UNIT 15 WORLD WIDE NETWORKS

Structure

15.1 INTRODUCTION

Discussion about networking would be incomplete till we discussed Internet. Internet is a global network connecting millions of computers. Presently it has more than 100 million users worldwide, and that number is growing rapidly. More than 100 countries are linked into exchanges of data, news and opinions.

For most of its existence the Internet was primarily a research and academic network. More recently commercial enterprises and a vast number of consumers have come to recognise the Internet's potential. Today people and business around the world can use the Internet to retrieve information, communicate and conduct business globally, and access a vast variety of services and resources on-line. The primary use of the Internet is for electronic mailing capabilities. Electronic mail however, is only a small part of what the Internet offers. It is possible to exchange the data, images, audio/ video clippings on the Internet. We can also participate in the chat sessions in on-line mode on the Internet.

The Internet has a decentralised design. Each Internet computer, called a host, is independent. Its operators can choose which Internet services to use and which local services to make available to the global Internet community.

As we go higher in the application usage, as a user we are not interested in knowing the actual signal flow protocols but expect a transparent passage through all the networks. This can be achieved by the standard network protocols, which allow information exchange between the different networks irrespective of their hardware topology. Open System Interconnection (OSI) and Transport Control Protocol/Internet Protocol (TCP/IP) are the most common reference models of networks standards.

In this unit we will discuss the basics related to Internet. In Sec.15.2 you will learn about how Internet works and how you can gain access to it. In Sec.15.3 you will learn about standard network protocols viz. OSI and TCP/IP. In Sec.15.4 we describe the structure of the address of a site on the Net. Various aspects of web browsers are described in Sec 15.5. In Sec. 15.6 you will be learning about the Intranet, which is being used for the implementation of Internet technologies within a corporate organisation, rather than for external connection to the global Internet. In Sec.15.7 you will be learning about e-mail, which is one of the most popular facilities provided by the Internet.

Objectives

After studying this Unit you should be able to:

- describe what is Internet and how it works;
- list the advantages and disadvantages of Internet;
- explain the various layers of OSI and TCP/IP reference models;
- describe what is Intranet and how it works;
- differentiate between Internet and Intranet; and
- explain how e-mailing works.

15.2 INTERNET

The reach of Internet is very vast. It is an access providing mechanism for every one around the globe seamlessly across the geographical boundaries of countries. This system has brought the whole world under one umbrella of information sharing forming a global village. Let us now see how the Internet evolved over the years.

15.2.1 History of the Internet

In the 1960s, researchers began experimenting with linking computers to each other through telephone hook-ups, using funds from the U.S Defence Department's Advanced Research Projects Agency (ARPA).

ARPA wanted to see if computers in different locations could be linked using a new technology known as packet switching, which had the promise of letting several users share just one communications line. Previous computer networking efforts had required a dedicated line between each computer on the network, sort of like a train track on which only one train can travel at a time. The packet system allowed for creation of a data highway, in which large numbers of vehicles could essentially share the same lane. Each packet was given the computer equivalent of a map and a time stamp, so that it could be sent to the right destination, where it would then be reassembled into a message that a computer or a human could use.

This system allowed computers to share data and the researchers to exchange electronic mail, or e-mail. In itself, e-mail was something of a revolution, offering the ability to send detailed letters at the speed of a phone call.

As this system, known as ARPANet grew; some enterprising college students developed a way to use it to conduct online conferences. These started as science-oriented discussions, but they soon branched out into virtually every other field, as people recognised the power of being able to "talk" to hundreds, or even thousands, of people at a time.

In the 1970s, ARPA helped support the development of rules, or protocols, for transferring data between different types of computer networks. These **internet** (from the term *internetworking*) **protocols** made it possible to develop the worldwide Net that linked all sorts of computers across national boundaries provided there was an Internet Service Provider (ISP) available.

In the 1980s, this network of networks, which became known collectively as the **Internet**, expanded at a phenomenal rate. Hundreds, then thousands of academic institutions, research organisations and government agencies began to connect their computers to this net. Some enterprising hobbyists and companies unwilling to pay the high costs of Internet access learned how to link their own systems to the Internet, even if only for e-mail and conferences. Some of these systems began offering access to the public. Now anybody with a computer and modem could tap into the world wide web.

