Computer Networking Technologies and Application to IT Enabled Services

Pranab Kumar Chakravarty
Computer Centre, Banaras Hindu University, Varanasi
Email: pranab@bhu.ac.in

Abstract

In today's world, a computer network is much more than a collection of interconnected devices. The computer network is the resource, which enables to analyse, organise, and disseminate the information that is essential to profitability. The rise of intranets and extranets is the important aspect of computer networking. Intranets and extranets are private business networks that are based on Internet technology. The businesses are currently implementing intranets at a breakneck pace and for one reason only—an intranet enables a business to collect, manage, and disseminate information more quickly and easily than ever before. Many businesses are implementing intranets simply to remain competitive; businesses that delay are likely to see their competition outdistance them. In this article we are presenting the basic definition of computer network, characteristics of transmission media-bounded and unbounded, networking components and a brief review of the applications of networking in IT enabled services.

Introduction to Computer networks

Definitions

A network is any collection of entities that exchange information or goods. The nervous system of an animal is a network that facilitates the movement of information to and from the brain and the other parts of the body. A railway system is a network, since it facilitates the movement of goods and at one point in time, information between destinations. The phone lines are also a network. They allow people to communicate and transfer information all over the world [2].

A computer network is no different than any of the before-mentioned networks. A computer network exchanges information to and from computers and has a system to direct the information to the correct computer. The Internet as it is known today is a huge network composed of millions and millions of smaller networks called LAN's or Intranets.

Two or more computers connected to, or can communicate with, each other in some way. Such computers are also called nodes or stations and run software that initiates and manages their interaction in sharing files and other resources.

A set of computers exchanging information by common conventions, called protocols, over communication media

A network is created when two or more computers are connected to share information and resources.

A computer network is a collection of computers, which are in some way connected such that they can exchange data between themselves and other computers on the network. It

might involve physical wire, infrared or radio frequency communication, and can be usually used to share files, devices and connections to other computers. The Internet is an example of a computer network. [3]

A computer network is simply computers wired together in a way that lets them share data and/or devices such as hard drives, CD-ROMs, fax-modems, printers, etc.

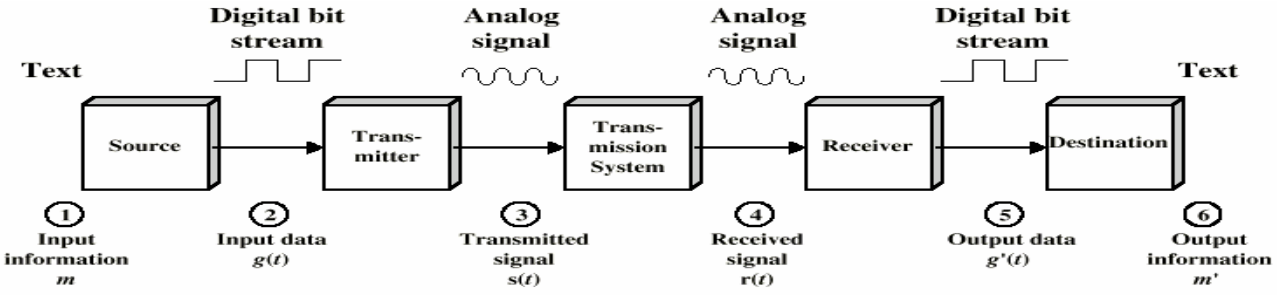
A computer network is an **interconnected** collection of **autonomous** computers where **interconnected** means that the computers can exchange information and **autonomous** means that no computer can start, stop or control another computer connected to the network.

On the most basic level, therefore, a computer network is a collection of devices that can store and manipulate electronic data, interconnected in such a way that network users can store, retrieve, and share information.

Commonly connected devices include microcomputers, minicomputers, mainframe computers, terminals, printers, fax machines, pagers, and various data storage devices. In the near future, numerous other types of devices will be network connectable, including interactive TVs, videophones, and navigational and environmental control systems. Eventually, devices everywhere will give a two-way access to a vast array of resources on a global computer network.

Basic Communication Model[1]

The information in the form of any text or document is converted in digital bit stream and then passed through a transmitter. The signal is then sent via a transmission media and received by the receiver. This data is finally passed to the destination.



Transmission Media

Fibre Optic Technology

- *Optical (Single mode/ Multi Mode)*
    - Fiber optic cabling is a technology where electrical signals are converted into optical signals, transmitted through a thin glass fiber, and re-converted into electrical signals
    - Fiber optic cabling is constructed of three concentric layers: The "core" is the central region of an optical fiber through which light is transmitted. The "cladding" is the material in the middle layer. It has a lower index of refraction than the core, which serves to confine the light to the core. An outer "protective layer", or "buffer", serves to protect the core and cladding from damage.

