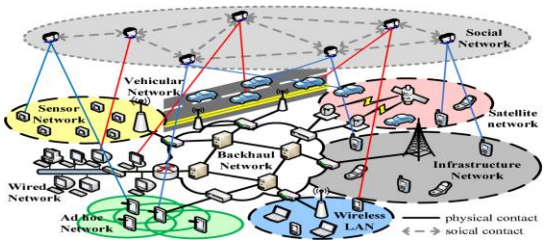
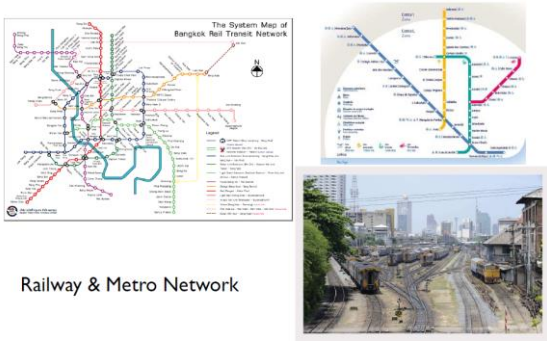
Internet Architecture and Protocols



What is a Network?



Railway & Metro Network

What is a Network?

Highway Network

What is a Network?

Plumbing Network

What is a Network?

Spider Net(work)

What is a Network?

- A system of lines/channels that are interconnected with each other.
- **What is a Computer Network?**

What is a Computer Network?

Networking Technologies

Network

Group of components or devices connected together to give the user a certain service (application).

A network is a set of devices (often referred to as nodes) connected by communication links.

A node can be a computer, printer, or any other device capable of sending and/or receiving data generated by other nodes on the network.

A link can be a cable, air, optical fiber, or any medium which can transport a signal carrying information.

What is a Computer Network?

- A set of computers which are connected together.
- This can mean two computers cabled together on the same desk, or thousands of computers across the world.
- The connections can be cables or wireless.

Definitions

- A *network* is a set of devices (often referred to as nodes) connected by communication links.
- A *node* can be a host (such as a computer, a laptop, a smart phone etc.) or a network device (such as a switch, a router, etc.).
- A *link* is a communication pathway that transfer data from one device to another.

- The encoded transmission of data via electrical, optical or wireless means between computers or network processors.
- Such systems are often called data/computer communication networks.
- In general these networks are established to collect data from remote points (Usually microcomputers).
- The word data refers to information presented in whatever form is agreed upon by the parties creating and using the data.
- Computer communication Services: These include all other types of communication where computer are used for exchange/transfer of information between users.

Advantages of Computer Networks

- Enables users to **share hardware** like scanners and printers. This reduces costs by reducing the number of hardware items bought.
- Allows users **access to data** stored on others' computers. This keeps everyone up-to-date on the latest data
- Can share access to the **Internet**.

Advantages of Computer Networks

- Can even let users **run programs** that are not installed on their own computers but are installed elsewhere in the network.
  - ➢ reduces the effort for networks administrators to keep programs configured correctly and saves a lot of storage space.

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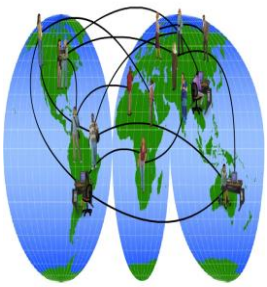
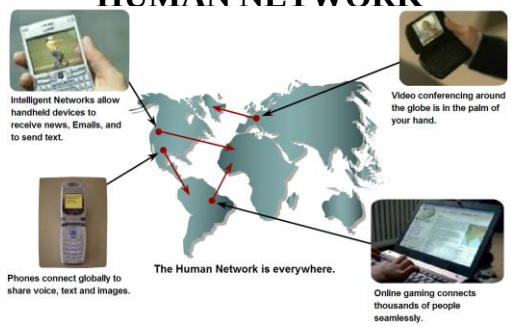
Importance of Networks:

- Easy access and sharing of information
- Sharing of expensive devices and network resources
- Modern Technologies (IP telephony, Video Conferencing, ….etc)

