NETWORK PROTOCOLS AND SECURITY

Dr. G. Omprakash

Assistant Professor, KLH

Course Outcome:	Syllabus
CO1:	Introduction to Computer networks and Data Link Layer: Use of Computer Networks, Network Hardware, Networksoftware, Reference models: OSI and TCP/IP, Physical Layer: The theoretical basis for Data Communication, Guided and UnguidedTransmission Media, Switching. Data Link Layer: DLL design issues. Error Detection and Correction, Elementary data link protocols,sliding window protocols.
CO2:	Medium Access Control Sub layer: Channel allocation problem, multiple access protocols, Design issues of Network layer, Inter-networking Devices: Distinguishing of Networking Devices and Inter-networking Devices, VLANS,Addressing: IP addressing (IPV4 & IPV6), subnetting; IP Tunneling, NAT,PAT

CO3:	ARP, DHCP Types of Routing: static, default anddynamic. Networking Protocols: RIP, OSPF, BGP; Access Control list for IPV4, IPV6, Other Protocols: Transport Layer: Process toProcess Delivery; UDP; TCP; Stream Control Transmission Protocol (SCTP); Congestion Control: Open Loop, Closed Loop ChokePackets; Quality of Service: Techniques to Improve QoS: Leaky bucket algorithm, Token bucket algorithm
CO4:	Application Layer:DNS, SMTP, SNMP Introduction to Security, Security goals, Security Attacks, Security Services and Mechanisms, A Security Model,Asymmetric & Symmetric key Ciphers, Substitution Techniques, Transposition Techniques, DES, RSA algorithm, Secure Socket Layer
CO5:	Ethernet, HDLC, CHAP, PAP, PPP, PPPoE, AAA, IPSec, ACL, OSPF V3, IPV6: EUI-64, DAD; MPLS, Firewalls, Hashing,Digital Signatures

Textbooks

- Data Communications and Networking (3rd Ed.) –B. A. Ferouzan – TMH
- Computer Networks (4th Ed.)", A. S.Tanenbaum – – Pearson Education/PHI
- Data and Computer Communications (5th Ed.) – W. Stallings – PHI/ Pearson Education
- Network for ComputerScientists & Engineers, Zheng & Akhtar, OUP
- Data Communication & Network,Miller, Vikas

Evaluation Plan

Evaluation Type	Evaluation Component	Weightage/Marks		Assessment Dates	Duration (Hours)	CO1	CO2	CO3	CO4	CO5	CO6
End Semester Summative Evaluation Total= 40 %	Lab End Semester Exam	Weightage	16	17,04,2025	120						16
		Max Marks	50								50
	End Semester Exam	Weightage	24	17,04,2025	180	4.8	4.8	4.8	4.8	4.8	
		Max Marks	100			20	20	20	20	20	
In Semester Formative Evaluation Total= 30 %	Continuous Evaluation - Lab Exercise	Weightage	10	17,02,2025	120						10
		Max Marks	50								50
	Home Assignment and Textbook	Weightage	10	17,02,2025	120	2	2	2	2	2	
		Max Marks	50			10	10	10	10	10	
In Semester Summative Evaluation Total= 30 %	Lab In Semester Exam	Weightage	5	16,04,2025	120						5
		Max Marks	50								50
	Semester in Exam-II	Weightage	10	10,04,2025	90			5	5		
		Max Marks	50					25	25		
	Surpize Quiz	Weightage	5	11,04,2025	60					5	
		Max Marks	20							20	
	Semester in Exam-I	Weightage	10	04,02,2025	90	5	5				
		Max Marks	50			25	25				

Aim of the session

To familiarize students with the basic concept of Computer Networks and its necessity

Instructional Objectives

- Introduction to Computer Networks
- Describe the Features Of Computer network
- Introduction to Network topologies

Learning Outcomes

Describe the components of the Computer Networks.
Describe the Network topologies

Introduction

History

- **Semaphore systems** A semaphore is a visual signaling method that uses flags, lights, or other devices to transmit messages over a distance
- Requires skilled operators and expensive towers (interval of 10-30Km)
- First semaphore system in 1792 in France by Claude Chappe
- **Electric Telegraph** replaced the semaphore system
- A successful electric telegraph was built by Francis Ronalds in 1816
- Morse-code is developed here
- Morse-code: Encoding text characters as a sequence of two different signal duration
- Telegraph lines spanned over 32000 km in the United States by 1851.
- In 1857, a transatlantic cable was installed.

