COMMUNICATION & NETWORK CONCEPTS

Aseem Sethi

aseemsethi@yahoo.com

18 Nov 2022

TABLE OF CONTENTS

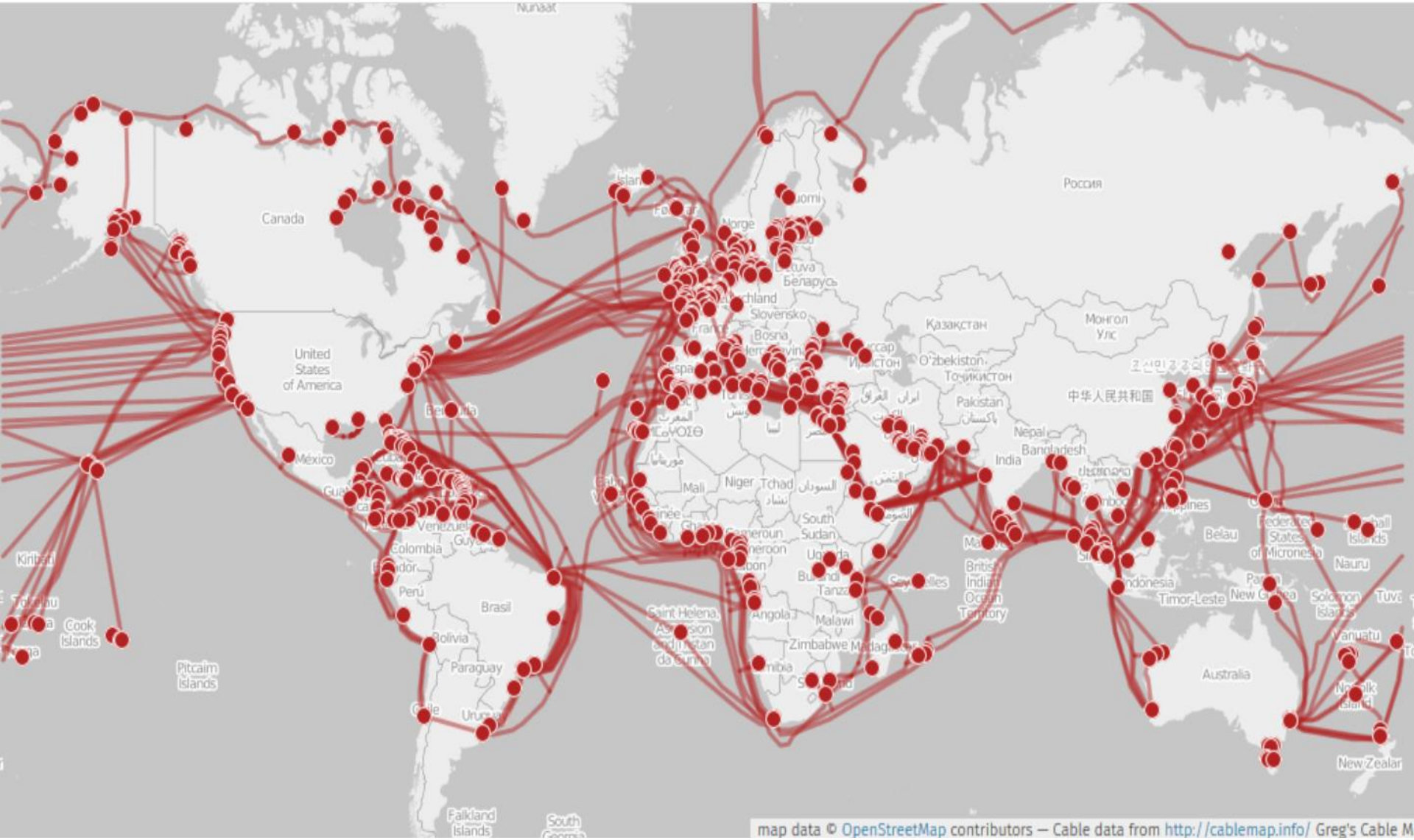
WHAT IS A NETWORK

- A group of two or more similar things or people interconnected with each other is called network.
- Wikipedia Definition - **a network as *'an interconnected collection of autonomous computers'*.**
  - AUTONOMOUS: no computer on a network can start, stop or control another.
  - INTERCONNECTED : Two or more computers are interconnected if they can exchange information.
- Examples:
  - Social Networks, Mobile Networks
  - Airlines, Railway, Banks Networks

NETWORK AND INTERNET

- A computer network includes
  - different types of hosts (also called nodes) like server, desktop, laptop, cellular phones.
  - Networking devices like switch, router, modem.
- The **Internet** is the global system of interconnected computer networks that uses the Internet protocol suite (TCP/IP) to communicate between networks and devices.
- It is a network of networks that consists of private, public, academic, business, and government networks of local to global scope, linked by a broad array of electronic, wireless, and optical networking technologies.

ROUTING OF PROMINENT UNDERSEA CABLES THAT SERVE AS PHYSICAL INFRASTRUCTURE OF INTERNET.



WHY WE NEED THE INTERNET ?

Resource sharing - files and peripherals

- Files and Software
- Peripherals
- Storage

Improving communication

Access to remote database

WIRED / WIRELESS

- ✓Usually, the connections between computers in a network are made using physical wires or cables.
- ✓However, some connections are wireless, using radio waves or infrared signals

Examples of Wireless: WiFi 802.11, 3G/4G/5G.

NETWORKING TERMS

- ✓The generic term **node** or host refers to any device on a network
- ✓**Packets** - Data transferred in a network is divided into smaller chunks called packets.
- ✓**Data transfer rate** - The speed with which data is moved from one place on a network to another
- ✓**File server** - A computer that stores and manages files for multiple users on a network
- ✓**Web server** - A computer dedicated to responding to requests (from the browser client) for web pages

EVOLUTION OF NETWORKING

- **1961** - a research project was commissioned by Advanced Research Projects Agency Network (ARPANET) in the U.S. Department of Defence
  - to connect the academic and research institutions located at different places for scientific collaborations.
- The first message was communicated between the University of California, Los Angeles (UCLA) and Stanford Research Institute (SRI).

EVOLUTION OF NETWORKING

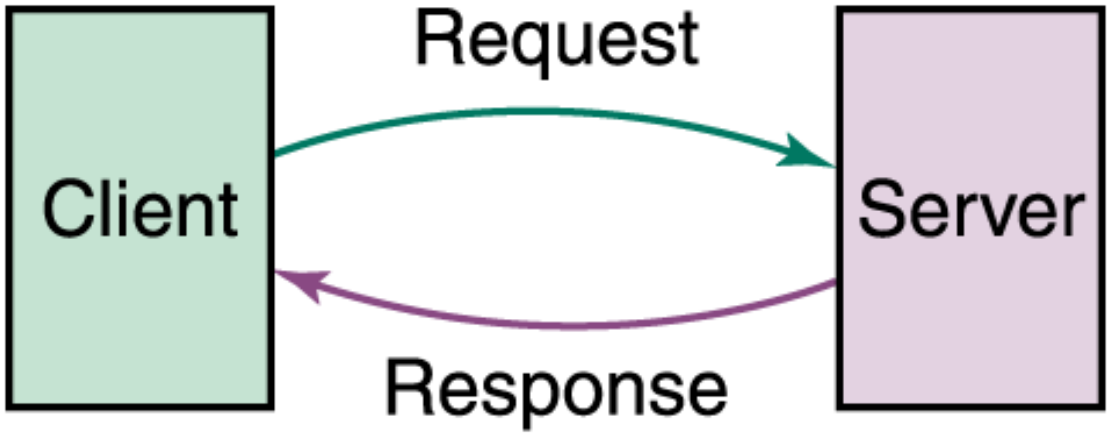
- ✓1971 - @ sign by Roy Tomlinson
- ✓1974 – Term Internet is coined
- ✓1982 – TCP/IP – standard protocol for Arpanet
- ✓1990 – Berners Lee at CERN developed HTML/URL – birth to WWW

SO, WHO OWNS THE INTERNET?

