Computer Networking

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Makerere University Business School

Coverage

- Introduction to networks
- Types of network
- Components of the Network
- Advantages and disadvantages of networks
- Network design Parameters
- Network Topologies

Why Study Networking?

- Indispensable part of modern society
  - Commercial – e-commerce, banking, inventorying, telecommunications, archiving, health
  - Social – critical infrastructure, homeland security, policing
  - Human interaction/communication – email, chat, videoconferencing, social networking, entertainment
- Appears in every facet of engineering
  - Modern trend – Network every (electronic) device (computers, phones, sensors, planes, cars, TVs, appliances, heart monitors, …)

Definitions

- A computer network is a group of computers and other computing hardware devices that are linked in order to share resources, exchange files, or allow electronic communications between network nodes while using a set of common communication protocols.
- The computers on a network may be linked through cables, telephone lines, radio waves, satellites, or infrared light beams.
- The purpose of a network is to share resources. A resource may be: A file, A folder, A printer, A disk drive, Or just about anything else that exists on a computer.

Basic network concepts

- **Network nodes**

A network node is an electronic device that is connected to a network and is capable of creating, receiving or transmitting information over a communication channel. For example, if a network connects a file server, five computers, and two printers, there are eight nodes on the network. Each device on the network has a network address, which uniquely identifies each device. This helps to keep track of where data is being transferred to and from on the network.

- **Network address**

A network address is any logical address that uniquely distinguishes a network node or host on a network. It is numeric and has two parts, the network ID and the host ID. Eg 172.16.31.240 Examples; Telephone number (in the public switched telephone network), MAC (Media access control) address (in Ethernet), IP (Internet Protocol) address (in IP networks including the internet)

- **Communication channels**

A communication channel refers either to a physical transmission medium such as a wire, or to a logical connection over a multiplexed medium such as a radio channel that can be used to transmit data from one network device to another. Examples; Coaxial cable, fiber Optics, twisted pair, radio frequency, Microwave system, Infrared, communication satellite, Bluetooth, Wi-Fi.

- **Network protocols**

Network protocols are a set of rules, conventions, and data structures that dictate how devices exchange data across networks. Essentially, it allows connected devices to communicate with each other, regardless of any differences in their internal processes, structure or design. Protocols may be implemented by hardware, software or a combination of both.

Types of protocols include:

- *Hyper Text Transfer Protocol* (HTTP): Used over the world wide web (shows information in web pages).
- *Transmission Control Protocol*(TCP): Used for communication over a network.
- *Internet Protocol*(IP): An addressing protocol (Makes sure data/signals are transmitted to the right address.
- *File Transfer Protocol* (FTP): Used to transfer files to different networks.
- *Simple Mail Transfer Protocol*(SMTP): Manages the transmission and outgoing e-mails over the internet.

Benefits of Computer Networks to Organizations

- The desire to share valuable information is one of the driving forces behind the development of computer networks. Networks have improved response time by overcoming time barrier.
- Resource sharing, multiple computers can share resources like printers. Sharing files and communicating.
- Support organizational decision making processes by overcoming geographical barriers
- Enable the formation of strategic alliances. E.g forming superior working relationships with customers and suppliers by linking to them via networks.
- Generation of revenue. Generating new revenue from online sales or electronic commerce applications.

Benefits of Computer Networks to Organizations Cont

- **The Internet** is a worldwide public network, interconnecting thousands of other networks to form one large "web" for communication and collaboration
- **Cost**: Networkable versions of many popular software programs are available at considerable savings when compared to buying individually licensed copies.
- **Development of new markets and information based products**. e.g web based markets and distribution channels.
- **To attract new customers** through web marketing and advertising as well as online sales of innovative products.

Benefits of Computer Networks to Organizations Cont

- **Flexible Access**: Networks enable users to use any computer that is connected regardless of their location. One is able to do work in one computer and then complete the same piece of work from another computer within the network

Limitations of using computer Networks

- Expensive to Install
- Requires Administrative Time
- File Server Failure
- Cables May Break
- Unreliability in network. For example wireless network signals that suffer from interference from other obstacles in the electromagnetic spectrum
- Security concerns over the network including virus spreading over the network in a very fast way.