History

- **Electric telephone** by Graham Bell in 1870s
- Radio wave-based communication was established in 1901.
- Guglielmo Marconi and Karl Braun received a noble prize
- Jagdish Chandra Bose (1894 -1896) investigated millimeter wave communication. He introduced the semiconductor to detect radio waves
- Cathode Ray tube television is developed in the 1930s
- 1950 onwards -use of semiconductor devices led to modern telecommunication.

History

- 1950-During the cold war, US Defense wanted a command-and-control network that could survive a nuclear war.
- Military communications used the public telephone network-vulnerable
- DoD awarded a contract to the RAND Corporation to find a solution.
- Paul Baran, came up with the highly distributed and fault-tolerant design (right side figure)
- Since the paths are longer, analog signals get distorted

- Baran proposed using digital packet-switching technology
- Pentagon liked the concept and asked AT&T (U.S.' national telephone monopoly)
- AT&T dismissed Baran's ideas

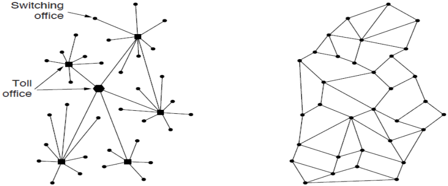


Figure: Structure of Telephone System

History

- Soviet Union beat the U.S. into space with the launch of the first artificial satellite, Sputnik
- President Dwight Eisenhower found that Army, Navy, and Air Force are squabbling over the Pentagon's research budget
- He immediately created a single defense research organization, **Advanced Research Projects Agency** (ARPA).
- ARPA did its work by issuing grants and contracts to universities and companies whose ideas looked promising to it.

Project ARPANET

ARPANET-Advanced Research Projects Agency Network

- ARPANET was an overlay built on the top of a telephone network
- ARPANET was a network that connected computers at universities and government agencies
- Packet switching technology is developed -broke data into smaller packets and sent them across a decentralized network
- After ARPANET, many packet switch networks came into existence

Motivation

- In 1972, **CYCLADES** Network is developed in France
- Used the idea of **sliding window protocol**
- Different kinds of packet switched networks came into existence, for example, Aloha network, Ethernet, and token ring
- **How to connect different kinds of networks together?**
- A **network protocol** is a set of rules for formatting and processing data that enables computers to communicate.
- **TCP/IP** was invented to enable communication among different networks
- IP:Internet protocol-in the network, TCP: Transmission Control Protocol -at the end point

Standards

- Standard is required to **establish coordination** among multiple ideas
- Device manufacturers, and Service providers should maintain common standards to avoid chaos
- Standards deals with the requirements of interoperability
- International standardization authorities are established
- International Telecommunication Union (ITU)-facilitate international connectivity
- International Organisation for Standardization (ISO)

Computer Networks

- The old model of a single computer serving all of the organization's computational needs has been replaced
- Large number of separate but interconnected computers do the job.
- A **computer network** is an interconnection of computers for communication.
- Internet is a network of computer networks that interconnects billions of devices

Computer Networks: A set of communication elements connected by communication links.

Communication elements

- Computers, printers, mobile phones...
- Routers, switches..

Communication links

- optic fiber, coaxial cable, twisted pair
- wireless (radio, microwave, satellite)

Connectivity Topologies

- Ring, Star, Bus, Tree, Mesh

Data communications

- Data communications
  - Components: Message, Sender, Receiver, Transmission Medium, Protocol
  - Message: Text, Numbers, Images, Audio, Video
  - Data Flow: Simplex, Half-duplex, Full-duplex
- Networks
  - Network Criteria: Performance, Reliability and Security
  - Physical Structures
    - Type of Connection: Point-to-Point, Multipoint
    - Physical Topology- Mesh, Star, Bus, Ring
- Network types
  - LAN,WAN, Internet

