8.1 Basic Networking: Definition, Types, and Topologies

A. What is a Computer Network?

- **Definition:** A computer network is a system of **two or more interconnected computers** that share resources and exchange data using common protocols (rules).
- **Purpose:**
  - Share files, printers, and internet connections
  - Communicate (email, chat, video calls)
  - Centralize data storage and backup
  - Improve security and management

B. Types of Networks (by Size & Geographic Coverage)

Type	Full Form	Coverage	Speed	Example
PAN	Personal Area Network	Within a person's reach (few meters)	Low-Medium	Bluetooth headset to phone
LAN	Local Area Network	Single building, office, or campus	High (100 Mbps to 10 Gbps)	Office network, school computer lab
MAN	Metropolitan Area Network	A city or large campus	Medium-High	Cable TV network, city-wide Wi-Fi
WAN	Wide Area Network	Across cities, countries, or continents	Lower than LAN (due to distance)	Internet, bank ATM network
VPN	Virtual Private Network	Anywhere (over internet)	Varies	Secure remote access to office

For exam focus: LAN (most common in government offices), WAN (connects different ministry branches), VPN (secure remote work).

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C. Network Topologies (Physical & Logical Layout)

Topology = How devices are connected and arranged.

1. Bus Topology

- All devices connected to a **single central cable** (backbone).
- **Pros:** Cheap, uses less cable.
- **Cons:** If backbone fails, whole network fails; slow with many devices.
- **Used in:** Older, small temporary networks.

2. Star Topology (Most Common)

- All devices connected to a **central device** (switch/hub).
- **Pros:** If one cable fails, only that device is affected; easy to add devices; faster.
- **Cons:** Central device is a single point of failure.
- **Used in:** Most office LANs, schools, government buildings.

3. Ring Topology

- Each device connected to two others forming a **ring**.
- **Pros:** Data travels in one direction, predictable.
- **Cons:** One break breaks the whole network (unless dual ring).
- **Used in:** Older networks, some MANs.

4. Mesh Topology

- Every device connected to every other device (full mesh) or partially connected.
- **Pros:** Highly redundant, no single point of failure.
- **Cons:** Very expensive, complex cabling.
- **Used in:** Critical networks (military, data centers, banking).

5. Tree (Hierarchical) Topology

- Combination of star and bus; parent-child hierarchy.
- **Pros:** Scalable, easy to manage in sections.
- **Cons:** If root device fails, large portion fails.
- **Used in:** Large campuses, corporate WANs.

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6. Hybrid Topology

- Combination of two or more topologies.
- **Pros:** Flexible, reliable.
- **Used in:** Large enterprises, ISPs.

Topology	Best For	Single Point of Failure?
Bus	Small, temporary	Yes (backbone cable)
Star	Office LAN	Yes (central switch)
Ring	Predictable traffic	Yes (single break)
Mesh	High-availability	No
Tree	Large organizations	Yes (root device)

8.2 Connectivity and Media: Network Cables and Connectors

A. Guided Media (Wired) – Most Common for Exams

Cable Type	Speed	Max Distance	Connectors	Advantages	Disadvantages
Coaxial Cable	10-100 Mbps	500m	BNC	Resists interference, cheap	Slow, obsolete
Twisted Pair (UTP/STP)	100 Mbps - 10 Gbps	100m	RJ45	Cheap, flexible, easy to install	Limited distance, interference
Fiber Optic	1 Gbps - 100+ Gbps	2km-80 km	ST, SC, LC, MTRJ	Very fast, long distance, no interference	Expensive, hard to install

UTP Categories (for exam):

Category	Speed	Use
Cat5	100 Mbps	Obsolete
Cat5e	1 Gbps	Still common
Cat6	1-10 Gbps	Modern offices
Cat6a / Cat7	10 Gbps+	Data centers

