LNCT GROUP OF COLLEGES

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Computer Network

A Computer network consists of two or more autonomous computers that are linked (connected) together in order to:

• Share resources (files, printers, modems, fax machines).
• Share Application software like MS Office.
• Allow Electronic communication.
• Increase productivity (makes it easier to share data amongst users).

Figure 1: A computer-networked environment

Figure 1 shows people working in an networked environment. The Computers on a network may be linked through Cables, telephones lines, radio waves, satellites etc.
A Computer network includes, the network operating system in the client and server machines, the cables, which connect different computers and all supporting hardware in between such as bridges, routers and switches. In wireless systems, antennas and towers are also part of the network.

Computer networks are generally classified according to their structure and the area they are localised in as:

• **Local Area Network (LAN):** The network that spans a relatively small area that is, in the single building or campus is known as LAN.

• **Metropolitan Area Network (MAN):** The type of computer network that is, designed for a city or town is known as MAN.

• **Wide Area Network (WAN):** A network that covers a large geographical area and covers different cities, states and sometimes even countries, is known as WAN.

The additional characteristics that are also used to categorise different types of networks are:

- **Topology:** Topology is the graphical arrangement of computer systems in a network. Common topologies include a bus, star, ring, and mesh.

- **Protocol**: The protocol defines a common set of rules which are used by computers on the network that communicate between hardware and software entities. One of the most popular protocols for LANs is the Ethernet. Another popular LAN protocol for PCs is the token-ring network.

- **Architecture**: Networks can be broadly classified as using either a peer-to-peer or client/server architecture.

NETWORK GOALS AND MOTIVATIONS

Before designing a computer network we should see that the designed network fulfils the basic goals. We have seen that a computer network should satisfy a broad range of purposes and should meet various requirements. One of the main goals of a computer network is to enable its users to share resources, to provide low cost facilities and easy addition of new processing services. The computer network thus, creates a global environment for its users and computers.

Some of the basic goals that a Computer network should satisfy are:

- Cost reduction by sharing hardware and software resources.
- Provide high reliability by having multiple sources of supply.
- Provide an efficient means of transport for large volumes of data among various locations (High throughput).
- Provide inter-process communication among users and processors.
- Reduction in delay driving data transport.
- Increase productivity by making it easier to share data amongst users.
- Repairs, upgrades, expansions, and changes to the network should be performed with minimal impact on the majority of network users.
- Standards and protocols should be supported to allow many types of equipment from different vendors to share the network (Interoperatability).
- Provide centralised/distributed management and allocation of network resources like host processors, transmission facilities etc.

OSI Reference Model

The Open System Interconnection (OSI) model is a set of protocols that attempt to define and standardise the data communications process; we can say that it is a concept that describes how data communications should take place.

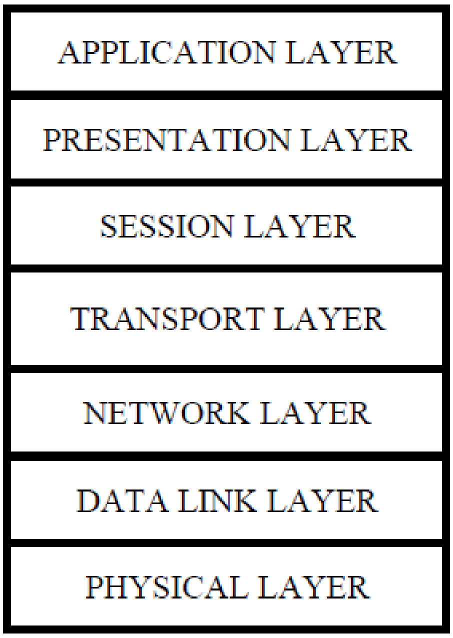

Figure 2: Layers of OSI reference model

The OSI model was set by the International Standards Organisation (ISO) in 1984, and it is now considered the primary architectural model for inter-computer communications. The OSI model has the support of most major computer and network vendors, many large customers, and most governments in different countries.

