BACHELOR OF COMPUTER APPLICATIONS

SEMESTER 3

DCA2104

BASICS OF DATA COMMUNICATION

Unit 2

Protocol Architecture and Internet Based Applications

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1. INTRODUCTION

In the previous unit, you have studied about the basics of communication system and data communication and their various tasks. In data communication, the layered structure of hardware and software required to support the data transfer between systems called protocol architecture. At each layer of a protocol architecture, one or more protocols are implemented, and these protocols gives a set of standard guidelines for the data or information to exchange between systems. Most broadly used protocol architecture is TCP/IP protocol suite which comprises of five layers: physical, network access, internet, transport, and application. Another important protocol architecture is the seven-layer OSI model.

In this unit, we will discuss the need for a protocol architecture. Then we will discuss the TCP/IP protocol architecture and OSI model. This unit also discusses standardization within a protocol architecture.

1.1 Objectives:

After studying this unit, you should be able to:

- *Describe the need for a protocol architecture*
- *Explain TCP/IP protocol architecture*
- *Describe OSI model*
- *Describe standardization within a protocol architecture*
- *Explain traditional internet based applications*

2. THE NEED FOR A PROTOCOL ARCHITECTURE

Data transfer of data processing devices such as computers, Point of Sale terminals or other devices requires quite complex procedures. For instance, in case of a file transfer between two computers, a data path is required either directly between two computers, or using a communication link. Different tasks involved in this process are:

- The sender (source system) should activate a direct communication path or inform the communication network of the address of the desired receiver (destination system).
- The sender must assure that the receiver is ready to receive data.
- The file transfer application on the sender should assure that the file management program at the receiver is ready to receive and store the file for this particular user.
- If the systems use different file formats, any one of the systems should perform a format translation procedure.

The task of exchanging information between devices requires a high degree of cooperation between the involved parties. Rather implementing a single function, the task must be separated into subtasks, each of which is implemented independently. Modules are organized vertically in a protocol architecture, as a vertical stack. In the stack, every layer performs a related subset of the functions necessary to communicate with other system. Each layer depends on the following lower layer to accomplish more primitive functions and to hide the details of those functions. Each layer provides services to the next higher layer. Layers are defined in a manner that adjustments in one layer don't influence other layers.

During communication between a source and destination system, the same set of layered functions must exist in two systems. Communication is accomplished by peer layers in source and destination systems which communicate each other. These peer layers communicate using formatted blocks of data that adapt a set of rules or conventions known as a protocol. The key feature of protocols are: syntax, semantics and timing. Syntax refers the format of the data blocks. Semantics incorporate control data for coordination and error handling. Timing incorporates speed matching and sequencing.

Self-Assessment Questions - 1

1. The set of rules or conventions for communication is known as_____ .
2. During communication between a source and destination system, the same set of layered functions must exist in two systems. State true or false. (a) True (b) False
3. The key features of a protocol are_____ ,_____ and _____.
4. The format of the data blocks are referred by_____.

3. THE TCP/IP PROTOCOL ARCHITECTURE

As we discussed in Unit 1, TCP/IP protocol architecture is a result of protocol research and development conducted on ARPANET (Advanced Research Projects Agency Network), a packet-switched network funded by the Defense Advanced Research Projects Agency (DARPA). TCP/IP protocol architecture is referred to as the TCP/IP protocol suite which consists of a large collection of protocols that have been issued as Internet standards by the Internet Activities Board (IAB).

The TCP/IP layers

A typical data communication involves three agents: applications, computers and networks. File transfer, electronic mail etc. are the examples of the said applications. Data is transferred from source to destination through the network.

The communication task can be organized into five layers such as:

- Physical layer
- Network access layer
- Internet layer
- Host-to-host, or transport layer
- Application layer

Physical layer addresses the physical interface between computers (workstation) and transmission medium or network. This layer specifies the nature of the signals, characteristics of the transmission medium, the data rate, and related matters.

Next layer is network access layer, which is responsible for the exchange of data between an end system and the network to which it is connected. Sender should provide the destination address so that data should be routed properly to the intended receiver. In this layer, different standards have been developed for circuit switching, packet switching, LANs and others. Higher layer software functions properly regardless of the network to which the computer is attached.