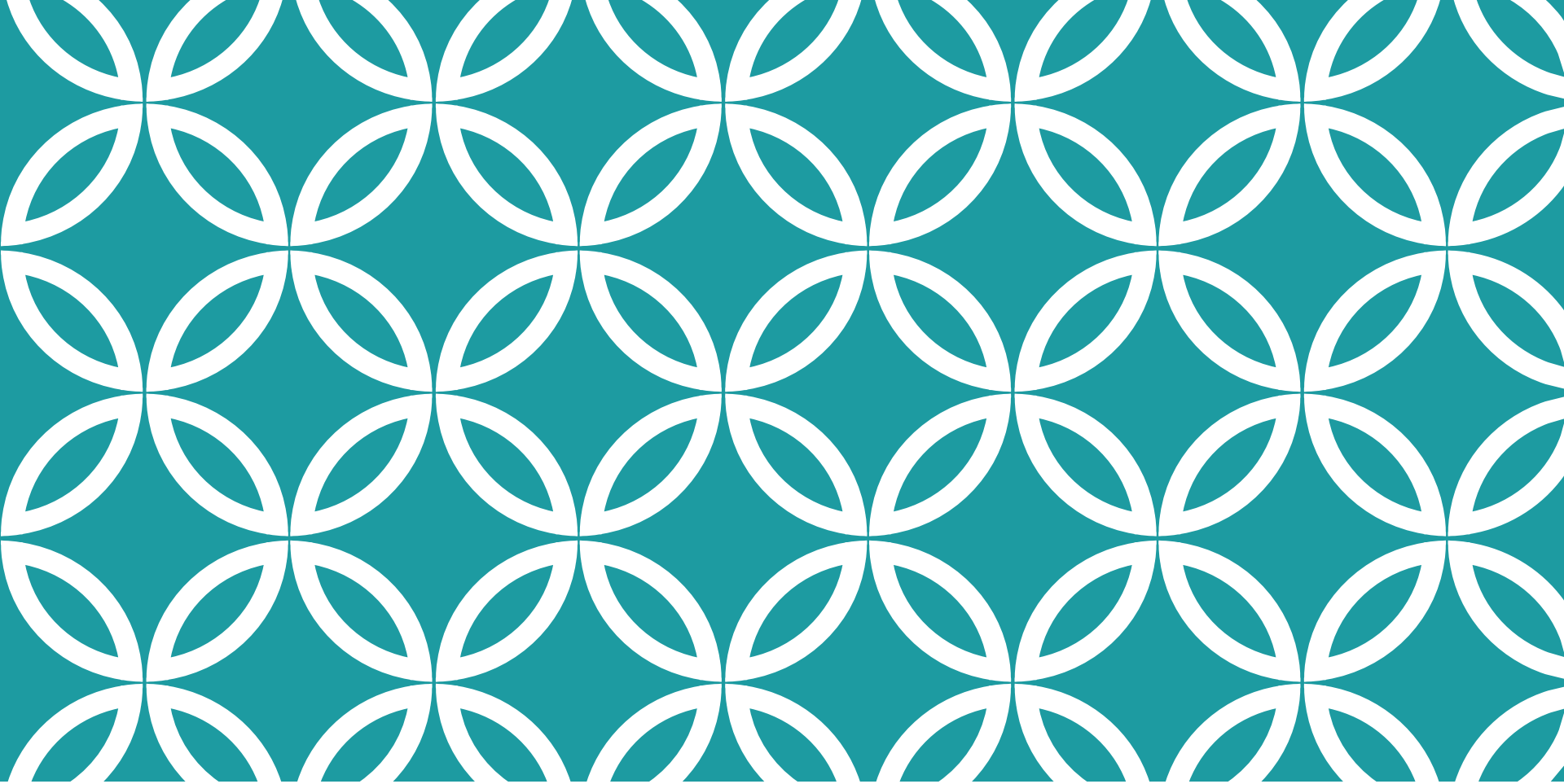
- ✓Well, nobody does.
- ✓No single person or company owns the Internet or even controls it entirely.
- ✓As a wide-area network, it is made up of many smaller networks.
- ✓These smaller networks are often owned and managed by a person or organization.

NETWORKING

Computer networks have opened up an entire frontier in the world of computing called the **client/server model**



Client/Server interaction



TYPES OF NETWORKS

TYPES OF NETWORKS

Based on the geographical area covered and data transfer rate, computer networks are broadly categorized as:

- PAN (Personal Area Network)
- LAN (Local Area Network)
- MAN (Metropolitan Area Network)
- WAN (Wide Area Network)

PAN

Network formed by connecting a few personal devices like computers, laptops, mobile phones, smart phones, printers etc.,

All these devices lie within an approximate range of 10 metres.

A personal area network may be wired or wireless.

Examples –

- a mobile phone connected to the laptop through USB – wired PAN
- two smartphones communicating with each other through Bluetooth technology - wireless PAN or WPAN.

Figure 10.4: A Personal Area Network

LAN

- ✓Network that connects computers, mobile phones, tablet, mouse, printer, etc., placed at a limited distance.
- ✓The geographical area covered by a LAN can range from a single room, a floor, an office having one or more buildings in the same premise.
- ✓The connectivity is done by means of wires, Ethernet cables, fibre optics, or Wi-Fi.

Figure 10.5: A Local Area Network

LAN – (CONTINUED)

- ✓LAN is secure as only authentic users in the network can access other computers or shared resources.
- ✓Users can print documents using a connected printer, upload/download documents and software to and from the local server.
- ✓These types of networks can be extended up to 1 km.
- ✓Data transfer in LAN is quite high, and usually varies from 10 Mbps (called Ethernet) to 1000 Mbps (called Gigabit Ethernet), where Mbps stands for Megabits per second.
- ✓Ethernet is a set of rules that decides how computers and other devices connect with each other through cables in a local area network or LAN.

MAN

- ✓Metropolitan Area Network (MAN) is an extended form of LAN which covers a larger geographical area like a city or a town.
- ✓Data transfer rate in MAN also ranges in Mbps, but it is considerably less as compared to LAN.
- ✓Examples - Cable TV network or cable based broadband internet services are examples of MAN.
- ✓This kind of network can be extended up to 30-40 km. Sometimes, many LANs are connected together to form MAN.
- ✓MANs can be created via the use of a public switched network, private fiber network or one or more point-to-point wireless links.