Five Components

Data communications is the exchange of data between two devices via some form of transmission medium

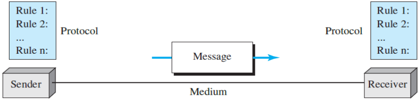


Figure: Five Components

- **Message**: information (data) to be communicated
- **Sender** is the device that sends the data message. Eg. Computer, Smartphone
- **Receiver** It can be a computer, workstation, telephone handset, television
- **Transmission Medium**: Physical path by which a message travels. Eg: twisted-pair wire, coaxial cable, fiber-optic cable, and radio waves
- **Protocols**: Set of rules that govern data communications

Data Flow

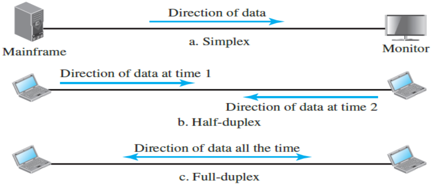


Figure: Data Flow

- **Simplex**: The communication is unidirectional. Only one of the two devices on a link can transmit; the other can only receive. Eg. Keyboard, Monitor
- **Half-Duplex**: Each station can both transmit and receive, but not at the same time.
- **Full-Duplex**: Both stations can transmit and receive simultaneously

Networks

A network is the interconnection of a set of devices capable of communication.

Network Criteria:

- **Performance** can be measured in many ways: Transit time of a message and Response time of an acknowledgement
- **Reliability** is measured by the frequency of failure
- **Security** Protecting data from unauthorized access

Types of Connections

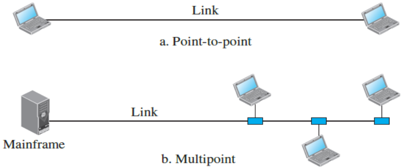


Figure: Types of Connections

- **Point-to-Point** connection provides a dedicated link between two devices
- **Multipoint** (also called multidrop) connection is one in which more than two devices share a single link

Physical Topology

Physical topology refers to the way in which a network is laid out physically.

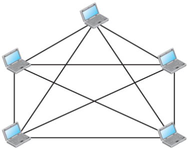


Figure: Mesh Topology

- **Mesh topology**: Every device has a *dedicated* point-to-point link to every other device
- *dedicated* means that the link carries traffic only between the two devices it
- Need $n(n-1)$ links to connect n nodes; Each node should have $n-1$ I/O ports

Star Topology

Star Topology: Each device has a dedicated point-to-point link only to a central controller(**Hub**)

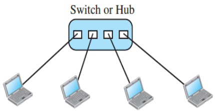


Figure: Star Topology

- The devices are not directly linked to one another.
- Hub acts as an exchange; Data is relayed from one device to another device through Hub

Star Topology

Advantages:

- Less expensive than a mesh topology
- Each device needs only one link and one I/O port to connect to any other device
- Less cabling is required, Easy to install and reconfigure
- Robust: If one link fails, only that link is affected. All other links remain active.

Disadvantage: If hub fails entire processing will be stopped

Bus Topology

In Bus topology one long cable (**bus**) acts as a backbone to link all the devices in a network.

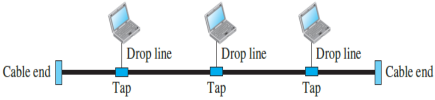


Figure: Bus Topology

- Nodes are connected to the bus cable by drop lines and taps
- A drop line is a connection running between the device and the main cable
- A tap is a connector that punctures the sheathing of a cable to create a contact with the metallic core.

Bus Topology

Advantages:

- Installation is easy. Bus Backbone cable can be laid along the most efficient path
- A bus uses less cabling than mesh or star topologies

Disadvantages:

- If the bus cable fails the entire system fails.
- Difficult for Fault isolation
- There is a limit on the number of taps a bus can support and on the distance between those taps.
- More heat is generated if the number of taps are more. Heat degrades the quality of signal

Ring Topology

Ring Topology: Each device has a dedicated point-to-point connection with only the two devices on either side of it

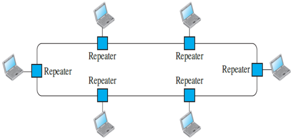


Figure: Ring Topology

- A signal is passed along the ring in one direction, from device to device, until it reaches its destination
- Each device in the ring incorporates a repeater, which regenerates the bits and passes them along

Ring Topology

Advantages:

- Ring is relatively easy to install and reconfigure
- Adding or Deleting a device requires changing only two connections
- Constraints: Maximum ring length and number of devices

Disadvantages:

- Unidirectional traffic
- Break in the ring can disable the entire network.

