solutions