Network access layer exchanges data across a network for two systems connected to the same network. In case of devices attached to different networks, different procedures are required to allow data to traverse multiple interconnected networks. This is the function of

the network layer it accepts and delivers packets for the networks. In this layer, Internet protocol (IP) is used to provide the routing function across multiple networks. Internet protocol is applied in intermediate and end systems. Router connects two networks and its function is to transmit data from one network to another.

As we know, data communication should be reliable i.e., we should be assured that the data which has been sent arrives at the destination, and the data is arriving in the same order in which they were sent. The mechanisms which provide reliability of data are independent of the nature of applications. These mechanisms are collected in a common layer, which is then shared by all applications. This layer is known as host-to-host layer or transport layer. In this layer, Transmission Control Protocol (TCP) and User Datagram Protocol (UDP) is used to provide the functionality.

Application layer include a set of application layer protocols to support various user application. For every application, a separate module is required which is particular to that application.

TCP and IP -Operations

Figure 2.1 shows how TCP and IP protocols are configured for communications. The total communication facility consists of multiple networks, which are usually referred as subnetworks. Network access protocol enables the sender to send data across the subnetwork to another host or router. IP is implemented in all systems. Routers act as a relay to transmit data from one host through one or more routers to another host.

TCP keeps track of the blocks of data to assure that all are reliably delivered to the destination.

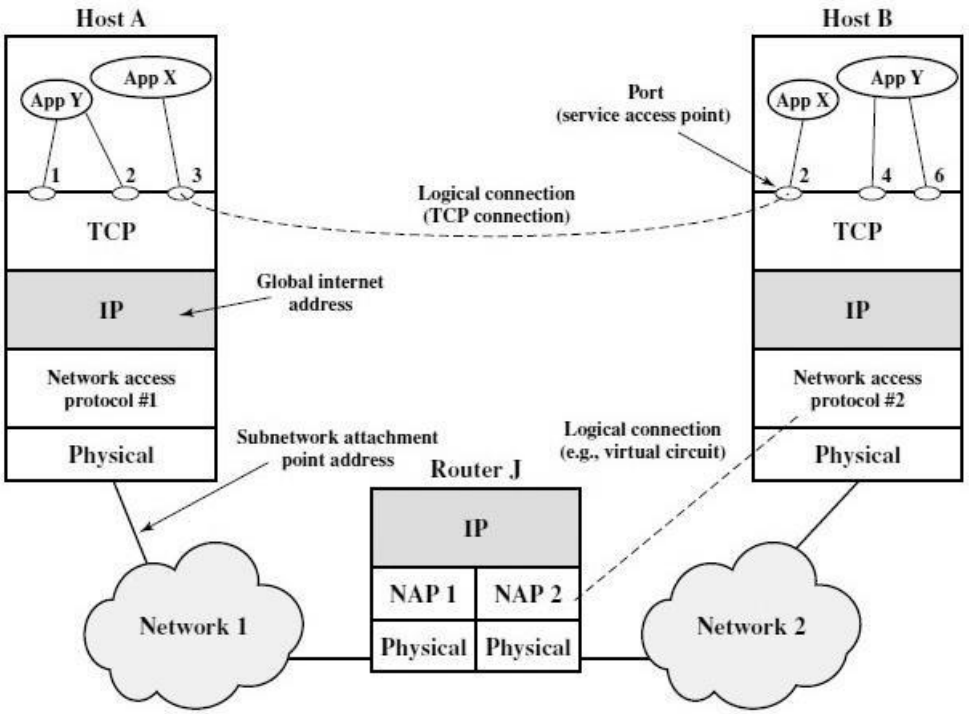

Figure 2.1: TCP/IP Concepts

There are two levels of addressing required for proper communication. Each host has a unique global internet address which act as the destination address to deliver data to the proper host. Also, each process in the host must have a unique address which allows the TCP protocol (host-to-host protocol) to deliver data to the appropriate process. This address is known as port address.

Figure 2.1 shows operations involved in TCP/IP data transfer. For example, in figure 2.1, a process associated with port 3 at host A sends a message to another process at host B with port 2. The process at host A transfer the message down to TCP with instructions to transmit it to host B, port 2. TCP transfer the message to IP with instructions to send it to host B. IP transfer the message to network access layer with instructions to send it to router J (which is the first hop on the way to B). Control information is also transmitted to control this operation. Sender creates block of data and passes this to TCP. TCP again break this data into smaller blocks to form a TCP segment. TCP segment contains application data and control information known as TCP header. TCP header includes a destination port, sequence number and checksum.