Local Area Network (LAN)

A **local area network (LAN)** is usually privately owned and connects some hosts in a single office, building, or campus

- Each host in a LAN has an unique identifier-Address
- A packet sent by a host to another host carries both the source host's and the destination host's addresses

- Each computer talks to a device called an AP (Access Point), wireless router
- Popular standard for wireless LANs called IEEE 802.11 (WiFi)

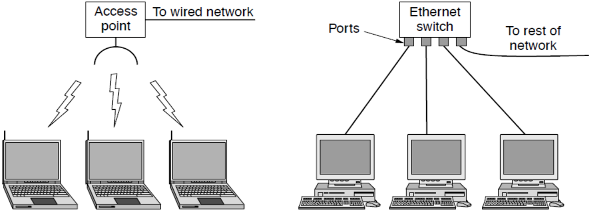


Figure: LAN

Wide Area Network (WAN)

- WAN is also an interconnection of devices spanning wider geographical area: State, Country, or even the world
- Computers intended for running user (i.e., application) programs- **Hosts**
- Network that connects these hosts is then called the communication **subnet**
- **Transmission lines** move bits between machines
- **Switches** are specialized devices that connect two or more transmission lines.
- Two routers that do not share a transmission line must do so via other routers
- How the network makes the decision as to which path to use is called a **routing algorithm**.

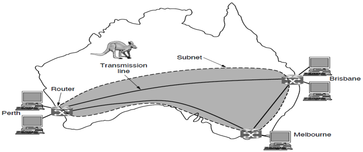


Figure: WAN that connects three branch offices in Australia

Personal Area Networks

- PAN- lets devices communicate over the range of a person
- Connecting Computer with its peripherals-monitor, keyboard, mouse, headphones and printer.
- Bluetooth to connect these components without wires
- Bluetooth networks use the master-slave paradigm
- Master tells the slaves what addresses to use, when they can transmit, how long they can transmit, what frequencies they can use

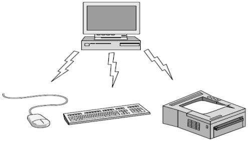


Figure: Bluetooth PAN

Metropolitan Area Networks

A MAN (Metropolitan Area Network) covers a city. The best-known examples of MANs are the cable television networks.

- Large antenna was placed on top of a nearby hill and a signal was then piped to the subscribers' houses
- Changes to the system- Internet service in unused parts of the spectrum

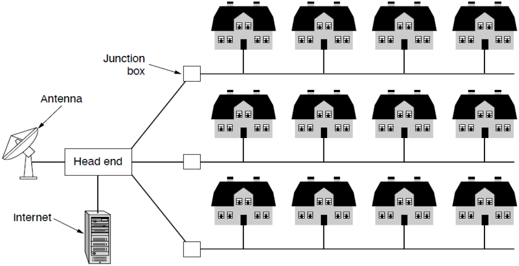
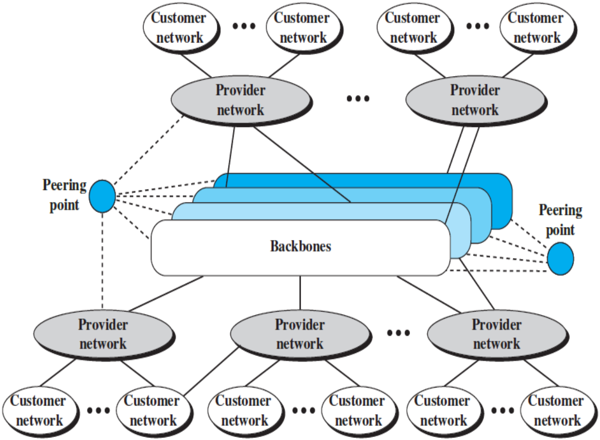


