

Foundations of Computer Science

Computer Network

ONE LOVE. ONE FUTURE.

Contents

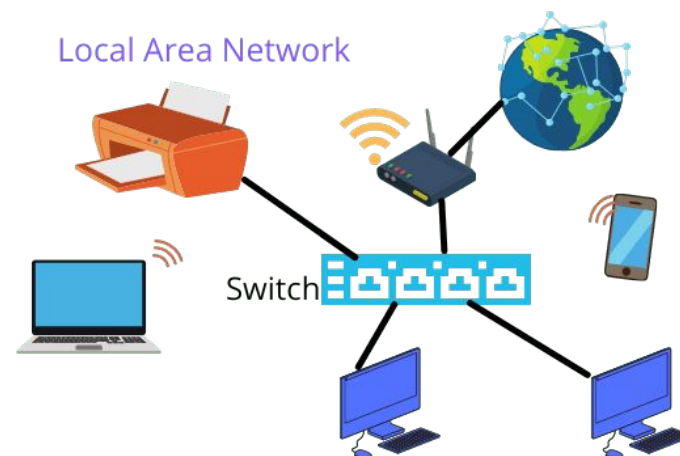
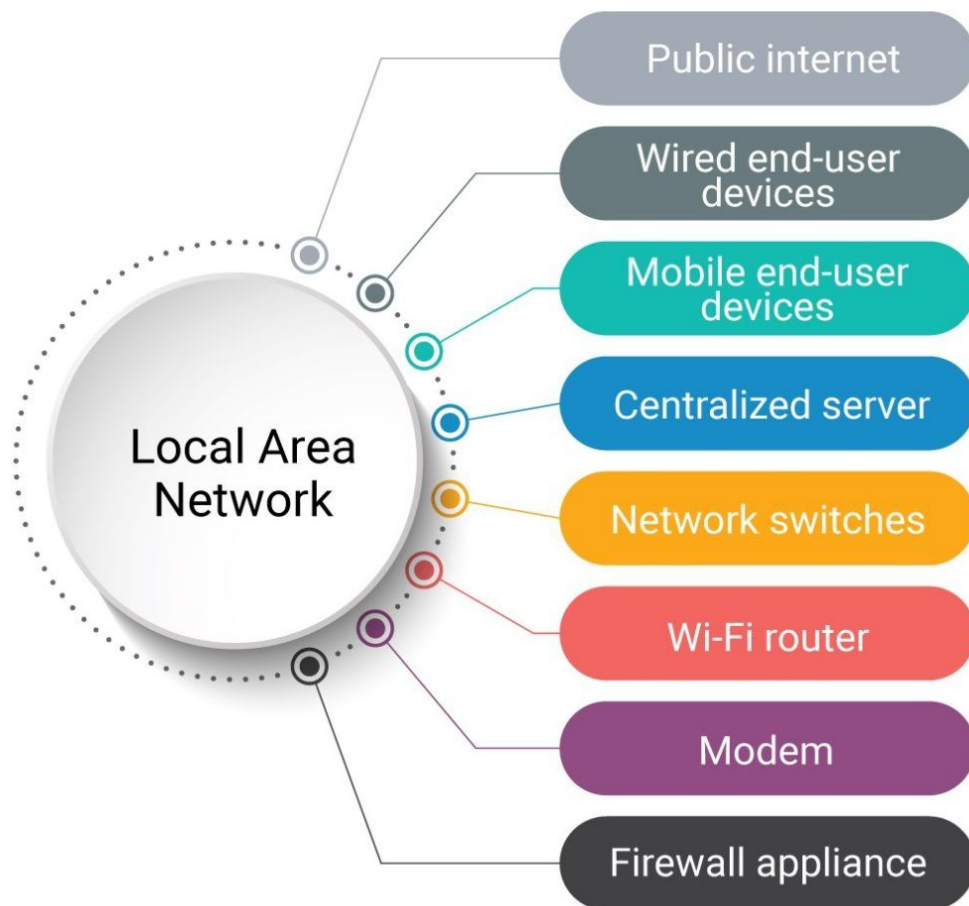
- Introduction
- LAN
- Communication Links
- Types of Network
- Communication Protocols
- Network Services
- Cloud Computing
- Internet of Things

HUST

- A **computer network** is a set of independent computer systems interconnected by telecommunication links for the purpose of sharing information and resources.
- The individual computers on network are referred to as **nodes** or *hosts*, and they can range in size from smartphones, tablets, and tiny laptops to massively parallel supercomputers.



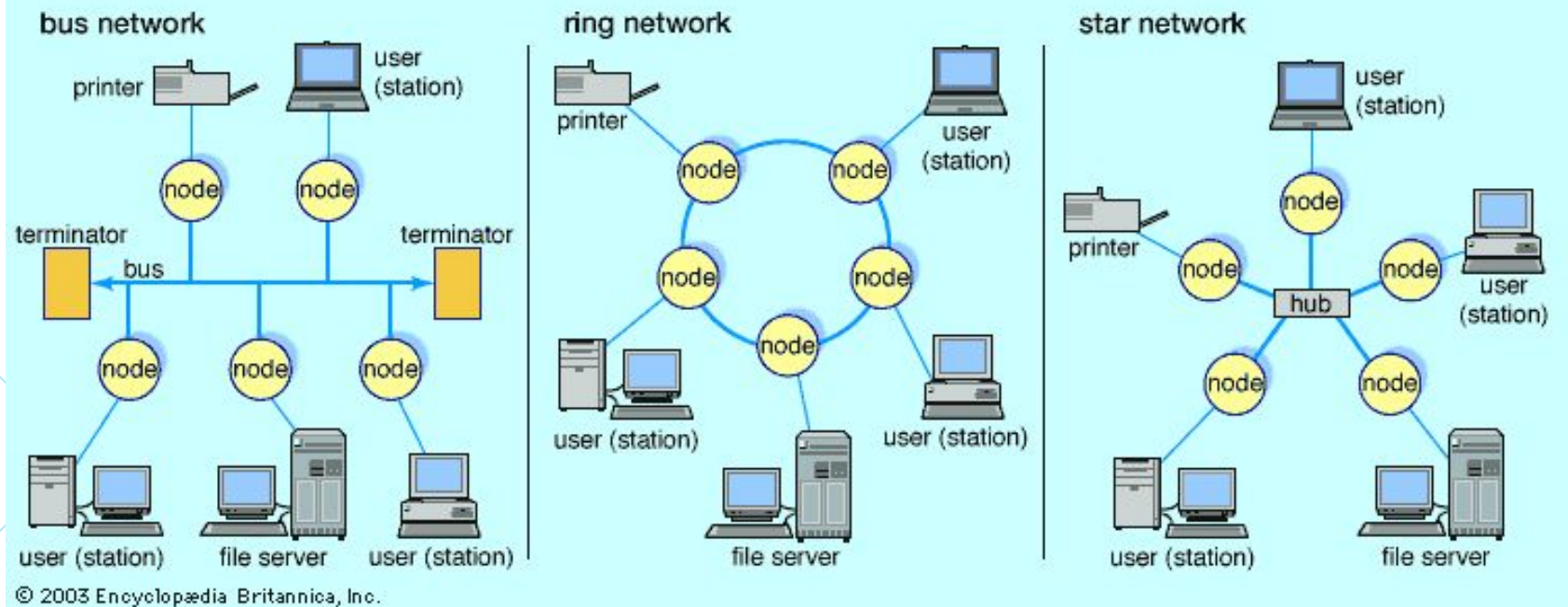
KEY COMPONENTS OF LAN ARCHITECTURE

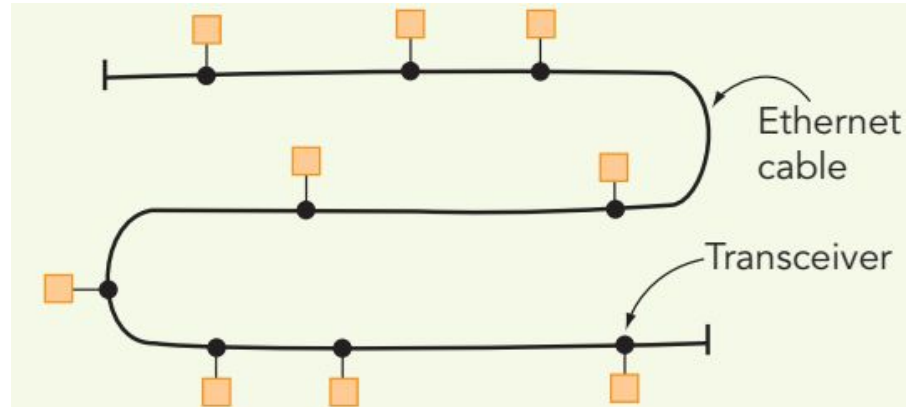




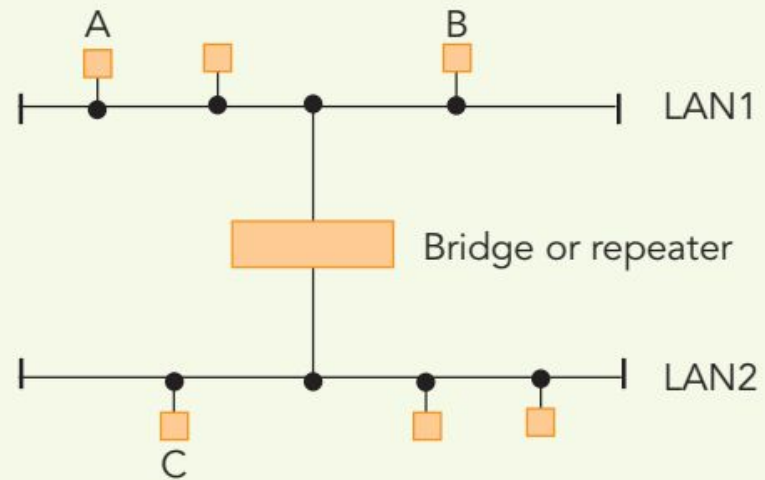
LANs are private owned-network, can be extended up to a few kilometers.

- LANs operate at relatively high speed as compared to the typical WAN
- It connects computers within a single office, building, block or campus, i.e. they work in a relatively small geographical area.



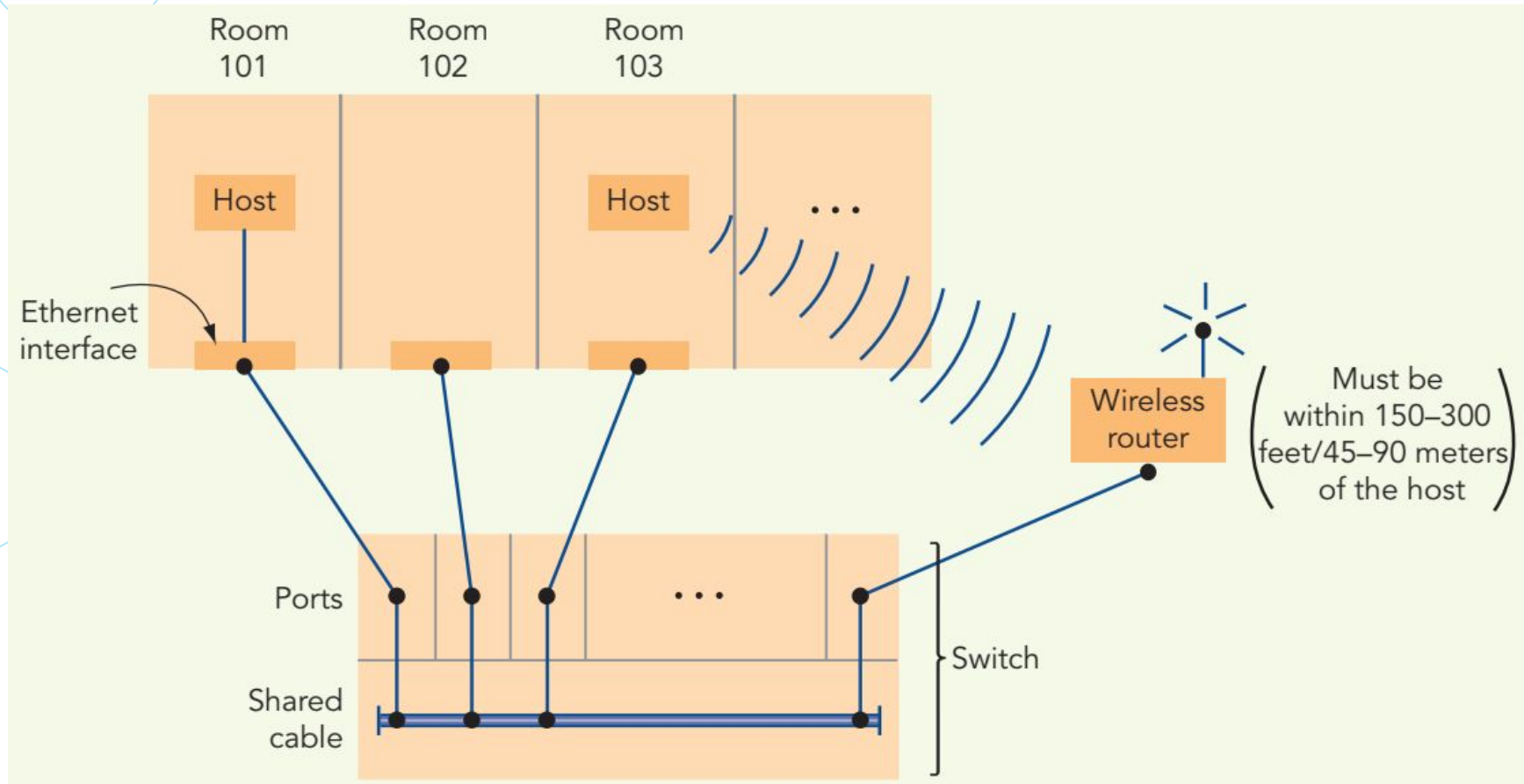


(a) Single-cable configuration

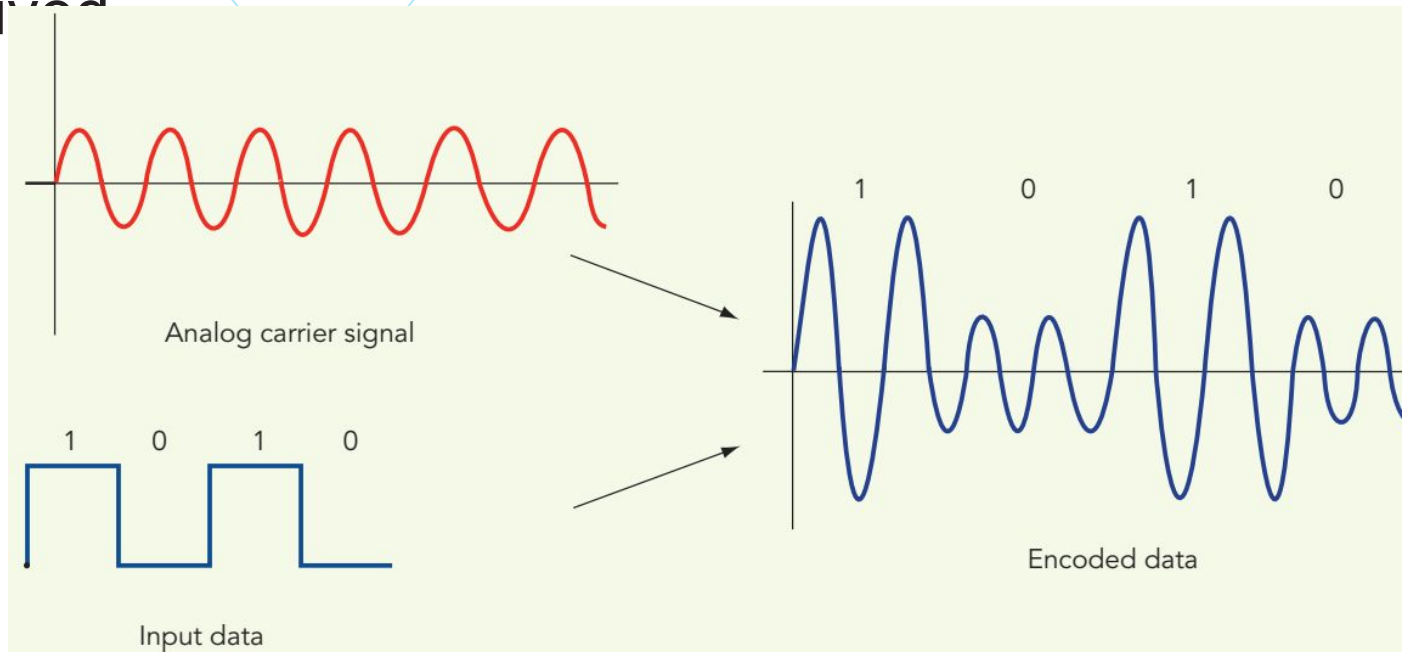


(b) Multiple-cable configuration

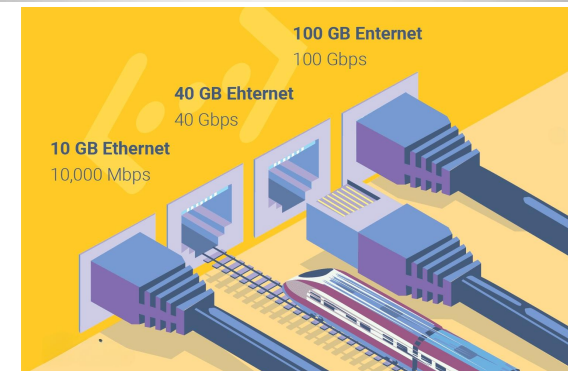
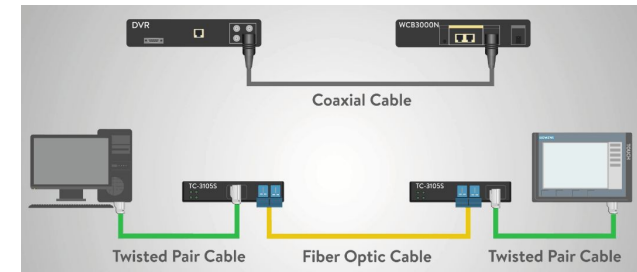
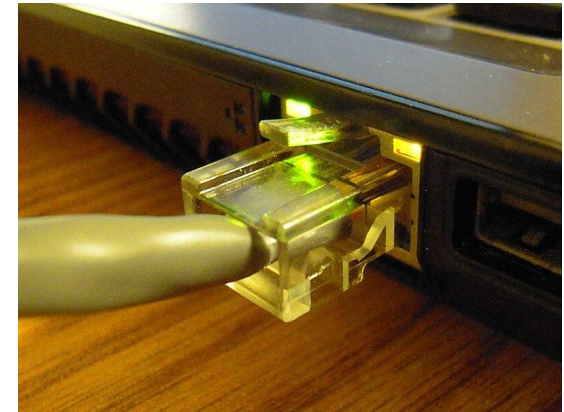
Ethernet LAN with Switch