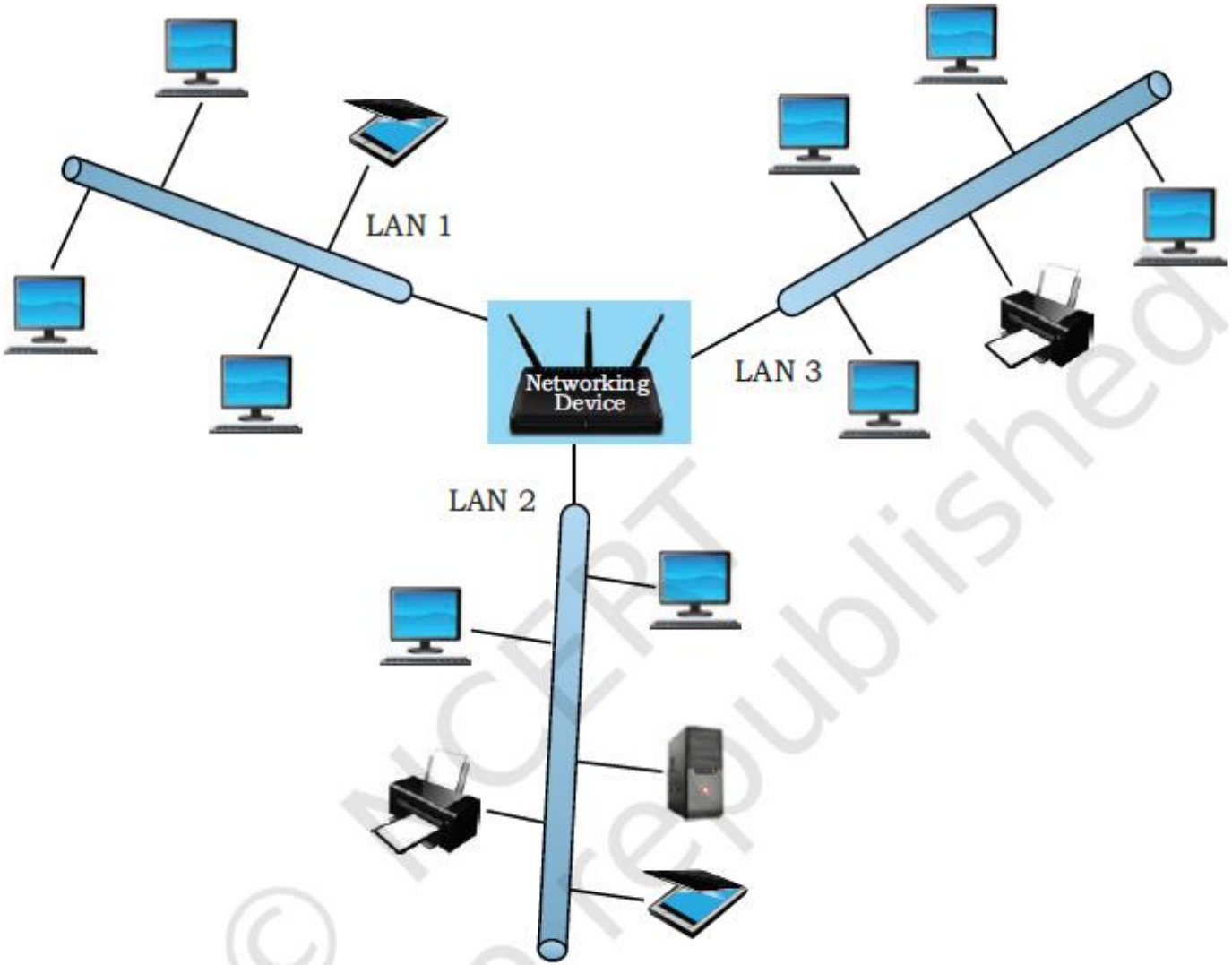


Figure 10.6: A Metropolitan Area Network

WAN

- ✓Wide Area Network connects computers and other LANs and MANs, which are spread across different geographical locations of a country or in different countries or continents.
- ✓A WAN could be formed by connecting a LAN to other LANs via wired/wireless media.
- ✓ Large business, educational and government organisations connect their different branches in different locations across the world through WAN.
- ✓The Internet is the largest WAN across continents.

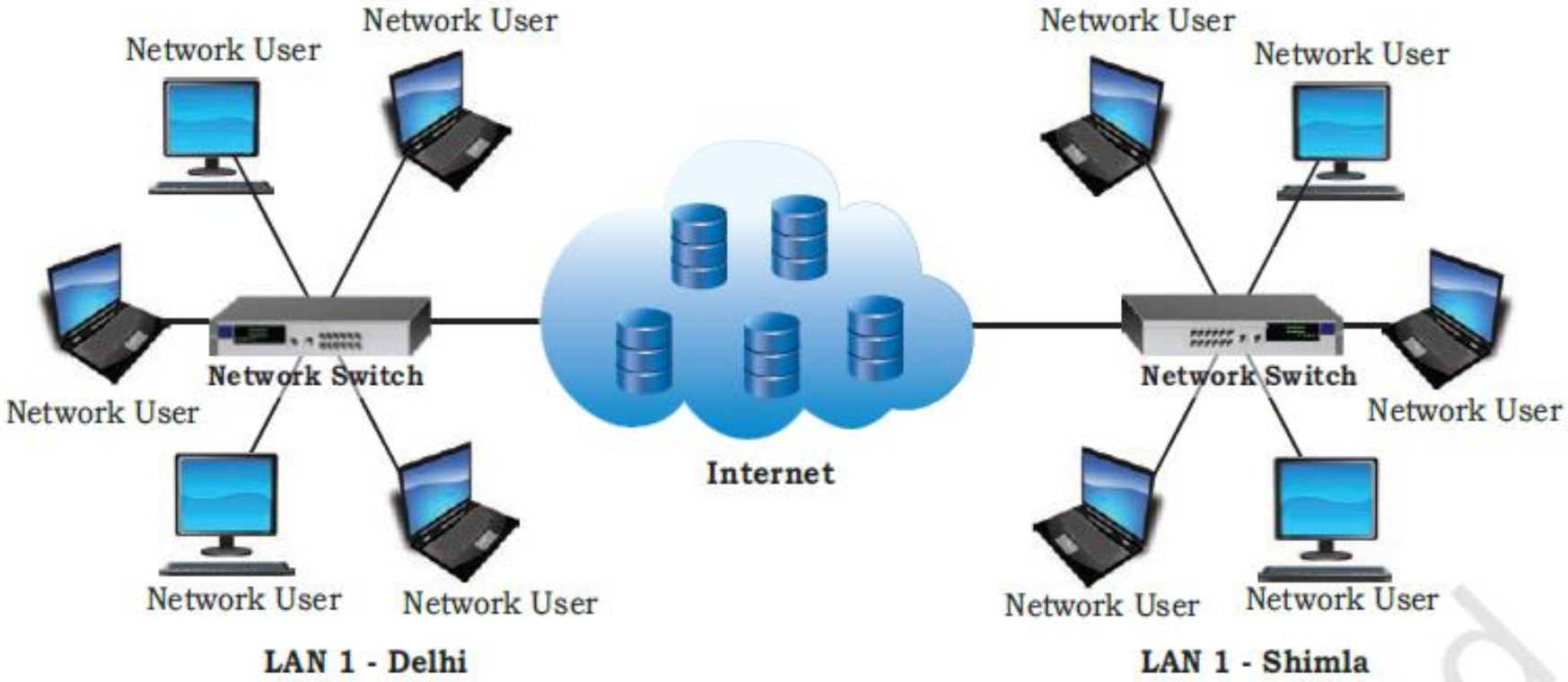


Figure 10.7: A Wide Area Network

QUIZ-1

QUESTIONS

Expand the following:

- a) ARPANET
- b) MAC
- c) ISP
- d) URI

2. What do you understand by the term network?

3. Mention any two main advantages of using a network of computing devices.

4. Differentiate between LAN and WAN.

5. Write down the names of few commonly used networking devices.

6. Two universities in different States want to transfer information. Which type of network they need to use for this?

ANSWERS

Expand the following:

- a) ARPANET - Advanced Research Projects Agency Network
- b) MAC - Media Access Control
- c) ISP - Internet service provider
- d) URI - Uniform Resource Identifier

2. What do you understand by the term network?

- A group of two or more similar things or people interconnected with each other is called network

3. Mention any two main advantages of using a network of computing devices.

4. Differentiate between LAN and WAN.

5. Write down the names of few commonly used networking devices.

6. Two universities in different States want to transfer information. Which type of network they need to use for this?

QUIZ-2

QUESTIONS - 1

✓Why do we network computers together?

1. So they can share files and resources.
2. To have sole use of a machine and avoid bandwidth limitations.

✓What is the purpose of a WAN?

1. To allow computers to communicate with each other in the same area
2. To allow computers to communicate with each other - anywhere in the world

✓Internet is an example of-

1. MAN
2. WAN
3. PAN
4. LAN

✓A_____is a data communication system within a building, plant, or campus, or between near by buildings.