TCP transfer each TCP segment down to IP (Internet Protocol). IP appends a header of control information to form IP datagram. Then each IP datagram is transferred to network access layer. Network access layer appends its own header and creates a packet which is transmitted across the subnetwork to router J. Packet header includes destination subnetwork address and other facilities requests such as priority. At router J, packet header is examined and based on the destination address, packet is routed across subnetwork 2 to host B. Once the packet is received at B, the reverse process occurs, that means at each layer the corresponding header is removed and rest of the data is passed on to next higher layer until the original data are delivered to the destination process.

TCP and UDP

TCP is a Transport Layer Protocol which provides a reliable connection for the transfer of data between applications.

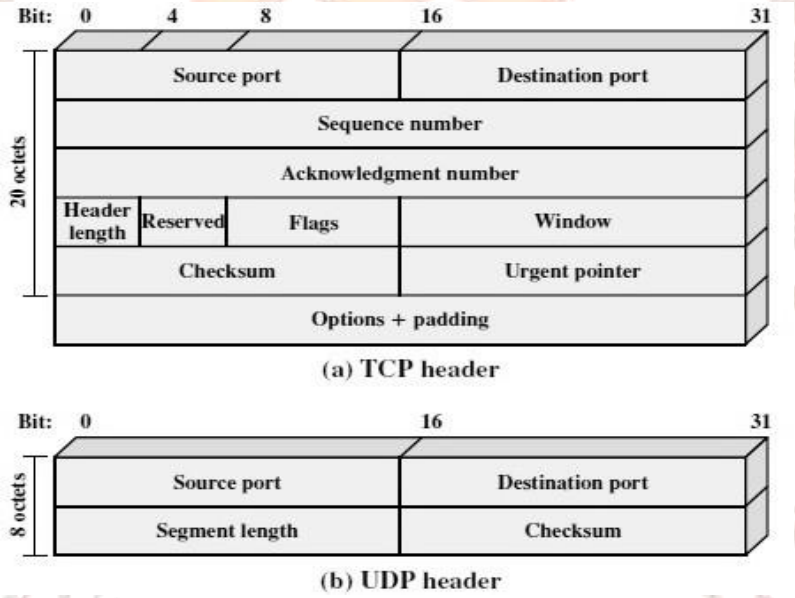

Figure 2.2: TCP and UDP Headers

Figure 2.2 (a) shows the header format of TCP, which is 20 bytes or 160 bits. Source port and destination port both consist of 16 bits, it identifies the applications at source and destination that are using this connection. The Sequence Number (32 bits), Acknowledgment Number (32 bits), and Window fields (32 bits) provide flow control and error control. The checksum is a 16-bit frame check sequence used to detect errors in the TCP segment.

Another transport layer protocol is UDP (User Datagram Protocol). UDP is a connection less protocol. UDP does not guarantee delivery, as there is no mechanisms for error control and flow control. Figure 2.2 (b) shows UDP header, which is 8 bytes in size. UDP header include source and destination port address, segment length and checksum.

Self-Assessment Questions - 2

5. TCP/IP protocol architecture is referred to as_____ .
6. Which layer specifies the nature of the signals, characteristics of the transmission medium etc. in TCP/IP?
   (a) Physical layer
   (b) Internet layer
   (c) Transport layer
   (d) Application layer
7. In network access layer,_____ protocol is used to provide the routing function across multiple networks.
8. In transport layer,_____protocol is used to provide functionality.

4. OSI MODEL

The reference model, Open Systems Interconnection (OSI) was developed by international standardization organization (ISO) as a model for a computer protocol architecture and as a framework for developing protocol standards. The OSI model consists of seven layers. They are:

1. Application layer
2. Presentation layer
3. Session layer
4. Transport layer
5. Network layer
6. Data link layer
7. Physical layer

Different protocols are there to perform functions of each layer. Figure 2.3 shows different layers in OSI model.

Physical layer: This layer coordinates the functions required to carry a bit stream over a physical medium. It deals with the electrical specifications of the interface and transmission medium. It defines the procedures and functions that physical devices and interfaces have to perform for transmission to occur.