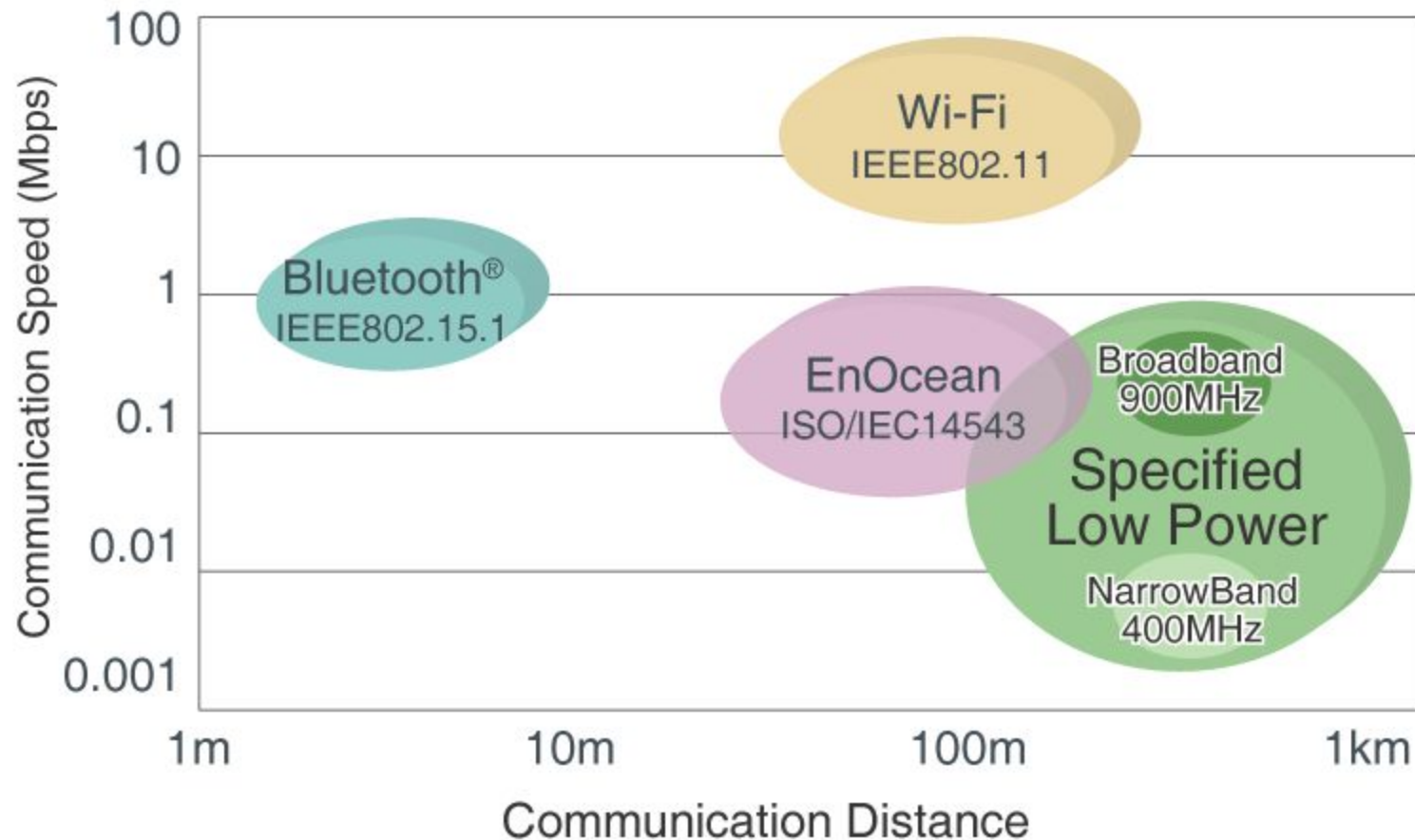
- **Switched, dial-up telephone lines** using **modem** (M**O**dulator – D**E**Modulator)
- **Bandwidth**: rate at which information could be sent and received

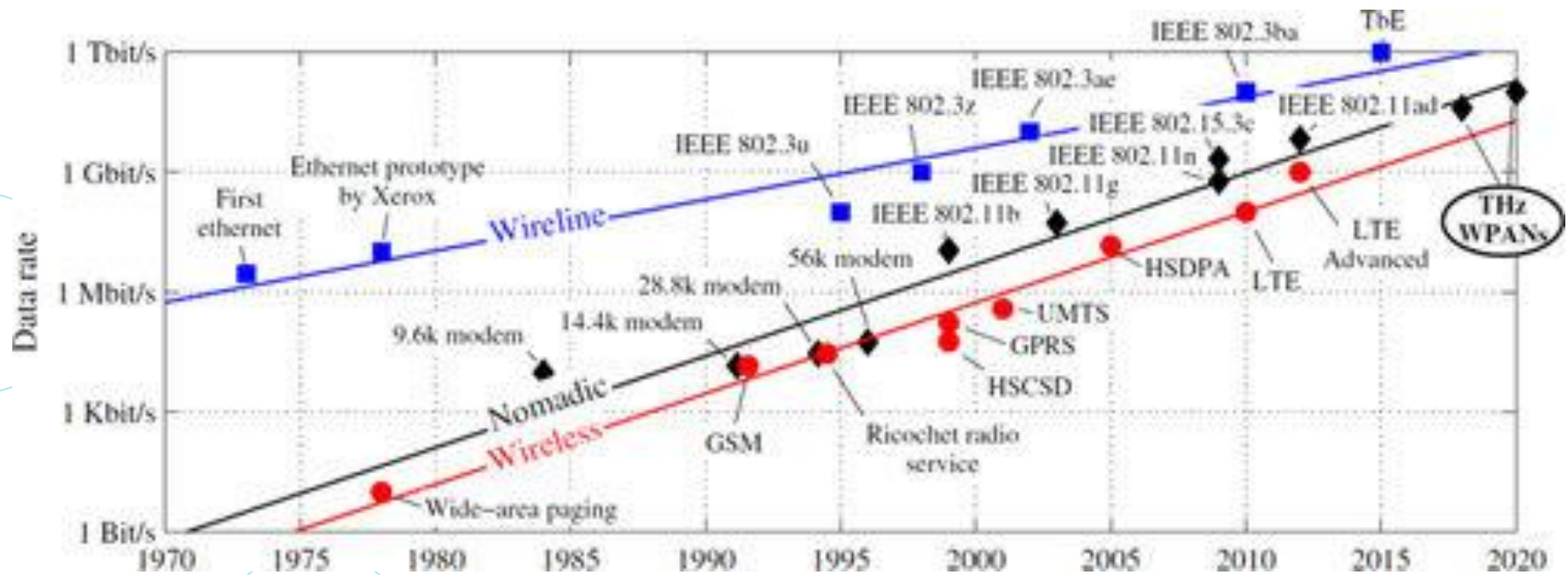


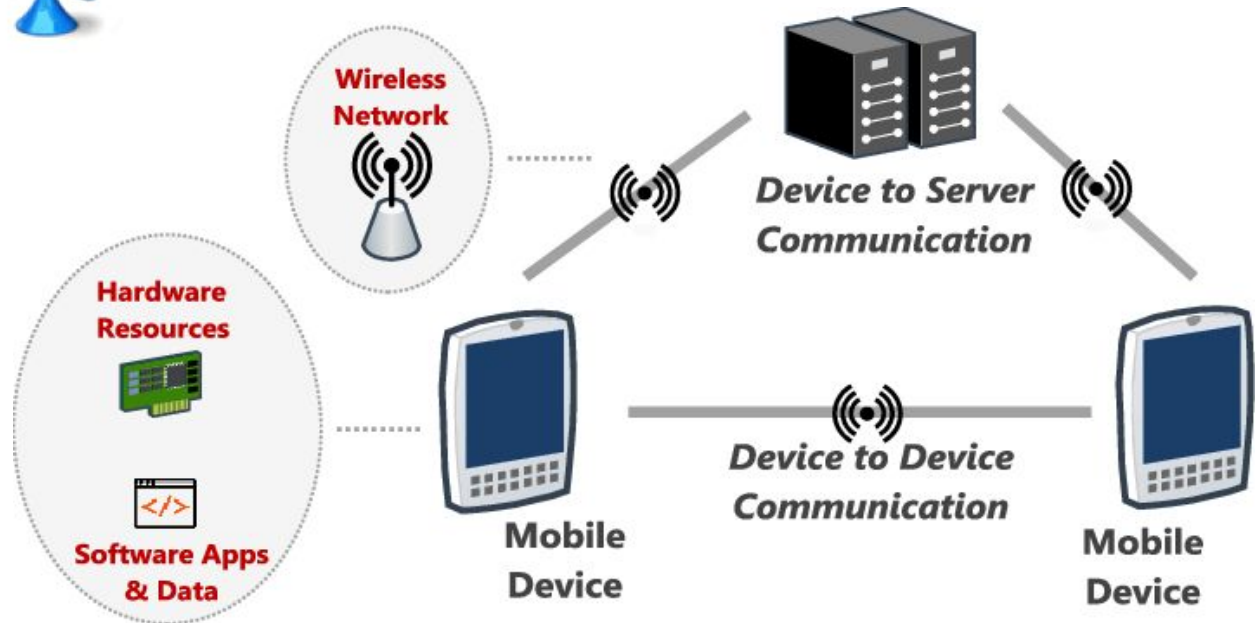
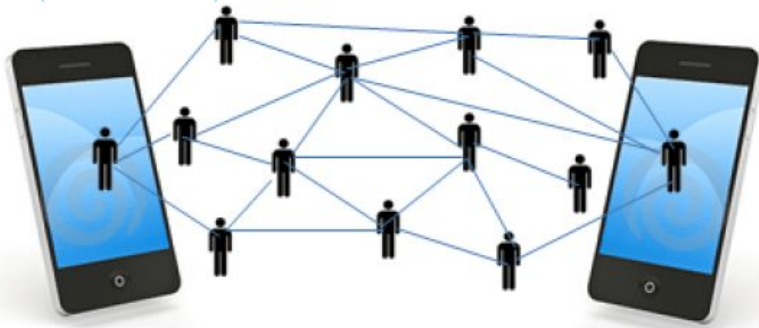
- **Broad band:** more than 256,000 bps
- ADSL: (Asymmetric) Digital Subscriber Line
- Cable modem: based on cable TV
- Ethernet: twist-pair copper wire, coaxial cable, fiber-optic cable
 - Ethernet: 10 Mbps
 - Fast Ethernet: 100 Mbps
 - Gigabit Ethernet



Line Type	Speed	Time to Transmit 8 Million Bits (One Compressed Image)	
Dial-up phone line	56 Kbps	2.4	minutes
DSL line, cable modem	2 Mbps	4	seconds
Ethernet	10 Mbps	0.8	second
Fast Ethernet	100 Mbps	0.08	second
Gigabit Ethernet	1 Gbps	0.008	second
10-gigabit Ethernet	10 Gbps	0.0008	second
100-gigabit Ethernet	100 Gbps	0.00008	second

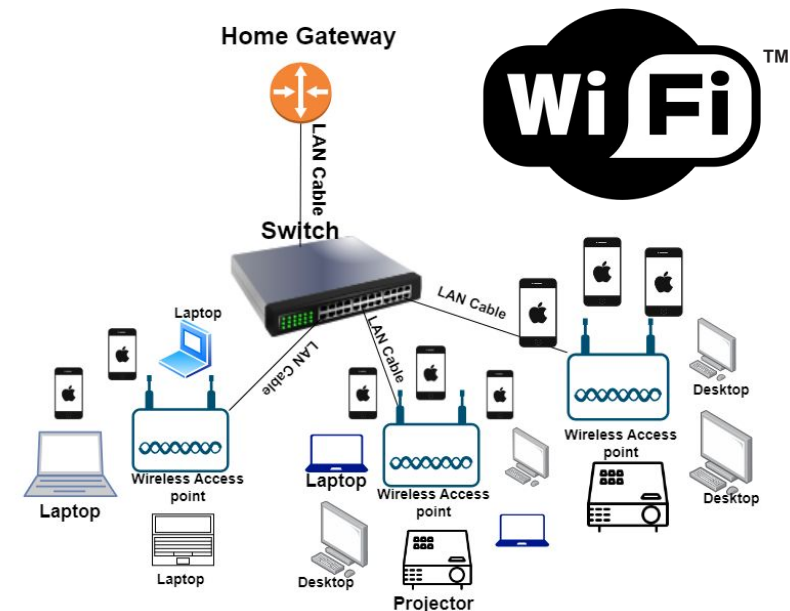




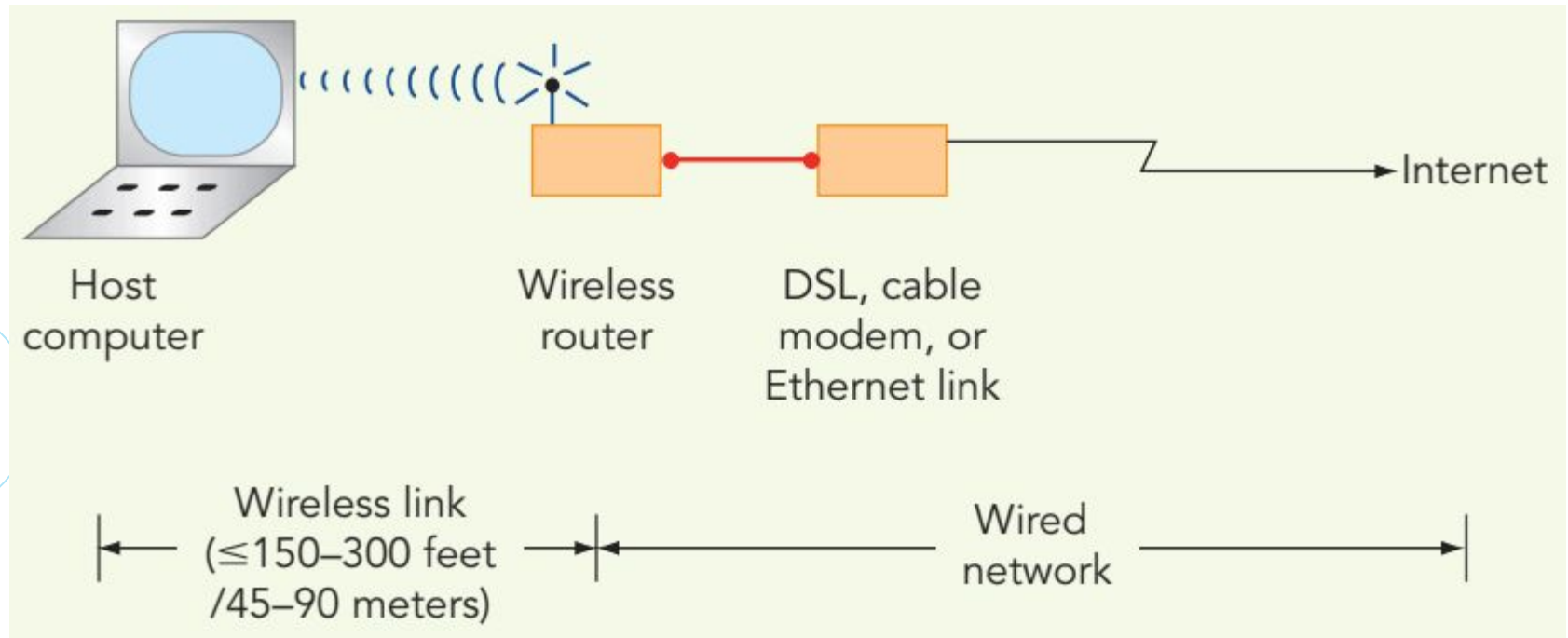


- A **WLAN** is a wireless computer network that links two or more devices using wireless communication to form a LAN
- Through a gateway, a WLAN can also provide a connection to the wider Internet.
- WLANs based on the IEEE 802.11 standards are the most widely used computer networks in the world, commonly called Wi-Fi (Wi-Fi Alliance).
- Wi-Fi is used to connect a computer to the Internet when it is within range (typically 150–300 feet or 45–90 meters) of a wireless base station, often advertised as a **Wi-Fi hot spot**.
- Wi-Fi systems generally use the 2.4 GHz radio band for communications and support download transmission speeds of about 10–50 Mbps.