Networks Support the way we live



HUMAN NETWORK



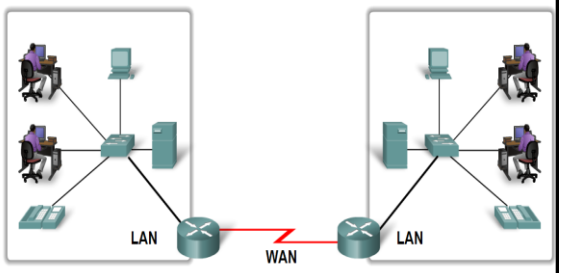
Network components

- **Network has three main components**
- **Computers** (servers and hosts)
  - Source of applications (network aware applications)
  - ex: HTTP (Hyper Text Transmission Protocol),
    FTP (File Transfer Protocol),
    SMTP (Simple Mail Transfer Protocol)
    POP3 (Post Office Protocol 3)
    Telnet
- **Network Devices**
  - Devices that interconnect different computers together
  - ex: Repeaters, hub, bridge, switch, router, NIC and modems
- **Connectivity**
  - Media that physically connect the computers and network devices
  - ex: Wireless and cables

Characteristics of Networks

- ***Delivery*** : System must deliver data to correct destination. Data must be received by only intended device or user.
- ***Accuracy:*** The system must deliver data accurately
- ***Timeliness:*** the system must deliver data in a timely manner. Data delivered later are useless.
- ***Jitter:*** Variation in the packet arrival time. It is the uneven delay in the delivery of audio or video packets.

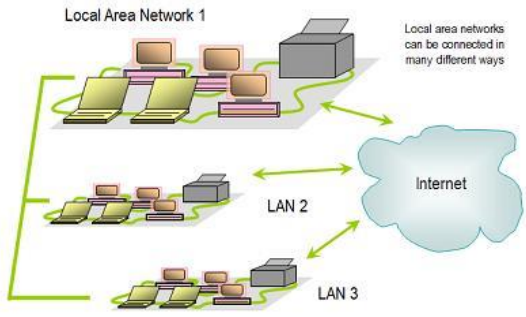
LAN & WAN



Local Area Networks

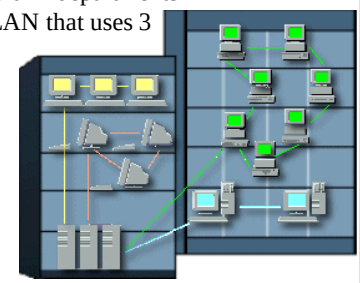
- A **LAN** is a **Local Area Network**. This would include networks where the computers are relatively close together. So LANs would be within the same office, a single building, or several buildings close together.

Local Area Networks



Local Area Network Example 1

- Two buildings with 4 departments connected as a LAN that uses 3 servers.

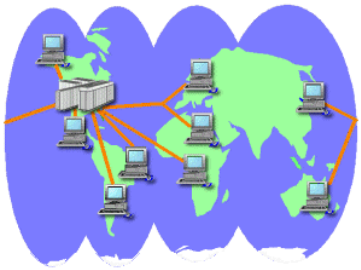


Local Area Network Example 2

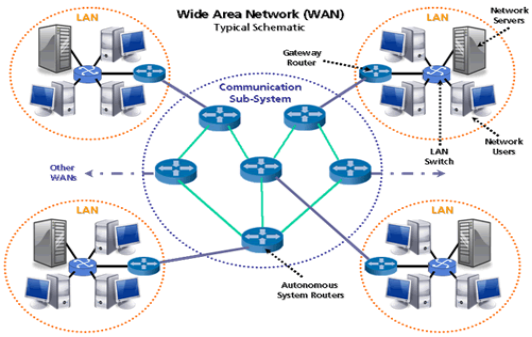
Wide Area Network

- A **WAN** is a **Wide Area Network**, which would be all networks too large to be LANs.
- A WAN would be most useful for large companies with offices or factories in widely separated areas, like Microsoft, IBM, Ford, AT&T, etc.

