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1.1 DATA COMMUNICATION AND NETWORKING IN TODAY'S ENTERPRISE

Trends

Three different forces have consistently driven the architecture and evolution of data communications and networking facilities: traffic growth, development of new services, and advances in technology.

Communication traffic, both local (within a building or building complex) and long distance, both voice and data, has been growing at a high and steady rate for decades. The increasing emphasis on office automation, remote access, online transactions, and other productivity measures means that this trend is likely to con- tinue. Thus, managers are constantly struggling to maximize capacity and minimize transmission costs.

As businesses rely more and more on information technology, the range of services expands. This increases the demand for high-capacity networking and trans- mission facilities. In turn, the continuing growth in high-speed network offerings with the continuing drop in prices encourages the expansion of services. Thus, growth in services and growth in traffic capacity go hand in hand. Figure 1.1 gives some examples of information-based services and the data rates needed to supportthem.

Finally, trends in technology enable the provision of increasing traffic capacity and the support of a wide range of services. Four technology trends are particularly notable:

The trend toward faster and cheaper, both in computing and communications, continues. In terms of computing, this means more powerful computers and clusters of computers capable of supporting more demanding applications, such as multimedia applications. In terms of communications, the increasing use of optical fiber has brought transmission prices down and greatly increased capacity. For example, for long-distance telecommunication and data network links, recent offerings of dense wavelength division multiplexing (DWDM) enable capacities of many terabits per second. For local area net- works (LANs) many enterprises now have Gigabit Ethernet backbone net- works and some are beginning to deploy 10-Gbps Ethernet.

Both voice-oriented telecommunications networks, such as the public switched telephone network (PSTN), and data networks, including the Internet, are more "intelligent" than ever. Two areas of intelligence are noteworthy. First, today's networks can offer differing levels of quality of service (QoS), which include specifications for maximum delay, minimum throughput, and so on. Second, today's networks provide a variety of customizable services in the areas of net- work management and security

The Internet, the Web, and associated applications have emerged as dominant features of both the business and personal world, opening up many opportunities and challenges for managers. In addition to exploiting the Internet and the Web to reach customers, suppliers, and partners, enterprises have formed intranets and extranets[1] to isolate their proprietary information free from unwanted access.

There has been a trend toward ever-increasing mobility for decades, liberating workers from the confines of the physical enterprise. Innovations include voice mail, remote data access, pagers, fax, e-mail, cordless phones, cell phones and cellular networks, and Internet portals. The result is the ability of employ- ees to take their business context with them as they move about. We are now seeing the growth of high-speed wireless access, which further enhances the ability to use enterprise information resources and services anywhere.

1.2 DATA COMMUNICATION MODEL IN NETWORKING

The fundamental purpose of a communications system is the exchange of data between two parties. Figure 1.2b presents one particular example, which is commu- nication between a workstation and a server over a public telephone network. Another example is the exchange of voice signals between two telephones over the same network. The key elements of the model are as follows:

Source. This device generates the data to be transmitted; examples are tele- phones and personal computers.

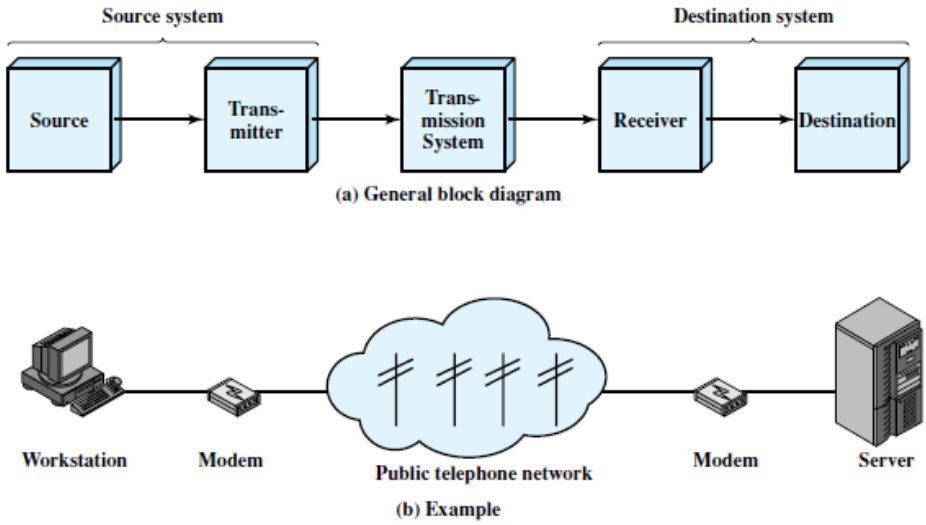


Figure 1.2 Simplified Communications Model

Transmitter: Usually, the data generated by a source system are not transmit- ted directly in the form in which they were generated. Rather, a transmitter transforms and encodes the information in such a way as to produce electro- magnetic signals that can be transmitted across some sort of transmission sys- tem. For example, a modem takes a digital bit stream from an attached device such as a personal computer and transforms that bit stream into an analog sig-nal that can be handled by the telephone network.

Transmission system: This can be a single transmission line or a complex net- work connecting source and destination.

Receiver: The receiver accepts the signal from the transmission system and converts it into a form that can be handled by the destination device. For example, a modem will

accept an analog signal coming from a network or transmission line and convert it into a digital bit stream.

Destination: Takes the incoming data from the receiver.

1.3 DATA COMMUNICATION

Data Communication is defined as exchange of data between two devices via some form of transmission media such as a cable, wire or it can be air or vacuum also. For occurrence of data communication, communicating devices must be a part of communication system made up of a combination of hardware or software devices and programs.