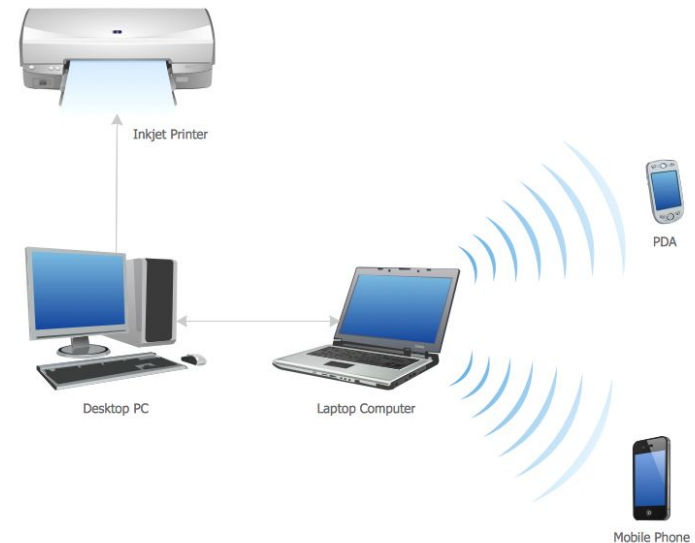
Wireless Local Area Network



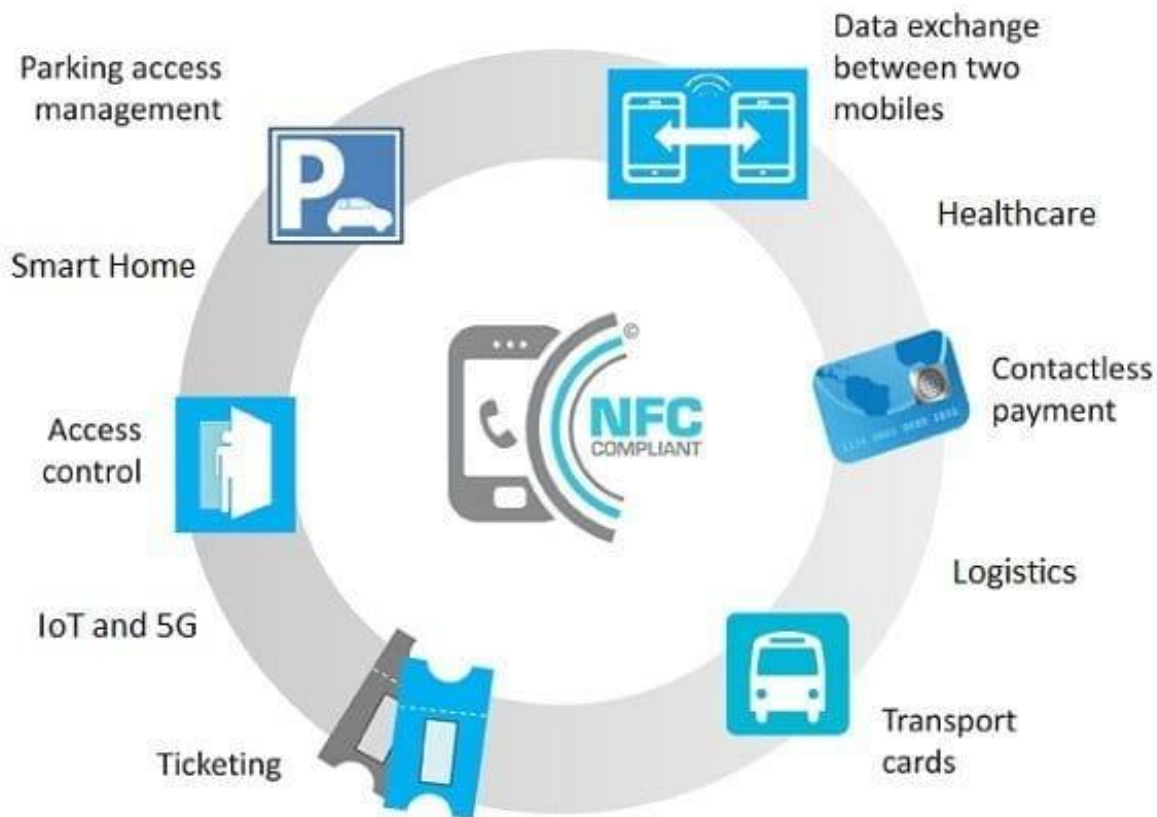
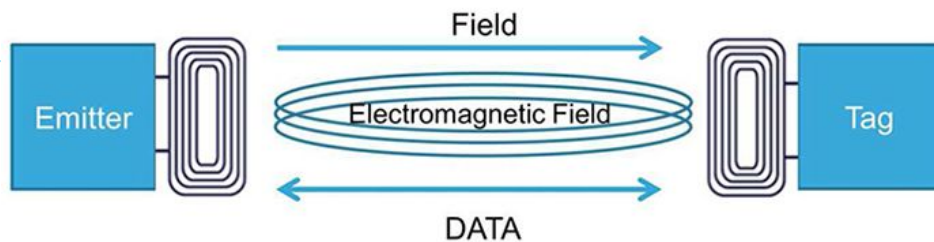
Typical WLAN Configuration



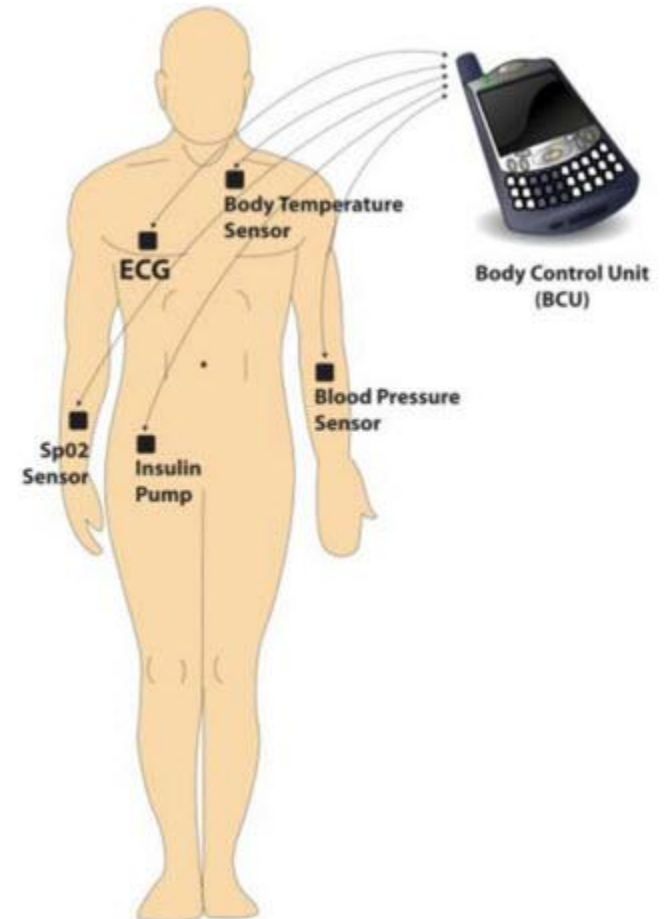
- A **personal area network (PAN)** is a computer network for interconnecting electronic devices within an individual person's workspace.
- A PAN provides data transmission among devices such as computers, smartphones, tablets and personal digital assistants (PDA).
- **Bluetooth** is a short-range wireless technology standard that is used for exchanging data between fixed and mobile devices over short distances
- In the most widely used mode, transmission power is limited to 2.5 milliwatts, giving it a very short range of up to 10 metres (33 ft).
- It employs UHF radio waves in the ISM bands, from 2.402 GHz to 2.48 GHz.



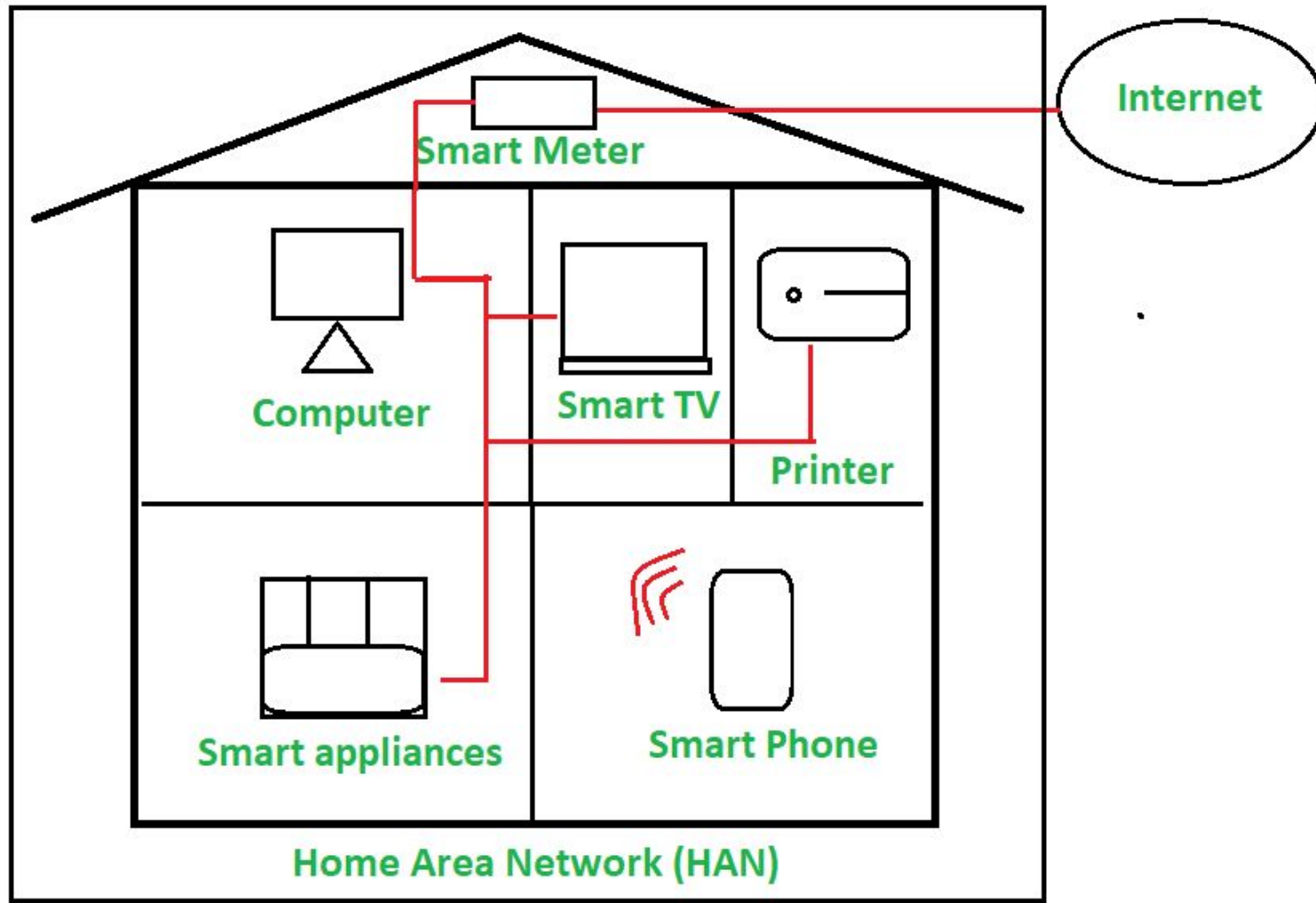
Near Field Communication (NFC)



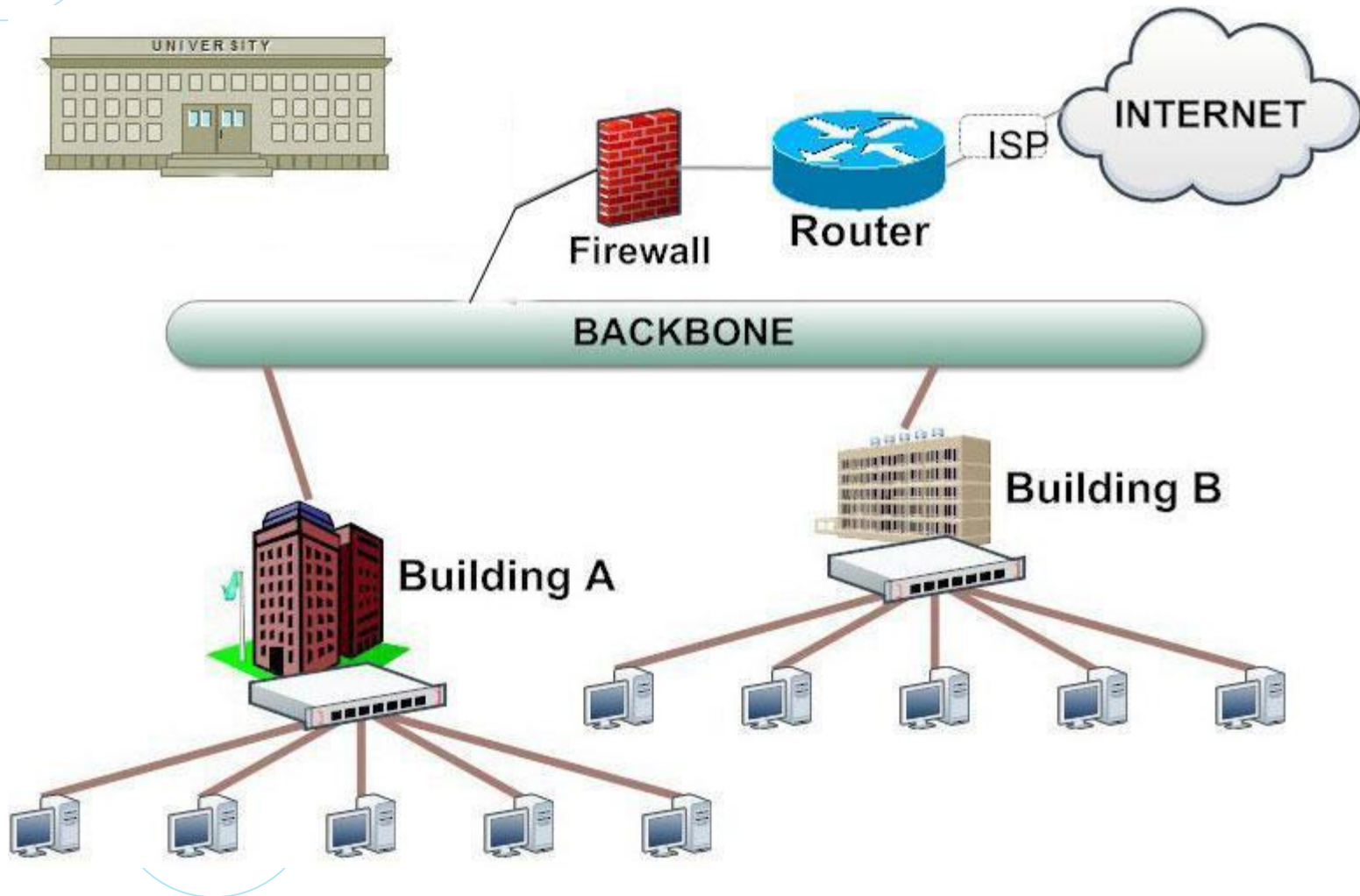
- A **body area network (BAN)**, also referred to as a *wireless body area network (WBAN)* or a *body sensor network (BSN)* or a *medical body area network (MBAN)*, is a wireless network of wearable computing devices.
- BAN devices may be embedded inside the body as implants or pills, may be surface-mounted on the body in a fixed position, or may be accompanied devices which humans can carry in different positions, such as in clothes pockets, by hand, or in various bags.

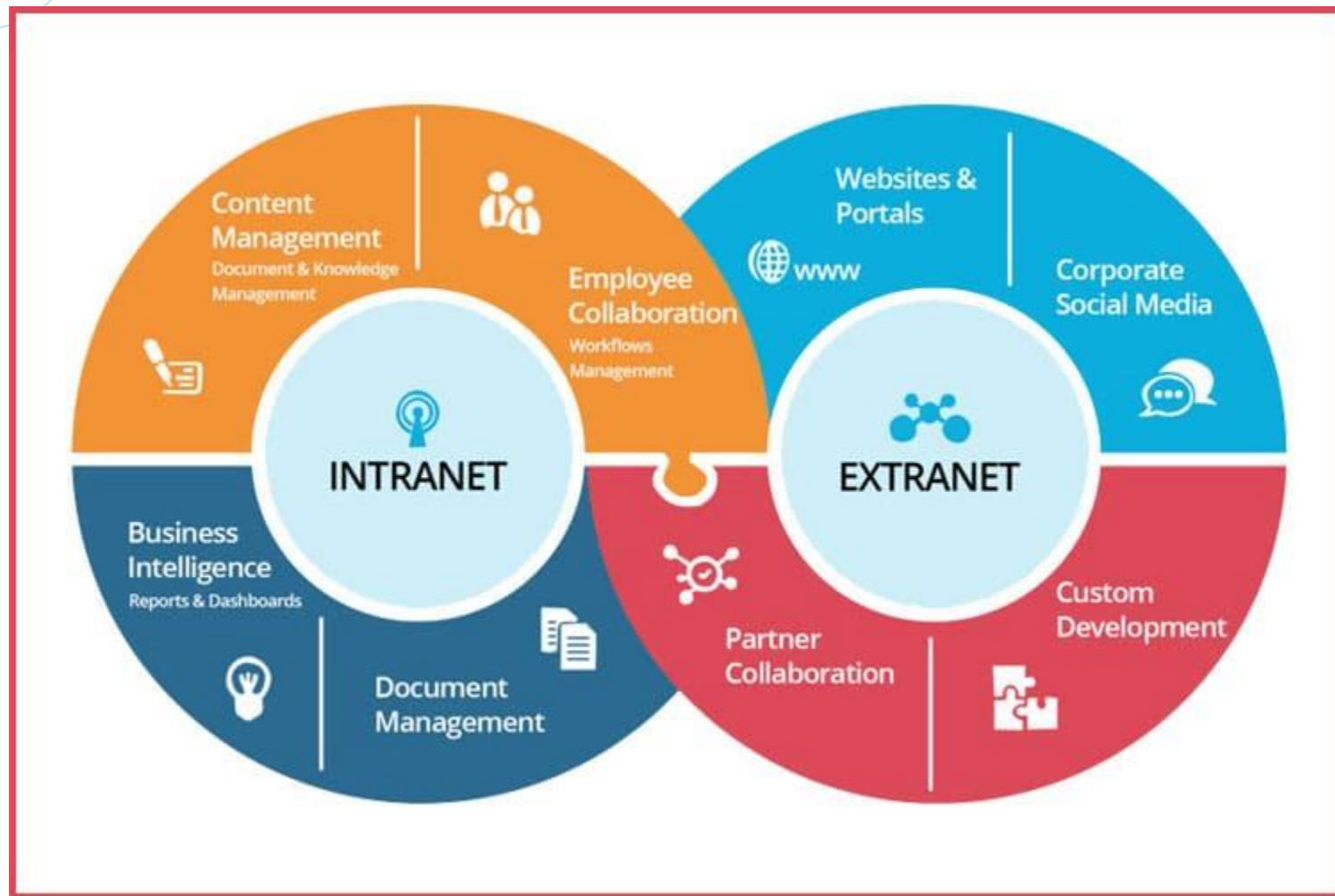


Home Area Network (HAN)