1. a) MAN
2. b)LAN
3. c)WAN
4. d) None of the above

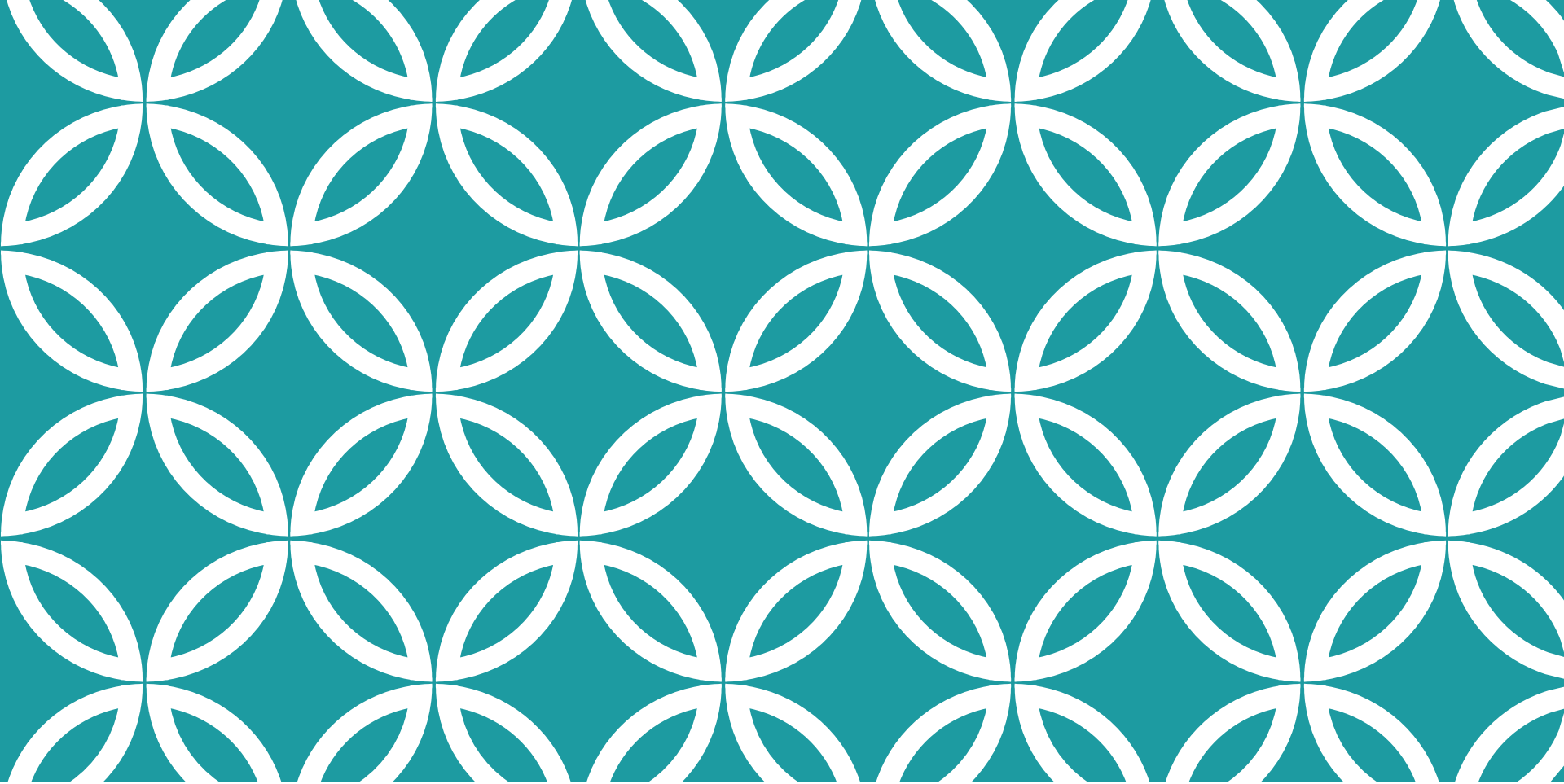
QUESTIONS - 2

✓Full form of NIC
1. National Income chart
2. Network Interface card
3. Network Interface Chain
4. None of these

✓what is an ip address
1. A number this is embedded on a NIC
2. A number that is given for you to type on the computrer
3. An Internet Protocol address is a numerical label assigned to each device connected to a computer network

✓.A Computer Network:
1. Is a collection of hardware components and computers?
2. Is interconnected by communication channels
3. Allows sharing of resources and information
4. All of the above

✓Bluetooth is an example of
1. Wide area network
2. Virtual private network
3. Local area network
4. Personal area network.

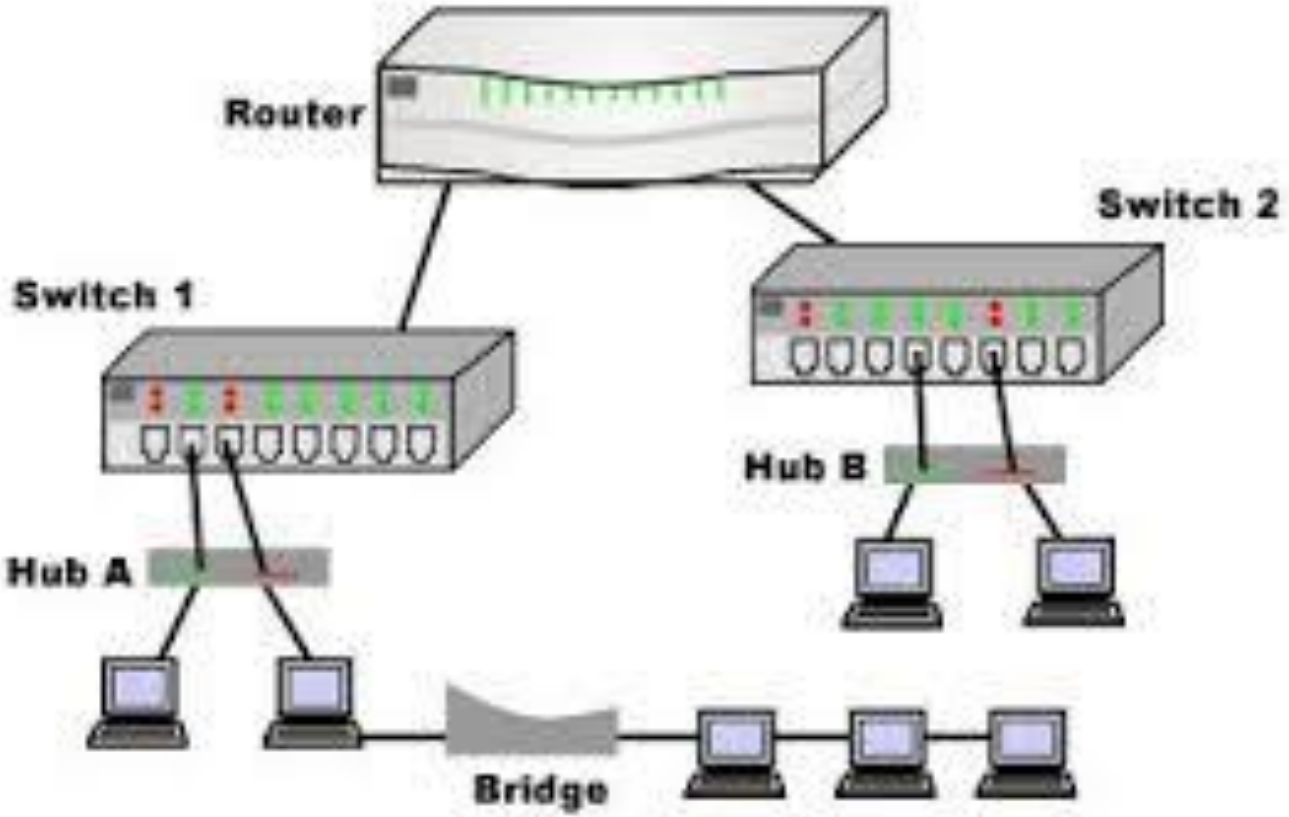


NETWORK DEVICES

TYPES OF DEVICES

- ✓MODEM
- ✓RJ45 CONNECTOR
- ✓ETHERNET CARD
- ✓HUB
- ✓SWITCH
- ✓ROUTER
- ✓GATEWAY

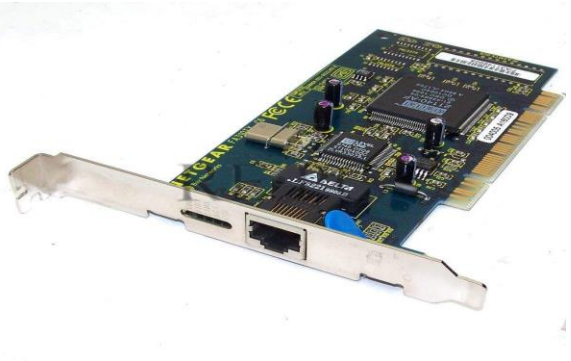
NETWORK DEVICES



MODEM

- ✓ Modem - 'MOdulator DEModulator'.
- ✓ Device used for conversion between analog signals and digital bits.
- ✓ We know computers store and process data in terms of 0s and 1s. However, to transmit data from a sender to a receiver, or while browsing the internet, digital data are converted to an analog signal.
- ✓ There are modems connected to both the source and destination nodes.
- ✓ Modem at sender's end is a modulator that converts the digital data into analog signals.
- ✓ Modem at the receiver's end is a demodulator that converts the analog signals into digital data.

ETHERNET CARD (NIC CARD)



- ✓Ethernet card, also known as Network Interface Card (NIC card in short) is a network adapter used to set up a wired network.
- ✓It acts as an interface between computer and the network.
- ✓The Ethernet cable connects the computer to the network through NIC.
- ✓Ethernet cards can support data transfer between 10 Mbps and 1 Gbps (1000 Mbps).
- ✓Each NIC has a MAC address, which helps in uniquely identifying the computer on the network.