Figure: Metropolitan area network based on cable TV

Internet Today



Internet Architecture

- **Backbones** are large networks owned by some communication companies
- The backbone networks are connected through some complex switching systems, called **peering points**
- Second level, there are smaller networks, called **provider networks**, that use the services of the backbones for a fee
- **Customer networks** are networks at the edge of the Internet that actually use the services provided by the Internet
- Backbones are often referred to as international ISPs
- The provider networks are often referred to as national or regional ISPs

Internet Architecture

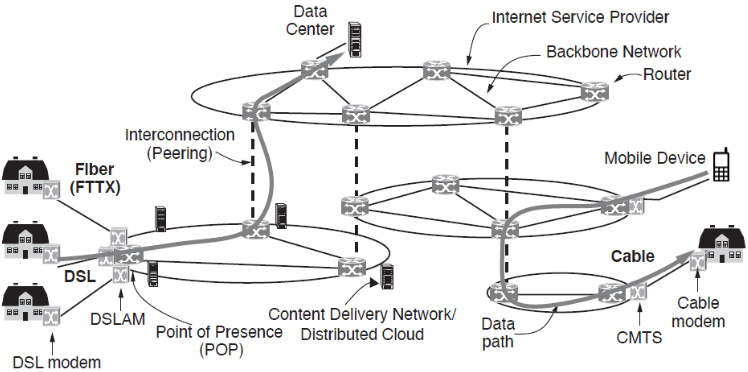


Figure: Overview of Internet Architecture

Internet Architecture

- The point at which customer packets enter the ISP network for service the ISP's POP (Point of Presence).
- The cable network, sometimes called an HFC (Hybrid Fiber-Coaxial) network, is a single integrated infrastructure that uses a packet-based transport
- The device at the home end is called a **cable modem**, and the device at the cable headend is called the **CMTS (Cable Modem Termination System)**.
- Another deployment involves running optical fiber to residences using **FTTH (Fiber to the Home)**.

- **Dial-up service**
  - Connect a modem that converts data to voice to the telephone line
  - Software installed on the computer dials the ISP and imitates making a telephone connection
  - The dial-up service is very slow, and when the line is used for an Internet connection
- **DSL Service-Digital Subscriber Line**
  - DSL service also allows the line to be used simultaneously for voice and data communications
  - Some telephone companies have upgraded their telephone lines to provide higher-speed Internet services

Aim of the session

To familiarize students with the basic concept of Computer Networks and its necessity

Instructional Objectives

- Introduction to Network Hardware
- Use of Computer Networks

Learning Outcomes

Describe the uses of Computer Networks .
Describe the Network Hardware components in the Computer Networks

Network Hardware

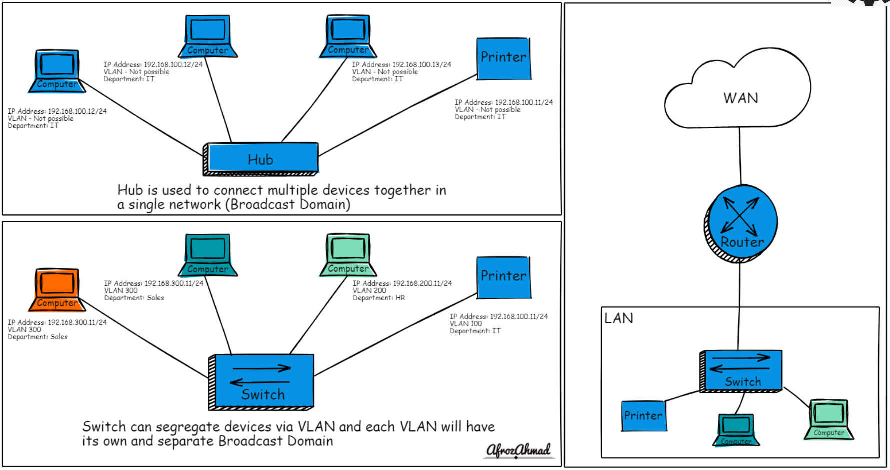
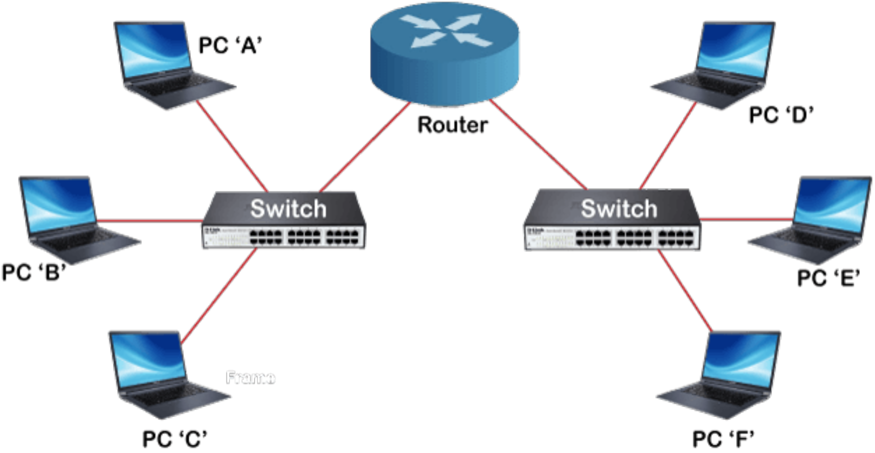