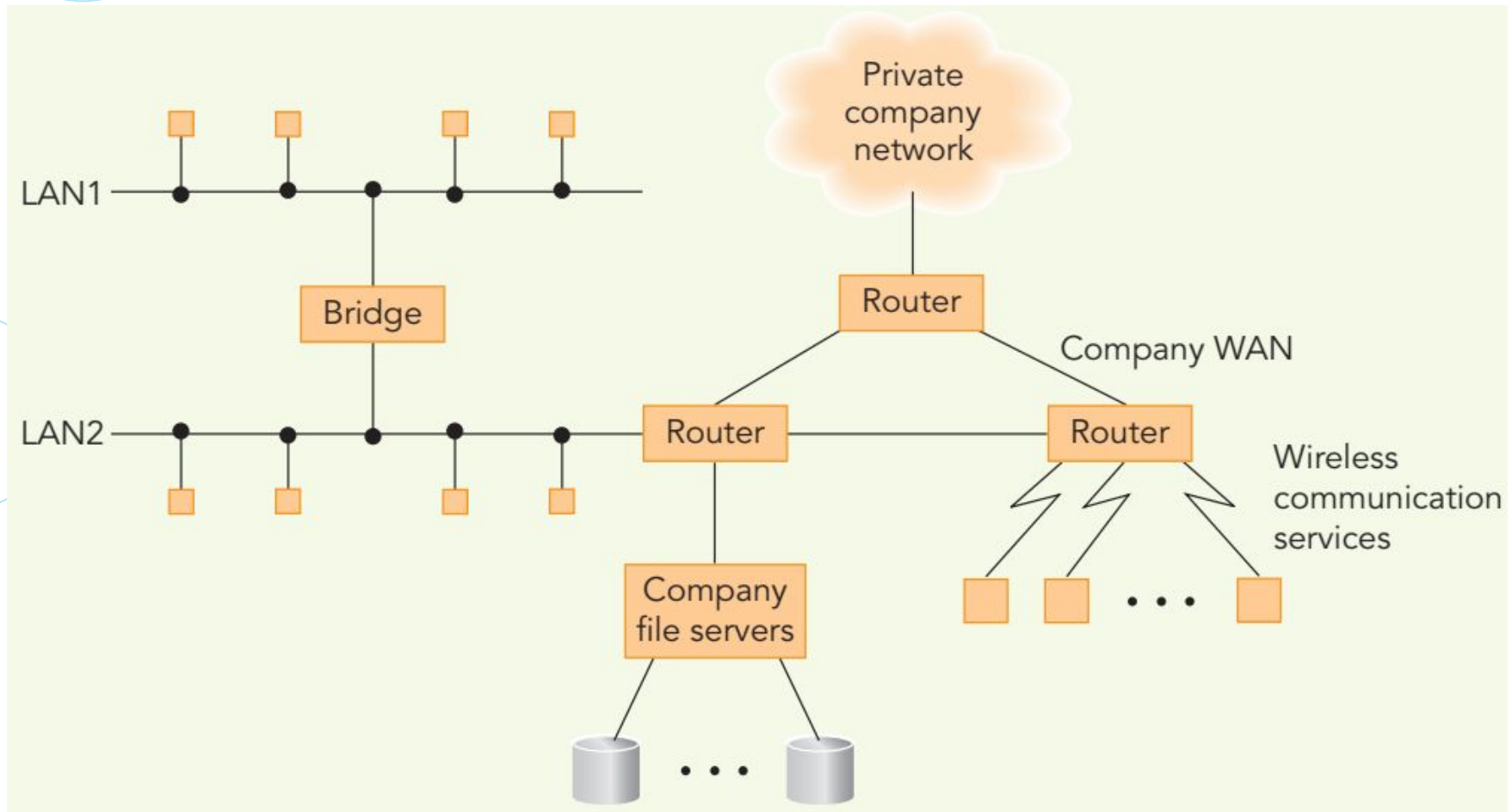


Campus Area Network (CAN)

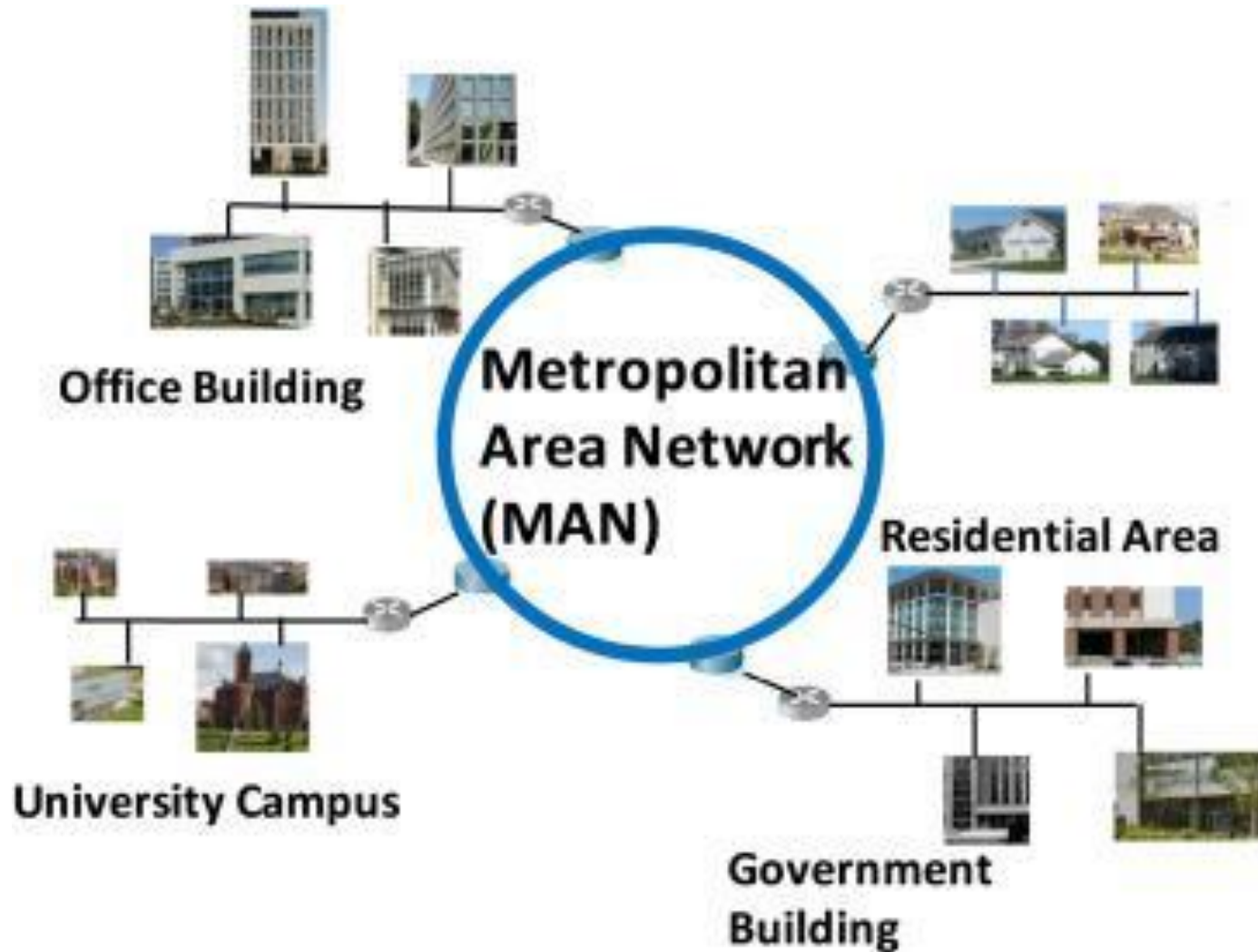


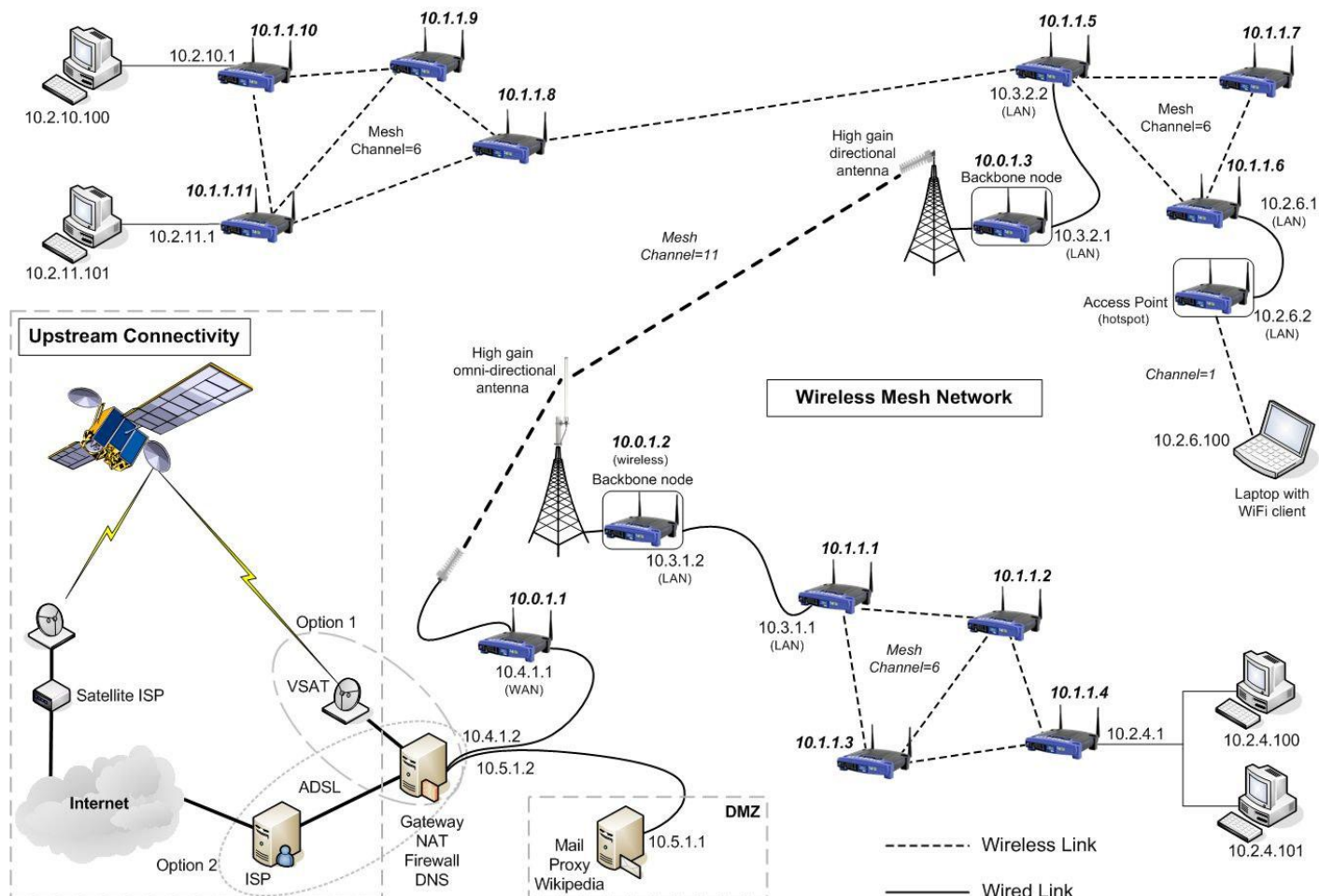


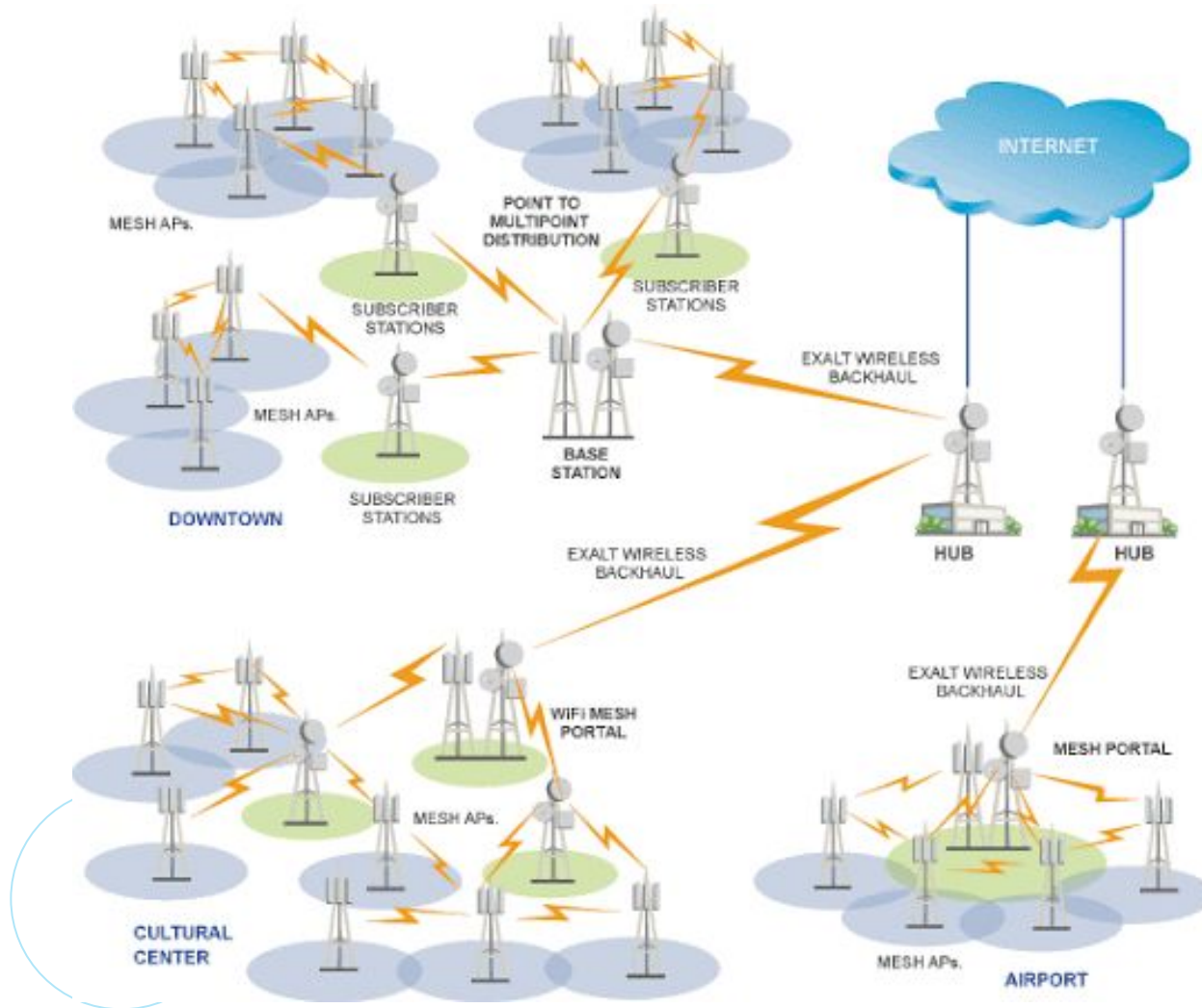
Structure of a Company Network



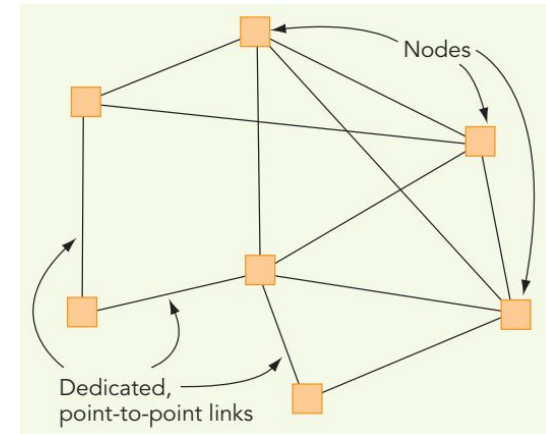
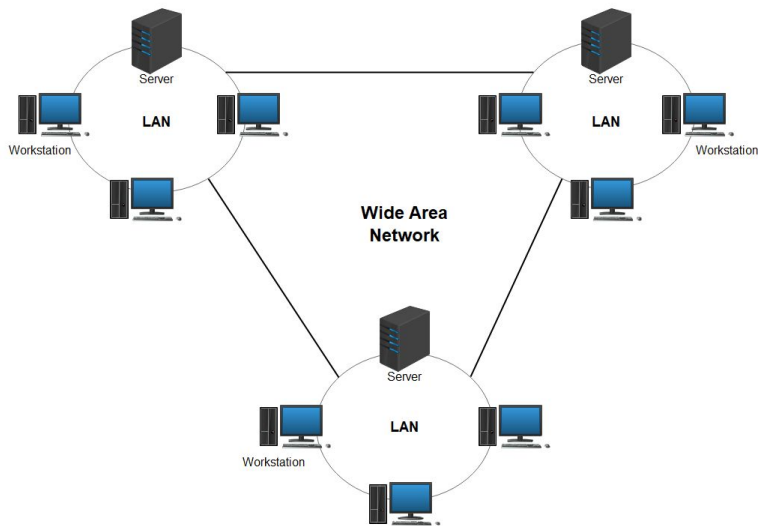
Metropolitan Area Network (MAN)