- Can also transmit the signal further without regeneration and it is less sensitive to noise
- Minimum bend radius though the itself is very small
- Protective sheathing required makes the optical quite bulky for connections to end user equipment
- Multi-mode fiber allows many "modes", or paths, of light to propagate down the fiber optic path. The relatively large core of a multi-mode fiber allows good coupling from inexpensive LEDs light sources, and the use of inexpensive couplers and connectors. Multi-mode fiber typically has a core diameter of 50 to 100 microns.
- Multi-mode fiber can support segment lengths as long as 2000 meters for 10 and 100 Mbps Ethernet, and 550 meters for 1 Gbps Ethernet.
- Single-mode fiber has a core diameter that is so small (on the order of 10 microns) that only a single mode of light is propagated. This eliminates the main limitation to bandwidth, modal dispersion.
- Segment lengths of 5000 meters and beyond are supported at all Ethernet data rates through 1 Gbps. However, single-mode fiber has the disadvantage of being significantly more expensive to deploy than multi-mode fiber.

- **Advantages of fibre optic cable:**
  - Very high bandwidth.
  - Immunity to Electro Magnetic Interference; fibre optic cables can be used in environments that make wire cables unusable.
  - No radio frequency emissions; signals on fiber optic cables cannot interfere with nearby electronic devices and cannot be detected by conventional electronic eavesdropping techniques.

Unbounded Transmission Media

- *Radio*
  - radio will be increasingly used to remove or reduce the need for cabling.
  - In recent years radio equipment has been developed to exploit the higher frequency Gigahertz part of the radio spectrum.
  - At these higher frequencies and with low power transmitters the distances over which the signal travel is quite limited. This is an advantage as the principal problem with radio is that it is a broadcast medium. The shorter the range of transmissions the greater is the number of transmitters, which may share a given frequency without contending with one another.
  - Omni-directional and Low bandwidth.
  - Lack of security. Enables *mobile* communication & computing!
  - Broadcast mechanisms: *cellular radio, radio nets*, & *low-orbit satellites*.
  - Susceptible to interference (primarily multi-path interference).
  - Reallocation of limited frequencies may be required for wireless communication growth.

- *Microwave*
  - Transmitter is a parabolic dish, mounted as high as possible
  - Up-front investment in towers & repeaters.

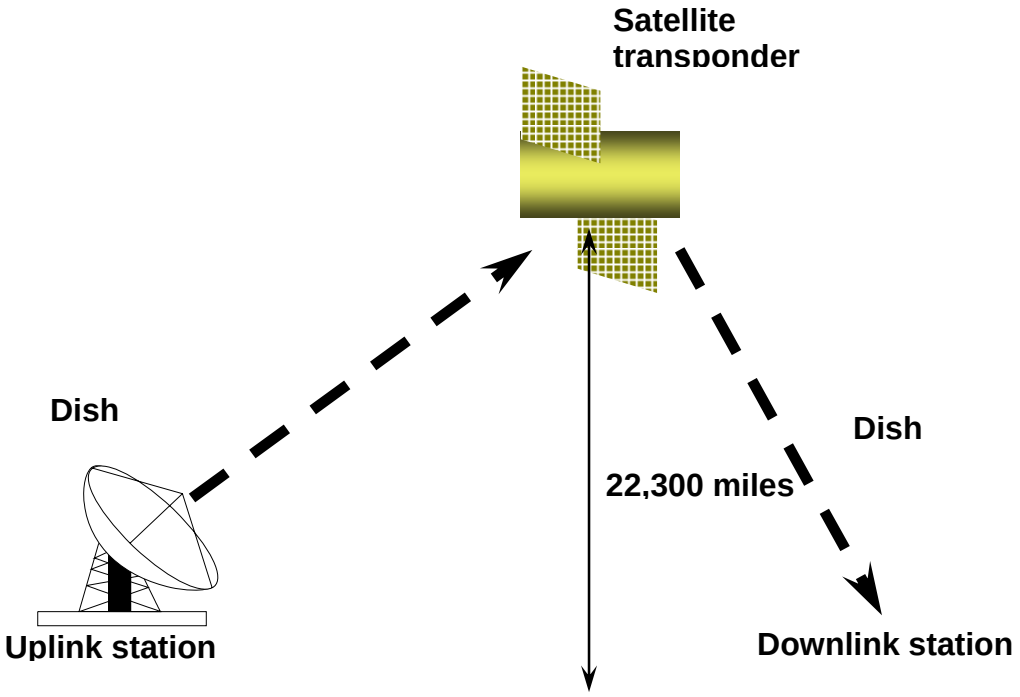
- Uses the radio frequency spectrum, commonly from 2 to 40 Ghz
- High bandwidth (~45 Mbps)
- Curvature of the earth requires stations (called repeaters) to be ~30 miles apart
- No cabling between sites.
- Requires unobstructed line of sight between source and receiver (Clear line-of-sight required).
- Susceptible to radio interference.
- Attenuation increases with rainfall
- Lack of security.
- Low power used to minimize effects on people
- Used by common carriers as well as by private networks
- Long-haul telecommunications service for both voice and television transmission
- Short point-to-point links between buildings for closed-circuit TV or a data link between LANs

