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Computer Networking Layers Based on the OSI Model

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Abstract

Computer networking is a communication tool that enables theconvenient exchange of information and resources between two physical devices by physical as well as wireless means;the physical means being cables andthe wireless means being internet technology. The concept of computer networking is simplified by a standardized classification model called the Operating System Interconnection i.e. OSI Model. The OSI Model breaks down each of the conceptually similar functions into a framework of seven layers where each layer can communicate with the layer adjacent to it. Essentially, each layer provides a service to the layer above it and in turn requests a service from the layer directly below it.The need for the OSI Model originated from the necessity to give assistance in communication between consumers and software developers in order to produce efficient network systems. The OSI Model rose up to this challenge by providing a better comprehension of Computer Networking Layers and their functionality by simplifying the already present models. The main idea behind the OSI Model is to group similar functions and services into a single layer.

Keywords: *Computer Networking, Operating System Interconnection, OSI Model, Layer etc.*

Introduction to Computer Networks

Computer networks refers to a system of computers that are interconnected in such a way that the sharing of digital information is made possible.The computer network deals with the information in such a way as to maximize profit. This is achieved by performing the following actions on the given information:

- Analyzing
- Organizing
- Disseminating

Concept of Intranet and Internet:

Computer networking has led to the concept of intranet and internet. Intranets and internets are internet technology-based private networks which are utilized for the

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purpose of business dealings. Intranet technology has gained in reputation in the business world mainly because it enables a business to deal with the information in an improved and more efficient manner by allowing it to:

- Collect the information
- Manage the information
- Disseminate the information

What is a Network?

A network is essentially a collection of physical devices such as computers which are linked in such way that enables the exchange of information to and fro. The act of exchanging information between devices in such a manner is termed as networking. Networking enables two or more physical devices that are separated geographically to be able to communicate and exchange files and services. Some examples of such physical networks are:

→ CD-ROMs
→ Hard drives
→ Fax-modems
→ Printers, etc.

The aspects of a computer network are discussed under:

•Number of Components:

For the successful establishment of a computer networks it is necessary to have at least two physical devices present, such as two computers or laptops, etc.

•Wireless Communication:

Wireless communication is gaining more recognition although cables that can connect two computers to each other are still used. This is because wireless communication is less tedious and a wireless network can cover a larger area, geographically, than a cable network.

•Network Interface Device (NIC):

It is necessary for two physical devices that need to be connected to have an NIC, Network Interface Device, present to enable communication between the two devices.

•Switch:

Unlike a traditional switch, the switch in computer networking allows the switching of information from one device to another.

•Network Operating System (NOS) Software:

Networking operating system software allows users to exchange files and devices easily while working on two separate devices.

Types of Networks:

A network can be divided on the basis of the geographical areasit covers; hence, the major categories of networks are as follows:

- Wireless networks
- Local Area Network i.e. LANs
- Wide Area Network i.e. WANs
- Metropolitan Area Networks, i.e. MANs

Computer Networking Layers

In terms of computer networking, a layer refers to a library or programming interface

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i.e. the software being used. Layers can exchange information or communicate with only the layer directly above or below them.

Computer networking layers constitute the following:

- **Local Area Networks (LANs):** This is the Link Layer
- **Internet Protocol (IP):** This is the Internetwork Layer
- **Transmission Control Protocol (TCP):** This is the Transport Layer

It is the understanding that communication between various layers is a gradual process rather than a direct one. In other words, a layer can only communicate with the layer directly above or below it;these layers also communicate in a similar fashion. This means if a program transfers data to the TCP library, the TCP calls the IP library and then the IP calls the LAN layer. There is no direct transfer of data between the TCP and LAN Layer.

Each of these layers and their functionalities are described in detail as:

Local Area Networks (LANs):
Local Area Networks i.e. LANs generally operate in a small local area. The area is confined in order to use only one transmission medium, such as cables.

Advantages of LANs:
Some of the reasons why LANs have widespread use despite coverage limitations are:

→ Cheaper to implement as compared to a Wide Area Network i.e. WAN
→ Operates at higher speed due to smaller coverage area
→ Connectsa number of devices such as personal computers and devices in offices
→ Enables sharing of the assets
→ Produces low delay
→ Ensures minimum errors

A Local Area Network i.e. LAN constitutes thefollowing features:

• Physical Links

• Common Interfacing Hardware

• Protocols

Physical Topologies of LANs:

Common physical topologies are of various types. Some of the most important topologies are discussed below:

•Bus topology
Bus topology is the oldest existing topology that represents the connection of various devices over a single cable in a series. The single cable being utilized is referred to as the "backbone". It is aptly named so since all the connections depend on it. This topology is outdated now because of its lack of efficiency.