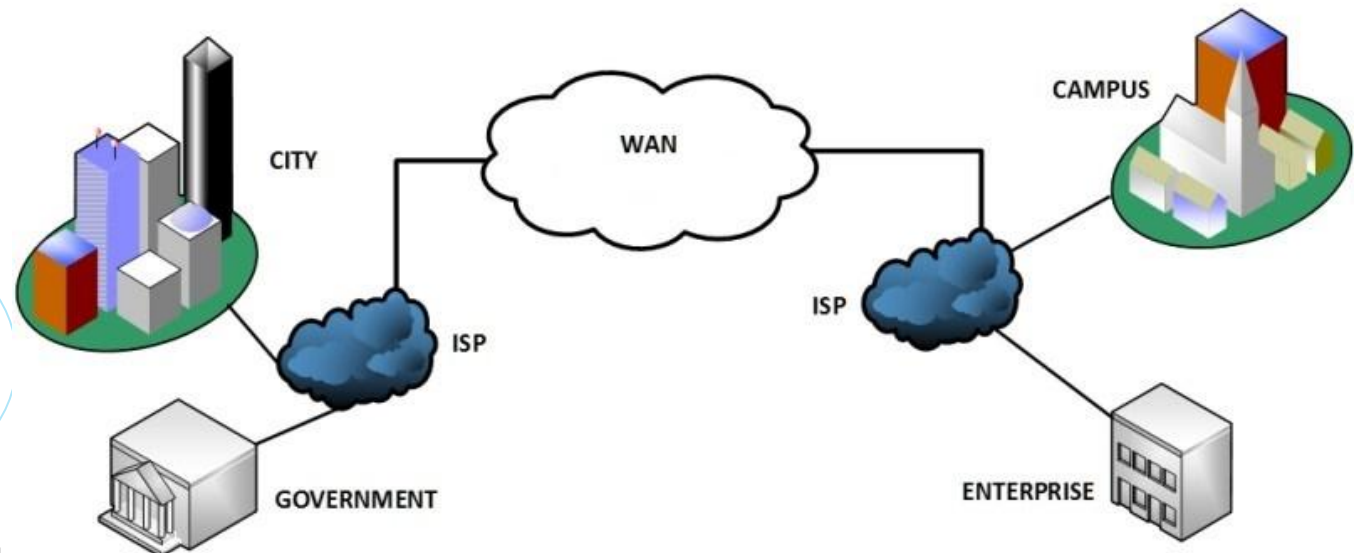




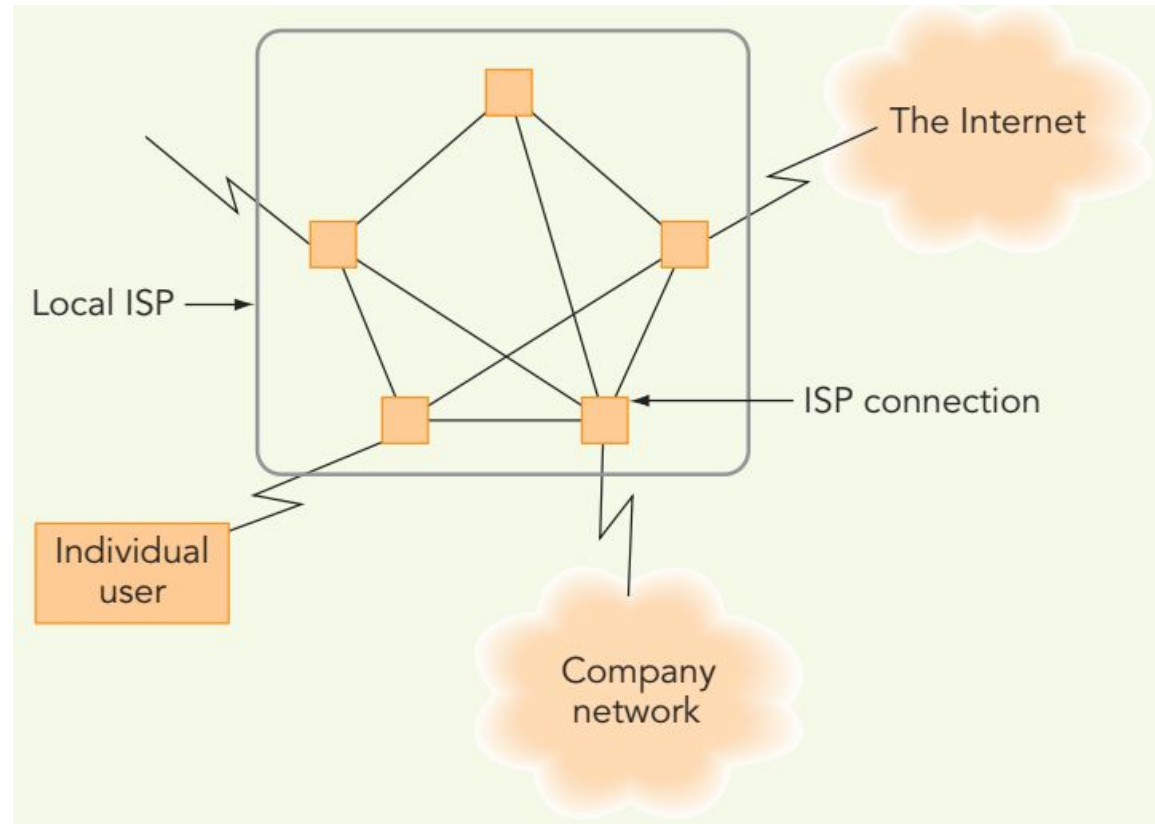
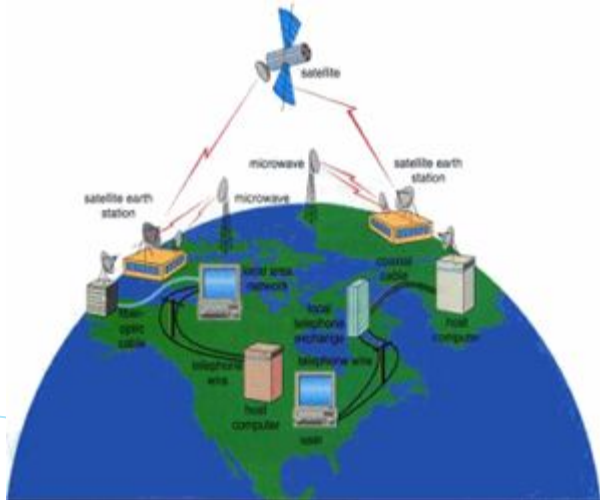
Wide Area Network (WAN)

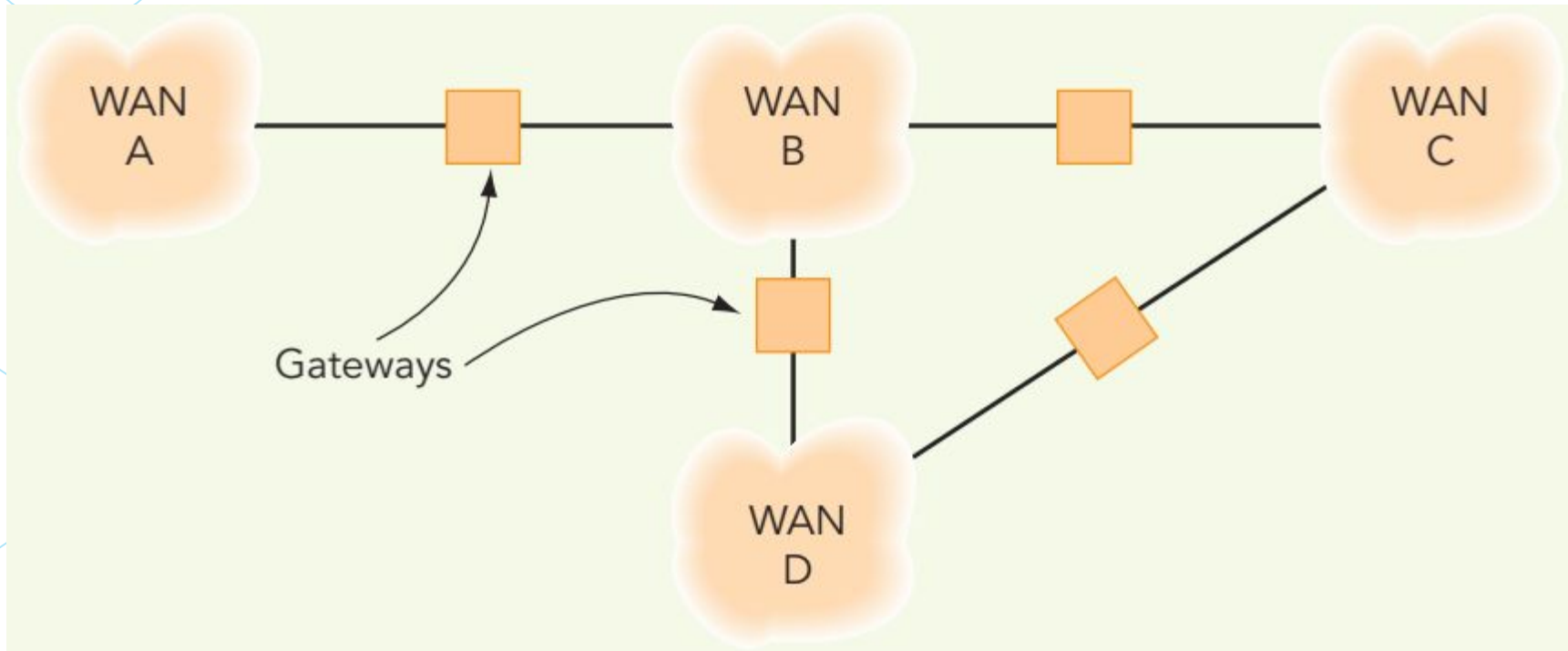


WIDE AREA NETWORK (WAN)

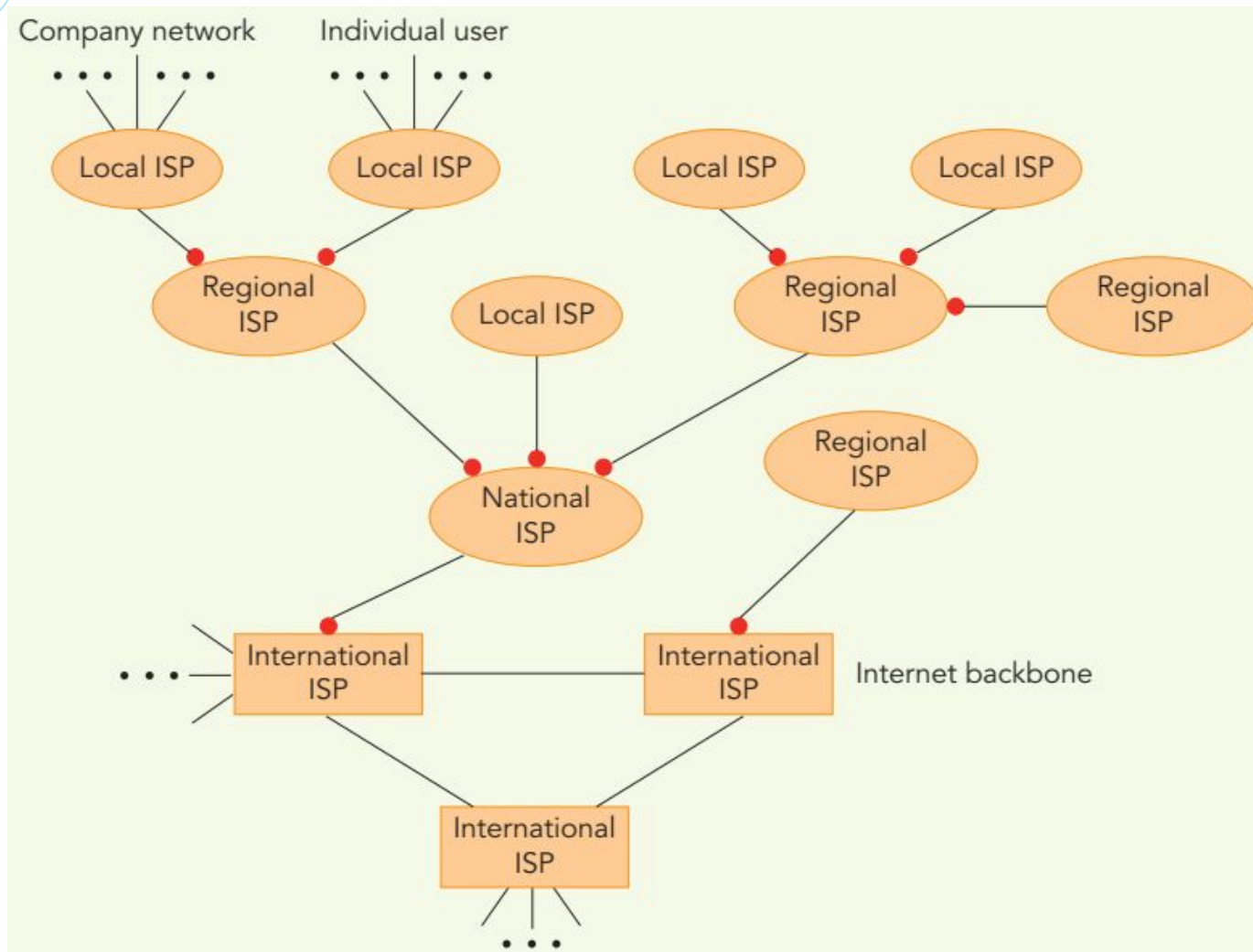


Global Area Network (GAN) - Internet

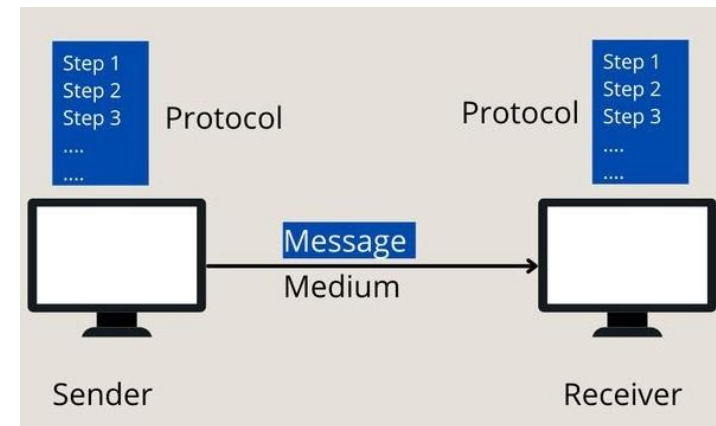




ISP (Internet Service Provider) Hierarchy



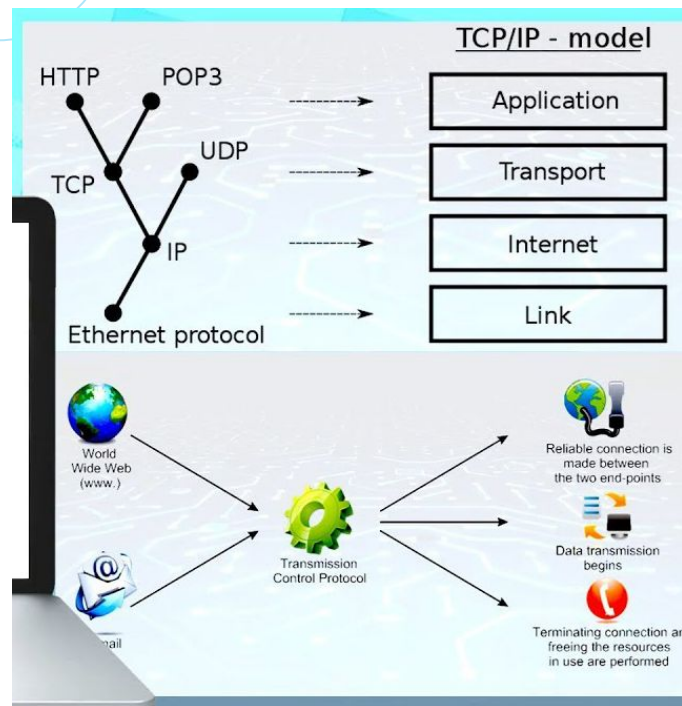
- **Protocol:** a mutually agreed-upon set of rules, conventions, and agreements for the efficient and orderly exchange of information
- **Internet Society**, a nonprofit, nongovernmental, professional society composed of 145 worldwide organizations (foundations, government agencies, educational institutions, companies) along with 80,000 individual members in 100 countries united by the common goal of maintaining the viability and health of the Internet
- Along with subcommittees: the Internet Architecture Board (IAB) and the Internet Engineering Task Force (IETF), establishes and enforces network protocol standards.