- *Satellite Networks*
  - The use of geostationary orbiting satellites to relay transmissions from one sending earth station to another, perhaps multiple other, earth stations
  - Relay station in sky that creates point-to-point and point-to-multipoint (broadcast) with Uplink and Down Link
  - High bandwidth.

    No line-of-sight requirement & no cabling.
  - Susceptible to interference and interception.
  - Transmission costs are independent of distance
  - Initial uplink & downlink station (earth stations) costs and Satellite channel lease costs.
  - It has been possible to transmit data via satellite since the 1960's using radio for the uplinks and downlinks with the satellite.
  - Much of the capacity of current communications satellites is concerned with the transmission of point-to-point TV pictures or multiplexed telephone links. Since the early 1980s it has been possible to transmit broadcast TV signals direct to consumer premises with small (0.6m?) dish aerials.
  - This is a result of higher power transmitters at the satellite and more sensitive receivers at the user. Increasingly it is becoming possible to transmit direct transmit and receive direct from mobile handsets. This requires low orbit satellites at between 100 and 200 miles above the Earth's surface rather than

the geostationary satellites currently in widespread use for communication, which are around 25,000 miles above the surface.

- Systems are under discussion, which involve from 20 to 800 low earth orbit satellites. This would permit transmission of high quality data and voice directly to and from the mobile user.



Components of a Computer Network[3]

Most of the components of a computer network can be classified into one of the categories below. There are many hundreds of different specific network components available which perform various functions. As we encounter new components, try to figure out which category they fit into. Components are not determined by any physical characteristics but by the function they perform. A typical computer could be configured as plain computer or a router.

1. Node… (or a workstation)
    - Computer with Network Interface Card
    - Sender and/or Receiver

2. Transmission Media

Carry electronic signals from one computer to another

3. Network Operating Systems and Device Drivers

   It is the program that manages the resources and services of a network. It also provides network security including permissions.

4. Protocols, Language & Error detection

   Network Protocols on the other hand are the languages that allow computers to communicate with each other. The protocols and data are transmitted through packets.

   Accepted common format (i.e., computer language) that all computers on a network use to transmit data. There are many standard protocols, among them: AppleTalk, Ethernet, NetBEUI, and TCP/IP

5. Message, Application or Service

   Computer applications used to operate the network and its many components.

6. Actual Devices and other Auxiliary Components

   - *File Servers*

   Which is the central data storage unit for the network; all other computers connected to the network work off of the server.

   A file server stands at the heart of most networks. It is a very fast computer with a large amount of RAM and storage space, along with a fast network interface card. The network operating system software resides on this computer, along with any software applications and data files that need to be shared. The file server controls the communication of information between the nodes on a network. File servers should have at least the following characteristics:

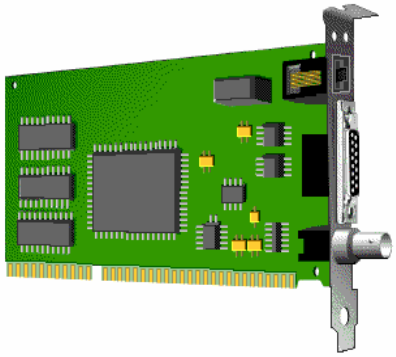
   - A fast microprocessor (Pentium, PowerPC)
   - A fast hard drive with many gigabytes of storage
   - A RAID (Redundant Array of Inexpensive Disks) to preserve data after a disk casualty
   - A tape back-up unit
   - Numerous expansion slots
   - Fast network interface card
   - A big RAM

   - *Workstations*

   All of the computers connected to the file server on a network are called workstations. A typical workstation is a computer that is configured with a network interface card, networking software, and the appropriate cables.

Workstations do not necessarily need floppy disk drives or hard drives because files can be saved on the file server.