Network Design Parameters

In the design, installation and operation of networks, some fundamental parameters are used to define how the network must perform to meet the needs of its users and these include;

- **Availability**- the network being available all the time for the users to do their work, however, its always difficult to have it available throughout.
- **Reliability** – It's the percent of the scheduled available time that the network is actually useful and fully operational.
- **Security** – The network should be secure enough not to be accessed by un authorized users or hackers.
- **Response time**. How fast is the network in terms of responding to different commands by the users

Network Design Parameters

- **Throughput** – This is a measure of the number of characters that can be sent correctly through the network over a period of time.
- **Robustness** – This is a measure of the network's ability to continue operating through, or to recover after the failure of one or more of its services.
- **Cost** – The key costs to be controlled and managed include the cost of design, build, install, operate and maintain the network.

Types Of Computer Networks

Computer networks can be classified into different categories. The classifications help to explain the types of networks in use today, and what they're used for.

The following are the criteria widely used;

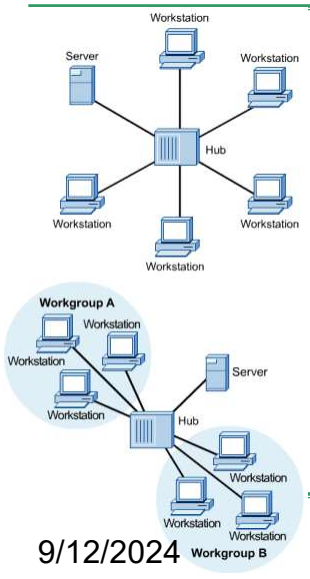
- Classification based on Scale (geographical spread/physical size)
- Classification based on Functional relationships (Network architecture)
- Classification based on network topology

Types of Networks

- Some networks are designed to interconnect many users and systems in a limited geographical region and to enable high-speed communication among them.
- Other networks connect a smaller number of devices that are separated by large geographical distances.
- To meet the requirements of these two broad categories of users, different types of networks have been designed.

	Name	Scope	Example
LAN	Local Area Network	Limited geographical area, usually within the same building	Schools, homes, small businesses
WAN	Wide Area Network	Larger global network with no physical boundaries	Large corporations, government organizations

Local-Area Networks (LANs)

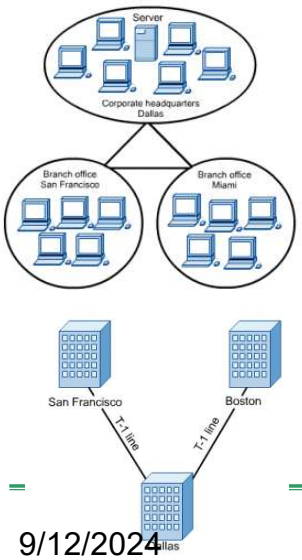


- Local-area networks (LANs) connect many computers in a relatively small geographical area such as a home, an office, a building, or a campus.
- The general shape or layout of a LAN is called its topology.
- All LANs require the networked computers to share the communications channel that connects them.

Metropolitan Area Network

- Metropolitan Area Network is a network spanning a physical area larger than a LAN but smaller than a WAN, such as a city. A MAN is typically owned and operated by a single entity such as a government body or large corporation

Wide-Area Networks (WANs)

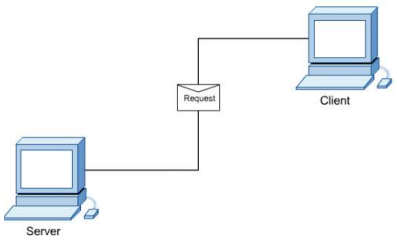


- A WAN is usually segmented into multiple LANs that make up a WAN.
- These lines are called point-to-point because they connect only two devices, one on each side of the line.
- They are called serial lines because the bits of information are transmitted one after another in a series.
- Connections across WAN lines may be temporary or permanent.
- WANs normally operate at lower speeds than LANs.
- Example of WAN is Internet