RJ45

- ✓RJ 45 or Registered Jack-45 is an eight-pin connector that is used exclusively with Ethernet cables for networking.
- ✓It is a standard networking interface that can be seen at the end of all network cables.
- ✓Basically, it is a small plastic plug that fits into RJ-45 jacks of the Ethernet cards present in various computing devices.

REPEATER

- ✓Data are carried in the form of signals over the cable. These signals can travel a specified distance (usually about 100 m). Signals lose their strength beyond this limit and become weak. In such conditions, original signals need to be regenerated.
- ✓A repeater is an analog device that works with signals on the cables to which it is connected.
- ✓The weakened signal appearing on the cable is regenerated and put back on the cable by a repeater.

HUB

- An Ethernet hub is a network device used to connect different devices through wires.
- Data arriving on any of the lines are sent out on all the others.
- The limitation of Hub is that if data from two devices come at the same time, they will collide.

SWITCH

- ✓A switch is a networking device that plays a central role in a Local Area Network (LAN).
- ✓Like a hub, a network switch is used to connect multiple computers or communicating devices.
- ✓When data arrives, the switch extracts the destination address from the data packet and looks it up in a table to see where to send the packet.
- ✓Thus, it sends signals to only selected devices instead of sending to all.
- ✓It can forward multiple packets at the same time. A switch does not forward the signals which are noisy or corrupted

ROUTER

- A router is similar in a switch in that it forwards packets based on address. But, instead of the MAC address that a switch uses, a router can use the IP address. This allows the network to go across different protocols.
- The most common home use for routers is to share a broadband internet connection. The router has a public IP address and that address is shared with the network. When data comes through the router it is forwarded to the correct computer.
- A router connects a local area network to the internet – WiFi (Wireless) or Wired (Ethernet)
- A router can also fragment a packet as it sends it between networks.

GATEWAY

- ✓Acts as a “gate” or “entry point” between an organisation's network and the outside world of the Internet.
- ✓Besides routing data packets, gateways also maintain information about the host network's internal connection paths and the identified paths of other remote networks.
- ✓Gateways run Routing Protocols to route packets.
- ✓For simple Internet connectivity at homes, the gateway is usually the Internet Service Provider that provides access to the entire Internet.
- ✓Generally, a router is configured to work as a gateway device in computer networks.
- ✓Gateways can be implemented completely in software, hardware, or a combination of both. Because a network gateway is placed at the edge of a network, the firewall is usually integrated with it.

QUIZ - 3

QUESTIONS - 1

✓ What is a Firewall in computer network?

1. a) The physical boundary of network
2. b) An operating system of computer network
3. c) A system designed to prevent unauthorized access.
4. d) A web browsing software

✓**MAN Stands for _____.**

1. a) Metropolitan Area Network.
2. b) Main Area Network
3. c) Metropolitan Access Network
4. d) Metro Access Network

✓**Switch is a**

1. a) Broadcast device
2. b) Unicast device.
3. c) Multicast device
4. d) None of the above

QUESTIONS - 2

✓**The device that can operate in place of a hub is a:**

1. a) Switch.
2. b) Bridge
3. c) Router
4. d) Gateway

✓**In computer, converting a digital signal in to an analog signal is called**

1. a) modulation
2. b) demodulation
3. c) conversion
4. d) transformation

✓ **What is the address size of IPv6?**

1. a) 32 bit
2. b) 64 bit
3. c) 128 bit.
4. d) 256 bit

QUESTIONS - 3

✓**The device that can operate in place of a hub is a:**

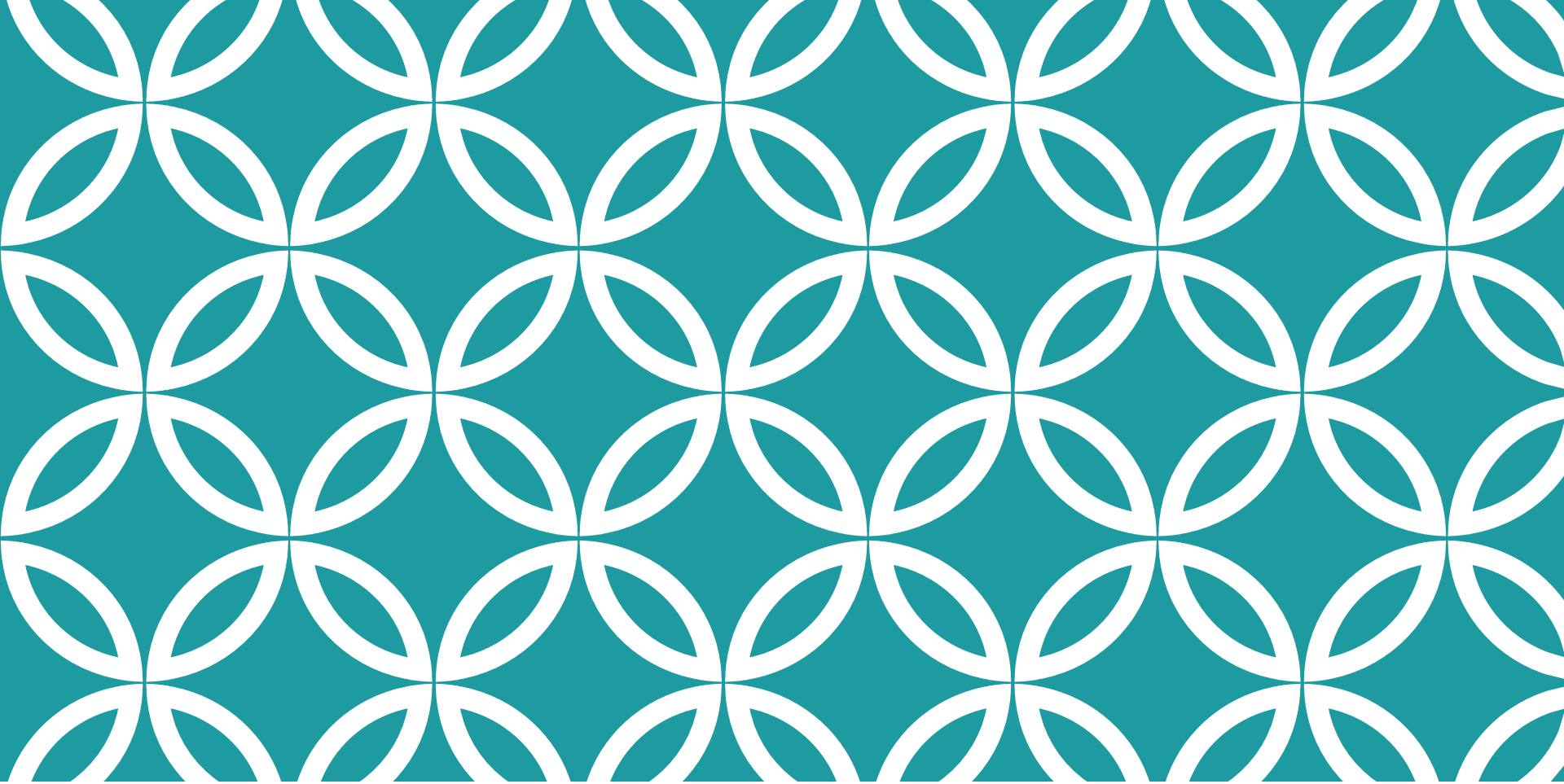
1. a) Switch.
2. b) Bridge
3. c) Router
4. d) Gateway

✓**Which of the following is not the Networking Devices?**

1. a) Gateways
2. b) Linux.
3. c) Routers
4. d) Firewalls

✓**This was the first network.**

1. a)CSNET
2. b)NSFNET
3. c)ANSNET
4. d)ARPANET.