Data link layer: This layer transforms the physical layer, a raw transmission facility, to a reliable link. It makes the physical layer appear error-free to the upper layer (to the Network layer). It is also responsible for other functions such as framing, error control, flow control, physical addressing, and access control mechanisms.

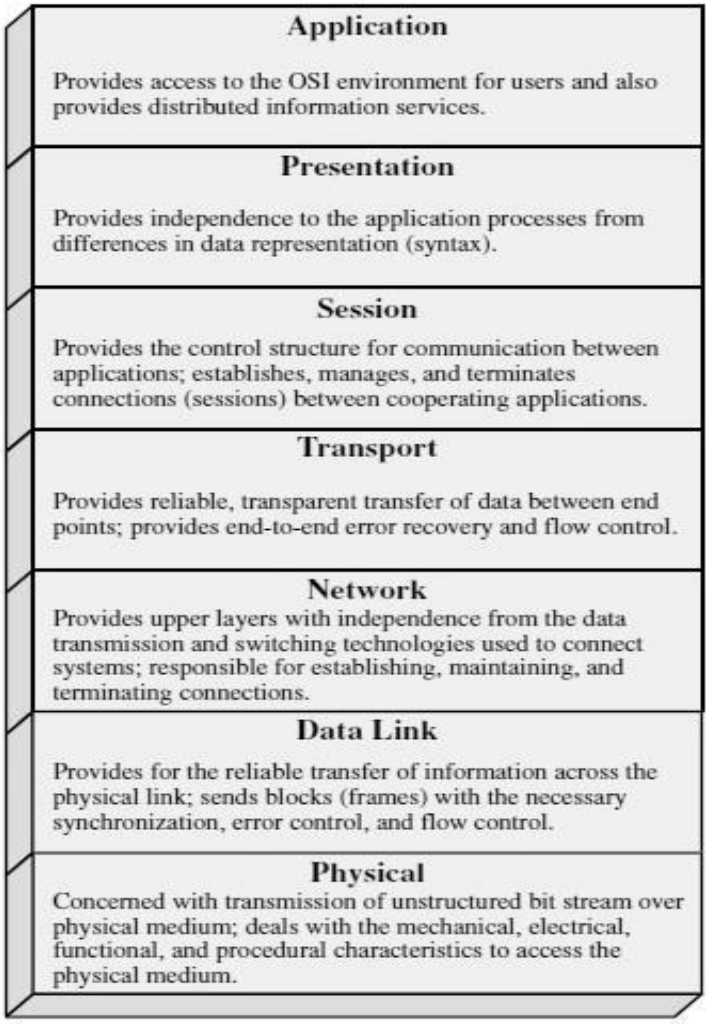

Figure 2.3: OSI Model

Network layer: This layer provides the switching and routing technologies.This layer guarantees the source-to-destination delivery of a packet, over various networks. The Data Link Layer regulates the delivery of the packet between two systems on the same network. In case, if two systems are attached to the same network, there is no need for the network layer. Regardless, if the two systems are attached to different networks with connecting devices between the networks, there is often a need for the network layer to accomplish source-to-destination delivery. Logical addressing, routing, internetworking, error handling, congestion control and packet sequencing are also a key responsibility of network layer.

Transport layer: This layer maintains flow control of data and accommodates for error checking and recovery of data between the devices. Flow control means that the Transport

layer looks to check whether information is originating from more than one application and coordinates every application's information into a single stream for the physical system. This layer is responsible of process-to-process delivery of the entire message. A process is an application program running on the host. The Network layer manages the source-to-destination delivery of individual packets, it does not recognize the relationship between those packets. It treats each packet independently, as though each piece belonged to a different message, regardless of whether it does. The Transport layer, similarly ensures that the entire message arrives in place and all together, overseeing both error and flow control at the source-to-destination level.

Session layer: This layer works as the network dialog controller. This session layer permits applications working on devices to set up, manage, and end a dialog through a network. Session layer usefulness incorporates: retransmission of information if it is not received by device, synchronization of information flow, and acknowledgements of data received during a session.

Presentation layer: This layer is concerned with the syntax and semantics of the information exchanged between two systems. The specific responsibilities of this layer incorporate translation, encryption, and compression. This layer takes data from the application layer and then converts it into a format which another layer can understand.