The LAN Bus topology is illustrated below:

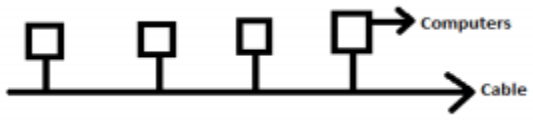

Figure 1 BUS Topology of LAN

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•Ring topology

In order to make up for the limitations of the bus topology, ring topology was introduced. In this method, the devices are interconnected in a circular manner where exchange of information is only possible in one direction. However, since the signal is regenerated at each device, there is minimum signal degeneration.

LAN ring topology is illustrated as follows:

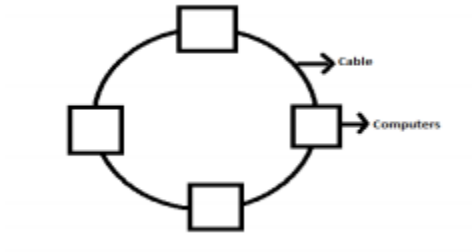

Figure 2 RING Topology of LAN

As is evident from the illustration, each device is further connected to two other devices, doubling the efficiency of this topology by twice compared to the bus topology.

•Star topology

Star topology was introduced to overcome the shortcomings of bus and ring topologies. This is the commonly used topology nowadays. In this arrangement there is a central device and all other devices are connected to it through point-to-point link. This central device is also referred to as a hub, multiport repeater, or even a switch. The hub has drop cables extending in every direction which enables it to form connections with other devices. In this manner a star arrangement can also be nested into other star arrangements.

The LAN Star topology is illustrated as follows:

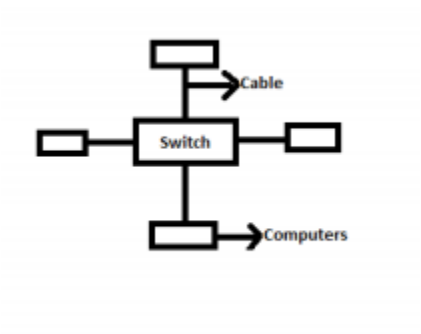

Figure 3 STAR Topology of LAN

• Mesh topology

Mesh topology is another type of point-to-point link arrangement. However, this is not considered one of the more practical topologies. Despite that, this topology is worth mentioning because of the advantages it offers in terms of high fault tolerance and a remarkable capacity.

•Cellular topology

Cellular topology can be considered a hybrid of ring and star topology, as this topology also deals with point-to-point links with a central operating device referred to as a switch. What sets cellular topology apart from star topology is that it divides the entire geographical area it covers into cells and each cell represents a part of the total network of devices.

Internet Protocol (IP):

Internet protocol (IP) is a set of guidelines that govern the terminals that may have access to the internet technology. Computers and the networks established between two or more computers, wirelessly, is also made possible through the internet so internet protocol (IP) is necessary for computer networking.

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IP is the layer that resides directly above thetransmission control protocol (TCP) layer. Both IP and TCP are essential elements of computer networking. IP deals with assigning the addresses to the sender and the receiver, whereas TCP deals with the delivery of data from the sender to the receiver.

The purpose of IP is to:

- Cater to the scaling problem posed by the ethernet
- Support different types of LAN
- Support point-to-point links

Limitation of IP:

The major limitation faced by IP is the large-scale connectivity support, better termed as universal connectivity support. This means allowing every type of LAN to connect to each other. The issue arises in the form of cumbersome forwarding tables that can extend to enormous lengths based on the size of scaling. The larger the scaling, the larger the forwarding tables.

Transmission Control Protocol (TCP):

The transport layer is the layer directly above the IP layer. TCP deals with issues by creating connection abstraction. Transmission Control Protocol (TCP) is the widely used mechanism forthe transport layer. This TCP layer extends the IP with the following features:

• **Reliability:**

→ Each packet is numbered by the TCP. This is done in order to keep track of the number of packets sent and received,so that in the case where a packet is lost, the TCP retransmits it after a timeout.

→ For retransmission purposes, each arriving packet is acknowledged by the receiver. This aids in alerting the sender of the lost packet.

→ After receiver acknowledgment, timeout and retransmission occurs.