B. Unguided Media (Wireless)

Type	Speed	Range	Use
Radio (Wi-Fi)	Up to several Gbps	30-100m	Office/home wireless
Bluetooth	~3 Mbps	10m	Short-range device pairing
Satellite	50-500 Mbps	Global	Remote areas, TV
Microwave	High	Line-of-sigh t	ISP backhaul

C. Common Network Connectors (Exam Focus)

Connector	Used With	Appearance / Note
RJ45	Ethernet (UTP/STP)	Looks like phone plug but wider; most common
BNC	Coaxial cable	Bayonet lock; older networks
SC / ST / LC	Fiber optic	SC = square push-pull; LC = small form factor
USB	Direct PC-to-PC or to modem	Universal serial bus
SFP	Switches/routers for fiber	Small form-factor pluggable (module)

8.3 Introduction to Network Devices

Device	Layer (OSI)	Function	Key Points
NIC	Physical/Data Link	Connects computer to network	Each NIC has unique MAC address
Hub	Physical	Broadcasts data to all ports	Obsolete; no intelligence; collisions occur
Switch	Data Link	Forwards data to specific device based on MAC address	Intelligent; modern networks use switches, not hubs
Router	Network	Connects different networks (e.g., LAN to WAN/Internet); forwards based on IP address	Home routers combine router + switch + modem
Gateway	Application/Network	Connects networks with different protocols	Can translate between different network types (e.g., LAN to mainframe)
Bridge	Data Link	Connects two similar network segments	Rare now; switches replaced them
Repeater	Physical	Regenerates signal to extend distance	Extends cable length
Access Point (AP)	Data Link	Provides wireless access to wired network	Common in offices for Wi-Fi
Modem	Physical	Converts digital ↔ analog for ISP connection	Needed for DSL/cable internet

Key Distinction for Exam:

- **Hub:** Dumb, broadcasts to all ports → collisions → slow.
- **Switch:** Smart, sends only to destination port → fast, secure.
- **Router:** Connects networks (LAN to WAN); uses IP addresses.
- **Gateway:** Connects different types of networks (e.g., email gateway).

8.4 Network Cabling and Cable Testing

A. Structured Cabling Standards

- **TIA/EIA-568** is the standard for commercial building cabling.
- **Subsystems:** Entrance facility, equipment room, backbone cabling, telecommunications room, horizontal cabling, work area.

B. Straight-Through vs. Crossover Cables

Cable Type	Wiring	Use
Straight-Through	Same pinout both ends (T568A or T568B)	Connect different devices: PC to switch, router to switch
Crossover	Transmit/receive pairs swapped (T568A one end, T568B other)	Connect similar devices: PC to PC, switch to switch (older)

Note: Modern switches with **Auto-MDI/X** automatically detect and adjust, making crossover cables less common.

C. Cable Testing Tools (Exam Questions Often Ask)

Tool	Purpose
Cable Tester	Checks continuity, pinout, and detects broken wires
Time Domain Reflectometer (TDR)	Finds distance to a fault (break or short) in a cable
Optical Time Domain Reflectometer (OTDR)	Same as TDR but for fiber optic cables
Multimeter	Measures voltage, resistance; can test for shorts
Wire Mapper	Identifies which cable goes to which wall jack
Certification Tester	Verifies cable meets standards (Cat6, etc.) – expensive

D. Common Cable Problems

Problem	Cause	Test Tool
Open/break	Cable cut or unplugged	Cable tester, TDR
Short	Two wires touching	Multimeter, cable tester
Crosstalk	Interference between wires	Certification tester
Length exceed	Too long for signal	TDR
Wrong pinout	Mis-wired connector	Cable tester

8.5 IP Addressing, Subnet Mask, Gateway, DNS, Static/Dynamic Addressing

A. What is an IP Address?

- **IP (Internet Protocol) Address** is a unique numerical label assigned to each device on a network.
- **Purpose:** Identifies a device and its location on the network (like a mailing address).
- **Two versions:**
  - **IPv4:** 32 bits, written as 4 numbers 0-255 separated by dots (e.g., 192.168.1.1)
  - **IPv6**: 128 bits, written in hexadecimal (e.g., 2001:0db8:85a3::8a2e:0370:7334)