Intranet and Internet Specifications

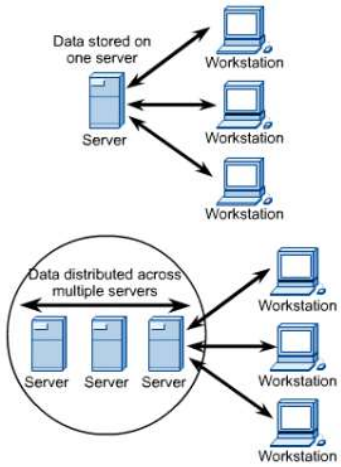
- ***Intranet:*** An intranet is a private network that is contained within an enterprise. It may consist of many interlinked local area networks. An intranet uses a set of rules known as protocols to enable connectivity. Such rules include TCP/IP, HTTP, SMTP and other Internet protocols and in general looks like a private version of the Internet.
- ***Extranet*** – a network that connects people within your company with people who are outside your company--all within a secure, password-protected network that can be accessed from anywhere
- ***Internet:*** is a worldwide system of computer networks - a network of networks in which users at any one computer can, if they have permission, get information from any other computer (and sometimes talk directly to users at other computers).

Peer-to-Peer Networks



- In a peer-to-peer network, the networked computers act as equal partners, or peers to each other. As peers, each computer can take on the client function or the server function.
- Individual users control their own resources.
- They may decide to share certain files with other users. They may also require passwords before they allow others to access their resources.

Client/Server Networks



- In a client/server arrangement, network services are located on a dedicated computer called a server, which responds to the requests of clients.
- The server is a central computer that is continuously available to respond to a client requests for file, print, application, and other services.

Client/Server Networks

- The distribution of functions in client/server networks brings substantial advantages, but it also incurs some costs.
- Although the aggregation of resources on server systems brings greater security, simpler access and coordinated control, introduces a single point of failure into the network.

Client/Server Network Vs Peer to Peer

Advantages of a Peer-to-Peer Network	Advantages of a Client/Server Network
Less expensive to implement.	Provides for better security.
Does not require NOS server software.	Easier to administrator when the network is large because administration is centralized.
Does not require a dedicated network administrator.	All data can be backed up on one central location.

Client/Server Vs Peer to Peer

Disadvantages of a Peer-to-Peer Network	Disadvantages of a Client/Server Network
Does not scale well to large networks; administration becomes unmanageable.	Requires expensive NOS software such as NT or Windows 2000 Server or Novell Netware.
Each user must be trained to perform administrative tasks.	Requires expensive, more powerful hardware for the server machine.
Less secure.	Requires a professional administrator.
All machines sharing the resources negatively impact performance.	Has a single point of failure if there is only one server; users data can be unavailable if the server is down.

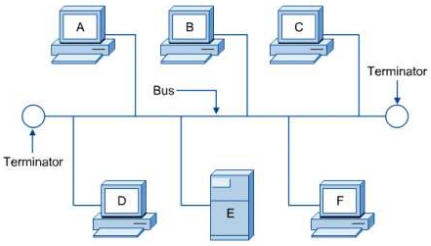
The Network Topology

- The network topology defines the layout of the network.
- It shows how devices on the network are interconnected.
- Devices on the network are termed nodes.
- A network has both a physical and a logical topology

Physical versus Logical Topology

- **Physical topology** shows the physical topology of a network, which refers to the actual physical layout of the devices and media
- **Logical topology** refers to the paths that signals travel from one point on the network to another

Bus Topology

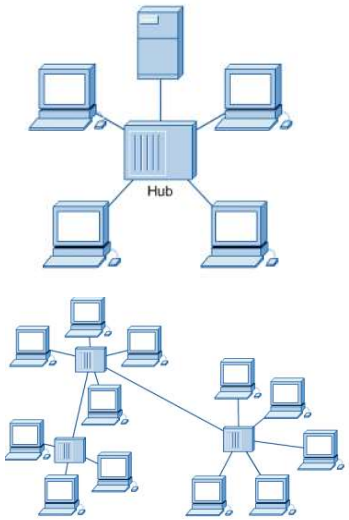


- Commonly referred to as a linear bus, all the devices on a bus topology are connected by one single cable, which proceeds from one computer to the next.
- This topology is rarely used and would only be suitable for a home office or small business with only a few hosts.