Figure: Hub-Switch-Router



Connection of networks through Router

Hub

Hub: A hub is a type of device that's commonly used as a connection point for various devices in a Local Area Network (LAN)

- When a single port in the hub responds, all other ports will also receive the response
- No capability to distinguish which port it should send a data packet to
- Connected devices will receive the response and must determine whether they should accept it or not.
- A hub is the least complex and least expensive device

Switch

Switch: A networking switch is a type of hardware that uses packet switching to receive and forward data to its intended destination

- A switch is a more efficient, more intelligent version of a hub.
- Switch records the addresses of the connected devices
- When a port receives a data packet, the switch reads its destination address and sends it directly to the intended networking device in the network
- Switch can greatly improve the speed of networks that receive a lot of traffic

Router

- A router is the most intelligent and complex of the three network connection devices
- Routers are designed to forward data packets between two or more networks, as well as direct traffic between them
- They are typically located at gateways
- Many modern routers are designed to integrate the capabilities of a switch and hub router all in a single device

Network Interface card

Network Interface card

- NIC is a hardware component used to connect a computer with another computer onto a network
- Physical address is encoded on the network card chip which is assigned by the IEEE to identify a network card uniquely.
- Wired NIC is present inside the motherboard. Cables and connectors are used with wired NIC to transfer data.
- Wireless NIC contains the antenna to obtain the connection over the wireless network.

Modem

A modem is a hardware device that allows the computer to connect to the internet over the existing telephone line.

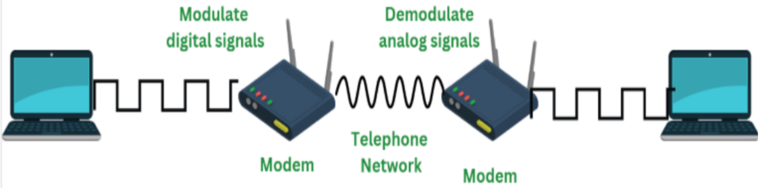


Figure: Modem

Access Point

A wireless access point (WAP) is a networking device that allows wireless-capable devices to connect to a wired network.

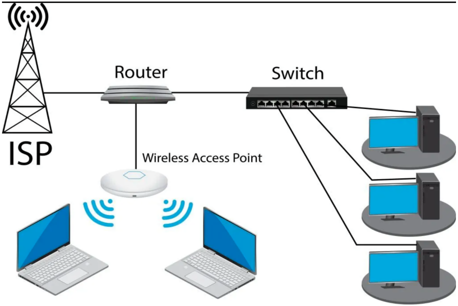


Figure: Access Point

Access Point Vs Router

Access Point

- An access point (AP) primarily supports wireless devices
- An AP adds wireless capacity to a wired network
- Wireless access points are adopted in larger organizations
- To cover a wide physical area or supporting thousands of users.
- Install more APs as demand develops