IPv4 Address Classes (Traditional – Know for Exam)

Class	First Octet Range	Default Subnet Mask	Use
A	1-126	255.0.0.0	Very large networks (e.g., Google)
B	128-191	255.255.0.0	Medium networks (e.g., universities)
C	192-223	255.255.255.0	Small networks (most offices)
D	224-239	(multicast)	Multicast groups
E	240-255	(reserved)	Experimental

Private IP Addresses (Not routable on internet – used inside LANs):

Class	Private Range
A	10.0.0.0 – 10.255.255.255
B	172.16.0.0 – 172.31.255.255
C	192.168.0.0 – 192.168.255.255

Special IP:

- 127.0.0.1 = localhost (your own computer)
- 0.0.0.0 = default route or any IP
- 255.255.255.255 = limited broadcast

B. Subnet Mask

- **Definition:** A 32-bit number that separates the **network portion** from the **host portion** of an IP address.
- **Purpose:** Tells a device which part of the IP is the network ID and which part is the device ID.

Example:

IP Address	192.168.1.100
Subnet Mask	255.255.255.0
Network ID	192.168.1.0
Host ID	0.0.0.100

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Common Subnet Masks:

Mask	CIDR Notation	Number of Hosts
255.0.0.0	/8	16,777,214
255.255.0.0	/16	65,534
255.255.255.0	/24	254
255.255.255.128	/25	126

C. Default Gateway

- **Definition:** The device (usually a router) that connects a local network to other networks (like the internet).
- **How it works:** If a computer wants to send data to an IP address outside its own network, it sends it to the **gateway**, which forwards it.
- **Example:** Home router often has IP 192.168.1.1 as the gateway.

D. DNS (Domain Name System)

- **Definition:** The "phonebook of the internet." Translates human-readable domain names (e.g., www.psc.gov.np) into IP addresses (e.g., 192.168.1.10).
- **Why needed:** People remember names; computers need numbers.
- **Common DNS servers:**
  - Google: 8.8.8.8, 8.8.4.4
  - Cloudflare: 1.1.1.1
  - Nepal Telecom / ISPs: Provided automatically
- **DNS Lookup Process:**
  1. Type www.nepal.gov.np in browser.
  2. Computer asks DNS server for IP.
  3. DNS server returns IP (e.g., 203.34.117.5).
  4. Browser connects to that IP.

E. Static vs. Dynamic Address Assignment

Feature	Static IP	Dynamic IP (DHCP)
How it works	Manually configured on device	Automatically assigned by DHCP server
Changes	Never changes (unless manual)	Can change periodically
Best for	Servers, printers, routers	End-user devices (PCs, phones, laptops)
Management	Requires tracking; labor-intensive	Automatic; no tracking needed
Risk	IP conflicts if duplicated	No conflicts (DHCP manages)
Cost	Free	Free (DHCP server needed)

DHCP (Dynamic Host Configuration Protocol)

- **Purpose:** Automatically assigns IP address, subnet mask, gateway, and DNS to devices when they join a network.
- **Process (DORA):**
  1. **D**iscover – Device broadcasts "I need an IP"
  2. **O**ffer – DHCP server offers an IP
  3. **R**equest – Device requests that IP
  4. **A**cknowledge – Server confirms
- **Lease time:** The IP is borrowed for a set time (e.g., 24 hours), then renewed.

When to use Static IP in Government Offices:

- Servers (web, email, database)
- Network printers
- Security cameras
- Routers and switches (management interfaces)

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8.6 Application of Network Utilities

These are command-line tools used to **test, diagnose, and troubleshoot** network connectivity issues. In Windows, open **Command Prompt (cmd)** or **PowerShell** to run these.