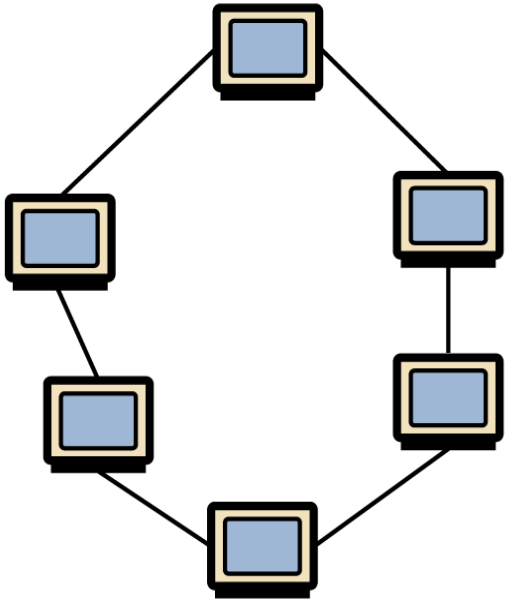


TOPOLOGIES

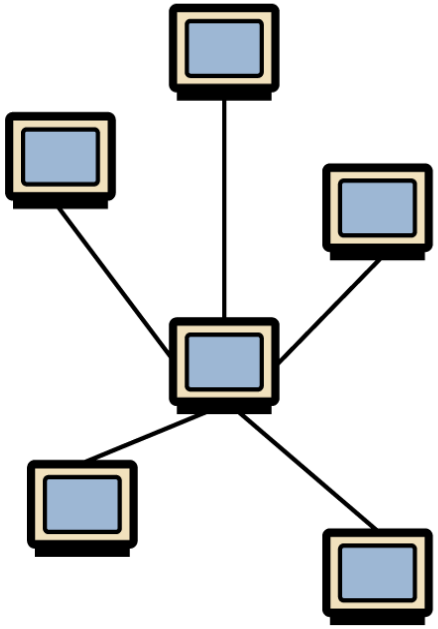
NETWORK TOPOLOGY

- The arrangement of computers and other peripherals in a network is called its topology.
- Common network topologies are
  - Mesh,
  - Ring,
  - Bus,
  - Star and
  - Tree.

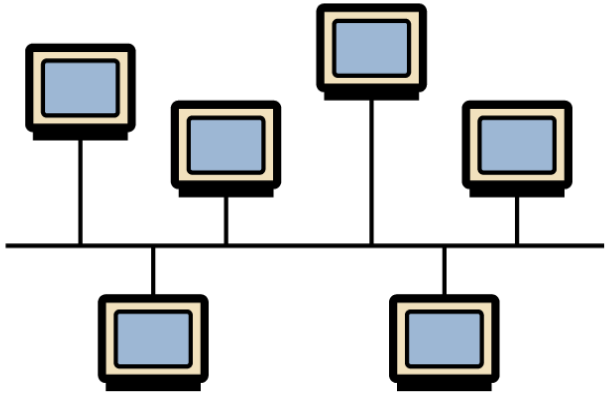
TYPES OF TOPOLOGIES



Ring topology



Star topology



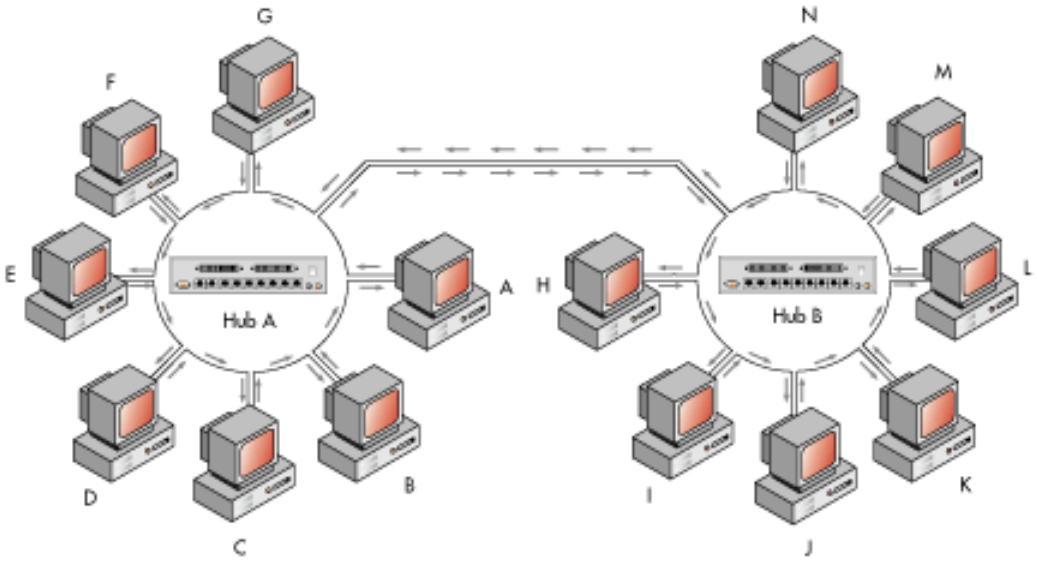
Bus topology

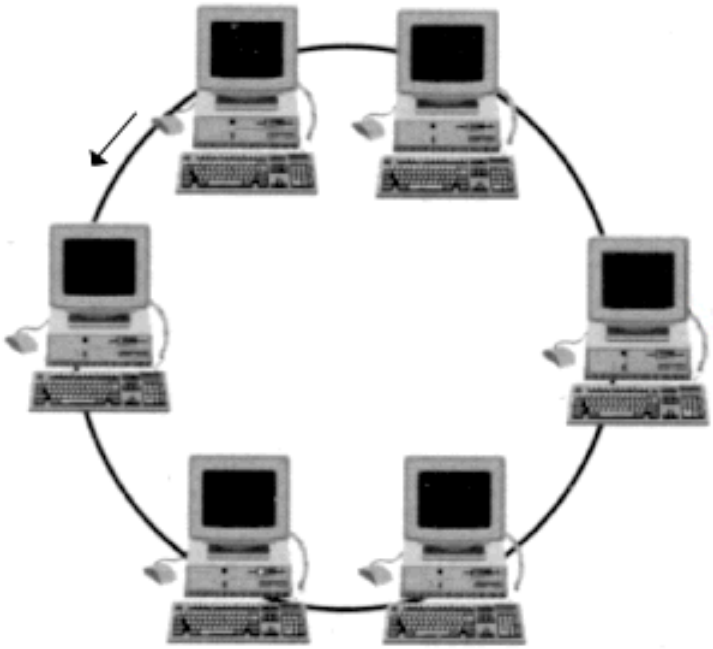
A bus technology called **Ethernet** has become the industry standard for local-area networks

MESH

- ✓In this networking topology, each communicating device is connected with every other device in the network.
- ✓ Such a network can handle large amounts of traffic since multiple nodes can transmit data simultaneously.
- ✓More reliable in the sense that even if a node gets down, it does not cause any break in the transmission of data between other nodes.
- ✓This topology is also more secure as compared to other topologies because each cable between two nodes carries different data.
- ✓However, wiring is complex and cabling cost is high in creating such networks and there are many redundant or unutilised connections.

RING TOPOLOGY



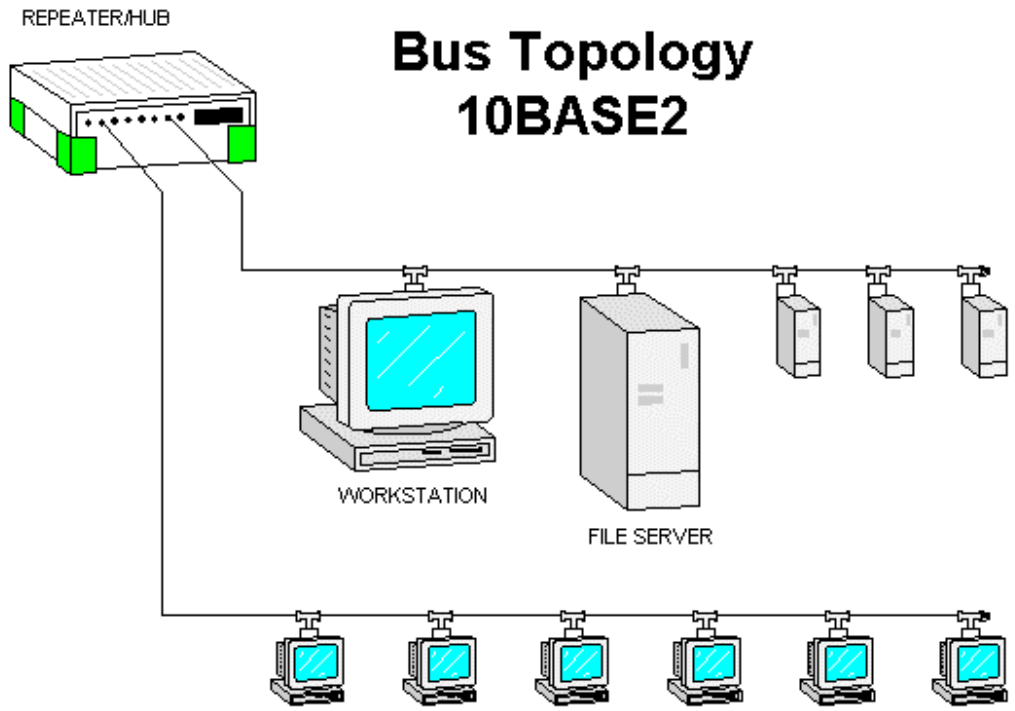


"A ring topology connects one host to the next and the last host to the first. This creates a physical ring of cable."