- *Network Interface Cards*



Ethernet card. From top to bottom: *RJ-45*, *AUI*, and *BNC connectors*

The network interface card (NIC) provides the physical connection between the network and the computer workstation. Most NICs are internal, with the card fitting into an expansion slot inside the computer. Some computers, such as Mac Classics, use external boxes that are attached to a serial port or a SCSI port. Laptop computers generally use external LAN adapters connected to the parallel port or network cards that slip into a PCMCIA slot.
Network interface cards are a major factor in determining the speed and performance of a network. It is a good idea to use the fastest network card available for the type of workstation one are using.
The three most common network interface connections are *Ethernet cards*, *LocalTalk connectors*, and *Token Ring cards*. Ethernet is the most popular, followed by Token Ring and LocalTalk.

Each NIC has a physical address assigned to it at the factory. This address is programmed onto a chip on the NIC. No two physical addresses are ever the same. The addresses are referred to as Media Access Control (MAC) addresses.

- *Transceivers*

This is a shortened form for transmitter-receiver. It is a device that contains electronic circuitry to both transmit onto and receive signals carried by the coaxial cable. It contains a tap that when pushed against the coaxial cable penetrates the cable and makes contact with the core of the cable. The transceiver, it tap and its housing are often referred to as medium attachment units (MAU). Transceivers are used to connect nodes to the various Ethernet media. Transceivers also provide an Application User Interface, or AUI, connector for the computer. The MAU is generally attached directly to the computer's AUI connector, or the MAU may be attached to the computer with a specially shielded AUI cable. In addition to an AUI connector, many computers and interface network cards also contain a built-in 10 BASE-T or 10 BASE 2 MAU, allowing them to be connected directly to Ethernet without requiring an external MAU. The AUI connector consists of a 15-pin D-shell type connector, female on the computer side, male on the MAU side. Many Ethernet-compatible computers provide such an AUI connector.

- *Repeaters*

When a signal travels along a cable, it tends to lose strength. A repeater is a device that boosts a network's signal as it passes through. The repeater does this by electrically amplifying the signal it receives and re-broadcasting it. Repeaters can be separate devices or they can be incorporated into a concentrator. They are used when the total length of the network cable exceeds the standards set for the type of cable being used.
A good example of the use of repeaters would be in a local area network using a star topology with unshielded twisted-pair cabling. The length limit for unshielded twisted-pair cable is 100 meters. The most common configuration is for each workstation to be connected by twisted-pair cable to a multi-port active concentrator. The concentrator regenerates all the signals that pass through it allowing for the total length of cable on the network to exceed the 100-meter limit.

- *Hub*

Connects all computers in a network to each other and helps direct messages to appropriate recipients; as more users join the network, more hubs may be added

The hub is a central connection point for wiring the network. A typical hub has multiple ports to which computers and peripheral devices such as servers are attached.

The hub performs the following functions

The hub receives, re-times and regenerates signals received from any attached station.
The hub also functions as a filter i.e. it discards severely distorted frames.
Hubs monitor, record and count consecutive collisions that occur on each individual station link. Since an excessive number of consecutive collisions will prevent data transfer on all of the attached links, hubs are required to cut off or partition any link on which too many collisions occurred. This partitioning enables the remainder of the network to operate where a faulty NIC transmits continuously

The term hub is generally associated with the many proprietary network topologies that use the hubs to connect multiple cable runs in a star-wired network topology into a single network. The term multistation access unit (MSAU) is used to refer to the Token Ring wiring concentrator. Just as these two LAN technologies use different media access methods, hubs and MSAUs perform different media access functions internally, but at one level they perform the same function: They are both network wiring concentrators.

- *Bridges*

A bridge will connect to distinct segments (usually referring to a physical

length of wire) and transmit traffic between them. A bridge therefore serves two purposes.

It connects two similar networks. For example, if two LANs are connected with a bridge, the users of each LAN can access the other network's file server without making any physical changes to their data.

A bridge allows segmentation of large networks into two smaller, more efficient networks. It does this by monitoring the information traffic on both sides of the network so that it can pass packets of information to the correct location. Filtering is done based on the destination address of the packet. If a packet's destination is a station on the same segment where it originated, it is not forwarded. If it is destined for a station on another LAN, it is connected to a different bridge port and forwarded to that port.
Used to connect the two or more networks. They must, however, be used between networks with the same protocol e.g. Ethernet to Ethernet or Token Ring to Token Ring.

The bridge works at the LAN Medium Access Control (MAC) protocol level. Some bridges will connect an Ethernet to a Token Ring, which is made possible by the standardized use of addresses in the IEEE 802 series standards.