A. IPCONFIG (Internet Protocol Configuration)

- **Purpose:** Displays all current TCP/IP network configuration values for your computer.
- **Most common uses:**

Command	What it does
ipconfig	Shows basic IP address, subnet mask, default gateway
ipconfig /all	Shows detailed info: MAC address, DNS servers, DHCP status, lease times
ipconfig /release	Releases current DHCP IP address (loses connection)
ipconfig /renew	Requests a new IP address from DHCP server
ipconfig /flushdns	Clears the DNS cache (fixes "website not found" errors)
ipconfig /displaydns	Shows cached DNS entries

Sample output of ipconfig:
text
Ethernet adapter Local Area Connection:
IPv4 Address. . . . . : 192.168.1.100
Subnet Mask . . . . . : 255.255.255.0
Default Gateway . . . . . : 192.168.1.1

B. PING (Packet Internet Groper)

- **Purpose:** Tests whether a specific IP address or hostname is reachable across the network. Measures **round-trip time** (response time).
- **How it works:** Sends ICMP (Internet Control Message Protocol) Echo Request packets and waits for Echo Reply.

Syntax: ping <destination>

Examples:

Command	Purpose
ping google.com	Tests internet connectivity to Google
ping 192.168.1.1	Tests connection to local router
ping 127.0.0.1	Tests your own network stack (loopback)
ping -t 8.8.8.8	Pings continuously (Ctrl+C to stop)
ping -n 10 google.com	Sends only 10 pings instead of default 4

Sample output:

text
Reply from 142.250.183.46: bytes=32 time=25ms TTL=115
Reply from 142.250.183.46: bytes=32 time=24ms TTL=115
Packets: Sent = 4, Received = 4, Lost = 0 (0% loss)

Interpreting results:

- **Reply received** = destination is reachable.
- **Request timed out** = destination did not respond (maybe down, firewalled, or offline).
- **Destination unreachable** = your network cannot find the path.
- **TTL (Time To Live)** = remaining hops before packet expires.

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C. TRACERT (Trace Route)

- **Purpose:** Shows the **path** (each router hop) that packets take from your computer to a destination.
- **Useful for:** Finding where a connection is slowing down or failing.

Syntax: tracert <destination>

Example: tracert google.com

Sample output:

text

```
1   1 ms   1 ms   1 ms  192.168.1.1 (your router)
2  10 ms  10 ms  10 ms  10.0.0.1 (ISP router)
3  25 ms  25 ms  25 ms  72.14.194.1 (Google router)
4  26 ms  25 ms  26 ms  142.250.183.46 (Google server)
```

What each column means:

Column	Meaning
Hop number	Each router along the path
3 round-trip times	Three attempts to that hop (in milliseconds)
IP address	Router's IP address

- **High latency (e.g., 200ms)** = slow connection at that hop.
- **Request timed out** = router does not reply (may still forward packets).
- *Stars (*)* = no response (could be firewall blocking).

Linux/Mac version: traceroute (command may need installation)

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D. NSLOOKUP (Name Server Lookup)

- **Purpose:** Queries **DNS servers** to find the IP address of a domain name (or the domain name of an IP address - reverse lookup).
- **Useful for:** Troubleshooting DNS issues, verifying DNS records.

Syntax: nslookup <hostname>

Examples:

Command	Output
nslookup google.com	Returns IP address(es) of google.com
nslookup 8.8.8.8	Reverse lookup: returns hostname for that IP
nslookup psc.gov.np	Checks Nepal PSC website's IP

Sample output:
text
Server: dns.google
Address: 8.8.8.8

Non-authoritative answer:
Name: google.com
Addresses: 142.250.183.46

To specify a different DNS server:
nslookup google.com 1.1.1.1 (uses Cloudflare DNS instead of default)

Quick Comparison Table (Network Utilities)

Utility	Purpose	Best for
IPCONFIG	View/manage IP configuration	"What's my IP?" "Renew my address"
PING	Test reachability & response time	"Is Google down or just me?"
TRACERT	Show route path and hop delays	"Where is the connection slow?"
NSLOOKUP	DNS queries (name ↔ IP)	"Why can't I reach the website by name?"