Data Communication System Components:
There are mainly five components of a data communication system:
1. Message
2. Sender
3. Receiver
4. Transmission Medium
5. Set of rules (Protocol)

All above mentioned elements are described below:

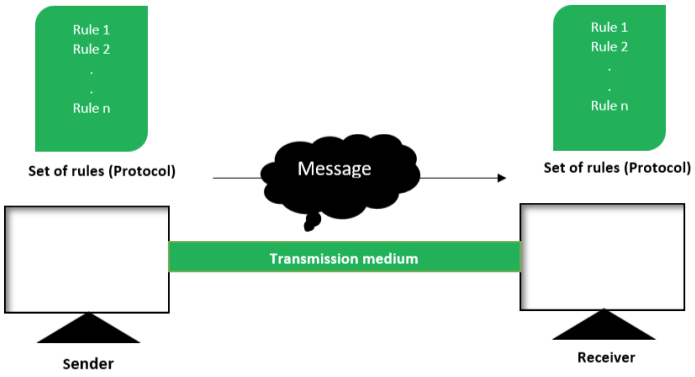


Figure – Components of Data Communication System

Message :
This is most useful asset of a data communication system. The message simply refers to data or piece of information which is to be communicated. A message could be in any form, it may be in form of a text file, an audio file, a video file, etc.

Sender :
To transfer message from source to destination, someone must be there who will play role of a source. Sender plays part of a source in data communication system. It is simple a device that sends data message. The device could be in form of a computer, mobile, telephone, laptop, video camera, or a workstation, etc.

Receiver :
It is destination where finally message sent by source has arrived. It is a device that receives message. Same as sender, receiver can also be in form of a computer, telephone mobile, workstation, etc.

Transmission Medium :
In entire process of data communication, there must be something which could act as a bridge between sender and receiver, Transmission medium plays that part. It is physical path by which data or message travels from sender to receiver. Transmission medium could be guided (with wires) or unguided (without wires), for example, twisted pair cable, fiber optic cable, radio waves, microwaves, etc.

Set of rules (Protocol) :
To govern data communications, various sets of rules had been already designed by the designers of the communication systems, which represent a kind of agreement between communicating devices. These are defined as protocol. In simple terms, the protocol is a set of rules that govern data communication. If two different devices are connected but there is no protocol among them, there would not be any kind of communication between those two devices. Thus the protocol is necessary for data communication to take place.

1.4 NETWORK

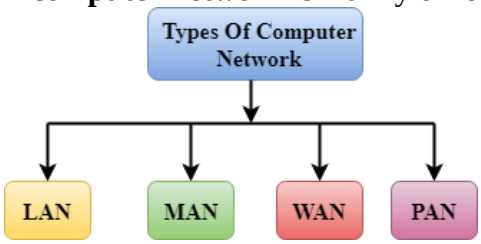
Definition
A computer network is a system in which multiple computers are connected to each other to share information and resources.Computer Network is a group of computers connected with each other through wires, optical fibres or optical links so that various devices can interact with each other through a network.The aim of the computer network is the sharing of resources among various devices. In the case of computer network technology, there are several types of networks that vary from simple to complex level.

The features of a computer network are −
Sharing − Computer networks enable sharing of files, software, hardware resources and computing capabilities.
Speed: The communication speed among the components is fast enough to be comparable with a centralized system.
Scalability − Sizes of computer networks dynamically increase with time. The networks have to be scalable so that they can evolve adequately for future deployments.

Integration − All the components of the network work in a coordinated manner for a seamless user experience.
Security − Networks allow security and access rights to the users for restricted sharing of resources and information.
Cost Effectiveness − Networking reduces the deployment cost of hardware and software of a centralized system.

Computer Network Types
A computer network is a group of computers linked to each other that enables the computer to communicate with another computer and share their resources, data, and applications.
A computer network can be categorized by their size.

A **computer network** is mainly of **four types**:



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

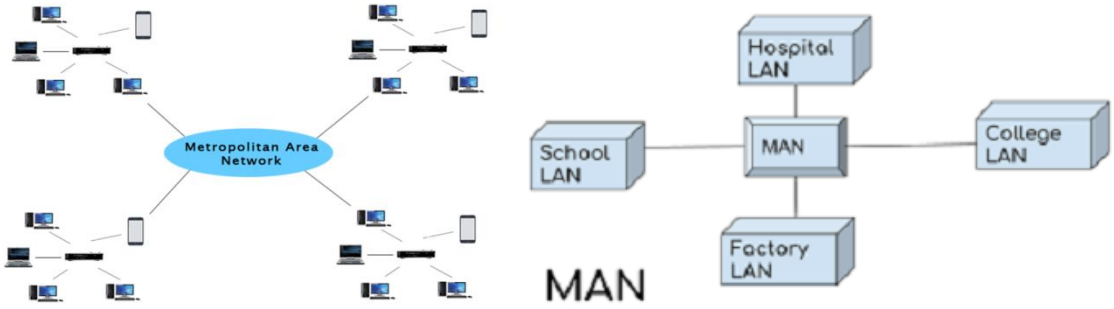
LAN(Local Area Network)
Local Area Network is a group of computers connected to each other in a small area such as building, offices, schools, colleges or universities

LAN is used for connecting two or more personal computers through a communication medium such as twisted pair, coaxial cable, etc. It is less costly as it is built with inexpensive hardware such as hubs, network adapters, and ethernet cables. The data is transferred at an extremely faster rate in Local Area Network. Local Area Network provides higher security. LAN provides a useful way of sharing the resources between end users.The resources such as printers, file servers, scanners, and internet are easily sharable among computers.

MAN(Metropolitan Area Network)

A metropolitan area network is a network that covers a larger geographic area by interconnecting a different LAN to form a larger network. Government agencies use MAN to connect to the citizens and private industries. In MAN, various LANs are connected to each other through a telephone exchange line.The most widely used protocols in MAN are RS-232, Frame Relay, ATM, ISDN, OC-3, ADSL, etc.