The Open Systems Interconnection (OSI) reference model describes how information from a software application in one computer moves through a network medium to a software application in another computer. The OSI reference model is a conceptual model composed of seven layers as shown in Figure 2 each specifying particular network functions and into these layers are fitted the protocol standards developed by the ISO and other standards bodies. The OSI model divides the tasks involved with moving information between networked computers into seven smaller, more manageable task groups. A task or group of tasks is then assigned to each of the seven OSI layers. Each layer is reasonably self-contained so that the tasks assigned to each layer can be implemented independently. This enables the solutions offered by one layer to be updated without affecting the other layers.

The OSI model is modular. Each successive layer of the OSI model works with the one above and below it.

Although, each layer of the OSI model provides its own set of functions, it is possible to group the layers into two distinct categories. The first four layers i.e., physical, data link, network, and transport layer provide the end-to-end services necessary for the transfer of data between two systems. These layers provide the protocols associated with the communications network used to link two computers together. Together, these are communication oriented.

The top three layers i.e., the application, presentation, and session layers provide the application services required for the exchange of information. That is, they allow two applications, each running on a different node of the network to interact with each other through the services provided by their respective operating systems. Together, these are data processing oriented.

The following are the seven layers of the Open System Interconnection (OSI) reference model:

- Layer 7 — Application layer
- Layer 6 — Presentation layer
- Layer 5 — Session layer
- Layer 4 — Transport layer
- Layer 3 — Network layer
- Layer 2 — Data Link layer
- Layer 1 — Physical layer

Application layer (Layer 7)

The Application layer is probably the most easily misunderstood layer of the model. This top layer defines the language and syntax that programs use to communicate with other programs. The application layer represents the purpose of communicating in the first place. For example, a program in a client workstation uses commands to request data from a program in the server. Common functions at this layer are opening, closing, reading and writing files, transferring files and e-mail messages, executing remote jobs and obtaining directory information about network resources etc.

Presentation layer (Layer 6)

The Presentation layer performs code conversion and data reformatting (syntax translation). It is the translator of the network; it makes sure the data is in the correct form for the receiving application.
When data are transmitted between different types of computer systems, the presentation layer negotiates and manages the way data are represented and encoded. For example, it provides a common denominator between ASCII and EBCDIC machines as well as between different floating point and binary formats. Sun's XDR and OSI's ASN.1 are two protocols used for this purpose. This layer is also used for encryption and decryption. It also provides security features through encryption and decryption.

Session layer (Layer 5)

The Session layer decides when to turn communication on and off between two computers. It provides the mechanism that controls the data-exchange process and coordinates the interaction (communication) between them in an orderly manner.
It sets up and clears communication channels between two communicating components. It determines one-way or two-way communications and manages the dialogue between both parties; for example, making sure that the previous request has been fulfilled before the next one is sent. It also marks significant parts of the transmitted data with checkpoints to allow for fast recovery in the event of a connection failure.

Transport layer (Layer 4)

The transport layer is responsible for overall end-to-end validity and integrity of the transmission i.e., it ensures that data is successfully sent and received between two computers. The lower data link layer (layer 2) is only responsible for delivering packets from one node to another. Thus, if a packet gets lost in a router somewhere in the enterprise Internet, the transport layer will detect that. It ensures that if a 12MB file is sent, the full 12MB is received.

If data is sent incorrectly, this layer has the responsibility of asking for retransmission of the data. Specifically, it provides a network-independent, reliable message-independent, reliable message-interchange service to the top three application-oriented layers. This layer acts as an interface between the bottom and top three layers. By providing the session layer (layer 5) with a reliable message transfer service, it hides the detailed operation of the underlying network from the session layer.

Network layer (Layer 3)

The network layer establishes the route between the sending and receiving stations. The unit of data at the network layer is called a packet. It provides network routing and flow and congestion functions across computer-network interface.
It makes a decision as to where to route the packet based on information and calculations from other routers, or according to static entries in the routing table.