Application layer: This layer is a top layer in OSI model. This is the layer that actually collaborates with the operating system or application whenever the client exchange in any layer of OSI architectures files, read messages or perform other network-related activities. This layer empowers the client, whether human or software to access the network. It gives client interfaces and support for services for example electronic mail, remote file access and transfer, shared database management, and other types of distributed information services. Specific services offered by the Application layer include: provision of network virtual terminals, file exchange, access, and management, mail services, and Directory Services.

Self-Assessment Questions - 3

9. The_____ Model is based on the protocol developed by ISO.
10. In OSI model, framing, error control, flow control, physical addressing are the functions of_____ layer.
11. Which layer acts as the network dialog controller?
    (a) Physical
    (b) Network
    (c) Session
    (d) Presentation

5. STANDARDIZATION WITHIN A PROTOCOL ARCHITECTURE

As we discussed, the primary aim for the development of the OSI model was to provide a framework for standardization. In each layer, one or more protocol standards can be developed. OSI model defines the functions to be performed in each layer and facilitates the standards making process in two ways. One is that, since the functions of each layer are well defined, standards can be developed independently for each layer which speeds up the standardization process. Second advantage is that, since the boundaries between layers are well defined, changes in standards in one layer will not affect already existing software in another layer. So new standards can be introduced easily.

Figure 2.4 demonstrate the use of OSI framework. As we discussed, overall communication function is fragmented into seven layers. OSI framework also use principle of information hiding, i.e., upper layers are independent of the detail and lower layers are concerned with greater levels of detail. Each layer provides services to the next higher layer and implements a protocol to the same layer on other systems.

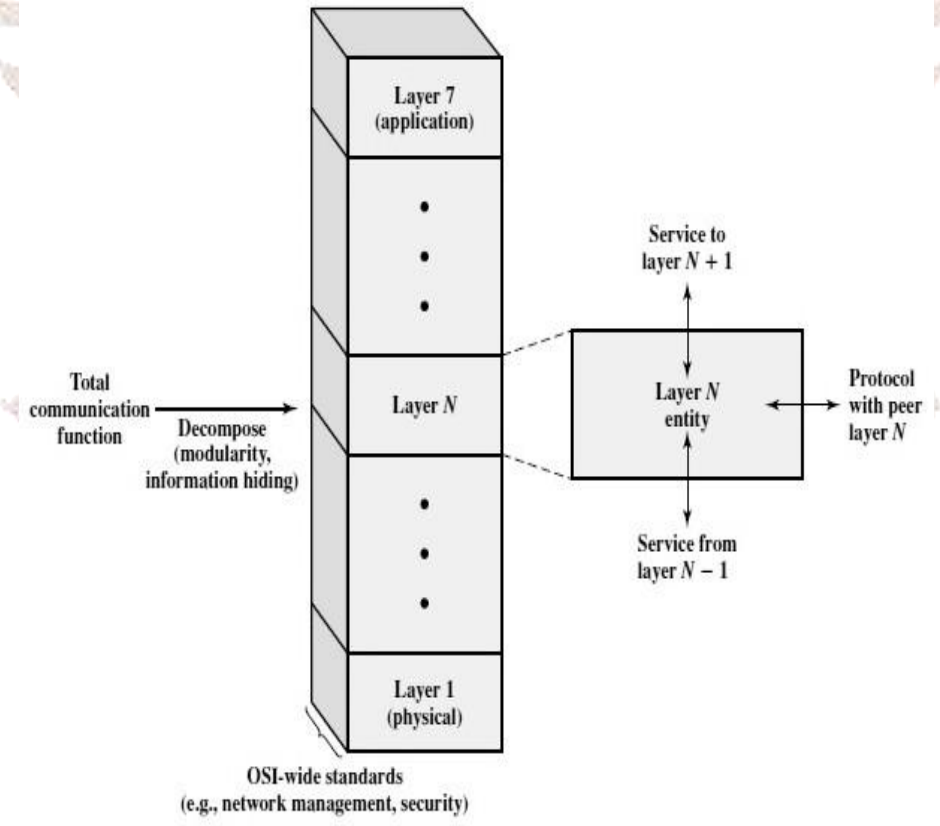

Figure 2.4: The OSI architecture as a framework for standardization

The type of standardization required at each layer is shown in figure 2.5. There are three key elements that are considered for standardization in any layer of OSI architecture. They are:

- **Protocol specification**: By using a protocol, two entities at the same layer in different systems cooperate and interact with each other. This protocol includes the format of the protocol data units exchanged, the semantics of all fields and allowable sequence of Protocol Data Units (PDUs).