It has a higher range than Local Area Network(LAN).

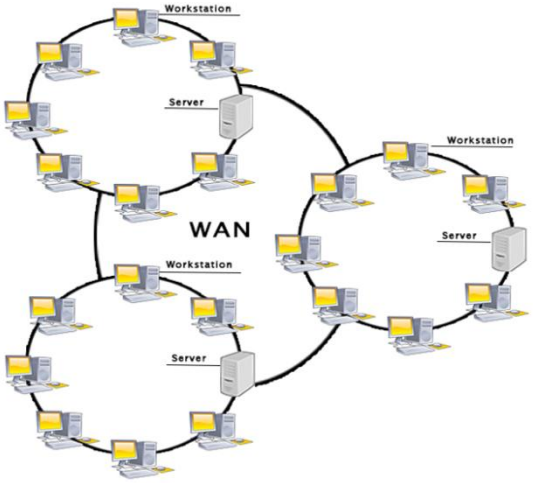


Uses Of Metropolitan Area Network:

- MAN is used in communication between the banks in a city.
- It can be used in an Airline Reservation.
- It can be used in a college within a city.
- It can also be used for communication in the military.

WAN(Wide Area Network)

A Wide Area Network is a network that extends over a large geographical area such as states or countries. A Wide Area Network is quite bigger network than the LAN. A Wide Area Network is not limited to a single location, but it spans over a large geographical area through a telephone line, fibre optic cable or satellite links. The internet is one of the biggest WAN in the world. A Wide Area Network is widely used in the field of Business, government, and education.



Examples Of Wide Area Network:
Mobile Broadband: A 4G network is widely used across a region or country.
Last mile: A telecom company is used to provide the internet services to the customers in hundreds of cities by connecting their home with fiber.
Private network: A bank provides a private network that connects the 44 offices. This network is made by using the telephone leased line provided by the telecom company.

1.5 INTERNET

Origins of the Internet
The Internet evolved from the ARPANET, which was developed in 1969 by the Advanced Research Projects Agency (ARPA) of the U.S. Department of Defense. It was the first operational packet-switching network. ARPANET began operations in four locations. Today the number of hosts is in the hundreds of millions, the num- ber of users in the billions, and the number of countries participating nearing 200. The number of connections to the Internet continues to grow exponentially.

The network was so successful that ARPA applied the same packet-switching technology to tactical radio communication (packet radio) and to satellite com- munication (SATNET). Because the three networks operated in very different communication environments, the appropriate values for certain parameters, such as maximum packet size, were different in each case. Faced with the dilemma of integrating these networks, Vint Cerf and Bob Kahn of ARPA started to develop methods and protocols for *internetworking*; that is, communicating across arbi- trary, multiple, packet-switched networks. They published a very influential paper in May of 1974 [CERF74] outlining their approach to a Transmission Control Pro- tocol. The proposal was refined and details filled in by the ARPANET community, with major contributions from participants from European networks, such as Cyclades (France), and EIN, eventually leading to the TCP (Transmission Control Protocol) and IP (Internet Protocol) protocols, which, in turn, formed the basis for what eventually became the TCP/IP protocol suite. This provided the foundation for the Internet.

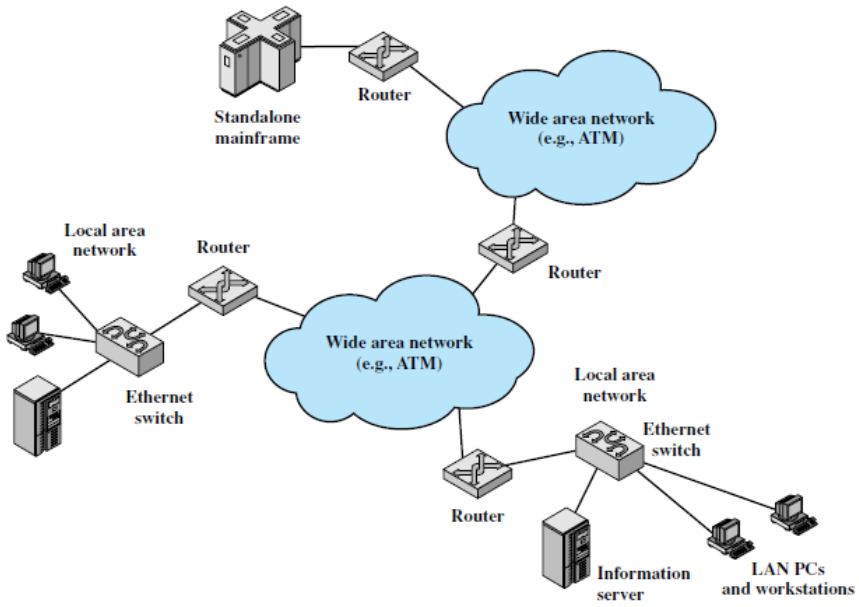
Internet is defined as an Information super Highway, to access information over the web. However, It can be defined in many ways as follows:

- Internet is a world-wide global system of interconnected computer networks.
- Internet uses the standard Internet Protocol (TCP/IP).
- Every computer in internet is identified by a unique IP address.
- IP Address is a unique set of numbers (such as 110.22.33.114) which identifies a computer location.
- A special computer DNS (Domain Name Server) is used to give name to the IP Address so that user can locate a computer by a name
- Evolution
- The concept of Internet was originated in 1969 and has undergone several technological & Infrastructural changes as discussed below:

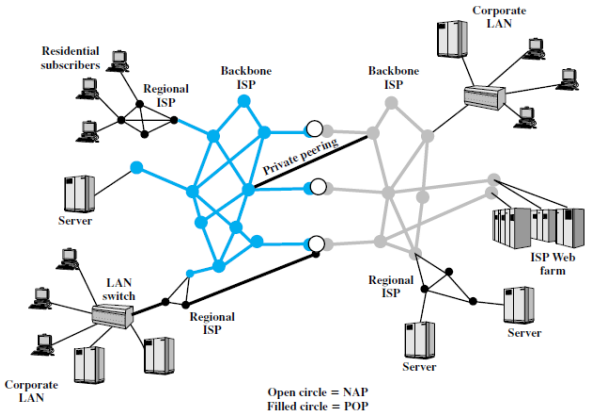
- The origin of Internet devised from the concept of Advanced Research Project Agency Network (ARPANET).
- ARPANET was developed by United States Department of Defense.
- Basic purpose of ARPANET was to provide communication among the various bodies of government.
- Initially, there were only four nodes, formally called Hosts.
- In 1972, the ARPANET spread over the globe with 23 nodes located at different countries and thus became known as Internet.
- By the time, with invention of new technologies such as TCP/IP protocols, DNS, WWW, browsers, scripting languages etc.,Internet provided a medium to publish and access information over the web.

Internet Architecture

The Internet today is made up of thousands of overlapping hierarchical networks. Because of this, it is not practical to attempt a detailed description of the exact architecture or topology of the Internet. However, an overview of the common, gen- eral characteristics can be made. Figure 1.5 illustrates the discussion and Table 1.2 summarizes the terminology.

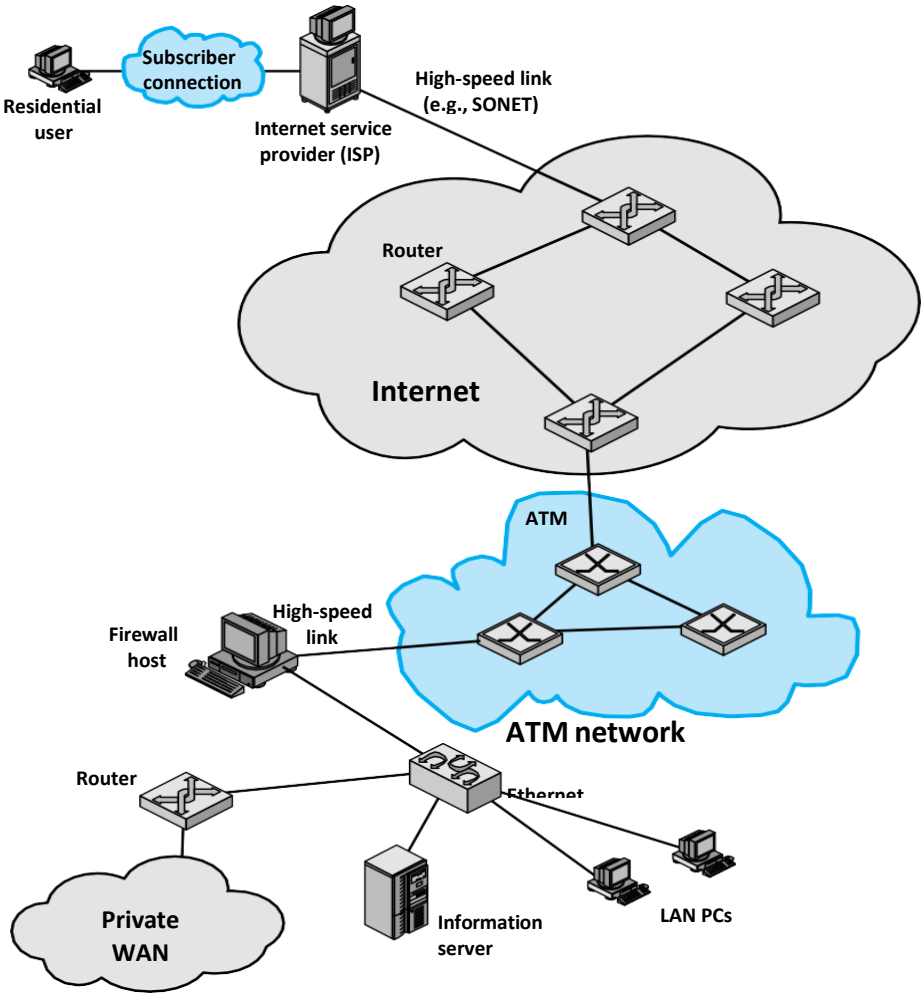


A key element of the Internet is the set of hosts attached to it. Simply put, a host is a computer. Today, computers come in many forms, including mobile phones and even cars. All of these forms can be hosts on the Internet. Hosts are sometimes grouped together in a LAN. This is the typical configuration in a corporate environ- ment. Individual hosts and LANs are connected to an Internet service provider (ISP) through a point of presence (POP). The connection is made in a series of steps starting with the customer premises equipment (CPE). The CPE is the communica- tions equipment located onsite with the host.



The example configuration

To give some feel for the scope of concerns of Parts Two through Four, Figure 1.6 illustrates some of the typical communications and network elements in use today. In the upper-left-hand portion of the figure, we see an individual residential user connected to an Internet service provider (ISP) through some sort of subscriber connection. Common examples of such a connection are the public telephone.



THE NEED FOR A PROTOCOL ARCHITECTURE

When computers, terminals, and/or other data processing devices exchange data, the procedures involved can be quite complex. eg. file transfer. There must be a data path between the two computers. But also need:

•Source to activate communications Path or inform network of destination
•Source must check destination is prepared to receive
•File transfer application on source must check destination file management system will accept and store file for his user
•May need file format translation

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A protocol is simply defined as a set of rules and regulations for data communication.
Rules are basically defined for each and every step and process at time of communication among two or more computers.
Networks are needed to follow these protocols to transmit data successfully. All protocols might be implemented using hardware, software, or combination of both of them.