Data link layer (Layer 2)

The data link layer groups the bits that we see on the Physical layer into Frames. It is primarily responsible for error-free delivery of data on a hop. The Data link layer is split into two sub-layers i.e., the Logical Link Control (LLC) and Media Access Control (MAC).
The Data-Link layer handles the physical transfer, framing (the assembly of data into a single unit or block), flow control and error-control functions (and retransmission in the event of an error) over a single transmission link; it is responsible for getting the data packaged and onto the network cable. The data link layer provides the network layer (layer 3) reliable information-transfer capabilities.

The main network device found at the data link layer is a bridge. This device works at a higher layer than the repeater and therefore is a more complex device. It has some understanding of the data it receives and can make a decision based on the frames it receives as to whether it needs to let the information pass, or can remove the information from the network. This means that the amount of traffic on the medium can be reduced and therefore, the usable bandwidth can be increased.

Physical layer (Layer 1)

The data units on this layer are called bits. This layer defines the mechanical and electrical definition of the network medium (cable) and network hardware. This includes how data is impressed onto the cable and retrieved from it.

The physical layer is responsible for passing bits onto and receiving them from the connecting medium. This layer gives the data-link layer (layer 2) its ability to transport a stream of serial data bits between two communicating systems; it conveys the bits that moves along the cable. It is responsible for ensuring that the raw bits get from one place to another, no matter what shape they are in, and deals with the mechanical and electrical characteristics of the cable.

This layer has no understanding of the meaning of the bits, but deals with the electrical and mechanical characteristics of the signals and signalling methods.

TCP/IP Reference Model

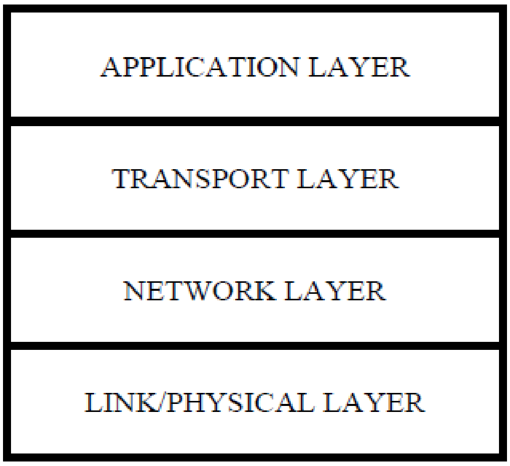

Figure 3: Layers of TCP/IP reference model

TCP/IP stands for Transmission Control Protocol / Internet Protocol. It is a protocol suite used by most communications software. TCP/IP is a robust and proven technology that was first tested in the early 1980s on ARPA Net, the U.S. military's Advanced Research Projects Agency network, and the world's first packet-switched network. TCP/IP was designed as an open protocol that would enable all types of computers to transmit data to each other via a common communications language.

TCP/IP is a layered protocol similar to the ones used in all the other major networking architectures, including IBM's SNA, Windows' NetBIOS, Apple's AppleTalk, Novell's NetWare and Digital's DECnet. The different layers of the TCP/IP reference model are shown in Figure Layering means that after an application initiates the communications, the message (data) to be transmitted is passed through a number of stages or layers until it actually moves out onto the wire. The data are packaged with a different header at each layer. At the receiving end, the corresponding programs at each protocol layer unpack the data, moving it "back up the stack" to the receiving application. TCP/IP is composed of two major parts: TCP (Transmission Control Protocol) at the transport layer and IP (Internet Protocol) at the network layer. TCP is a connection-oriented protocol that passes its data to IP, which is a connectionless one. TCP sets up a connection at both ends and guarantees reliable delivery of the full message sent. TCP tests for errors and requests retransmission if necessary, because IP does not.

An alternative protocol to TCP within the TCP/IP suite is UDP (User Datagram Protocol), which does not guarantee delivery. Like IP, it is also connectionless, but very useful for real-time voice and video, where it doesn't matter if a few packets get lost.