Router

- Router provides both wired and wireless connections for many end-user devices
- A router connects the LAN and the internet
- Wireless networking routers are typically used in private residences and small businesses
- combines AP and routing functions can easily handle the comparatively low user demand

It's common in larger WLANs to have many APs flowing into a single, independent router

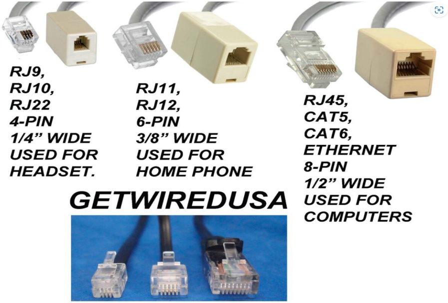


Figure: RJ45 Vs RJ11

Figure: RS232 and RJ45

RJ45

- RJ45 is a type of connector commonly used in Ethernet networking
- RJ45 can support data transfer speeds up to one Gigabit per second (Gbps)
- Its physical interface that allows devices to connect to a local area network (LAN) or the internet
- RJ45 connector is useful for high-speed data transmission over long distances.

RS232

- RS232 is used for slower data transmission over shorter distances
- RS232 can operate at data rates up to 20 Kbps.
- RS232 cables typically have a male connector at one end and a female connector at the other
- RS232 is also more susceptible to noise and interference
- RS232 is suitable for industrial IoT applications

Uses of Computer Networks

Uses of Computer Networks

- Access to Information
- Person-to-Person Communication
- Electronic Commerce
- Entertainment
- The Internet of Things

Access to Information

- Information: Arts, Business, Cooking, Government, Health, History, Hobbies, Recreation, Science, Sports, Travel
- Online Digital Libraries: ACM, IEEE
- Social Media platforms, News

Information is accessed through client-server model or peer-to-peer communication model

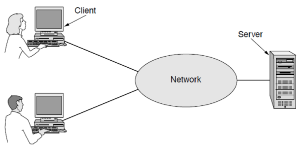


Figure: Client-Server Model

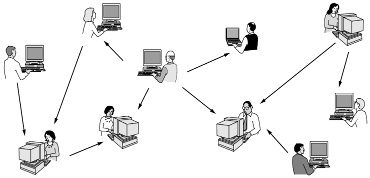


Figure: Peer-to-Peer Model

Access to Information

Client-Server Model:

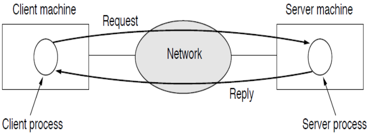


Figure: Client-Server Model

Peer-to-Peer Model: Every person can, in principle, communicate with one or more other people; there is no fixed division into clients and servers.Eg: BitTorrent

Person-to-Person Communication

- Email, Instant Messaging, Social Networks (Facebook)
- These applications can provide distance learning
- Hugely important to people who are geographically challenged
- People can work together to create content (Wikipedia)

Electronic Commerce

- Users can browse the online catalogs of thousands of companies and have products shipped right to their doorsteps
- Online technical support can be consulted
- Many people pay their bills, manage their bank accounts, and even handle their investments electronically

Tag	Full name	Example
B2C	Business-to-consumer	Ordering books online
B2B	Business-to-business	Car manufacturer ordering tires from a supplier
G2C	Government-to-consumer	Government distributing tax forms electronically
C2C	Consumer-to-consumer	Auctioning second-hand products online
P2P	Peer-to-peer	Music or file sharing; Skype

Figure: Some forms of e-commerce

Entertainment

- Music, Radio, Television programs and movies are available over the Internet
- Media streaming applications let users tune to Internet radio stations
- Multi-Person real-time simulation games

The Internet of Things

Ubiquitous computing, also known as pervasive computing, is the idea that computing capabilities are built into everyday objects and devices everywhere.

- Smoke detectors can call the fire department instead of just making a big noise
- Smart electricity, gas, and water meters report usage
- security systems that include door and window sensors.
- Smart refrigerators could order more milk when it is almost gone

Acknowledge various sources for the images.
Thankyou