- **Service definition:** In addition to the protocols, standards are also required for the services that each layer provides to the next higher layer. The definition of service is equivalent to a functional description which defines what services are provided, but not how the services are to be provided. At each layer, implementation of software is done according to the set of protocols. The requirement for giving only a functional description is as follows. First, the communication between two adjacent layers happens within the boundaries of a single open system and is not the concern of any other open system. Thus, as long as peer layers in different systems provide the same services to their next higher layer, the details of how the services are provided may differ from one system to another without loss of interoperability. The second situation can be that the adjacent layers are implemented on the same processor. In such a case, we will permit the system programmer to freely exploit the hardware and operating system to provide an interface that is as efficient as possible.

- **Addressing:** Each layer provides services to entities at the following higher layer. These entities are referenced by means of a Service Access Point (SAP). SAP is a conceptual location used to request services of one layer to another. So, a Network Service Access Point (NSAP) indicates a transport entity that is a user of the network service.

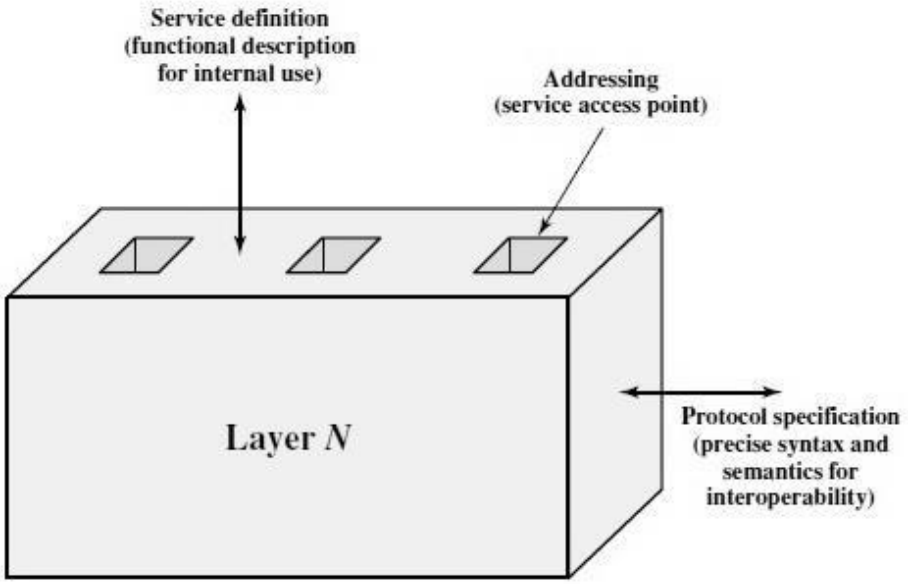

Figure 2.5: Layer-specific standards

The use of an addressing mechanism at each layer implemented as a service access point, allows each layer to multiplex multiple users from the next higher layer. Multiplexing of data from source to destination may not occur at each layer, but the model allows for that possibility.

Service primitives and parameters

In the OSI architecture, the services between adjacent layers are expressed in terms of primitives and parameters. A primitive specifies the function to be performed and the parameters are used to pass data and control information. The actual form of a primitive is implementation dependent. Procedure call is one such example. Four types of primitives are used in standards to define the interaction between adjacent layers in the architecture. Table 2.1 shows these primitives.

Table 2.1: Service Primitive Types

Primitive Type	Definition
Request	A primitive issued by a service user to invoke some service and to pass the parameters needed to specify fully the requested service
Indication	A primitive issued by a service provider either to 1. Indicate that a procedure has been invoked by the peer service user on the connection and to provide the associated parameters, or 2. Notify the service user of a provider-initiated action
Response	A primitive issued by a service user to acknowledge or complete some procedure previously invoked by an indicationto that user.
Confirm	A primitive issued by a service provider to acknowledge or complete some procedure previously invoked by a request bythe service user.