In the 1990s, the web grew at exponential rates. Some estimates are that the volume of messages transferred through this Net grows 20 percent a month. In response, government and other users have tried in recent years to expand the Net itself. Once, the main Net *backbone* in the U.S.A. moved data at 1.5 million bits per second. That proved too slow for the ever-increasing amounts of data being sent over the Net, and in recent years the maximum speed was increased to 45 million bits per second. Even before the Net was able to reach that latter speed, however, Net experts were already figuring out ways to pump data at speeds of up to 2 billion bits per second-fast enough to send the entire Encyclopaedia Britannica across the world in just one or two seconds.

The Encyclopaedia Britannica contains about 1,00,000 articles with approximately 50 million words.

In India the Internet access in a sense came in the early 90's. ERNet, a division of Department of Electronics (DoE), and NICNet (Department of Statistics) made the initial inroads in this field. Both ERNet and NICNet are Government projects. The ERNet (Educational and Research Network) project was designed to provide Internet connectivity to the premier educational and research institutions of India, while NICNet was assigned the responsibility of providing Internet services primarily to Government departments and organisations. ERNet grew to become the first to provide full TCP/IP access to dial-up modem customers through SLIP accounts around 1993. The customers were mainly restricted to the Government organisations and the academic institutions. This was followed by an upgrade to a nationwide V-SAT (very small aperture terminal) network and passably high reliability services by 1996.

ERNet and NICNet are thus India's first Internet Service Providers (ISP). Though their operations were constrained by Government regulations and policies they were doing quite well in providing the essential Internet services to an Internet-starved India, until the advent of VSNL (Videsh Sanchar Nigam Limited) Internet service.

On August 15, 1995 VSNL launched the Gateway Internet Access Service, for providing public Internet access. Now MTNL (Mahanagar Telecome Nigam Limited) and BSNL (Bharat Sanchar Nigam Limited) are also taking an active part in providing Internet access to the public.

In recent years private Internet Service Providers have started operating giving Internet access to wide spectrum of Indian population. The policies related to network administration in India are designed and implemented by the Department of Communication and Information Technology. The Telecom Regulatory Authority of India (TRAI) is in the process of implementing New Generation Networks (NGN) in India now.

15.2.2 How does the Net Work?

The Net physically consists of your personal computer with modem, web browser software, a connection to an Internet service provider, computers called servers that host digital data and routers and switches to direct the flow of information. Fig. 15.1 shows a LAN connected to the Internet via an ISP.

DSL is the Digital Subscriber Line technology providing digital data transmission over telephone lines.