8.7 Concept of E-mail / Internet / Extranet / Intranet / WWW

A. E-mail (Electronic Mail)

- **Definition:** Method of exchanging digital messages between people using electronic devices.
- **Key components:**
  - **Email address format:** username@domain.com (e.g., info@psc.gov.np)
  - **Mail servers:** Send, receive, and store emails (SMTP, POP3, IMAP)
  - **Email clients:** Outlook, Thunderbird, Gmail web, Yahoo Mail

Protocols used in email:

Protocol	Full Form	Purpose	Port
SMTP	Simple Mail Transfer Protocol	Sending outgoing email	25, 465, 587
POP3	Post Office Protocol v3	Downloads email to local device (deletes from server)	110, 995
IMAP	Internet Message Access Protocol	Keeps email on server; syncs across devices	143, 993

B. Internet

- **Definition:** A **global network** of billions of computers and devices connected using standardized protocols (TCP/IP).
- **No single owner** – it's a network of networks.
- **Services on the Internet:** WWW, email, FTP, VoIP, streaming, online gaming, social media.

Key fact: The Internet is the **infrastructure** (cables, routers, servers). The WWW is one service that runs *on top* of the Internet.

C. Intranet

- **Definition:** A **private network** accessible only to an organization's employees or members.
- **Uses:** Internal communication, employee directories, document sharing, internal forms, company policies.
- **Access:** Only from within the organization (requires login or VPN).
- **Example:** Nepal Government's internal employee portal, a school's internal grade system.

Feature	Intranet
Access	Only authorized internal users
Location	Inside organization's network
Security	High (firewalled, no public access)

D. Extranet

- **Definition:** An **extended intranet** that allows **limited, secure access** to external parties (partners, suppliers, clients, vendors).
- **Uses:** Supply chain management, partner collaboration, customer portals, B2B data exchange.
- **Example:** A government department sharing tender documents with registered vendors; a bank sharing data with partner insurance companies.

Comparison Table:

Feature	Intranet	Extranet	Internet
Access	Only internal employees	Internal + authorized external partners	Everyone (public)
Security	Very high	High (firewalled + authentication)	Low to medium
Example	Company HR portal	Vendor supply portal	Google.com

E. World Wide Web (WWW)

- **Definition:** A system of **interlinked hypertext documents** (web pages) accessed via the Internet.
- **Invented by:** Tim Berners-Lee in 1989 at CERN.
- **Key components:**
  - **Web pages** (HTML documents)
  - **Hyperlinks** (connect pages)
  - **Web browsers** (Chrome, Firefox, etc.)
  - **Web servers** (host the pages)
  - **HTTP/HTTPS** (protocols to transfer pages)

Difference between Internet and WWW (Common Exam Question):

Internet	World Wide Web (WWW)
Physical infrastructure (cables, routers, servers)	Information system (web pages, links)
Includes email, FTP, VoIP, gaming, etc.	Only web content (HTTP/HTTPS)
Existed before WWW (1960s onward)	Invented in 1989
Ships, roads, and postal system	Books and libraries

Analogy: Internet = the network of roads. WWW = the shops, houses, and buildings on those roads.

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8.8 Familiarity with Internet Browsers

A. What is a Web Browser?

- **Definition:** Software application used to **access, retrieve, and display** web pages and other content on the World Wide Web.
- **How it works:** Browser sends an HTTP/HTTPS request to a web server, receives HTML/CSS/JS files, and **renders** them as a visual page.