Bus Topologies

- Advantages of a bus topology:
  - The thinnet cabling it uses is quite inexpensive.
  - It uses less cable compared to other physical topologies like star or extended star
  - It works well for small networks
  - It does not need a central device, such as a hub, switch, or router
- Disadvantages of a bus topology:
  - It results in slower access to the network and less bandwidth due to the sharing of the same cable by all devices
  - It is challenging to identify and isolate problems
  - A break at any point in the bus cable can disable the entire bus network
  - It needs terminators

Star Topology

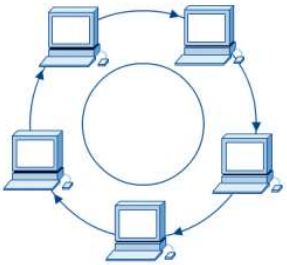


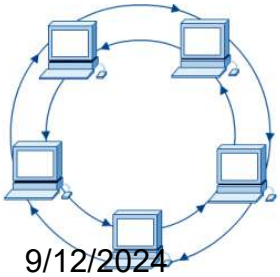
- The star topology is the most commonly used architecture in Ethernet LANs and resembles spokes in a bicycle wheel.
- A star topology generally costs more to implement than the bus topology because more cable is used and a central device is needed, such as a hub, switch, or router.

Star Topology

- Advantages of a Star Topology:
  - It is upgradeable, flexible, and reliable
  - It is easy to design and install
  - This topology makes diagnosing problems relatively easy since the problem is localized to one computer or device
  - This topology allows for more throughput than any other topology
- Disadvantages of a Star Topology:
  - It requires a lot of cable to connect computers since a cable is required between each device and the central location.
  - It is more expensive to build because of the additional cost of cables and devices like hubs and switches that are needed to run between the central device and each computer

Ring Topology



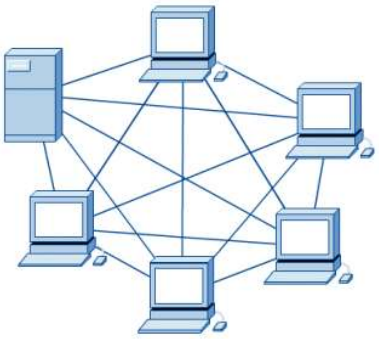


- A frame, called a token, travels around the ring and stops at each node.
- If a node wants to transmit data, it adds that data and the addressing information to the frame.
- The frame continues around the ring until it finds the destination node, which takes the data out of the frame.
- The advantage of using this method is that there are no collisions of data packets.

Ring Topology

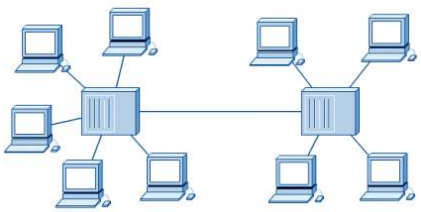
- Ring Topology
- With single ring all the devices on the network share a single cable, and the data travels in one direction only.
- With dual ring two rings allow data to be sent in both directions.
- This creates redundancy (fault tolerance), meaning that in the event of a failure of one ring, data will still be transmitted on the other ring.

Mesh Topology



- The mesh topology connects all devices (nodes) to each other for redundancy and fault tolerance.
- It is used in wide-area networks (WANs) to interconnect LANs and for critical networks.
- The mesh topology is expensive and difficult to implement.

Hybrid Topology



- The hybrid topology combines more than one type of topology.
- When a bus line joins two hubs of different topologies, the configuration is called a star bus.
- The bus line is used to transfer the data between the star topologies.