There are three aspects of protocols given below :
Syntax–
It is used to explain data format that is needed to be sent or received.
Semantics–
It is used to explain exact meaning of each of sections of bits that are usually transferred.
Timings–
It is used to explain exact time at which data is generally transferred along with speed at which it is transferred

TCP/IP REFERENCE MODEL

TCP/IP Reference Model is a four-layered suite of communication protocols. It was developed by the DoD (Department of Defence) in the 1960s. It is named after the two main protocols that are used in the model, namely, TCP and IP. TCP stands for Transmission Control Protocol and IP stands for Internet Protocol.

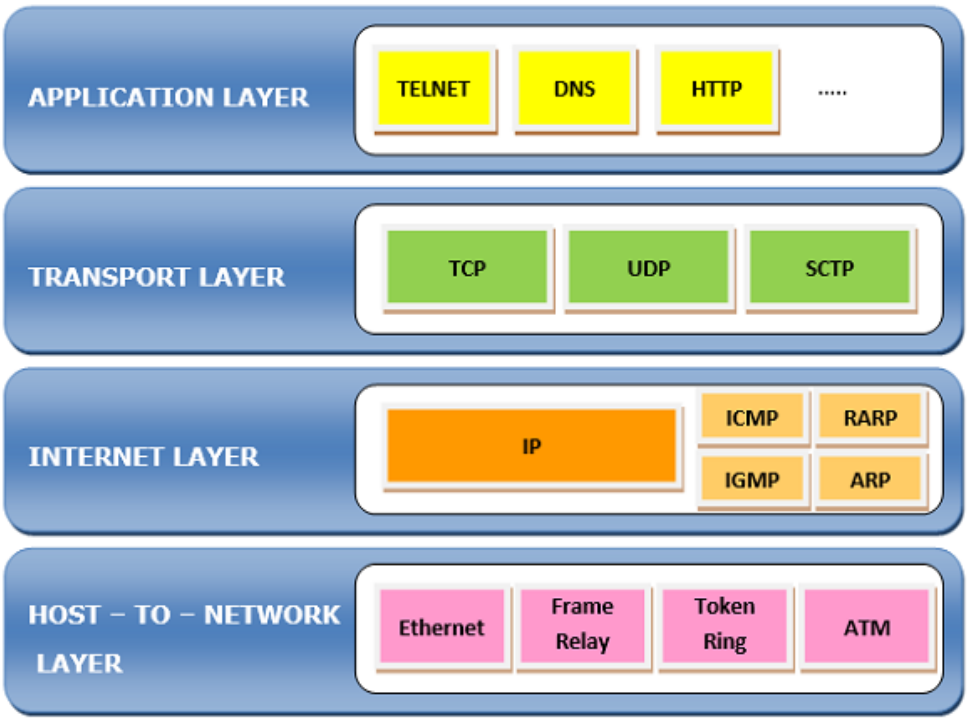
The four layers in the TCP/IP protocol suite are −

Host-to- Network Layer −It is the lowest layer that is concerned with the physical transmission of data. TCP/IP does not specifically define any protocol here but supports all the standard protocols.

Internet Layer −It defines the protocols for logical transmission of data over the network. The main protocol in this layer is Internet Protocol (IP) and it is supported by the protocols ICMP, IGMP, RARP, and ARP.

Transport Layer − It is responsible for error-free end-to-end delivery of data. The protocols defined here are Transmission Control Protocol (TCP) and User Datagram Protocol (UDP).

Application Layer − This is the topmost layer and defines the interface of host programs with the transport layer services. This layer includes all high-level protocols like Telnet, DNS, HTTP, FTP, SMTP, etc.
The following diagram shows the layers and the protocols in each of the layers −



Operation of TCP

To make clear that the total communications facility may consist of multiple networks,the constituent networks are usually referred to as subnetworks. Some sort of net- work access protocol, such as the Ethernet logic, is used to connect a computer to a subnetwork. This protocol enables the host to send data across the subnetwork to another host or, if the target host is on another subnetwork, to a router that will for- ward the data. IP is implemented in all of the end systems and the routers. It acts asa relay to move a block of data from one host, through one or more routers, to another host. TCP is implemented only in the end systems; it keeps track of the blocks of data to assure that all are delivered reliably to the appropriate application.