→ In addition to this, if a packet arrives early, also referred to as out-of-order packet, then this packet is held back untilthe correct arrival time.

• **Connection-Orientation:**

→ Data can be sent directly by writing to a particular connection once the TCP connection is successfully made.

→ Application-level addressing is not necessary.

→ The operating-system kernel manages TCP connections rather than the application.

• **Stream-Orientation:**

→ 1 byte at a time up to 100 kB at a time can be written by an application utilizing TCP.

→ Data is divided, buffered, or sometimes both into appropriately sized packets by the TCP.

• **Port Number:**

→ Gives a methodological way to identify the data from the sending application.

→ Similarly, a method to specify the data to the receiving application is possible.

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• **Throughput Management:**

→ Throughput is maximized by the TCP
→ Simultaneously working to avoid unnecessarily adding to the network congestion.

What is the OSI Model?

The Open Systems Interconnection (OSI) Model was introduced in 1977 by the ISO, also known as the International Organization for Standardization. The OSI Model was an attempt at creating a standard networking model that is not part of any individual government. The OSI Model has since then been used as a networking standard process.

The OSI Model constitutes of seven layers and this system is well known for these comprehensively divided sets of layers. In this model,session and presentation layers were added between the transport and application layers.

Session Layer

The session layer was added to handle the various sessions which might open up between applications. This includes:

- Closing transport layer connections
- Re-establishment of transport layer connections

Presentation Layer

The presentation layer was added for:

- Definition of universal data formats (for example: binary data or non-ASCII characters)
- Compression of data
- Encryption of data

Despite the convenience provided by the session and presentation layers, they are not considered computer networking layers in the true sense as a layer is specified to only communicate with the layer directly above or below it. However, an application layer sometimes tends to create its own transport layer connections and reads and writes data to and from the transport layer regardless of the presence of a session and presentation layer between the application and transport layers. In such a case, the presentation layer actions, such as format translation, compression and encryption are done using conventional libraries rather than the actual presentation layer. Similarly, session layer actions are also dealt with without having to call the session layer.

Advantages of OSI Model

The OSI Model creates makes life easier in following manner:

- Provides visual depiction of a computer networking System
- Helps narrow down problems to aid network managers
- Aids computer programmers in developing new applications
- Allows tech vendors to better communicate with their clients
- Enables customers to better grasp the concept of computer networks before investing in one

Layers of OSI Model

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Layers of the OSI Model

1. Physical Layer

- → Enables physical devices for transmission and reception of data
- → Establishment of a connection between two nodes
- → Termination of connection between two nodes
- → Defines the medium of transmission of data such as:
  - i. One-way transmission i.e. Simple
  - ii. Two-way transmission but partially, i.e. half duplex
  - iii. Two-way transmission of data, i.e. full duplex

2. Data Link Layer

- → Permits access todata between devices
- → Controls devices
- → Sends data in the form of packets
- → Controls error checking
- → Allows packet synchronization

3. Network Layer

- → Sends the data to its destination address or node.
- → Splits the data into several fragments
- → Delivers each fragment by a separate path
- → Reassembles the fragments
- → Reports delivery errors of each fragment

4. Transport Layer

- → Manages connections
- → Handles errors indeliveryof data

5. Session Layer

- → Starts, manages and stop the connection between nodes.
- → Checkpoints procedures
- → Adjourns procedures
- → Terminates procedures
- → Restarts procedures

6. Presentation Layer

- → Encryption of the data
- → Sendsdata to application layer

7. Application Layer

- → Interacts with software

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Computer Networking Layers and OSI Model Explained

The OSI Model layers mentioned above are further classified into upper and lower layers as under:

Upper Layers:

Application

The application layer is the topmost layer. In the OSI Model, this layer is considered the "closest to the end user". This is so because this is the layer that users directly interact with and is visible to them. This layer enables the user to receive the information directly and the data is displayed as well. Widely used examples of this are web browsers such as Google Chrome, Firefox, Safari, etc.

Everything in the application layer is application-specific. However, actual applications do not reside in this layer. Rather, it creates a bridge between the applications and lower layers. This layer enables file transferring, e-mailing, and other network software services. In addition to this, tiered application architectures are also part of this layer.