RING

- In ring topology, each node is connected to two other devices, one each on either side.
- The nodes connected with each other thus forms a ring.
- The link in a ring topology is unidirectional.
- Thus, data can be transmitted in one direction only (clockwise or counterclockwise).

BUS

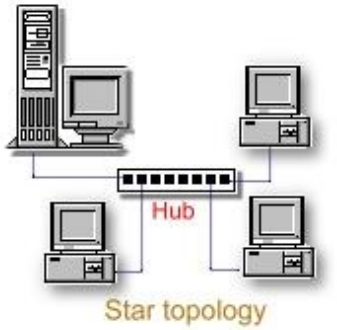


"A bus topology uses a single backbone segment (length of cable) that all the hosts connect to directly."

BUS

- ✓Each communicating device connects to a transmission medium, known as bus.
- ✓Data sent from a node are passed on to the bus and hence are transmitted to the length of the bus in both directions.
- ✓That means, data can be received by any of the nodes connected to the bus.
- ✓Both ring and bus topologies are considered to be less secure and less reliable.

STAR



- ✓Each communicating device is connected to a central node, which is a networking device like a hub or a switch.
- ✓Star topology is considered very effective, efficient and fast as each device is directly connected with the central device.
- ✓Although disturbance in one device will not affect the rest of the network, any failure in a central networking device may lead to the failure of complete network.
- ✓The central node can be either a broadcasting device means data will be transmitted to all the nodes in the network, or a unicast device means the node can identify the destination and forward data to that node only.

TREE

- ✓It is a hierarchical topology, in which there are multiple branches and each branch can have one or more basic topologies like star, ring and bus.
- ✓Such topologies are usually realised in WANs where multiple LANs are connected.
- ✓Those LANs may be in the form of a ring, bus or star.

QUIZ - 4

QUESTIONS - 2

✓**Which one of the following is not a network topology?**

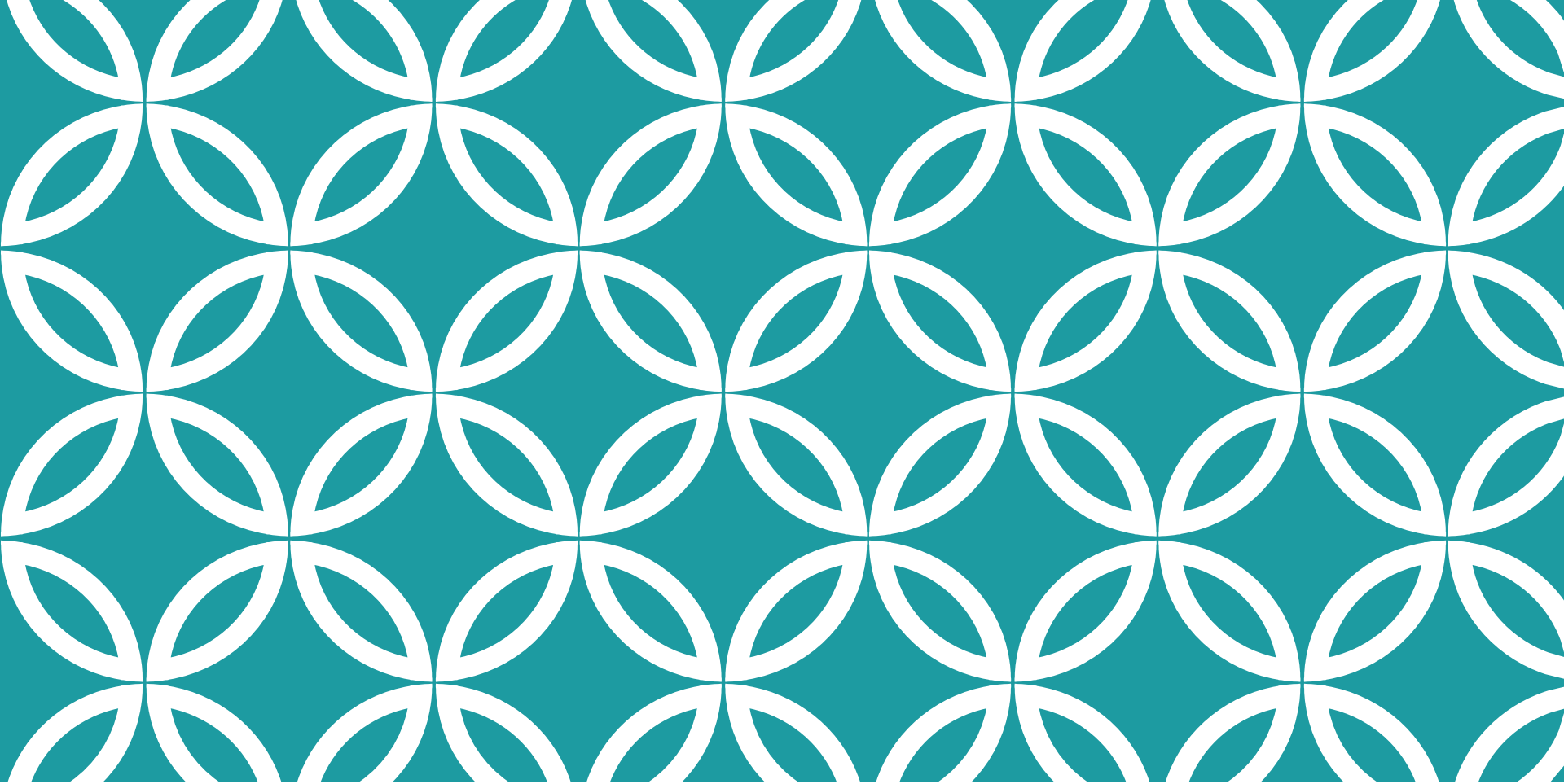
1. Star
2. Ring
3. Bus
4. Peer to Peer

✓**The topology in which all nodes are individually connected to a central connection point:**

1. Ring
2. Bus
3. Star
4. Tree

✓**In specific, if the systems use separate protocols, which one of the following devices is used to link two systems?**

1. Repeater
2. Gateway
3. Bridge
4. Hub



IDENTIFICATION / ADDRESSES

ADDRESSEES AND IDENTIFIERS

Each node in a network should be uniquely identified so that a network device can identify the sender and receiver and decide a routing path to transmit data.

Hostname A unique identification that specifies a particular computer on the Internet

For example

- timesofindia.com
- mail.google.com

NETWORK ADDRESSES

- ✓Network software translates a hostname into its corresponding IP address
- ✓ For example
- ✓ 205.39.145.18

- ✓IP address, also known as Internet Protocol address, is also a unique address that can be used to uniquely identify each node in a network.