Layers of TCP/IP reference model

Application Layer (Layer 4)

The top layer of the protocol stack is the application layer. It refers to the programs that initiate communication in the first place. TCP/IP includes several application layer protocols for mail, file transfer, remote access, authentication and name resolution. These protocols are embodied in programs that operate at the top layer just as any custom-made or packaged client/server application would.

Transport Layer (Layer 3)

The Transport Layer (also known as the Host-to-Host Transport Layer) is responsible for providing the Application Layer with session and datagram communication services.

TCP/IP does not contain Presentation and Session layers, the services are performed if required, but they are not part of the formal TCP/IP stack. For example, Layer 6 (Presentation Layer) is where data conversion (ASCII to EBCDIC, floating point to binary, etc.) and encryption /decryption is performed. Layer 5 is the Session Layer, which is performed in layer 4 in TCP/IP. Thus, we jump from layer 7 of OSI down to layer 4 of TCP/IP.

From Application to Transport Layer, the application delivers its data to the communications system by passing a stream of data bytes to the transport layer along with the socket of the destination machine.

The core protocols of the Transport Layer are TCP and the User Datagram Protocol (UDP).

• TCP: TCP provides a one-to-one, connection-oriented, reliable communications service. TCP is responsible for the establishment of a TCP connection, the sequencing and acknowledgment of packets sent, and the recovery of packets lost during transmission.

• UDP: UDP provides a one-to-one or one-to-many, connectionless, unreliable communications service. UDP is used when the amount of data to be transferred is small (such as the data that would fit into a single packet), when the overhead of establishing a TCP connection is not desired, or when the applications or upper layer protocols provide reliable delivery.

The Transport Layer encompasses the responsibilities of the OSI Transport Layer and some of the responsibilities of the OSI Session Layer.

Internet Layer (Layer 2)

The Internet layer handles the transfer of information across multiple networks through the use of gateways and routers. The Internet layer corresponds to the part of the OSI network layer that is concerned with the transfer of packets between machines that are connected to different networks. It deals with the routing of packets across these networks as well as with the control of congestion. A key aspect of the Internet layer is the definition of globally unique addresses for machines that are attached to the Internet.

The Internet layer provides a single service namely, best-effort connectionless packet transfer. IP packets are exchanged between routers without a connection setup; the packets are routed independently and so they may traverse different paths. For this reason, IP packets are also called datagrams. The connectionless approach makes the system robust; that is, if failures occur in the network, the packets are routed around the points of failure; hence, there is no need to set up connections. The gateways that interconnect the intermediate networks may discard packets when congestion occurs. The responsibility for recovery from these losses is passed on to the Transport Layer.

The core protocols of the Internet Layer are IP, ARP, ICMP, and IGMP.

• The Internet Protocol (IP) is a routable protocol responsible for IP addressing and the fragmentation and reassembly of packets.

• The Address Resolution Protocol (ARP) is responsible for the resolution of the Internet Layer address to the Network Interface Layer address, such as a hardware address.

• The Internet Control Message Protocol (ICMP) is responsible for providing diagnostic functions and reporting errors or conditions regarding the delivery of IP packets.

• The Internet Group Management Protocol (IGMP) is responsible for the management of IP multicast groups.

The Internet Layer is analogous to the Network layer of the OSI model.

Link/Physical Layer (Layer 1)

The Link/Physical Layer (also called the Network Access Layer) is responsible for placing TCP/IP packets on the network medium and receiving TCP/IP packets of the network medium. TCP/IP was designed to be independent of the network access method, frame format, and medium. In this way, TCP/IP can be used to connect differing network types. This includes LAN technologies such as Ethernet or Token Ring and WAN technologies such as X.25 or Frame Relay. Independence from any specific network technology gives TCP/IP the ability to be adapted to new technologies such as Asynchronous Transfer Mode (ATM).

The Network Interface Layer encompasses the Data Link and Physical layers of the OSI Model. Note, that the Internet Layer does not take advantage of sequencing and acknowledgement services that may be present in the Data Link Layer. An unreliable Network Interface Layer is assumed, and reliable communications through session establishment and the sequencing and acknowledgement of packets is the responsibility of the Transport Layer.

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