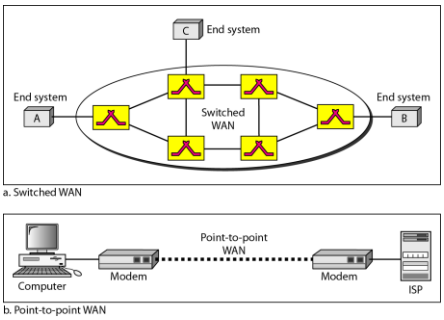
Wide Area Network Example 1



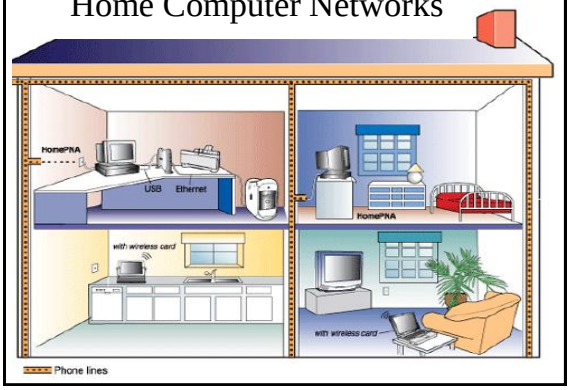
Wide Area Network Example 2



WANs: a switched WAN and a point-to-point WAN

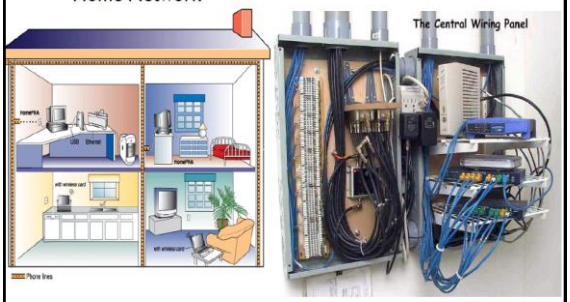


Home Computer Networks



Home Computer Networks

Home Network



Network Criteria

- **Performance**
  - Depends on Network Elements
  - Measured in terms of Delay and Throughput
- **Reliability**
  - Failure rate of network components
  - Measured in terms of availability/robustness
- **Security**
  - Data protection against corruption/loss of data due to:
    - Errors
    - Malicious users

Performance

- Can be measured in many ways!
  - Transmit time: the amount of time required for a message to travel from one device to another.
  - Response time: the elapsed time between an inquiry and a response.
- Often evaluated by two networking metrics: **throughput** and **delay**.

Throughput

- Throughput is an important network metric which is also known as bandwidth.
- The bandwidth of a network is given by the number of bits that can be transmitted over the network in a certain period of time.
- Depends on the network technology (hardware capabilities) and therefore is constant.

Throughput Example

- A network might have a bandwidth of 10 million bits/second (Mbps), meaning that it is able to deliver 10 million bits every second.

Delay

- Also known as latency.
- corresponds to how long it takes a message to travel from one end of a network to the other.
- Latency is measured strictly in terms of time.
- Effected by number of users and hence may change from time to time.

Delay Example

- A transcontinental network might have a latency of 24 milliseconds (ms); that is, it takes a message 24 ms to travel from one end of North America to the other.

Factors Affecting Performance

- Type of transmission media,
- Capabilities of connected H.W and the efficiency of software.
- Number of user

Reliability

- Accuracy of delivery.
- Measured by:
  - Frequency of failures
  - Time it takes to recover from a failure
  - The network's robustness in a catastrophe.

Security

- Many issues at the different layers!
- Examples:
  - Protecting data from unauthorized access.
  - Protecting data from damage.
  - Implementing policies and procedures for recovery from breaches and data losses.