TCP/IP hierarchy

Layer	Name	Examples
5	Application	HTTP, SMTP, FTP
4	Transport	TCP, UDP
3	Network	IP
2b	Logical Link Control	PPP, Ethernet
2a	Medium Access Control	Ethernet
1	Physical	Modem, DSL, Cable modem, Wi-Fi, 4G

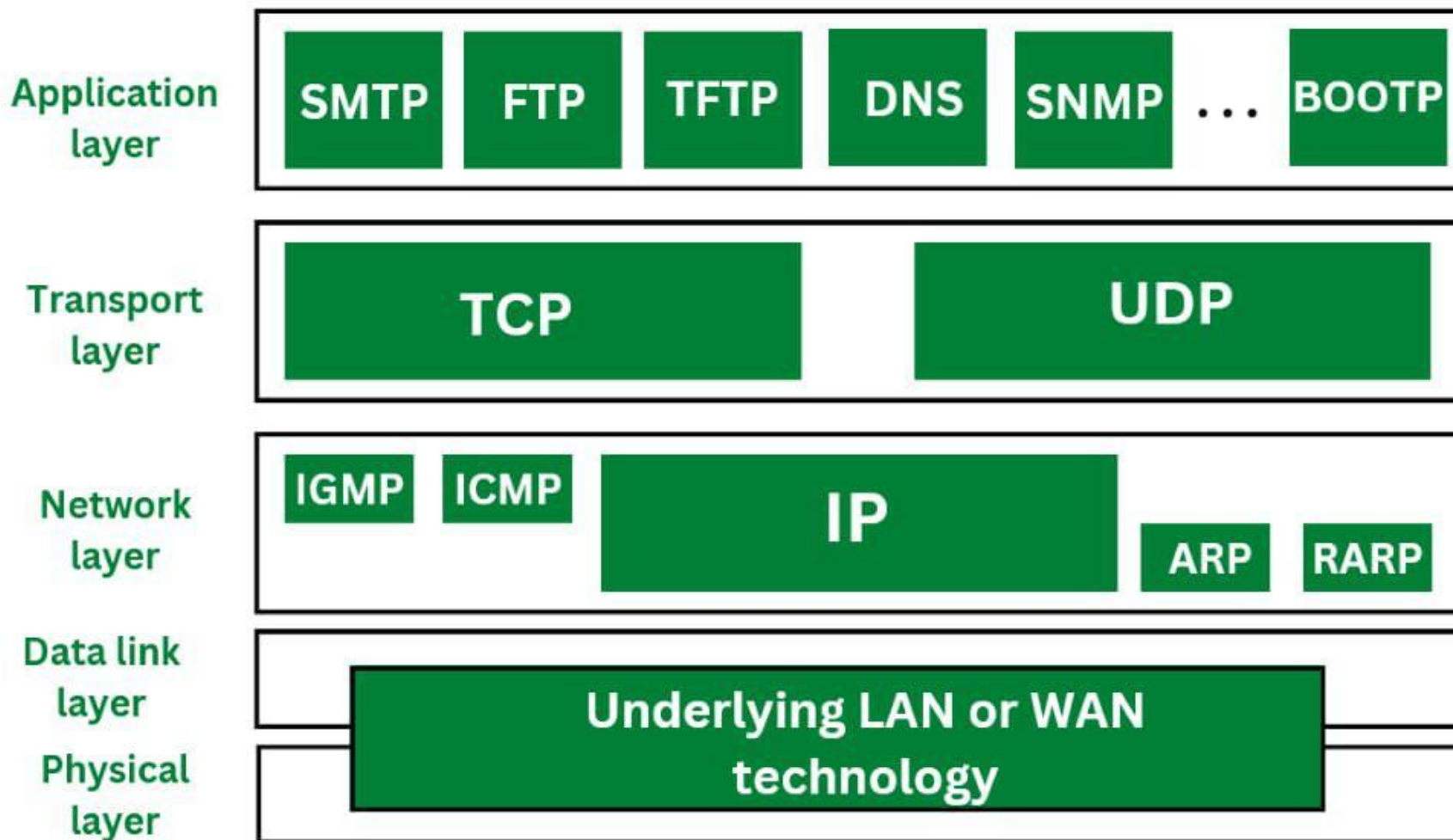
} Data Link layer



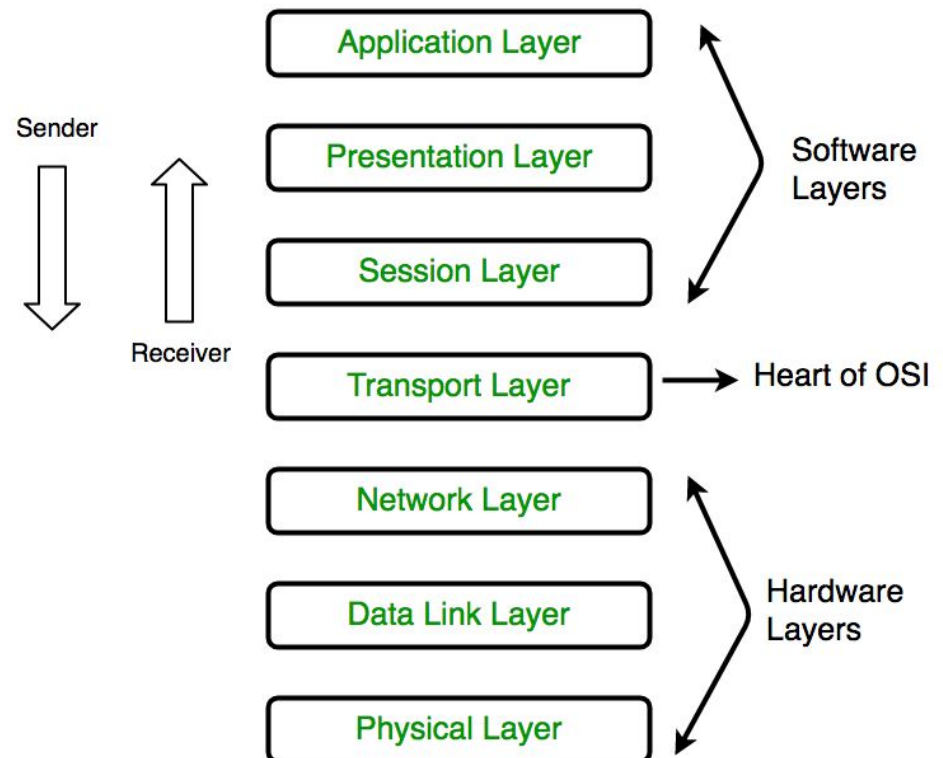
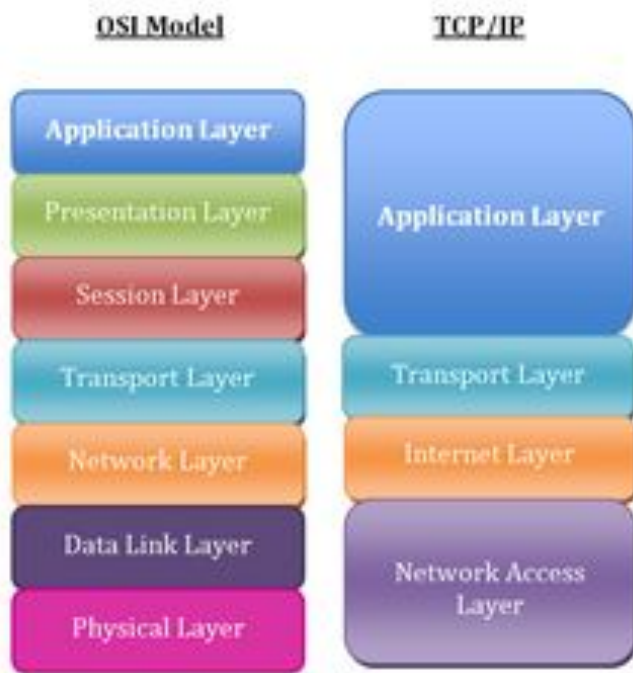
8 Popular Network Protocols

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Protocol	How does It Work?	Use Cases
HTTP		Web Browsing
HTTP/3 (QUIC)		IoT, Virtual Reality
HTTPS		Web Browsing
WebSocket		Live Chat, Real-Time Data Transmission
TCP		Web Browsing, Email Protocols
UDP		Video Conferencing
SMTP		Sending/Receiving Emails
FTP		Upload/Download Files



- **Open Systems Interconnection (OSI) model:** a reference model from the International Organization for Standardization (ISO) that "provides a common basis for the coordination of standards development for the purpose of systems interconnection."



Data Format

Data

Data

Data

Segment

Packet

Frame

Bit

Layer

Application Layer

Presentation Layer

Session Layer

Transport Layer

Network Layer

Data Link Layer

Physical Layer

Function

Applications access network services

Encryption and Compression of data

Connection management b/w nodes

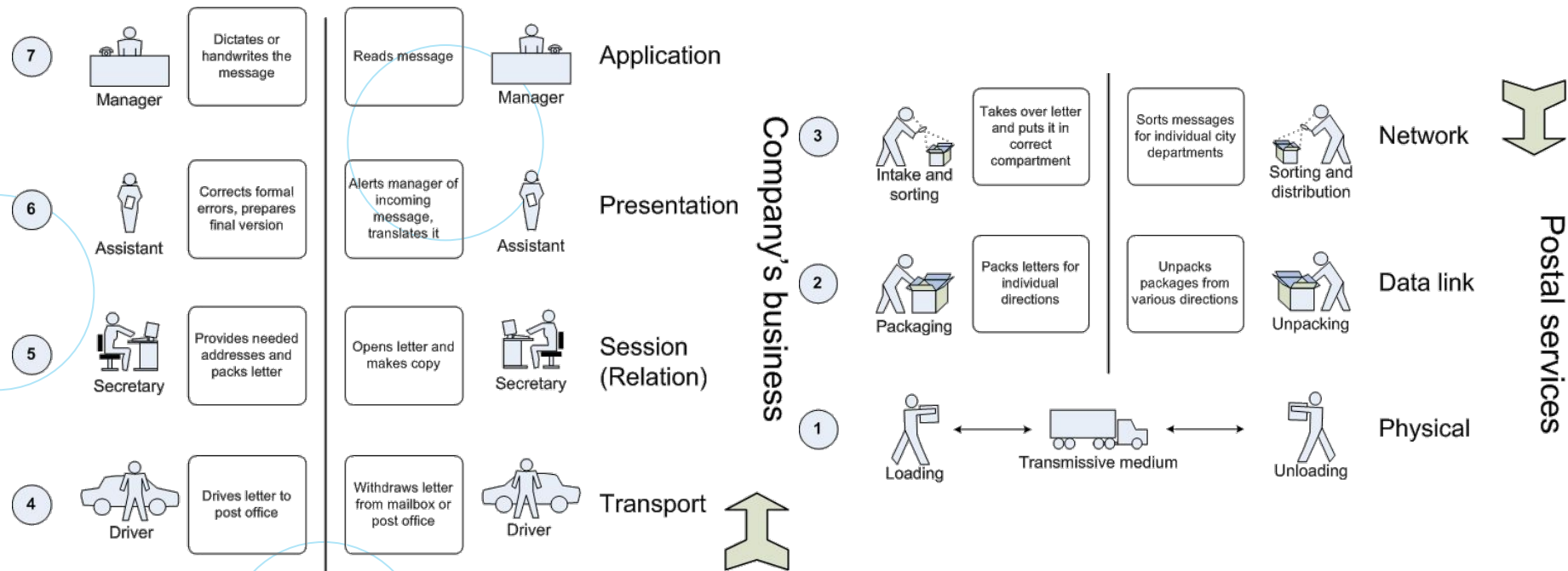
Maintains data flow during transmission

Determine the path for data transfer

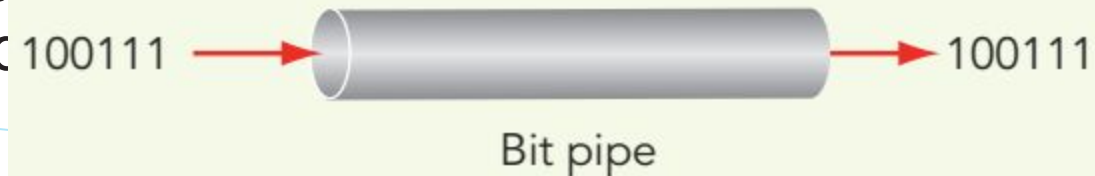
Connect physical nodes for transfer

Transfer raw bits using physical mode

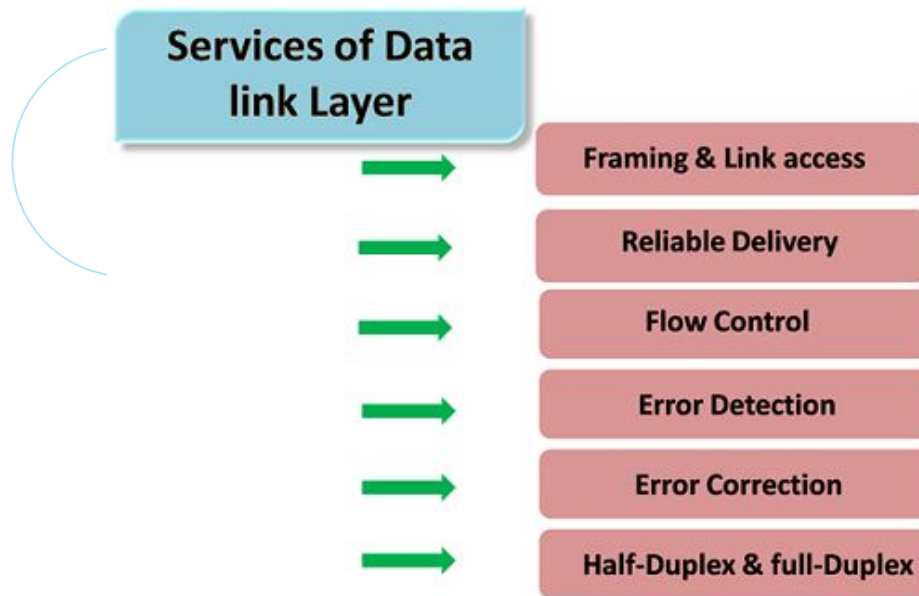
OSI and Letter Communication



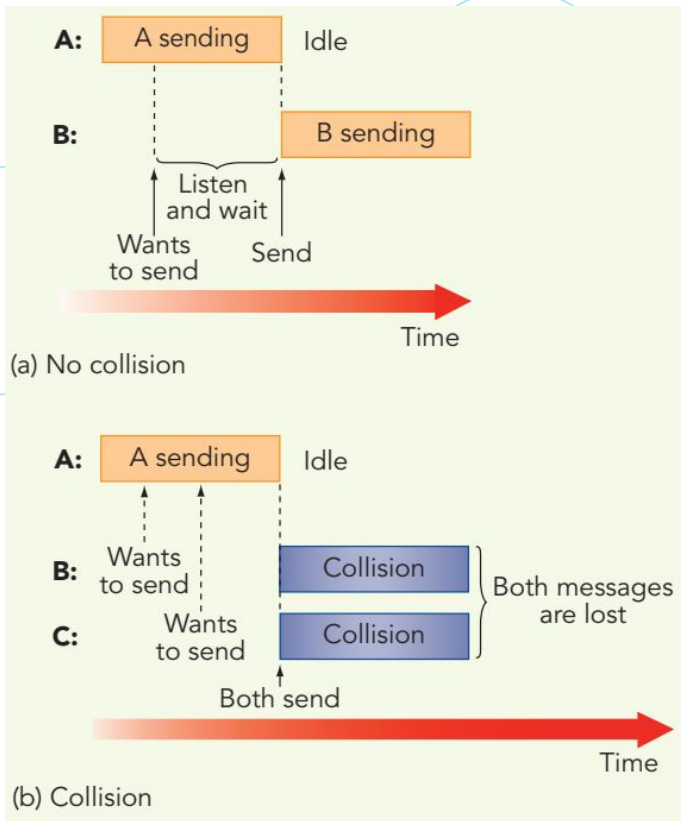
- **Physical layer protocols** govern the exchange of binary digits (bits) across a physical communication channel, such as a fiber-optic cable, copper wire, or wireless radio channel, especially:
 - How we know when a bit is present on the line
 - How much time the bit will remain on the line
 - Whether the bit is in the form of a digital or an analog signal
 - The physical quantities used to represent a binary 0 and a binary 1
 - The shape of the physical connector between the computer and transmission line
- The goal: create a “bit pipe” between two computers, such that bits put into the pipe at one end can be read and understood at the other end,



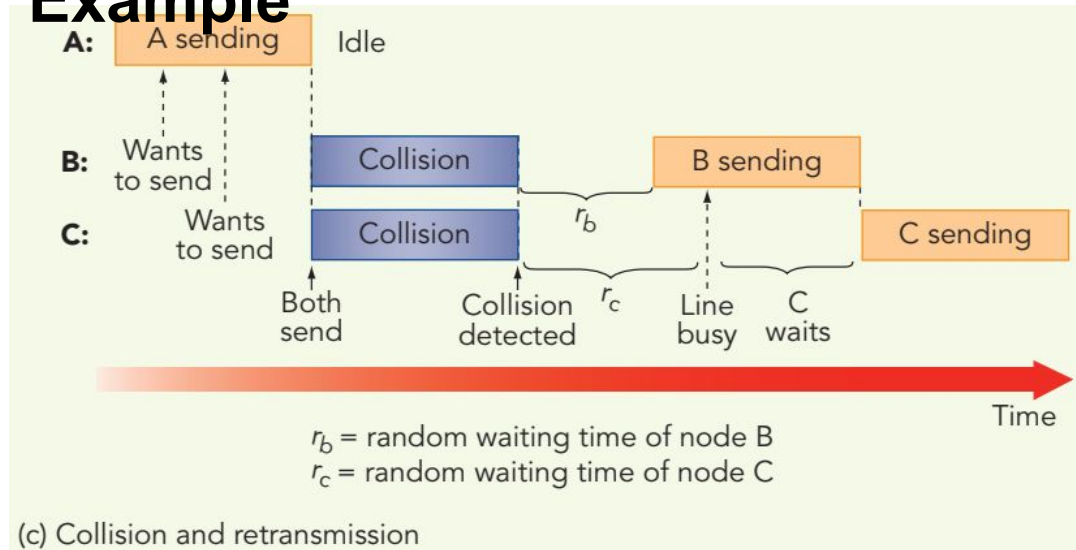
- Decide the formation of the data of data on the network



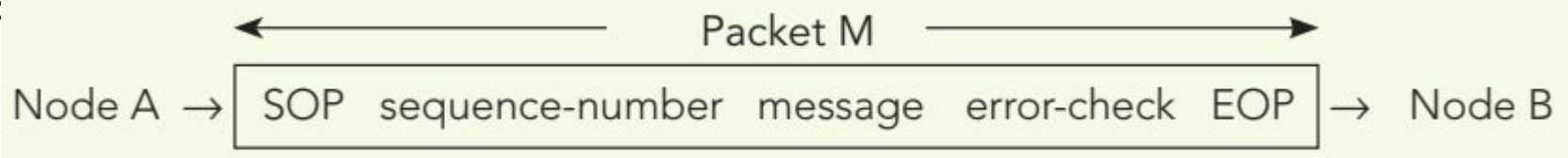
- **Medium Access Control (MAC) protocols:** determine how to arbitrate ownership of a shared communication line when multiple nodes want to send messages at the same time.



Ethernet Example



- **Logical Link Control protocols:** solve the error detection and correction problem and ensure that the message traveling across this channel from source to destination arrives correctly.