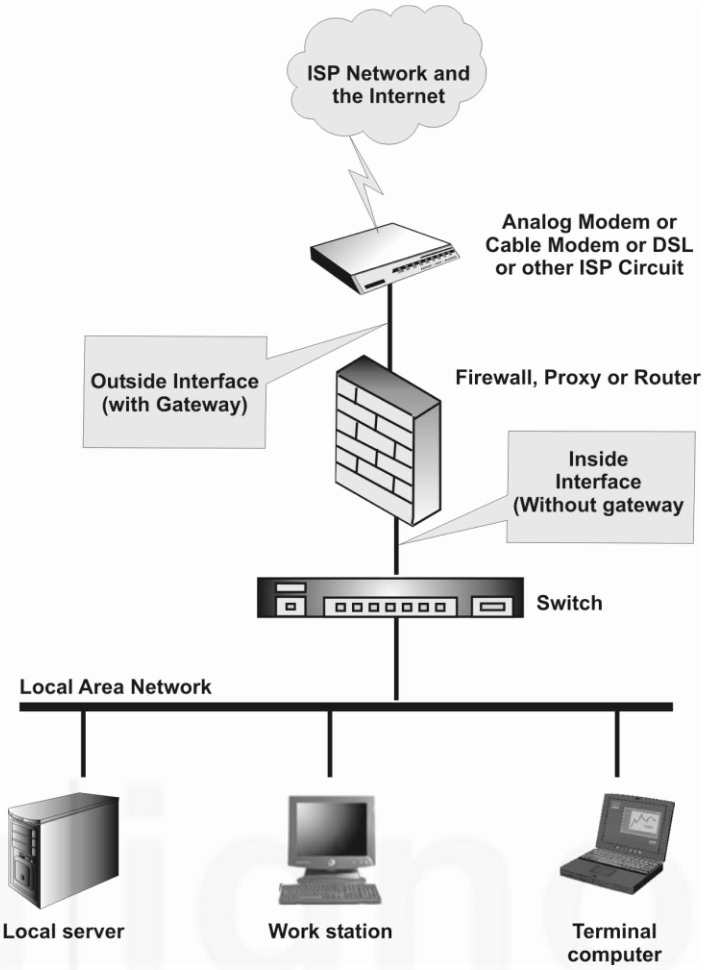

Fig. 15.1: Typical configuration showing Internet access via ISP

The local Internet service providers can then communicate with other local ISPs in the region by connecting through a regional gateway as shown in Fig. 15.2 Various regional gateways can obtain access to the web servers outside their region (or country) via global gateways. Global gateways can communicate with other global gateways via communication links like microwave, optical fibre, and satellite depending on their locations and accessibility to various media.

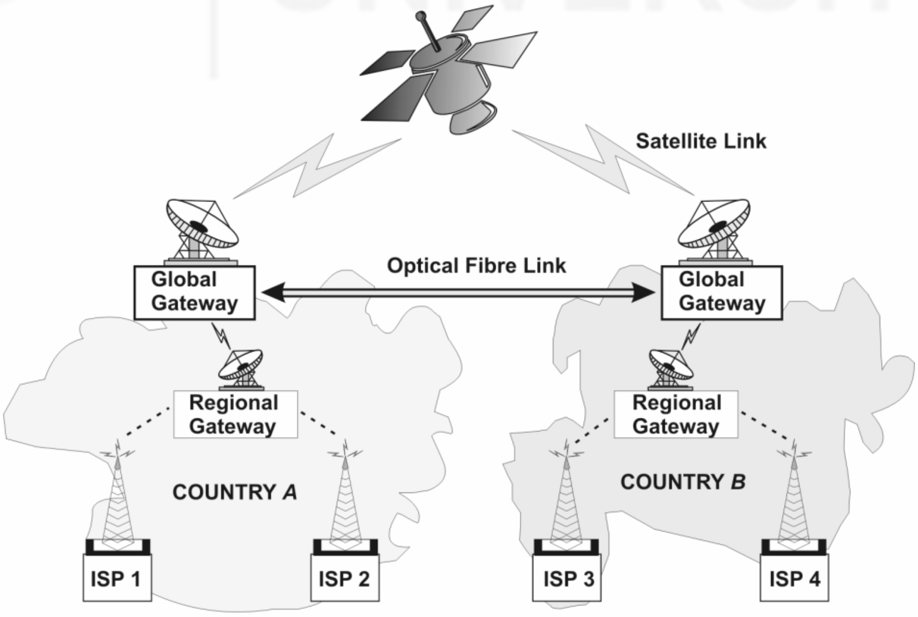

Fig. 15.2: Accessing global Internet

The Web is based on a client/server system. Your computer is the client; the remote computer that stores electronic files is the server. The glue that holds the Web together is called **hypertext** and **hyperlinks**. This feature allows electronic files on the Web to be linked so that you can easily jump between them. On the Web, you navigate through pages of information based on what interests you at that particular moment. This is commonly known as **browsing** or **surfing the Net**. To access the Web you need software, such as Netscape Navigator or Microsoft Internet Explorer, known as web browsers. Web pages are written in a computer language called HTML, which stands for **Hypertext Markup Language**.

15.2.3 Connecting to the Internet

Choosing Your Connection

Before you start looking for an Internet service provider, you should have a good idea of the type of connection you will need. The connection you need depends on how you plan to use the Internet. The common ways to gain web access are dial-up and ISDN connections. Large organisations may have their own dedicated high-bandwidth connections.