Considerations When Choosing a Topology

- ***Money.*** *A linear bus network may be the least expensive way to install a network.*
- ***Length of cable needed.*** *The linear bus network uses shorter lengths of cable.*
- ***Future growth.*** *With a star topology, expanding a network is easily done by adding another concentrator.*
- ***Cable type.*** *The most common cable in schools is unshielded twisted pair, which is most often used with star topologies.*

Components of a Network

- Clients
  - Computers that request or order information from a server
  - Usually desktop computers with their own local storage and processing power
  - Thin client – network computer with no local storage

  Servers
  - Computers that work behind the scenes to provide (serve) the resources requested by the clients. These can be
    - Non-dedicated – provides many different services to its client computers such as file retrieval, printing, and emailing
    - Dedicated – provides only one type of resource to its clients, such as printing

Components of a Network Cont;

Network Interface Card (NIC) provides the physical interface between computer and cabling. It prepares data, sends data, and controls the flow of data. It can also receive and translate data into bytes for the CPU to understand.

Repeaters - They allow a cabling system to extend beyond its maximum allowed length by amplifying the network voltages so they travel farther. Repeaters are nothing more than amplifiers and, as such, are very inexpensive. Repeaters can only be used to regenerate signals between similar network segments.

Hubs - are devices used to link several computers together. They repeat any signal that comes in on one port and copy it to the other ports (a process that is also called *broadcasting*).

Image of a network Interface Card

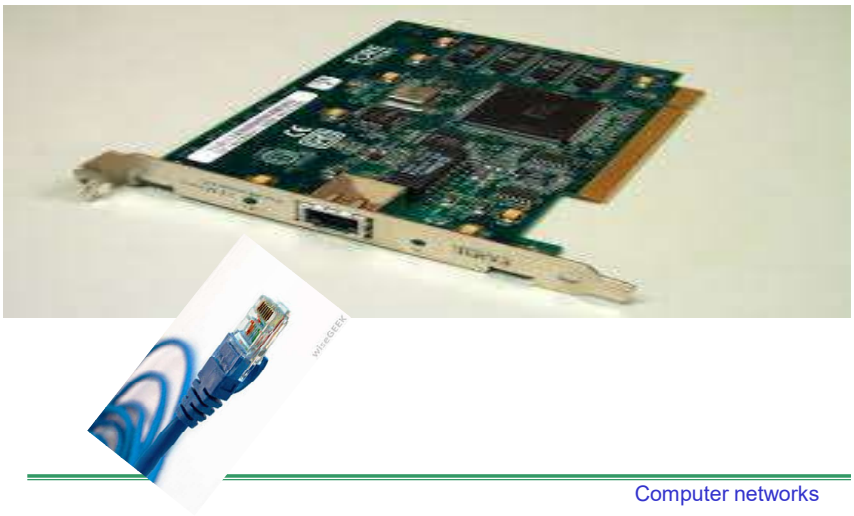
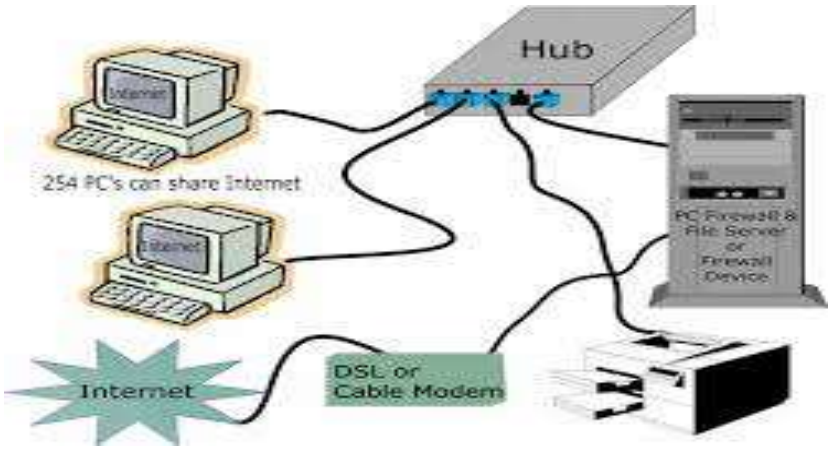


Image of a Repeater

Image of a Hub



Components of a Network Cont;

Bridges join similar topologies and are used to divide network segments. E g, with 200 people on one Ethernet segment, the performance will be mediocre, because of the design of Ethernet and the number of workstations that are fighting to transmit. If you divide the segment into two segments of 100 workstations each, the traffic will be much lower on either side and performance will increase.