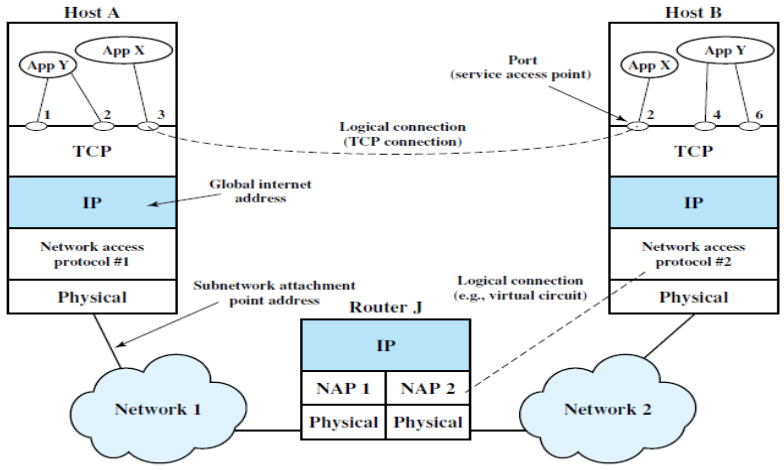


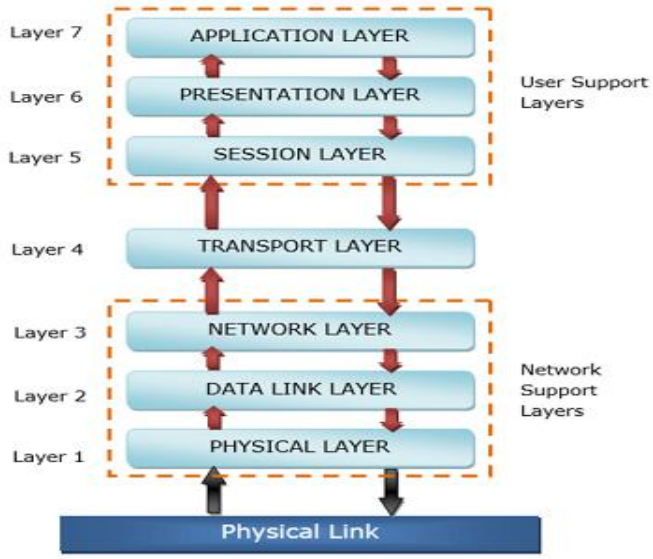
Figure 2.1 TCP/IP Concepts

Key features

TCP/IP model represents the Transmission Control Protocol / Internet Protocol.
TCP/IP model depends on standard protocols about which the computer network has created. It is a connection protocol that assigns the network of hosts over the internet.
The protocols were created first and then built the TCP/IP model.
It does not provide quality services.
It does not mention the services, interfaces, and protocols.
The TCP/IP model protocols are not hidden, and we cannot fit a new protocol stack in it.
It is simpler than OSI.
It provides connectionless transmission in the network layer and supports connecting and connectionless-oriented transmission in the transport layer.
It uses a vertical approach.
The smallest size of the TCP/IP header is 20 bytes.
In TCP/IP, returning protocol is not difficult.

OSI REFERENCE MODEL

OSI or Open System Interconnection model was developed by International Standards Organization (ISO). It gives a layered networking framework that conceptualizes how communications should be done between heterogeneous systems. It has seven interconnected layers. The seven layers of the OSI Model are a physical layer, data link layer, network layer, transport layer, session layer, presentation layer, and application layer, as shown in the following diagram –



The physical layer, data link layer and the network layer are the network support layers. The layers manage a physical transfer of data from one device to another. Session layer, presentation layer, and application layer are the user support layers. These layers allow communication among unrelated software in dissimilar environments. Transport layer links the two groups.

The main functions of each of the layers are as follows −

Physical Layer − Its function is to transmit individual bits from one node to another over a physical medium.

Data Link Layer − It is responsible for the reliable transfer of data frames from one node to another connected by the physical layer.

Network Layer − It manages the delivery of individual data packets from source to destination through appropriate addressing and routing.

Transport Layer −It is responsible for delivery of the entire message from the source host to destination host.

Session Layer − It establishes sessions between users and offers services like dialog control and synchronization.

Presentation Layer − It monitors syntax and semantics of transmitted information through translation, compression, and encryption.

Application Layer − It provides high-level APIs (application program interface) to the users.

The designers of OSI assumed that this model and the protocols developed within this model would come to dominate computer communications, eventually replacing proprietary protocol implementations and rival multivendor models such as TCP/IP. This has not happened. Although many useful protocols have been developed in the context of OSI, the overall seven-layer model has not flourished. Instead, the TCP/IP architecture has come to dominate.There are a number of reasons for this out- come. Perhaps the most important is that the key TCP/IP protocols were mature and well tested at a time when similar OSI protocols were in the development stage. When businesses began to recognize the need for interoperability across networks, only TCP/IP was available and ready to go. Another reason is that the OSI model is unnec- essarily complex, with seven layers to accomplish what TCP/IP does with fewer layers.

Figure 2.7 illustrates the layers of the TCP/IP and OSI architectures, showing roughly the correspondence in functionality between the two.

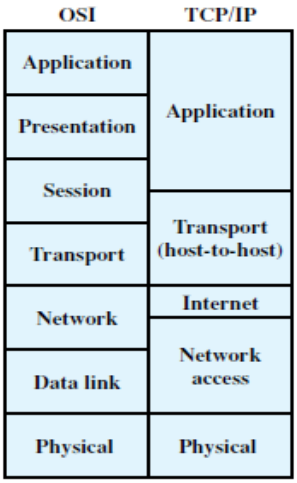


Figure 2.7 A Comparison of the OSI and TCP/IP Protocol Architectures

Key features

OSI represents Open System Interconnection.
OSI is a generic, protocol independent standard. It is acting as an interaction gateway between the network and the final-user.
The OSI model was developed first, and then protocols were created to fit the network architecture's needs.
It provides quality services.
The OSI model represents defines administration, interfaces and conventions. It describes clearly which layer provides services.
The protocols of the OSI model are better unseen and can be returned with another appropriate protocol quickly.
It is difficult as distinguished to TCP/IP.
It provides both connection and connectionless oriented transmission in the network layer; however, only connection-oriented transmission in the transport layer.
It uses a horizontal approach.
The smallest size of the OSI header is 5 bytes.
Protocols are unknown in the OSI model and are returned while the technology modifies.

STANDARDIZATION WITHIN A PROTOCOL ARCHITECTURE

Standardization within the OSI Framework

The principal motivation for the development of the OSI model was to provide a framework for standardization. Within the model, one or more protocol stan- dards can be developed at each layer. The model defines in general terms the functions to be performed at that layer and facilitates the standards-making process in two ways:

Because the functions of each layer are well defined, standards can be devel- oped independently and simultaneously for each layer. This speeds up the standards-making process.

Because the boundaries between layers are well defined, changes in standards in one layer need not affect already existing software in another layer. This makes it easier to introduce new standards.