Dialling in to the Internet

If your network is very small, you may be able to use a dial-up Internet connection with a modem. This connection is usually adequate to serve up to four or five people. Depending on whether you plan to use this connection twenty-four hours a day or only on demand, it may be a very inexpensive solution.

Most ISPs now provide unlimited dial-up accounts for very less fees. These are not intended to be connected twenty-four hours per day, seven days per week. If you need to connect to the Internet only occasionally, this may work for you. You can configure your computer to dial up when a computer attempts to connect to the Internet, and then hang up after a set amount of idle time passes.

If you need higher speed than a modem can provide, you may need a dial-up ISDN account. As you have learnt in Unit 7 of this course, Integrated Services Digital Network allows for high-speed connections over normal telephone lines. With an ISDN connection, you can connect to the Internet at 128 kbps. Dial-up ISDN accounts are becoming more common for use with ISPs. Earlier, the only way you could connect to an ISP with ISDN was by using an expensive dedicated connection. An ISDN connection can easily handle ten to twenty users.

Broadband Connections using ADSL

Recently in India, MTNL has started offering a broadband Internet access using the Asymmetric Digital Subscriber Line (ADSL). Here a special ADSL router is used instead of conventional modem to connect to the telephone cable. This router rather than converting the digital data into analog form, sends it as a digital signal through the telephone line. Making use of full bandwidth of the telephone line the available frequency band is divided into different frequency slots which are used to send the signals by frequency modulation techniques. Here the telephone voice signal is sent on one of the slots while remaining slots are used to communicate the digital data. Assuming that the user would be downloading more data (information) from the net than what s/he sends to the net, the incoming and outgoing digital data bandwidths are kept unequal (more number of slots for incoming data and less for outgoing data). Hence this scheme is good for the users using to download the information from the net, rather than uploading on the net.

Dedicating the Connection

If your Internet connection needs to be available any time, you need a dedicated connection. Dedicated connections are more expensive than dial-up connections.

Dedicated connections can use either modems or ISDN, depending on what you need and want to spend.

Spend 2 Min.

SAQ 1

What costs would be involved in accessing Internet by dial-up connection?

15.3 STANDARD NETWORK PROTOCOLS

After understanding the hardware configuration of the networks, let us now discuss the standard protocols used in computer networks, which allow the users to use the net without bothering about the hardware configurations of their networks. The two significant reference models are OSI and TCP/IP.

15.3.1 OSI Reference Model

Modern computer networks are designed in a highly structured way. To reduce their design complexity, most networks are organised as a series of layers, each one built upon its predecessor.

The OSI Reference Model is based on a proposal developed by the International Standards Organisation (ISO). The model is called ISO OSI (Open systems Interconnection) Reference Model because it deals with connecting open systems that is, systems that are open for communication with other systems.

Following principles were applied in designing the OSI model:

- A layer should be created where a different level of abstraction is needed.
- Each layer should perform a well defined function.
- The function of each layer should be chosen with an eye toward defining internationally standardised protocols.
- The layer boundaries should be chosen to minimise the information flow across the interfaces.
- The number of layers should be large enough that distinct functions need not be thrown together in the same layer out of necessity, and small enough that the architecture does not become unwieldy.

There are in all seven layers in the OSI model. These are shown in Fig. 15.3.

1. The Physical Layer

The physical layer is concerned with transmitting raw bits over a communication channel. The design should make sure that the transport of data is error free i.e. when one side sends a bit ‘1’; it is received by the other side as a ‘1’ and not as a ‘0’. Typical questions here are how many volts should be used to represent a 1 and how many for a 0; how many microseconds a bit lasts; whether transmission may proceed simultaneously in both directions; how the initial connection is established and how it is closed when both sides are finished with information exchange; and how many pins the network connector has and what each pin is used for. The design issues here deal largely with mechanical, electrical, and procedural interfaces, and the physical transmission medium, which lies below the physical layer. Physical layer design can properly be considered to be within the domain of the electrical engineer.