Network Configuration

- There are a number of ways that computers can be connected together to form **networks**.
- Physical attributes of a network include:
  - ❖Type of connection
  - ❖Physical topology

Type of Connection

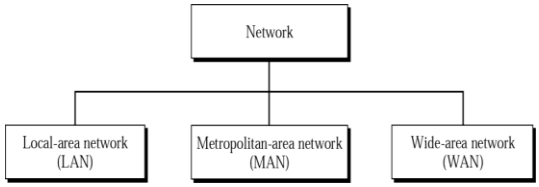
- For communication to occure, two devices must be connected in someway to the same link at the same time.
- Two possible connections:
  - Point-to-point
  - Multipoint

Networks Models

- Computer networks are created by different entities.
- Standards are needed so that these heterogeneous networks can communicate.
- The two most know standards:
  - OSI model: defines a seven layer network.
  - Internet model: defines a five layer network.

Network Categories

Network category is determined by its size, ownership, the distance it cover and its physical architecture.

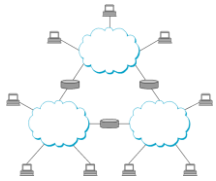


Internetworking

To interconnect two or more networks, one needs a ***gateway*** or ***router***.

Host-to-host connectivity is only possible if there's a uniform ***addressing*** scheme and a ***routing*** mechanism.

Messages can be sent to a single destination (***unicast***), to multiple destinations (***multicast***), or to all possible destinations (***broadcast***).



Internet

- a collaboration of more than 100 of 1000 interconnected network.

- Brief History (self-reading)
- In mid of 1960:
- The Advanced Research Projects Agency (ARPA) in the department of defense was interested in finding a way to connect computers so that the researchers they funded could share their findings, to reduce costs and eliminating duplication of effort.

Brief History

- 1n1967
  - ARPA presented its ideas for ARPANET, small network of connected computers (mainframe).
- 1n 1969,
  - ARPANET was reality. Four nodes at the UNV. Of California,(at los angles and Santa Barba), univ. of utah and SRI (Stand ford Research Institute connected via Interface Message Processor IMPs computers to form a network. Software called Network Control Protocol (NCP) provided communication between the hosts.

Brief History

- In 1972,
  - Protocol to achieve end -to-end delivery of packets, Transmission Control Protocol (TCP).
  - Authorities made decision to split TCP into two protocols:
  - IP: Internetworking protocol to handle datagram routing and
  - TCP: responsible for higher-level-functions such as error detection, segmentation and reassembly.

- **Internet today**
  - Made up of many wide and local area networks joined by connecting devices and switching stations. Today most end users use the **services of internet service providers (ISPs).**

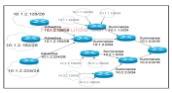
ATTRIBUTES OF INTERNET

Internet was developed to support

Adaptive Routing:

Adaptive routing means the traffic can take different Routes through the Internet depending on network conditions.

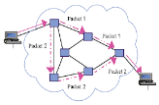
The possible result of adaptive routing is that the destination may receive the packets out of order.



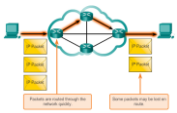
Connectionless System:

This means Circuits are not setup between the Users.

As a result, the internet does not maintain an ongoing knowledge of user traffic and does not build a fixed path.



"Best effort" delivery Service:



The Internet is a "best effort" delivery network.
The term best effort means that the Internet will attempt to deliver the traffic.

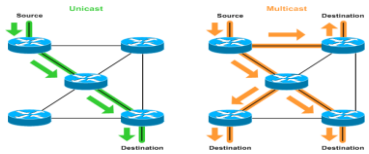
But traffic discarded if problem occur (damaged bits. Due to errors, congestion at router, etc).

Data Applications:

This aspect of Internet describes that Internet is not Particularly good choice for the transport of voice traffic, because there is not "tune" for voice or video.

Unicasting or Multicasting Operations:

The Internet supports either one-to-one or one-to-many means Multicasting operation.