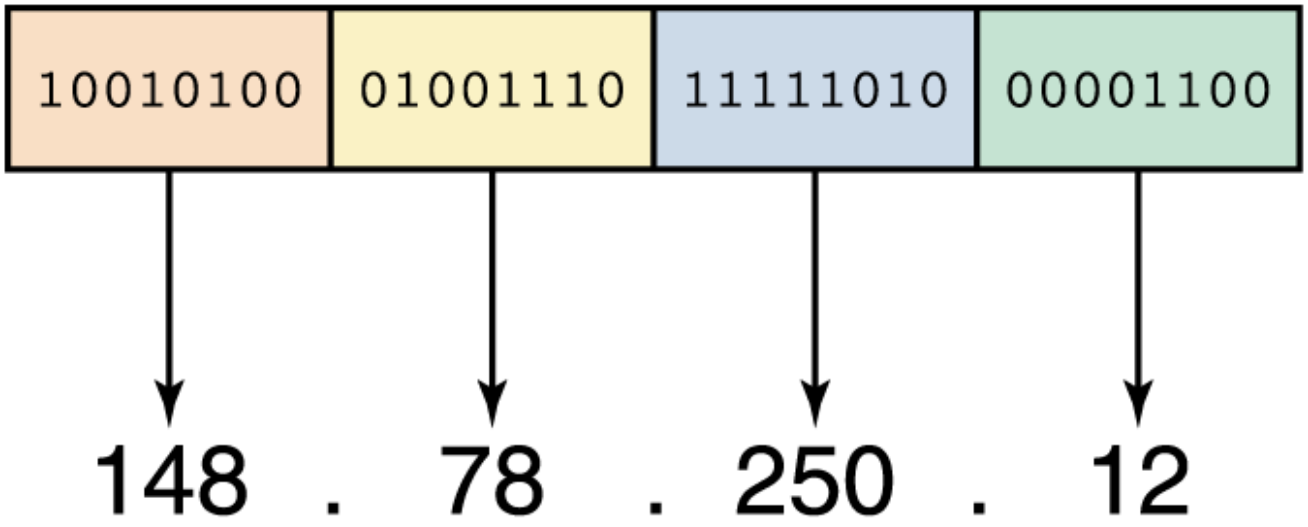
IP ADDRESSES

- If we know a computer's IP address, we can communicate with that computer from anywhere in the world.
- However, unlike MAC address, IP address can change if a node is removed from one network and connected to another network.
- IPv4 - The initial IP Address called version 4 (IPV4 in short), is a 32 bit numeric address, written as four numbers separated by periods, where each number is the decimal (base-10) representation for an 8-bit binary (base-2) number and each can take any value from 0 - 255.
  - offers just under 4.3 billion unique addresses.
- Thus, a 128 bits IP address, called IP version 6 (IPV6 in short) was proposed.
- An IPv6 address is represented by eight groups of hexadecimal (base-16) numbers separated by colons.
- A sample IPV6 address looks like:
  - 2001:CDBA:0000:0000:0000:0000:3257:9652

NETWORK ADDRESSES

An **IP address** can be split into

- **network address,** which specifies a specific network
- **host number,** which specifies a particular machine in that network



An IP address is stored in four bytes

MAC ADDRESSES

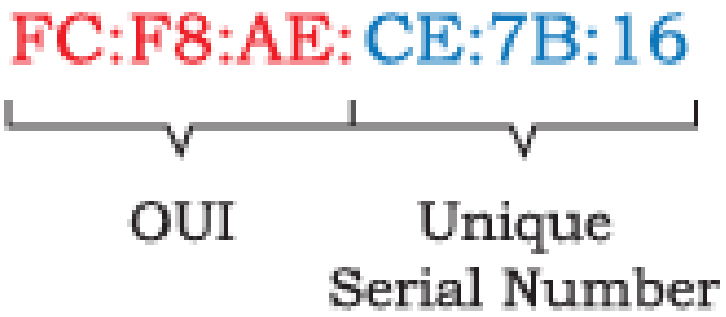
- ✓MAC stands for Media Access Control.
- ✓The MAC address, also known as the physical or hardware address, is a unique value associated with a network adapter called a NIC.
- ✓The MAC address is engraved on NIC at the time of manufacturing and thus it is a permanent address and cannot be changed under any circumstances.
- ✓The machine on which the NIC is attached, can be physically identified on the network using its MAC address.
- ✓Each MAC address is a 12-digit hexadecimal numbers (48 bits in length), of which
  - ✓- the first six digits (24 bits) contain the manufacturer's ID called Organisational Unique Identifier (OUI) and
  - ✓- the later six digits (24 bits) represents the serial number assigned to the card by the manufacturer. A sample MAC address looks like:

MAC ADDRESSES

Standardized by IEEE

Each station assigned a unique 48-bit address

- First 24-bits are the OUI
- Second 24-bits are vendor assigned



WWW – WORLD WIDE WEB

3 fundamental technologies

1. HTML

Document-layout & hyperlink-specification language i.e., a language used to design the layout of a document & specify the hyperlinks.

Html tells the browser how to display the contents of a hypertext document i.e., a document including text, images & other supported media. It also tells how to make the page interactive by using special hyperlinks.

HTTP

- ✓**Hyper Text Transfer Protocol is an application-level** but light & fast protocol.
- ✓The HyperText Transfer Protocol is a set of rules which is used to retrieve linked web pages across the web.
- ✓It's a generic, stateless, object oriented protocol.
- ✓It builds on the discipline of *URI (Uniform Resource Identifier)*, as a location or name, for locating resource on which method is to be applied.
- ✓The more secure and advanced version is HTTPS.

URI OR URL & DOMAIN NAMES

- HTTP uses internet address in a special format called a Uniform Resource Locator or URL or URI – Uniform Resoorce Identifier
- Every Web page has a unique URL
- Typically URLs look like this:
  - type://address/path
- Type:- type of server address (also the protocol they use):- address of the server path:- location of file on the server.
- In the address last group of characters (.com, .gov etc.) is domain indicator.

DOMAIN NAMES

- The naming scheme by which servers are identified is known as domain name system.
- *A character based internet address is a domain name.*
- Every device connected to the Internet has an IP address. To access a website, we need to enter its IP address on our web browser. But it is very difficult to remember the IP addresses of different websites as they are in terms of numbers or strings.

DOMAIN NAMES RESOLUTION

- ✓Conversion of the domain name of each web server to its corresponding IP address is called domain name resolution.
- ✓It is done through a server called DNS server.
- ✓Thus, when we enter a URL on a web browser, the HTTP protocol approaches a computer server called DNS server to obtain the IP address corresponding to that domain name.
- ✓After getting the IP address, the HTTP protocol retrieves the information and loads it in our browser.

DOMAIN NAMES RESOLUTION

- The DNS servers are placed in hierarchical order.
- At the top level, there are 13 servers called root servers.
- Then below the root servers there are other DNS servers at different levels.
- A DNS server may contain the IP address corresponding to a domain or it will contain the IP address of other DNS servers, where this domain entry can be searched.

DOMAIN NAME SYSTEM

- A hostname consists of the computer name followed by the domain name
- csc.villanova.edu is the domain name
  - A domain name is separated into two or more sections that specify the organization, and possibly a subset of an organization, of which the computer is a part
  - Two organizations can have a computer named the same thing because the domain name makes it clear which one is being referred to

DOMAIN NAME SYSTEM

The very last section of the domain is called its **top-level domain (TLD)** name

Top-Level Domain	General Purpose	New TLDs	General Purpose
.com	U.S. Commercial	.biz	Business
.net	Network	.info	Information
.org	Nonprofit organization	.pro	Professional
.edu	U.S. Educational	.museum	Museums
.int	International	.aero	Aerospace industry
.mil	U.S. Military	.coop	Cooperative
.gov	U.S. Government		

Top-level domains, including some relatively new ones

DOMAIN NAME SYSTEM

Organizations based in countries other than the United States use a top-level domain that corresponds to their two-letter country codes

Country Code TLD	Country
.au	Australia
.br	Brazil
.ca	Canada
.gr	Greece
.in	India
.ru	Russian Federation
.uk	United Kingdom

Some of the top-level domain names based on country codes

DOMAIN NAME SYSTEM

The **domain name system** (DNS) is chiefly used to translate hostnames into numeric IP addresses

- DNS is an example of a distributed database
- If that server can resolve the hostname, it does so
- If not, that server asks another domain name server

QUESTIONS AND ANSWERS

QUESTIONS

- The MAC address is located on the _____ .
  - Network Interface Card.
- MAC addresses are written using _____ .
  - Hexadecimal (hex) numbers.
- Describe the MAC address format.
  - A 48 bit address (12 hex digits) consisting of 24 bits (6 hex digits) for OUI and 24 bits (6 hex digits) for vendor.
- What is the OUI?
  - The OUI (Organizational Unique Identifier) indentify the manufacturer or vendor.
- The OUI number is administered by _____ .
  - IEEE.

QUESTIONS

- Another name for MAC Address is _____ .
  - Burned-In Address (BIA).
- Which OSI Layer handles MAC Addresses?
  - Layer 2.
- What is one major disadvantage of MAC Addresses?
  - They have no structure, and are considered flat address spaces.