Figure 2.8 illustrates the use of the OSI model as such a framework. The overall communications function is decomposed into seven distinct layers. That is, the overall function is broken up into a number of modules, making the inter- faces between modules as simple as possible. In addition, the design principle of information hiding is used: Lower layers are concerned with greater levels of detail; upper layers are independent of these details. Each layer provides services to the next higher layer and implements a protocol to the peer layer in other systems.

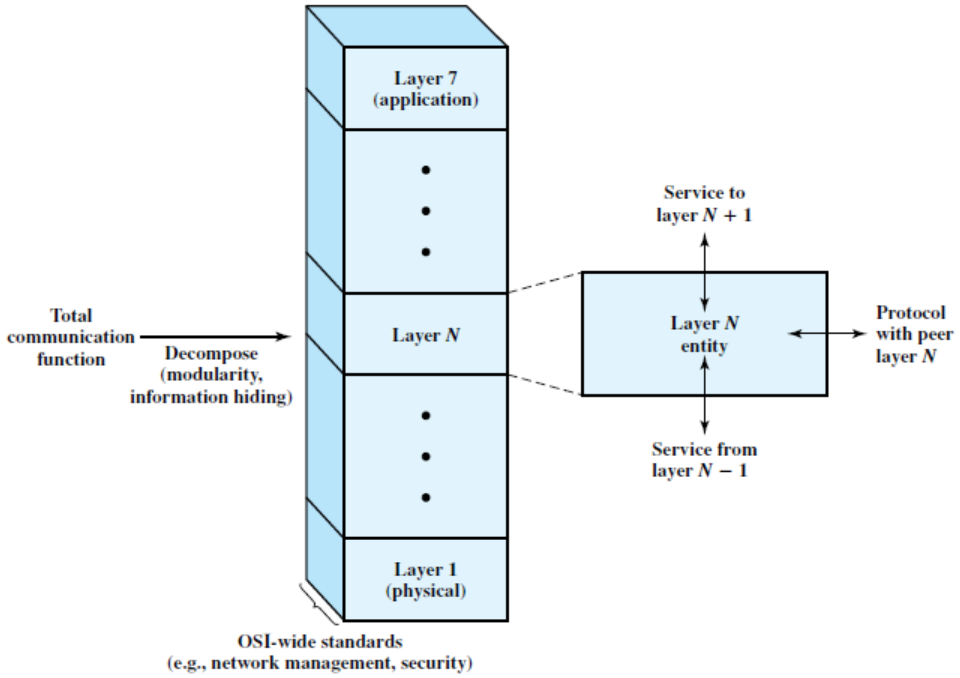


Figure 2.8 The OSI Architecture as a Framework for Standardization

Figure 2.9 shows more specifically the nature of the standardization required at each layer. Three elements are key:

Protocol specification: Two entities at the same layer in different systems cooperate and interact by means of a protocol. Because two different open systems are involved, the protocol must be specified precisely. This includes the format of the protocol data units exchanged, the semantics of all fields, and the allowable sequence of PDUs.
Service definition: In addition to the protocol or protocols that operate at a given layer, standards are needed for the services that each layer provides to the next higher layer. Typically, the definition of services is equivalent to a functional description that defines what services are provided, but not how the services are to be provided.

Addressing: Each layer provides services to entities at the next higher layer. These entities are referenced by means of a service access point (SAP). Thus, a network service access point (NSAP) indicates a transport entity that is a user of the network service.

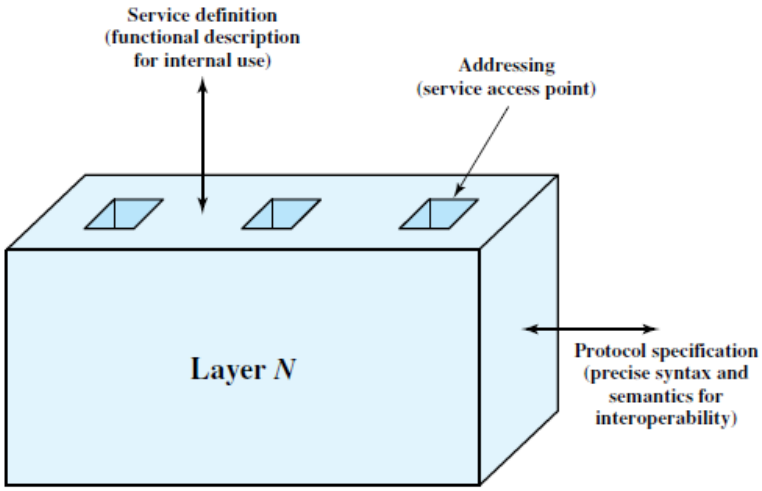


Figure 2.9 Layer-Specific Standards

TRADITIONAL INTERNET-BASED APPLICATIONS

A number of applications have been standardized to operate on top of TCP. We mention three of the most common here.

The Simple Mail Transfer Protocol (SMTP) provides a basic electronic mail transport facility. It provides a mechanism for transferring messages among sepa- rate hosts. Features of SMTP include mailing lists, return receipts, and forwarding. The SMTP protocol does not specify the way in which messages are to be created; some local editing or native electronic mail facility is required. Once a message is created, SMTP accepts the message and makes use of TCP to send it to an SMTP module on another host. The target SMTP module will make use of a local elec- tronic mail package to store the incoming message in a user's mailbox.