The application layer has the following functionality:

- Identifies communication partners
- Supports applications
- Identifies quality of service
- Supports end-user processes
- Identifies any constraints on data syntax
- Ensures user authentication and privacy

Presentation

The presentation layer is named so because it "presents" data to the network. It is also referred to as the syntax layer. It allows the data transferfrom application layout to network layout or similarly from network layout to application layout. In other words, the presentation layer deals with the data that is exempted from data representation on the application layer. An apt example of a presentation layer is the encryption of data or decryption of data, in order to make safe data transmission possible.

Main functions of the presentation layer include:

- **Independence from Data Representation Differences:** This is achieved by translating data fromapplication format to network format or vice versa. This action eliminates the possibility of any data loss due to the difference in data representation on the application level or network level.
- **Transformation of Data:** The act of translating data into an application format makes it acceptable for the application layer to process. Due to this, no compatibility problems arise and makes transmission of data across any network smoother.

Session Layer

The session layer comes into play when the need to create a session arises. A session is created when two physical devices, such as a

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computer or servers, need to communicate with one another. The major functions carried out at the session layer are as follows:

- **Setup:** Initiating a session to allow communication
- **Coordination:** Allowing to and fro transfer of information and specifying response time
- **Termination:** Ending a session

In other words, this layer deals with the connection coordination between two devices. It involves the set-up procedure, establishment of a secure connection, management of the connection, coordination of conversation and exchange of information, and termination of an application on both ends at the end of a session.

Transport

The transport layer ensures the complete and transparent transfer of data to and from end systems or hosts. The coordination of this data transfer is the main purpose of the transport layer. It deals with where the data goes, at what rate the data is transferred and how much data is transmitted, and so on. One of the majorly used transport layer procedures is TCP, Transmission Control Protocol. TCP is situated at the top of the IP layer. The main functions of the transport layer are:

- **End-to-end Error Recovery:** Making sure that the data transmitted is also received at the user end and if not, then re-transmission and time out procedure are carried out.
- **Flow Control:** Ensuring the safe and complete transfer of data.

Lower Layers:

Network

The main functionality of the network layer is as follows:

- **Router Functionality:** A router is a networking device that works by transferring data in the form of packets and is able to connect two or more networks together.
- **Packet Forwarding:** It is the act of transferring data packets from the sender, i.e. the host to the receiver.
- **Switching Technology:** This allows transmission of data from node to node by means of logical paths which may also be referred to as virtual circuits.

Other functions performed by the network layer are:

→ Internetworking
→ Error handling
→ Addressing
→ Packet sequencing
→ Congestion control

Data Link

The data link layer of the OSI Model has the following functionality:

- Error correction of physical layer
- Encoding of data packets
- Decoding of data packets
- Node-to-node data transfer
- Transmission protocol knowledge
- Frame synchronization

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- Flow control

The data link layer consists of two sub layers:

- **Media Access Control (MAC) Layer:**
  This deals with the acquisition of data and controls the transmission of that data.
- **Logical Link Control (LLC) Layer:**
  This layer deals with:
  → Error checking
  → Flow control
  → Frame synchronization

Physical

The physical layer is the electrical and mechanical representation of the OSI system as it conveys the bit stream in the form of an electrical impulse or a light or radio signal. This layer includes:

→ Cables
→ Radio frequency link
→ Layout of pins

In case of any physical problem in a network, this is the layer that is checked. It is then ensured that all the cables are connected and the power plug is intact or not.

The physical layer provides the hardware for sending and receiving data on a carrier, including defining cables, cards and physical aspects. Some examples of physical layer components are:

- Fast Ethernet
- RS232
- ATM, etc.

Cables are a reliable and easy method of establishing connections. However, wireless methods of connections are gradually taking over the computer networking field.

Conclusion

Computer networking has taken the technology world by a storm as it enables a more time-efficient and convenient method of information exchange. Computer networking can be seen as a method of enabling communication between two computers. This has revolutionized the concept of data transfer by allowing files and services to be exchanged to and fro over a large geographical region without the physical constraints of transmission being a hurdle. The major contributor that makes this interconnection of separate devices successful is the inclusion of the internet technology to the modern computer networking field. Prior to this, a non-wireless method of computer networking also existed by means of cables.However,that limited the area for the purpose of computer networking. The concept of the OSI Model made understanding of the computer networking system easier and standardized the system to not only help in the comprehension of the overall system, but also to aid in business transactions between network developers and users. In this day and age, computer networking and the OSI Model go hand in hand to ensure the users reap the full benefits of the networking experience and that they can be smart enough to identify any error and spot the level at which the error exists. This not only simplifies any

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possible future problems but also empowers users to be more self-reliant.

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