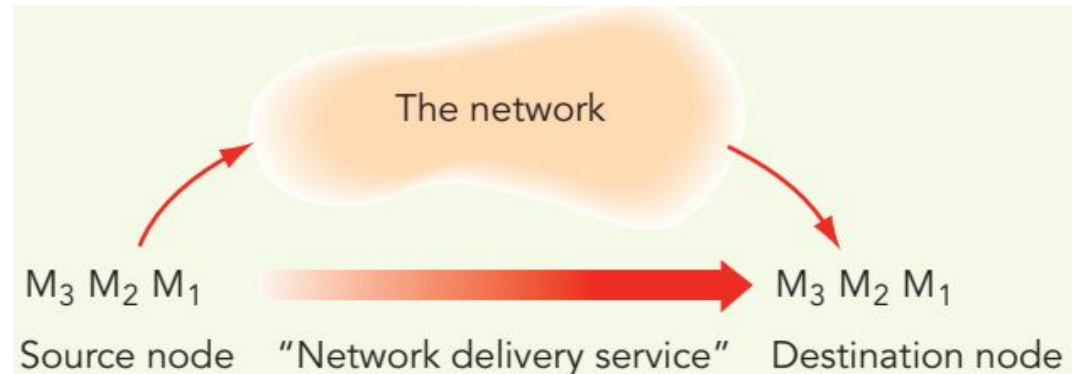
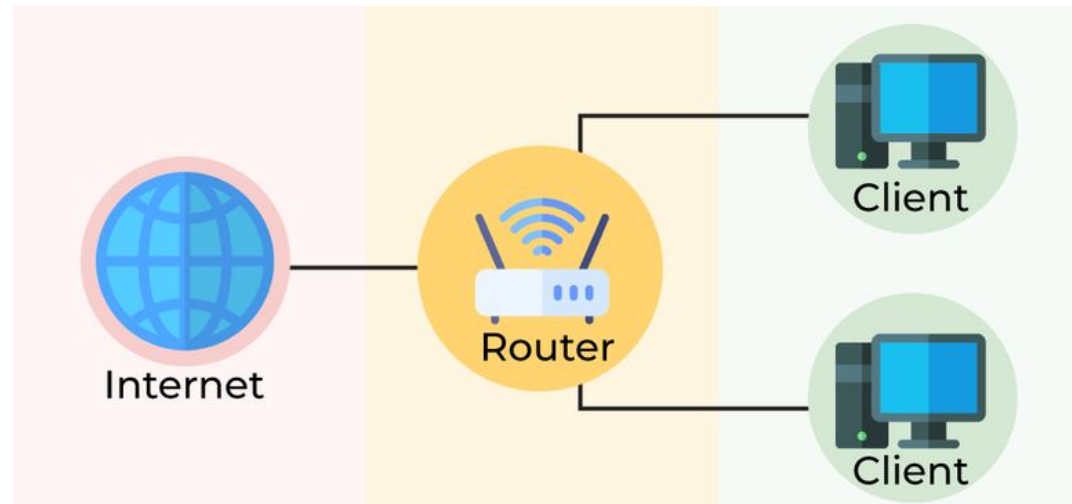


A	B	
M(1) →		Send the first packet from A to B
	← ACK(1)	B says to A, "I got it," A can discard it
M(2) →		Send the second packet from A to B
	← ACK(2)	B says to A, "I got it," A can discard it
⋮		

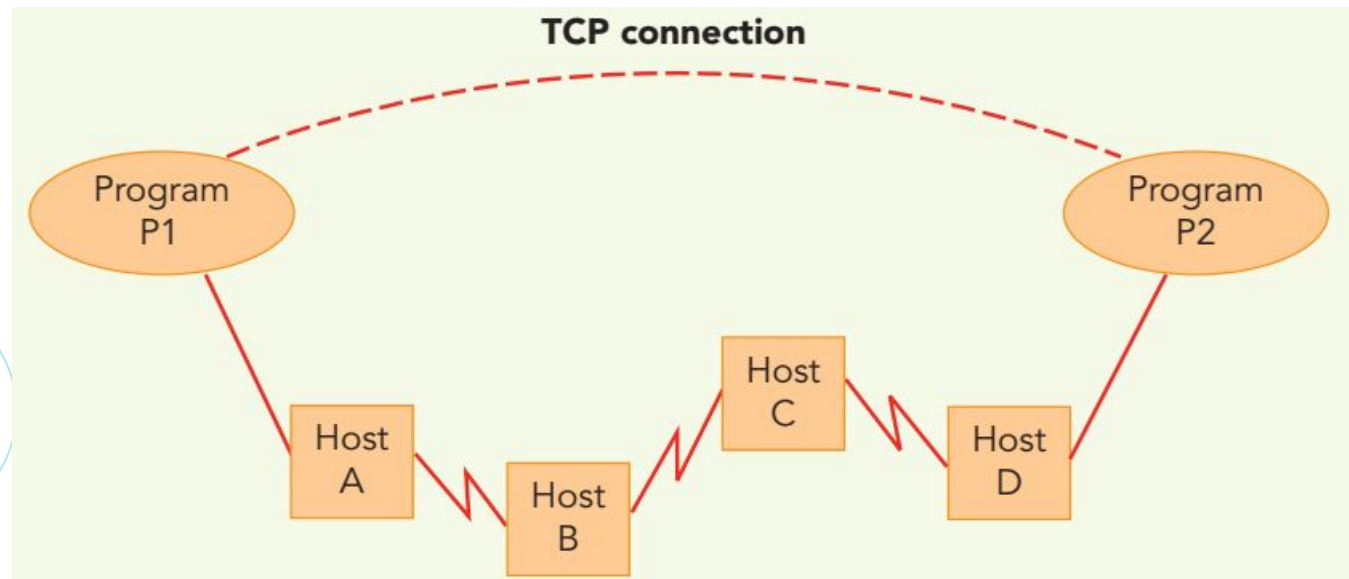
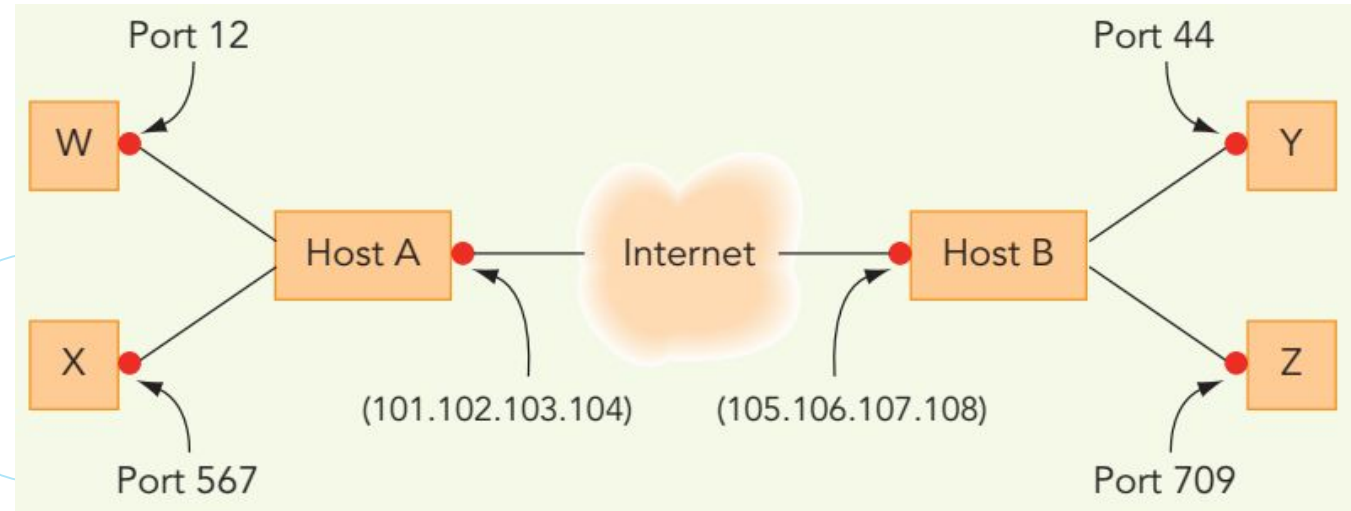


- **Network layer (Internet) protocols:** deliver a message from the site where it was created to its ultimate destination.

- Creating a universal addressing scheme for all network nodes
- Delivering messages between any two nodes in the network.
- Decides which physical path the data will take (routing)



- Transmits data using transmission protocols including TCP (Transport Control Protocol) and UDP (User Datagram Protocol)

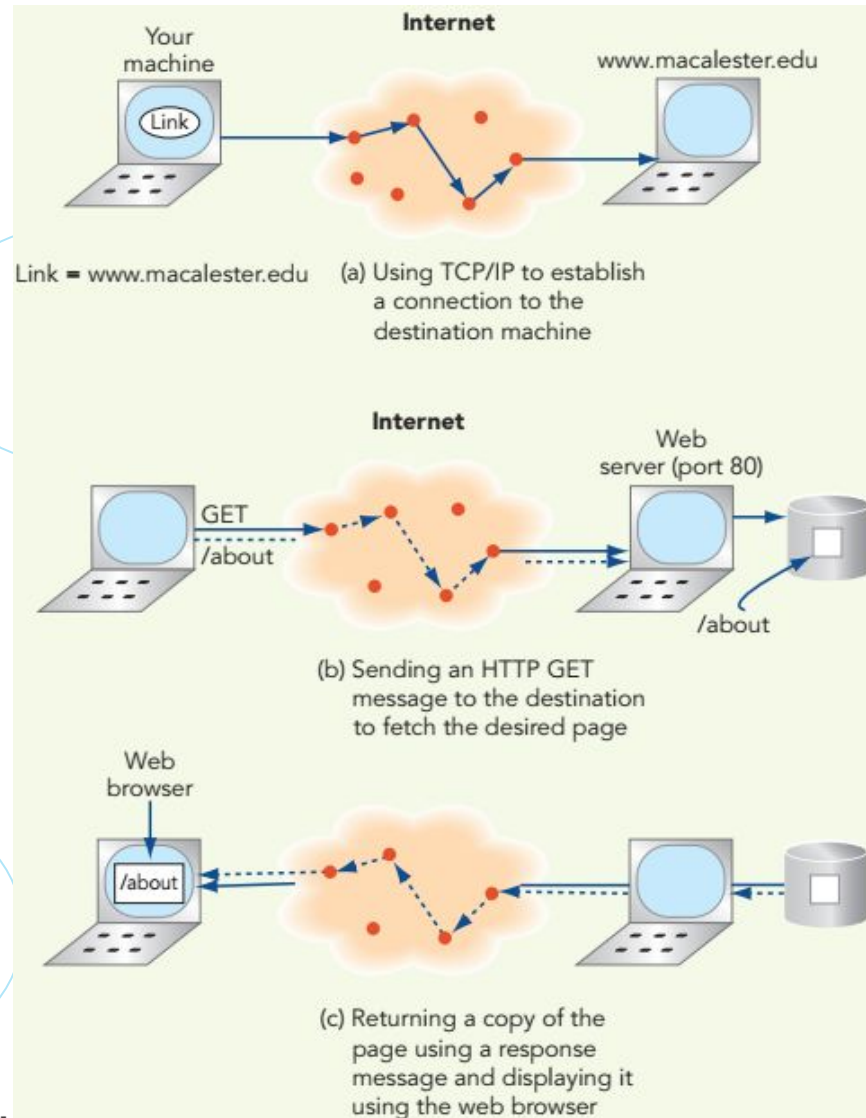


TCP VS UDP



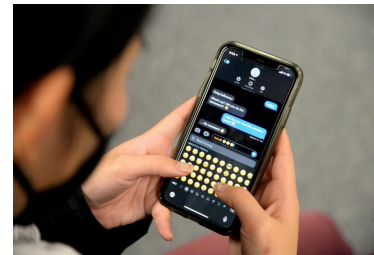
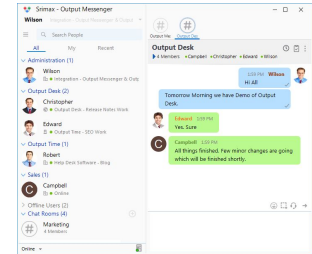
- Application Layer: Human-Computer interaction layer, where applications can access network services
- Presentation Layer: Ensure that data is in usable format and is where data encryption occurs
- Session Layer: Maintain connections and responsible for controlling ports and sessions

Acronym Name		Application	Well-Known Port
HTTP	Hypertext Transfer Protocol	Accessing webpages	80
SMTP	Simple Mail Transfer Protocol	Sending email	25
POP3	Post Office Protocol	Receiving email	110
IMAP	Internet Message Access Protocol	Receiving email	143
FTP	File Transfer Protocol	Accessing remote files	21
TELNET	Terminal Emulation Protocol	Accessing remote terminals	23
DNS	Domain Name System	Translating symbolic host names to IP addresses	42



• Interpersonal Communication

- Email: about 400 billion a day
- Bulletin board system
- Internet forum
- Chat room
- Texting: about 100 billion a day

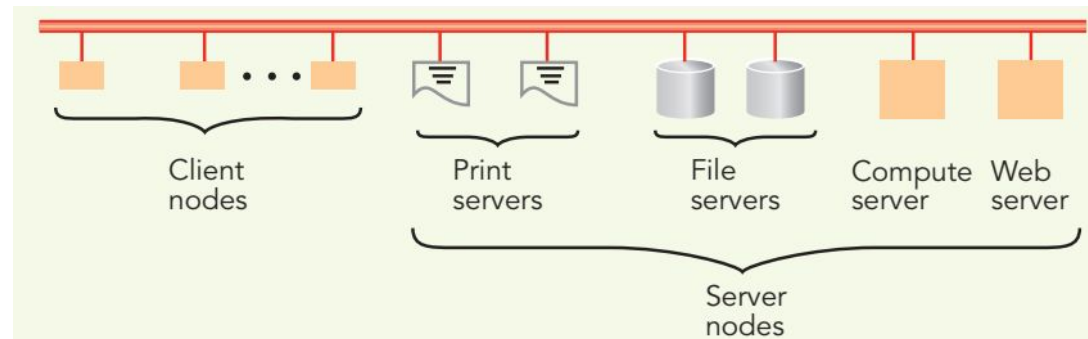


• Social Networking

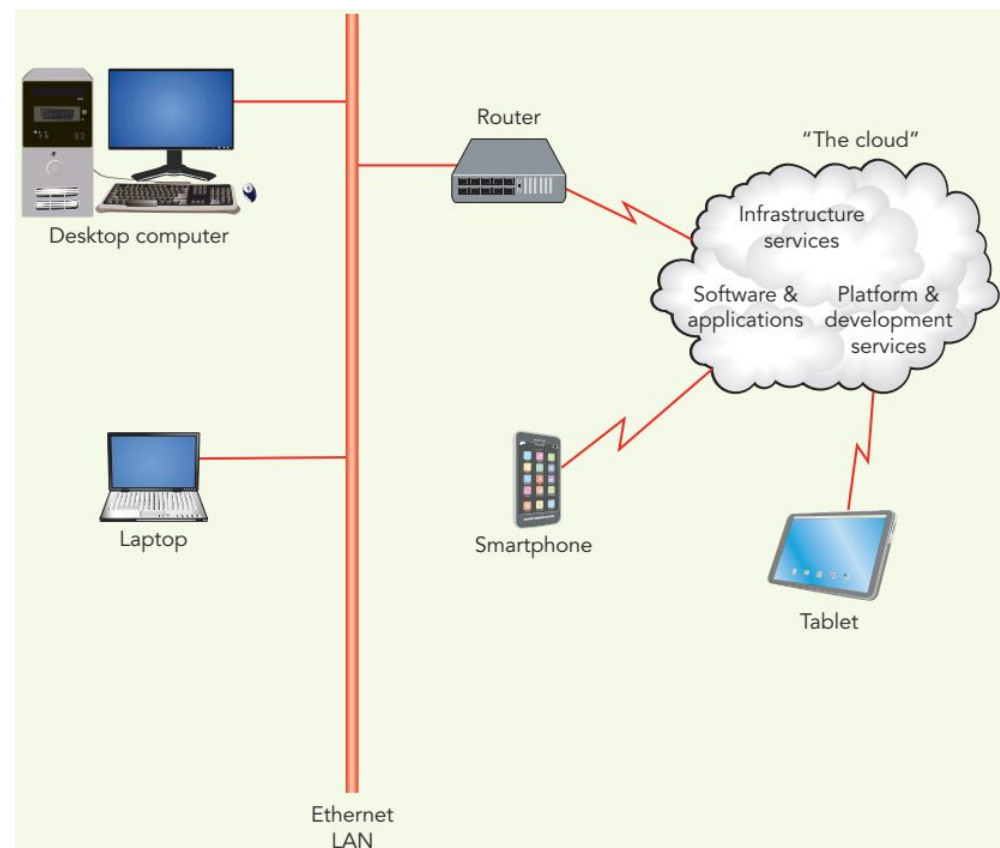
• Resource Sharing

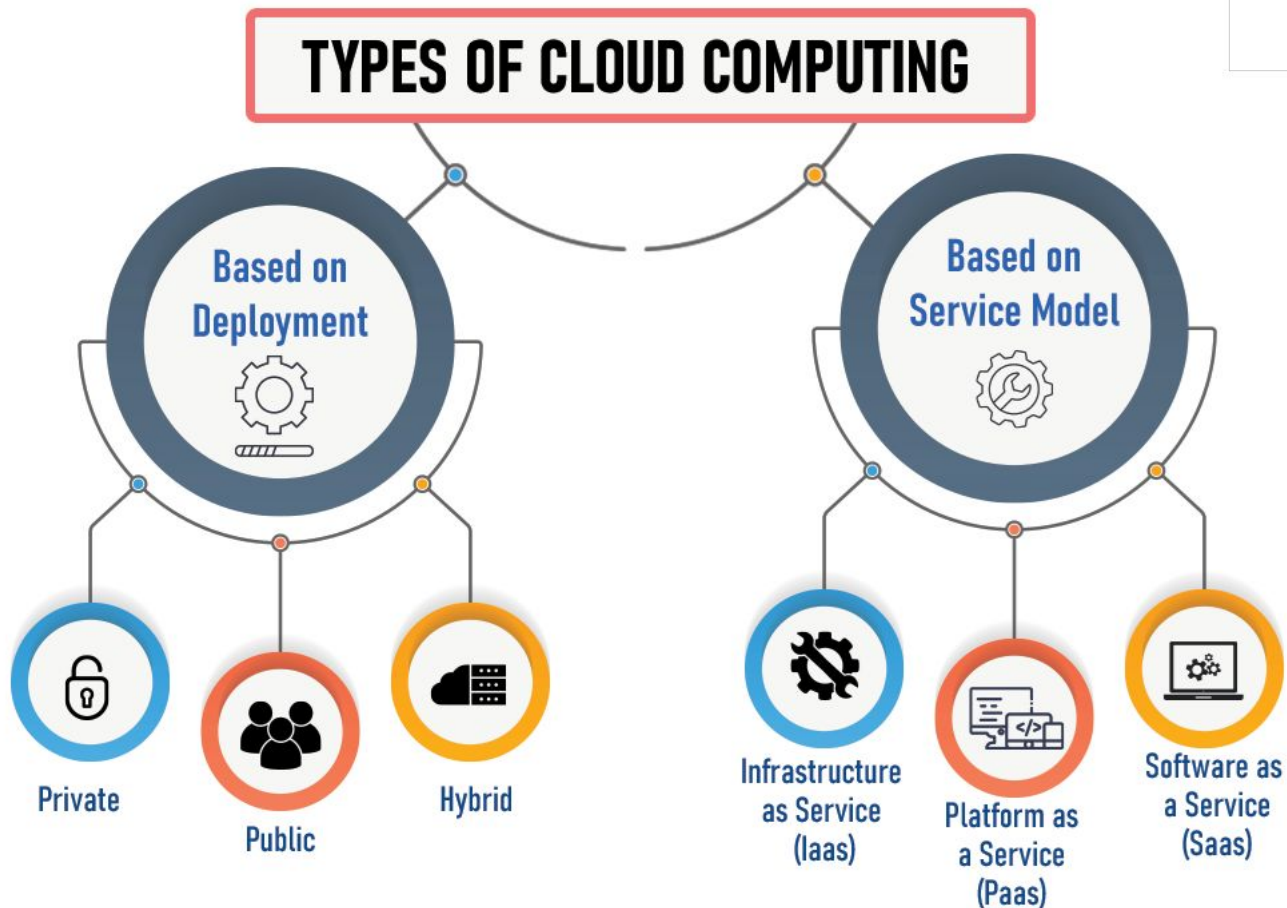
- Print Server
- File Server
- Client/server Computing