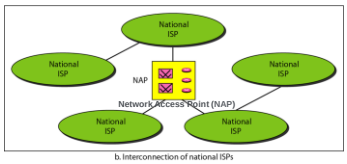


Internet Service Providers (ISPs)

- Hierarchical organization of the Internet includes:
  - **International Internet Service Providers**
  - **National Internet Service Providers**
  - **Regional Internet Service Providers**
  - **Local Internet Service Providers**

internet service providers (ISPs)

a. Structure of a national ISP



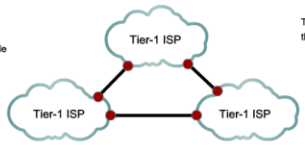
b. Interconnection of national ISPs

Internet

Internet Structure - A Network of Networks

At the center of the Internet, "tier-1" ISPs provide national and international connections. These ISPs treat each other as equals.

Examples are: Verizon, Sprint, AT&T, NTT, cable systems and wide area wireless networks.



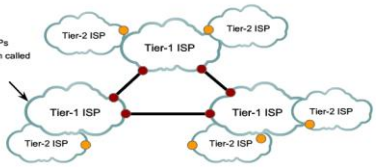
This is the "backbone" of the Internet.

Internet

Internet Structure - A Network of Networks

"Tier-2" ISPs are smaller and often provide regional service. Tier-2 ISPs usually pay Tier-1 ISPs for connectivity to rest of the Internet.

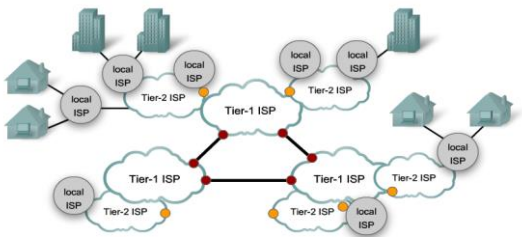
The point where ISPs interconnect is often called a "border."



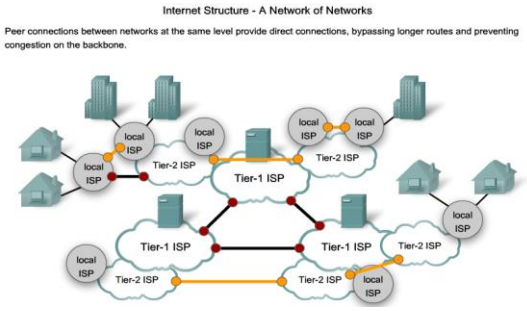
Internet

Internet Structure - A Network of Networks

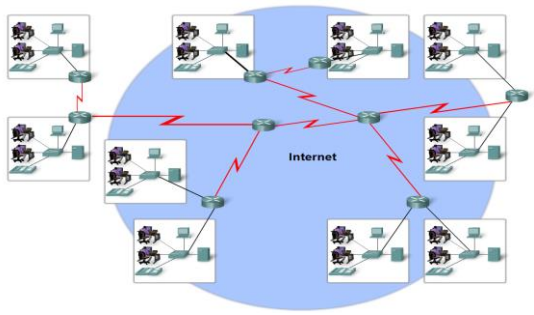
"Tier-3" ISPs are the local providers of service directly to end users. Tier-3 ISPs are usually connected to Tier 2 ISPs and pay Tier 2 providers for Internet access.



Internet



Internet



Data Centers

- Enterprise/ University Network.

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Data Center Tiers

- Tier 1 = Non-redundant capacity components (single uplink and servers).
- Tier 2 = Tier 1 + Redundant capacity components.
- Tier 3 = Tier 1 + Tier 2 + Dual-powered equipment and multiple uplinks.
- Tier 4 = Tier 1 + Tier 2 + Tier 3 + all components are fully fault-tolerant including uplinks, storage, chillers, HVAC systems (heating, ventilation, and air conditioning), servers etc. Everything is dual-powered.
- Data Center Availability According To Tiers
- The levels also describes the availability of data from the hardware at a location as follows:

- Tier 1: Guaranteeing 99.671% availability.
- Tier 2: Guaranteeing 99.741% availability.
- Tier 3: Guaranteeing 99.982% availability.
- Tier 4: Guaranteeing 99.995% availability

Protocols and Standards

- Protocols
- Standards
- Standards Organization

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Protocols and Standards

Two widely used terms: protocols and standards.