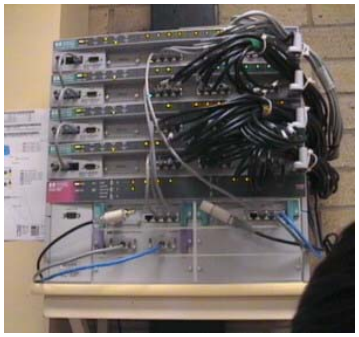
"Learning" bridges build the list of addresses gradually. They do this by noting the source address of any new packet sent when they are first switched on

- *Routers*

The difference between a router and a bridge is that a router operates at level 3 in the OSI seven layer model, whereas a bridge operates at level 2. This means that a router can be used to connect different types of networks and, because it has access to level 3 routing information, can dynamically make the best (cheapest, fastest, etc) choice of route between the networks. Routers divide the network logically instead of physically. A router will decide whether to forward a packet by looking at the protocol level addresses (e.g. TCP/IP addresses) rather than MAC address. Routers can therefore

Direct signal traffic efficiently
Route messages between any two protocols
Route messages between linear bus, star, and star-wired ring topologies
Route messages across fiber optic, coaxial, and twisted-pair cabling

- *Switches*



Switching in LANs is a relatively new technology that tries to overcome the *shared medium shared bandwidth bottleneck* associated with LANs. Switches perform the following functions in a network

- Link several separate LANs
- Provide packet filtering between the LANs.
- Increase network performance by providing each port with dedicated bandwidth (technology is referred to as *dedicated LANs*), without requiring users to change any existing equipment, such as NICs, hubs, wiring, or any routers or bridges that are currently in place. Switches can also support numerous transmissions simultaneously.

The shared medium shared bandwidth bottleneck

In Ethernet and Token Ring networks, a common medium to which devices are attached is used to link the various devices. This means that the bandwidth of the medium is shared with only one user able to transmit at any given time. This is what is referred to as shared medium shared bandwidth.

Ethernet – Devices compete for a slice of bandwidth on the backplane in cases where a hub is used or for the backbone cable
Token Ring – devices compete for the acquisition of the token.

A LAN switch has multiple ports, each of which can support a single end station or an entire Ethernet or Token Ring LAN. With a different LAN connected to each of the switch's port, it can switch packets between LANs as needed. It thus acts like a very fast multiport bridge.

- *A gateway*

Is the combination of hardware and software that connects two dissimilar computer networks? A gateway allows a LAN user to access a mainframe network without leaving his or her PC. Similarly, a gateway between a LAN and a WAN enables a LAN user to send E-mail over the WAN.

Application of Networking – IT enabled services

With the explosive growth of the Internet, businesses of all sizes aim on applying network-wide solutions on their IT (Information Technology) infrastructures, migrating their legacy systems and applications into web based environments, and thus transforming them into on-line. Web based distributed environments are forming the base for the provisions of large –scale electronic services by a multitude of service providers to the industrial type of clients. Web services are the natural consequence of the web evolution into an open medium, which facilitates complex business and application interactions, providing a viable solution for enabling data and system interoperability. Now a days there are a growing number of Web Services implementations across several industries, mainly in the Enterprise Application Integration and Business- to- Business (B2B) sectors.

The information technology enabled services (ITES) is defined as “the delegation of one or more business processes to an external service provider who in turn owns, manages and administers the selected processes based on defined and measurable performance metrics.”

The services in the ITES sector includes the following: Call Centres, Medical Transcriptions, Back office operations, Revenue claims processing, Legal databases, Content development (engineering design, animation) finance (payrolls, billing services, accounting transactions, tax consulting & compliance, risk management, financial reporting, financial analysis), logistics management, GIS (geographical information services), HR (human resources) services, Web services etc.

The government and education sector services are as follows: Multi-media content preparation, access and distribution, e-governance, e learning, virtual laboratories Digital Libraries, etc.

The core facilities are provided by these applications are through the ICT (Information Communication Technology) tools. The banking services, financial management, risk management, business data analysis etc. is the prime area of activities.
This has created a great development of BPO (Business Process Outsourcing), where the jobs can be outsourced to the call centres at a substantial cost. This will generate new type of business within our country and will have a great impact on the economy of our country and generate employment.

References:

1.William Stallings, Data and computer Communication, 7 th Edition, Pearson Education, Second Indian Reprint,2004

2.Fortier, P.J. Handbook of LAN technology 2nd Ed. New York: McGraw-Hill,1992

3.Behrouz A. Forouzan, Local area networks,First edition, Tata McGraw-Hill ,2002

Citation: Communication Support for Sustainable Development. Eds. Dipak De and Basavaprabhu Jirli, GangaKaveri Publishing House, Jangamawadi Math, Varanasi - 221001