• Electronic Commerce



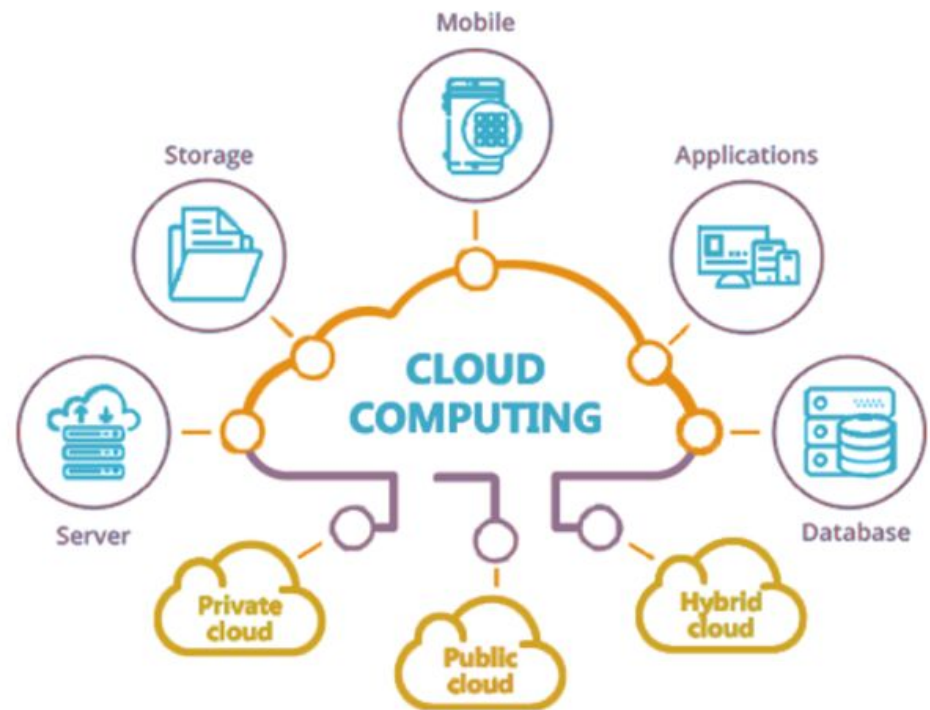
- **Cloud computing** is the on-demand availability of computer system resources, especially data storage (cloud storage) and computing power, without direct active management by the user.



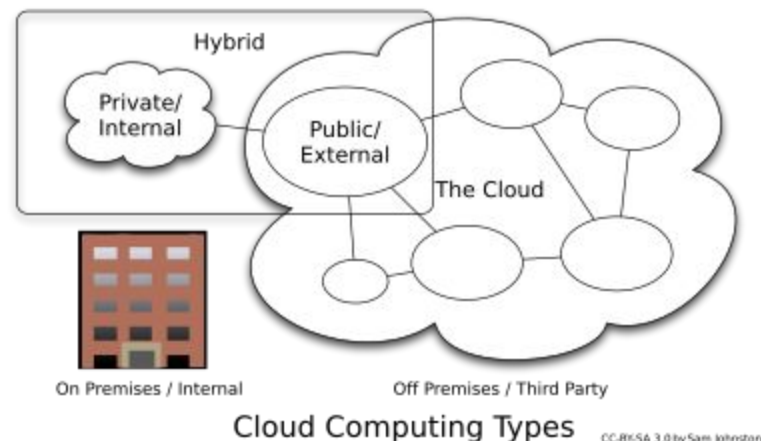


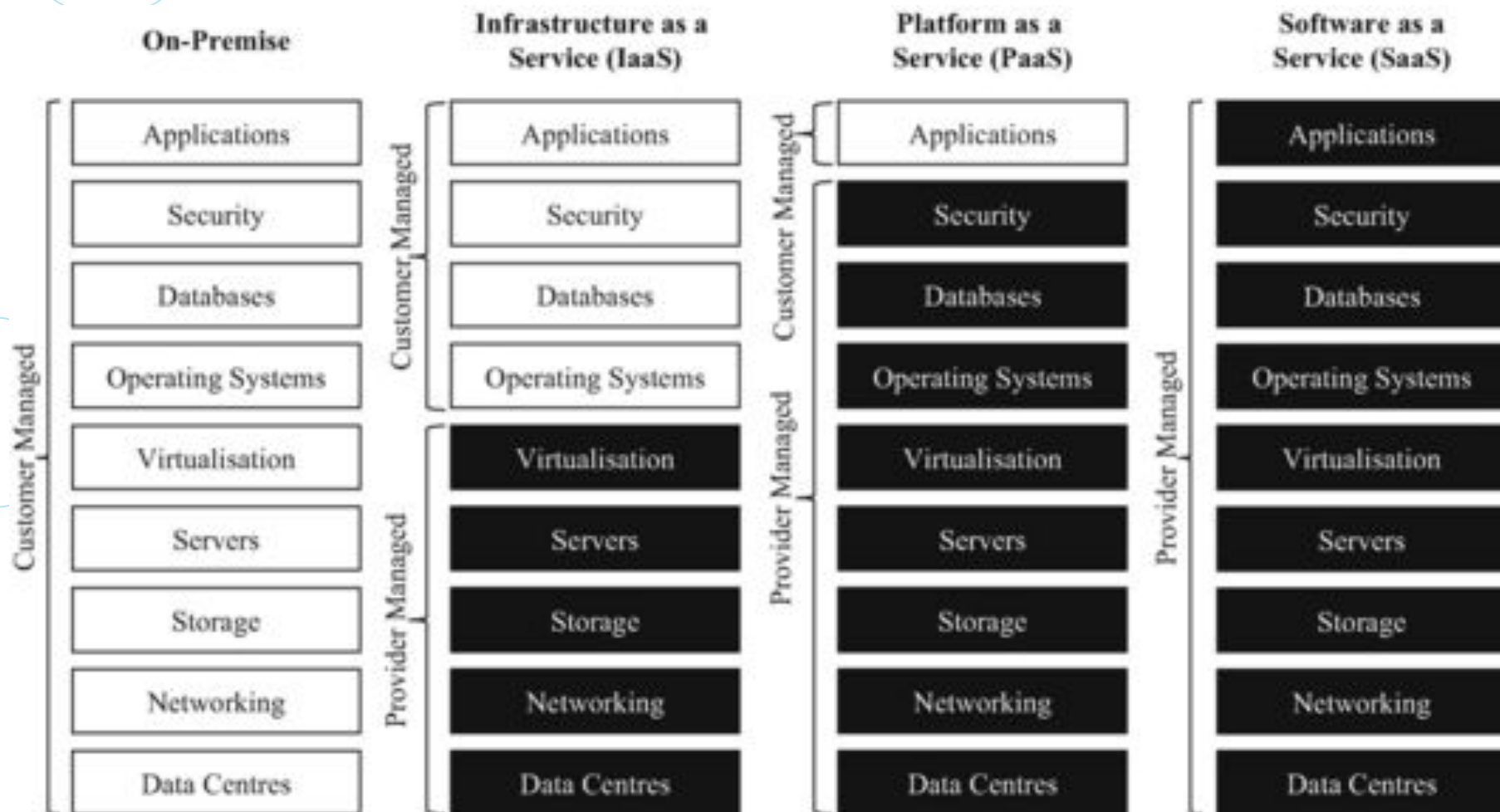
- **On-demand self-service:** A consumer can unilaterally provision computing capabilities, such as server time and network storage, as needed automatically without requiring human interaction with each service provider.
- **Broad network access:** Capabilities are available over the network and accessed through standard mechanisms that promote use by heterogeneous thin or thick client platforms (e.g., mobile phones, tablets, laptops, and workstations)
- **Resource pooling:** The provider's computing resources are pooled to serve multiple consumers using a multi-tenant model, with different physical and virtual resources dynamically assigned and reassigned according to consumer demand
- **Rapid elasticity:** Capabilities can be elastically provisioned and released, in some cases automatically, to scale rapidly outward and inward commensurate with demand. To the consumer, the capabilities available for provisioning often appear unlimited and can be appropriated in any quantity at any time.
- **Measured service.** Cloud systems automatically control and optimize resource use by leveraging a metering capability at some level of abstraction appropriate to the type of service (e.g., storage, processing, bandwidth, and active user accounts). Resource usage can be monitored, controlled, and reported, providing transparency for both the provider and consumer of the utilized service, although for some organizations the revenue impact of high usage may affect profitability, compared to an option of sunk capital costs.

- Cost Reduction
- Device Independent
- Maintenance
- Multitenancy
- Performance
- Productivity
- Availability
- Scalability
- Elasticity
- Security

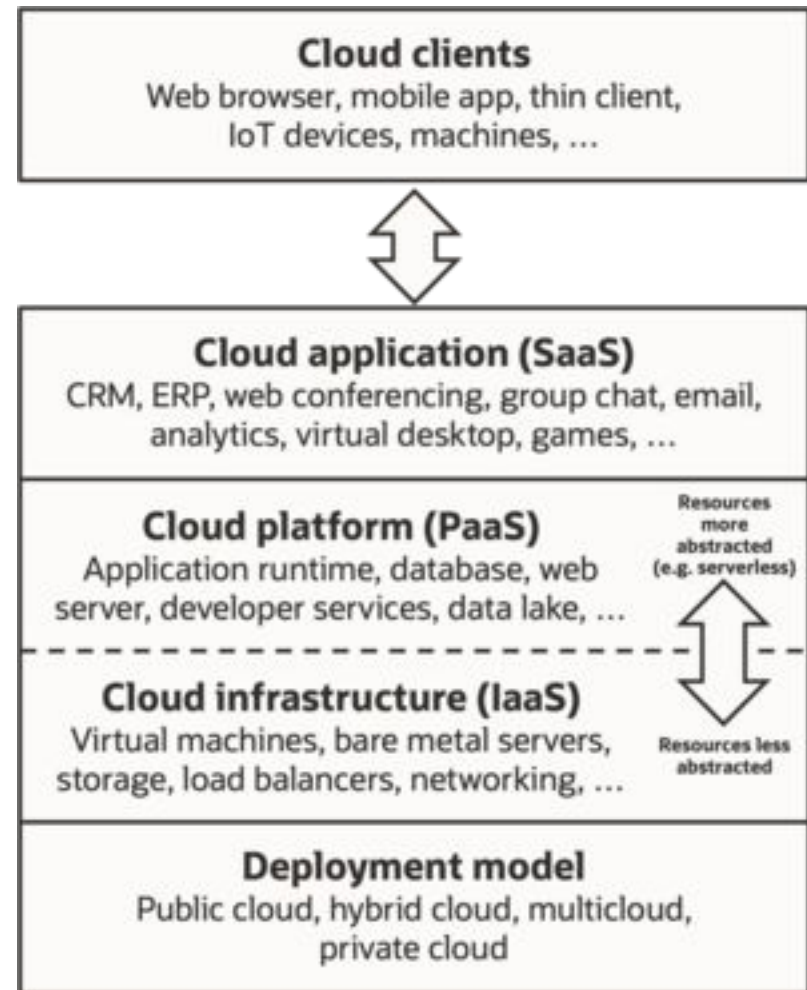


- Private: cloud infrastructure operated solely for a single organization, managed internally or by a third party, and hosted either internally or externally.
- Public: delivered over the public Internet, and may be offered as a paid subscription, or free of charge.
- Hybrid
- Community cloud: shares infrastructure between several organizations, managed internally or by a third-party, and hosted internally or externally





- IaaS: online services that provide high-level APIs used to abstract various low-level details of underlying network infrastructure like physical computing resources, location, data partitioning, scaling, security, backup, etc.
- PaaS: The capability provided to the consumer is to deploy onto the cloud infrastructure consumer-created or acquired applications created using programming languages, libraries, services, and tools supported by the provider. The consumer does not manage or control the underlying cloud infrastructure including network, servers, operating systems, or storage, but has control over the deployed applications and possibly configuration settings for the application-hosting environment.



- SaaS: The capability provided to the consumer is to use the provider's applications running on a cloud infrastructure. The consumer does not manage or control the underlying cloud infrastructure including network, servers, operating systems, storage, or even individual application capabilities, with the possible exception of limited user-specific application configuration settings.
- (Mobile) Backend as a Service – (M)BaaS: web app and mobile app developers are provided with a way to link their applications to cloud storage and cloud computing services with application programming interfaces (APIs) exposed to their applications and custom software development kits (SDKs). Services include user management, push notifications, integration with social networking services and more.

- SaaS: The capability provided to the consumer is to use the provider's applications running on a cloud infrastructure. The consumer does not manage or control the underlying cloud infrastructure including network, servers, operating systems, storage, or even individual application capabilities, with the possible exception of limited user-specific application configuration settings.
- (Mobile) Backend as a Service – (M)BaaS: web app and mobile app developers are provided with a way to link their applications to cloud storage and cloud computing services with application programming interfaces (APIs) exposed to their applications and custom software development kits (SDKs). Services include user management, push notifications, integration with social networking services and more.
- Serverless computing (Function as a Service – FaaS): cloud computing code execution model in which the cloud provider fully manages starting and stopping virtual machines as necessary to serve requests.



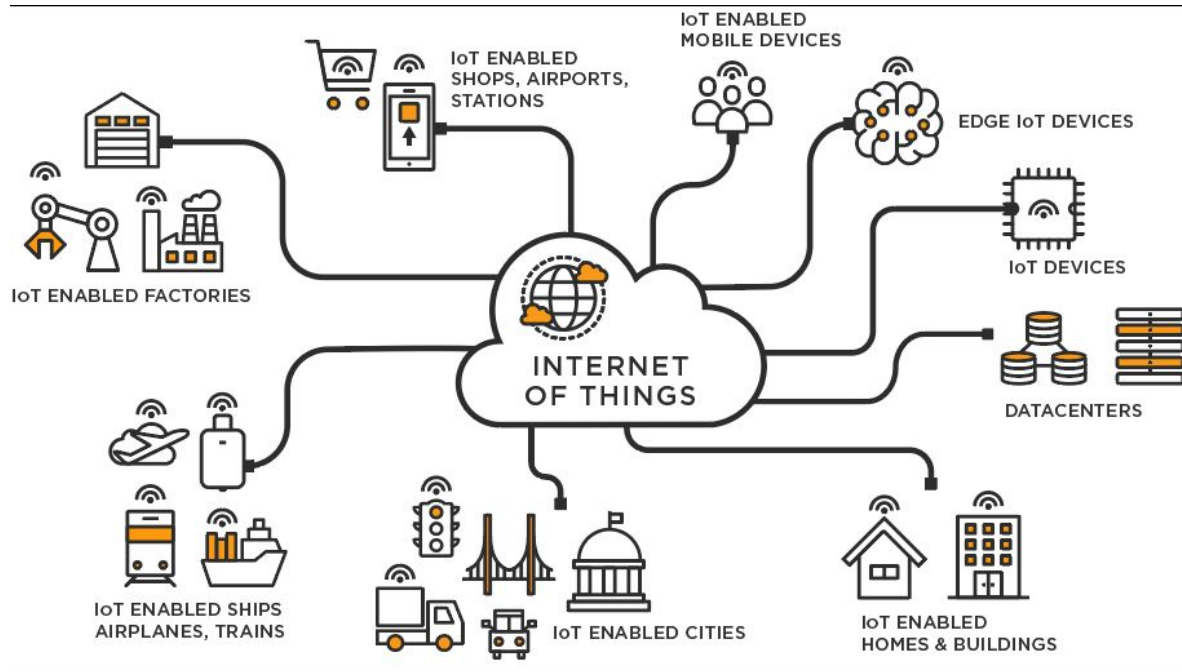
WHAT IS THE INTERNET OF THINGS?

The Internet of Things (IoT), refers to the online networks of devices and objects, which communicate with other devices in the same network via connections to data centers.

The Motley Fool



The applications for IoT technology are diverse and seemingly limitless. From home security to asset tracking to chronic disease management, IoT companies are uncovering new opportunities every day.



-  **HOME**
- Smart Temperature Control
 - Optimized Energy Use

-  **INDUSTRIAL**
- Machine-to-Machine Communication
 - Quality Control

-  **AUTOMOTIVE**
- Vehicle Auto-Diagnosis
 - Optimized Traffic Flow
 - Smart Parking

-  **AGRICULTURE**
- Offspring Care
 - Crop Management
 - Soil Analysis



-  **MILITARY**
- Situational Awareness
 - Threat Analysis

-  **MEDICAL**
- Optimized Patient Care
 - Wearable Fitness Devices
 - Quality Data Reporting

-  **ENVIRONMENTAL**
- Forest Fire Detection
 - Species Tracking
 - Weather Prediction

-  **RETAIL**
- Theft Protection
 - Inventory Control
 - Focused Marketing

HUST