6. TRADITIONAL INTERNET BASED APPLICATIONS

Many applications have been standardized to operate on top of TCP. Three most common TCP/IP applications are Simple Mail Transfer Protocol (SMTP), File Transfer Protocol (FTP) and TELNET (TELecommunicationNETwork). SMTP provides e-mail transport facility, mailing lists, return receipts and forwarding. Once a message is formed, SMTP accepts the message and transfer it to SMTP module on other host by using TCP. On the receiver side, SMTP module will use local electronic mail package to store the incoming message in a user's mailbox.

FTP is used to transfer both text and binary files from one system to another. It also provides features for controlling user access. When a user wants to transmit a file, FTP creates a TCP connection to the receiver for exchange of control information. User can transmit user id and password and can also specify file and action needed to perform on that file. Once the file transfer is approved, a second TCP connection is setup for data transfer, then user can transmit files over the data connection. Once the transfer is complete, it is signaled using control connection so that new file transfer commands can be initiated.

TELNET provides remote login capability. By using this, user can logon to a remote computer and can work as if directly connected to that computer. TELNET is implemented in two modules: User TELNET and Server TELNET. Traffic between these two modules is carried over a TCP connection. User terminal communicates with the terminal I/O module to communicate with local terminal. Server TELNET communicates with an application.

Self-Assessment Questions - 4

12. A _____ indicates a transport entity that is a user of the network service.
13. Three most common TCP/IP applications are_____, _____and_____.
14. Protocol used to transfer both text and binary files from one system to another is known as_____ .
15. TELNET is implemented in two modules, they are_____and_____.

7. SUMMARY

Let us recapitulate the important concepts discussed in this unit:

- A protocol architecture is the layered structure of hardware and software which supports the data transfer between systems and applications like electronic mail and file transfer.
- During communication between a source and destination system, the same set of layered functions must exist in two systems.
- Different layers of a TCP/IP protocol stack includes physical layer, network access layer, internet layer, transport layer and application layer.
- TCP is a transport layer protocol which provides a reliable connection for the transfer of data between applications.
- OSI model consists of seven layers such as application layer, presentation layer, session layer, transport layer, network layer, data link layer and physical layer.
- In the OSI architecture, the services between adjacent layers are expressed in terms of primitives and parameters.
- A primitive specifies the function to be performed and the parameters are used to pass data and control information.
- Three most common TCP/IP applications are simple mail transfer protocol (SMTP), file transfer protocol (FTP) and TELNET (TELecommunication NETwork).

7. TERMINAL QUESTIONS

1. Describe the need for a protocol architecture.
2. Explain TCP/IP protocol architecture.
3. Explain the seven layers of OSI model with suitable diagram.
4. Describe standardization within a protocol architecture.
5. Explain three TCP/IP applications.

8. ANSWERS

Self-Assessment Questions

1. Protocols
2. (a) True
3. Syntax, Semantics and Timings
4. Syntax
5. TCP/IP protocol suite
6. (a) Physical layer
7. Internet protocol
8. TCP (transmission control protocol)
9. OSI
10. Datalink Layer
11. (c) Session
12. Network service access point (NSAP)
13. SMTP, FTP, TELNET
14. FTP (File Transfer Protocol)
15. User TELNET, server TELNET

Terminal Questions

1. Data transfer of data processing devices such as computers, terminals or other devices requires quite complex procedures. For instance, in case of a file transfer between two computers, a data path is required either directly between two computers, or using a communication link. (Refer section 2.2 for more details).
2. TCP/IP protocol architecture is a result of protocol research and development conducted on ARPANET (Advanced Research Projects Agency Network), a packet-switched network funded by the Defense Advanced Research Projects Agency (DARPA). (Refer section 2.3 for more details).
3. The reference model, Open Systems Interconnection (OSI) was developed by International standardization organization (ISO) as a model for a computer protocol architecture and as a framework for developing protocol standards. The OSI model consists of seven layers. (Refer section 2.4 for more details).

4. The primary aim for the development of the OSI model was to provide a framework for standardization. In each layer, one or more protocol standards can be developed... (Refer section 2.5 for more details).
5. Many applications have been standardized to operate on top of TCP. Three most common TCP/IP applications are simple mail transfer protocol (SMTP), file transfer protocol (FTP) and TELNET (TELecommunication NETwork). SMTP provides e-mail transport facility. (Refer section 2.6 for more details).

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