B. Major Web Browsers (Know for Exam)

Browser	Developer	Rendering Engine	Key Features
Google Chrome	Google	Blink	Most popular; fast; large extension library; syncs with Google account
Mozilla Firefox	Mozilla	Gecko / Quantum	Privacy-focused; open source; strong tracking protection
Microsoft Edge	Microsoft	Blink (Chromium)	Default on Windows 10/11; integrates with Microsoft services
Safari	Apple	WebKit	Default on Apple devices (Mac, iPhone, iPad); energy efficient
Opera	Opera Software	Blink	Built-in VPN, ad blocker, battery saver, gaming features
Internet Explorer	Microsoft	Trident	**Obsolete/Deprecated** (retired June 2022); only for legacy sites

Note for exam: Internet Explorer is **no longer supported**. Edge is Microsoft's current browser.

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C. Common Browser Features

Feature	Purpose
Address Bar	Enter URL (e.g., www.psc.gov.np)
Bookmarks / Favorites	Save frequently visited pages
Tabs	Open multiple pages in one window
History	View previously visited pages
Downloads	Manage downloaded files
Private/Incognito Mode	Browsing without saving history, cookies, or cache (not completely anonymous)
Extensions/Add-ons	Add extra functionality (ad blockers, password managers)
Developer Tools (F12)	Inspect HTML/CSS, debug JavaScript
Search Bar / Omnibox	Chrome combines address bar and search

D. Browser Security Features

Feature	Purpose
HTTPS indicator (padlock)	Shows connection is secure (encrypted)
Pop-up blocker	Blocks unwanted pop-up windows
Phishing protection	Warns about suspicious/malicious websites
Automatic updates	Patches security vulnerabilities
Sandboxing	Runs each tab in isolated environment

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8.9 Familiarity with Cloud-based Services

A. What is Cloud Computing?

- **Definition:** Delivering computing services (storage, servers, databases, networking, software) **over the internet** ("the cloud") instead of on local devices.
- **Key benefits:**
  - Access from anywhere (any device with internet)
  - No need for local storage or hardware
  - Automatic backups and syncing
  - Pay-as-you-go (for businesses)

B. Types of Cloud Services (for general knowledge)

Type	Full Form	What it provides	Example
IaaS	Infrastructure as a Service	Virtual servers, storage, networking	AWS EC2, Google Compute Engine
PaaS	Platform as a Service	Platform to develop/deploy apps	Google App Engine, Heroku
SaaS	Software as a Service	Ready-to-use software over internet	Gmail, Google Drive, Dropbox, Office 365

C. Popular Cloud Storage Services (Know for Exam)

Service	Developer	Free Tier	Key Features
Google Drive	15 GB	Integrates with Google Docs, Sheets, Gmail; available on all devices	
Dropbox	Dropbox Inc.	2 GB	Very reliable sync; file sharing; integrates with many apps
iCloud	Apple	5 GB	Built-in for Apple devices (iPhone, Mac); syncs photos, contacts, backups
OneDrive	Microsoft	5 GB	Integrates with Windows and Microsoft Office
Box	Box Inc.	10 GB	Business-focused; strong security features

D. Cloud Computing in Government Context (Nepal)

- **Government Integrated Data Center (GIDC):** Nepal's own "government cloud" that hosts official websites and databases.
- **National Information Technology Center (NITC):** Provides cloud infrastructure to government bodies.
- **Benefits for Nepal government:**
  - Reduces need for individual servers in each ministry
  - Centralized security and backup
  - Cost savings (shared resources)

E. Cloud Deployment Models

Model	Description	Example
Public Cloud	Services offered over public internet, shared among multiple customers	Google Drive, Dropbox
Private Cloud	Dedicated to a single organization (more control, higher security)	Government GIDC
Hybrid Cloud	Combination of public and private	Some data in private cloud, some in public

F. Advantages & Disadvantages of Cloud Storage

Advantages	Disadvantages
Access from anywhere	Requires internet connection
Automatic backup and sync	Privacy concerns (data on third-party servers)
No need to carry USB drives	Monthly fees for large storage
Easy file sharing and collaboration	Vendor lock-in (hard to move data out)
Scalable (pay for what you use)	Security depends on provider

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