The File Transfer Protocol (FTP) is used to send files from one system to another under user command. Both text and binary files are accommodated, and the protocol provides features for controlling user access. When a user wishes to engage in file transfer, FTP sets up a TCP connection to the target system for the exchange of control messages. This connection allows user ID and password to be transmitted and allows the user to specify

the file and file actions desired. Once a file transfer is approved, a second TCP connection is set up for the data transfer. The file is transferred over the data connection, without the overhead of any headers or control information at the application level. When the transfer is complete, the control con- nection is used to signal the completion and to accept new file transfer commands. TELNET provides a remote logon capability, which enables a user at a termi-nal or personal computer to logon to a remote computer and function as if directlyconnected to that computer. The protocol was designed to work with simple scroll- mode terminals. TELNET is actually implemented in two modules: User TELNET interacts with the terminal I/O module to communicate with a local terminal. It con- verts the characteristics of real terminals to the network standard and vice versa. Server TELNET interacts with an application, acting as a surrogate terminal han- dler so that remote terminals appear as local to the application. Terminal traffic between User and Server TELNET is carried on a TCP connection

MULTIMEDIA NETWORKING

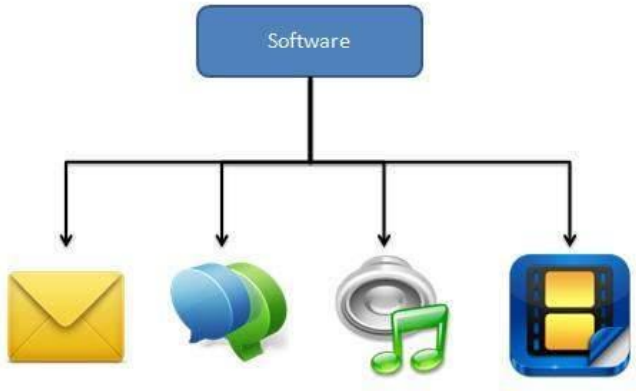
Definition of Multimedia

By definition Multimedia is a representation of information in an attractive and interactive manner with the use of a combination of text, audio, video, graphics and animation. ‘

In other words we can say that Multimedia is a computerized method of presenting information combining textual data, audio, visuals (video), graphics and animations. For examples: E-Mail, Yahoo Messenger, Video Conferencing, and Multimedia Message Service (MMS).

Multimedia as name suggests is the combination of Multi and Media that is many types of media (hardware/software) used for communication of information.

Components of Multimedia



Following are the common components of multimedia:

Text- All multimedia productions contain some amount of text. The text can have various types of fonts and sizes to suit the profession presentation of the multimedia software.

Graphics- Graphics make the multimedia application attractive. In many cases people do not like reading large amount of textual matter on the screen. Therefore, graphics are used more often than text to explain a concept, present background information etc. There are two types of Graphics:

Bitmap images- Bitmap images are real images that can be captured from devices such as digital cameras or scanners. Generally bitmap images are not editable. Bitmap images require a large amount of memory.

Vector Graphics- Vector graphics are drawn on the computer and only require a small amount of memory. These graphics are editable.

Audio- A multimedia application may require the use of speech, music and sound effects. These are called audio or sound element of multimedia.Speech is also a perfect way for teaching. Audio are of analog and digital types. Analog audio or sound refers to the original sound signal. Computer stores the sound in digital form. Therefore, the sound used in multimedia application is digital audio.

Video- The term video refers to the moving picture, accompanied by sound such as a picture in television. Video element of multimedia application gives a lot of information in small duration of time.

Animation- Animation is a process of making a static image look like it is moving. An animation is just a continuous series of still images that are displayed in a sequence. The animation can be used effectively for attracting attention. Animation also makes a presentation light and attractive. Animation is very popular in multimedia application.

Media Types

Typically, the term *multimedia* refers to four distinct types of media: text, audio, graphics, and video.

From a communications perspective, the term text is self-explanatory, referring to information that can be entered via a keyboard and is directly readable and printable. Text messaging, instant messaging, and text (non-html) e-mail are common examples, as

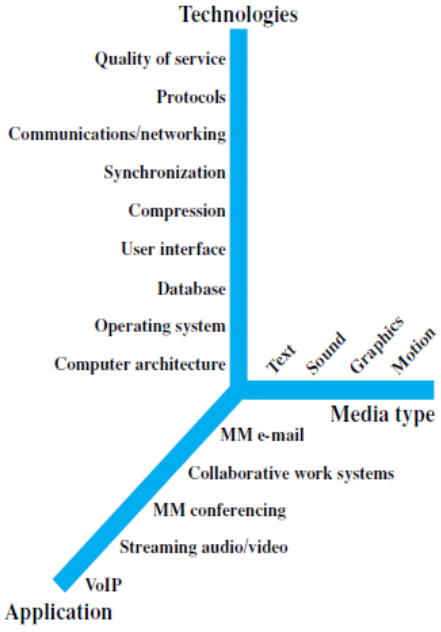


Figure 2.11 A Multimedia Taxonomy

Multimedia Applications

The Internet, until recently, has been dominated by information retrieval applications, e-mail, and file transfer, plus Web interfaces that emphasized text and images. Increas- ingly, the Internet is being used for multimedia applications that involve massive amounts of data for visualization and support of real-time interactivity. Streaming audio and video are perhaps the best known of such applications. An example of an interac- tive application is a virtual training environment involving distributed simulations and real-time user interaction. Some other examples are shown in Table 2.3. lists the following multimedia application domains:

Multimedia information systems: Databases, information kiosks, hypertexts, electronic books, and multimedia expert systems

Multimedia communication systems: Computer-supported collaborative work, videoconferencing, streaming media, and multimedia teleservices

Multimedia entertainment systems: 3D computer games, multiplayer network games, infotainment, and interactive audiovisual productions

Multimedia business systems: Immersive electronic commerce, marketing, multimedia presentations, video brochures, virtual shopping, and so on.

Multimedia educational systems: Electronic books, flexible teaching materials, simulation systems, automatic testing, distance learning, and so on.