First, we define protocol, which is synonymous with "rule."
Then we discuss standards, which are agreed-upon rules.

Terms:

Protocols
Standards

Protocol

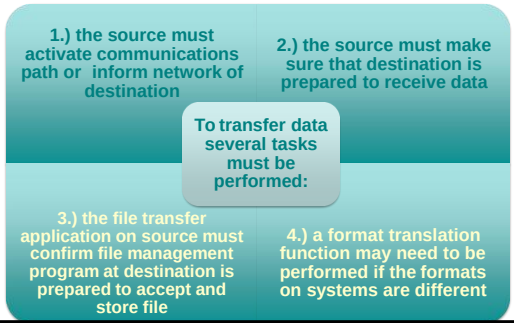
To destroy communication completely, there must be no rules in common between transmitter and receiver—neither of alphabet nor of syntax.

Colin Cherry

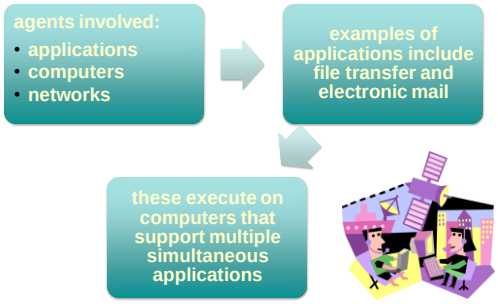
Network Protocols

- Describes the rules that govern the transmission of data over the communication Network.
- Provide a method for orderly and efficient exchange of data between the sender and the receiver.

The Need For Protocol Architecture



A Simple Protocol



- A network protocol is set of rules that govern the exchange of message between two or more processes in a network.
- Protocol is agreed upon a way through which computer and other communication devices/systems communicate with each another.
- A protocol is the "language" of the network. A method by which two dissimilar systems can communicate.

  Standards are developed through the cooperation of standards creation committees, forums, and government regulatory agencies.

What's a protocol?

human protocols:
- "what's the time?"
- "I have a question"
- introductions

… specific msgs sent
… specific actions taken when msgs received, or other events

network protocols:
- machines rather than humans
- all communication activity in Internet governed by protocols

protocols define format, order of msgs sent and received among network entities, and actions taken on msg transmission and/or receipt of a msg.

Roles of Network Protocol

1. Data Sequencing – to detect loss or duplicate packets.
2. Data Routing – to find the most efficient path between source and a destination.
3. Data formatting – defines group of bits within a packet which constitutes data, control, addressing and other information.
4. Flow control – ensures resource sharing and protection against traffic congestion by regulating the flow of data on communication lines.

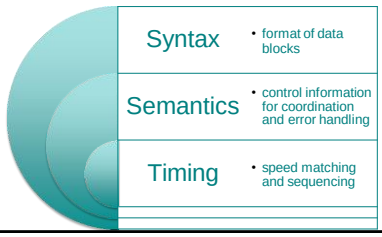
Roles of Network Protocol

5. Error control – detect errors in messages. Method for correcting errors is to retransmit the erroneous message block.
6. Precedence and order of transmission – condition all nodes about when to transmit their data and when to receive data from other nodes. Gives equal chance for all the nodes to use the communication channel.
7. Connection establishment and termination –
8. Data security – Prevents access of data by unauthorized users.

Key Features of a Protocol

A protocol is a set of rules or conventions that allow peer layers to communicate.

The key features of a protocol are:



Key elements of a protocol:

- **Syntax, semantics and timing**
- **Syntax:** Structure or format of the data, meaning the order in which they are presented. Example: A simple protocol might expect the first byte of data to be the address of the sender, the second byte to be the address of the receiver and the reset of the stream to be the message itself.

Key elements of a protocol:

- **Semantics:** Refers to the meaning of each section of bits.
  - Example: does an address identify the route to be taken or the final destination of the message.

Key elements of a protocol:

- **Timing:** When data to should be sent?
  - How fast they can be sent? Example: If a sender produces data at 100Mpbs but the receiver can process data at only 1Mpbs, transmission will overload the receiver and data will be largely lost.