Routers - highly intelligent devices that connect multiple network types and determine the best path for sending data.

- The advantage of using a router over a bridge is that routers can determine the best path that data can take to get to its destination.
- Like bridges, they can segment large networks and can filter out noise

Image of a Router

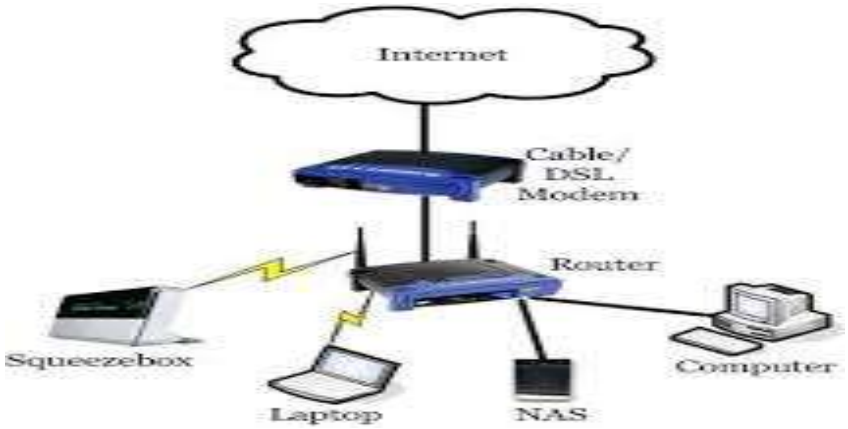
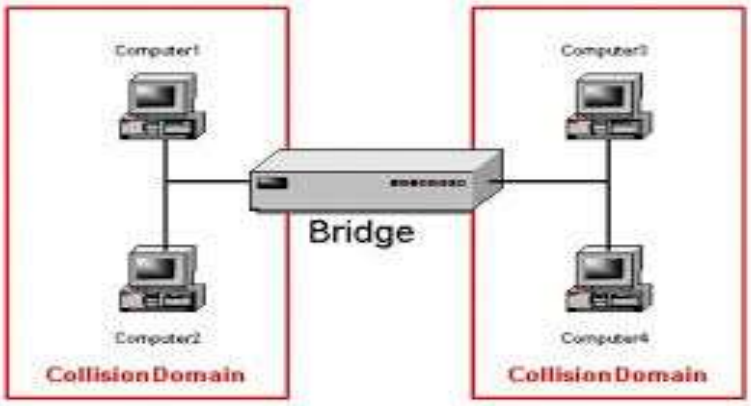


Image of a bridge



Components of a Network Cont;

- A ***network switch*** - is a computer networking device that connects network segments.
  - Low-end network switches appear nearly identical to network hubs, but a switch contains more "intelligence" (and a slightly higher price tag) than a network hub.
  - A **vital difference** between a **hub** and a **switch** is that all the nodes connected to a hub share the bandwidth among themselves, while a device connected to a switch port has the **full bandwidth** all to itself.
- ***A gateway*** - is a network point that acts as an entrance to another network. On the internet, in terms of routing, the network consists of gateway nodes and host nodes.
  - Gateway nodes are computers that control traffic within your company's network or at your local internet service provider (ISP)

Image of a Switch

Components of a Network Cont;

- Security Devices:
  - Firewalls:
    - Software or Hardware that allows only valid traffic to enter or leave the network. Always at the entry point of the network

Components of a Network Cont;

- Wireless NICs
  - Provide wireless connectivity
- Wireless Access Points
  - It is a wireless LAN transceiver
  - Acts as a hub or as a bridge
  - Multiple Access Points – Roaming Functionality

Wireless LAN Topology