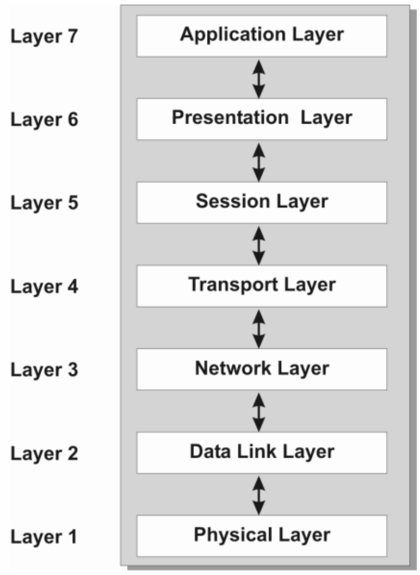

Fig. 15.3: Network architecture based on the OSI model

Example: The X.21 digital interface.

A digital signalling interface called X.21 was recommended by the CCITT in 1976. The recommendation specifies how the customer's computer (Data Terminal Equipment), the DTE, sets up and clears calls by exchanging signals with the carrier's Data Circuit-terminating Equipment, (DCE).

CCITT is now known as ITU.

The names and functions of the eight wires defined by X.21 are given in Fig. 15.4. The physical connector has 15 pins, but not all of them are used. The DTE uses the *T* and *C* lines to transmit data and control information, respectively. The DCE uses the *R* and *I* lines for data and control. The *S* line contains a signal stream emitted by the DCE to provide timing information, so the DTE knows when each bit interval starts and stops. At the carrier's option, a *B* line may also be provided to group the bits into 8-bit frames. If this option is provided, the DTE must begin each character on a frame boundary. If the option is not provided, both DTE and DCE must begin every control sequence with at least two SYN characters, to enable the other one to deduce the implied frame boundaries.

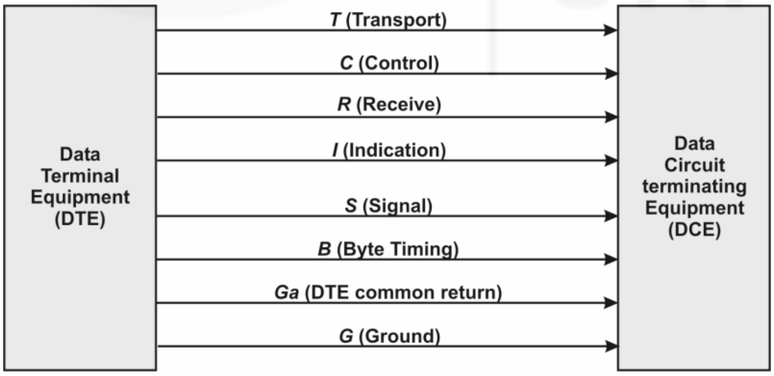

Fig. 15.4: Signal lines used in X.21

2. The Data Link Layer

The main task of the data link layer is to take a raw transmission facility and transform it into a line that appears free of transmission errors in the network layer. It accomplishes this task by having the sender break the input data up into data frames (typically a few hundred bytes), transmit the frames sequentially, and process the acknowledgment frames sent back by the receiver. Since the physical layer merely accepts and transmits a stream of bits without any regard to meaning of structure, it is up to the data link layer to create and recognise frame boundaries. The data link layer should provide error control between adjacent nodes.

Another issue that arises in the data link layer (and most of the higher layers as well) is how to keep a fast transmitter from drowning a slow receiver in data. Some traffic regulation mechanism must be employed in order to let the transmitter know how much buffer space the receiver has at the moment. Frequently, flow regulation and error handling are integrated, for convenience.

If the line can be used to transmit data in both directions, this introduces a new complication that the data link layer software must deal with. The problem is that the acknowledgment frames for *A* to *B* traffic compete for the use of the line with data frames for the *B* to *A* traffic.

Example: HDLC

In this example we will examine a group of closely related data link protocols, one of them is the HDLC (High-level Data Link Control). All of these protocols are bit-oriented, and all use bit-stuffing for data transparency.

Flag is a sequence of bits which indicates the beginning and end of a frame.

All bit-oriented protocols use the frame structure shown in the following Fig. 15.5.

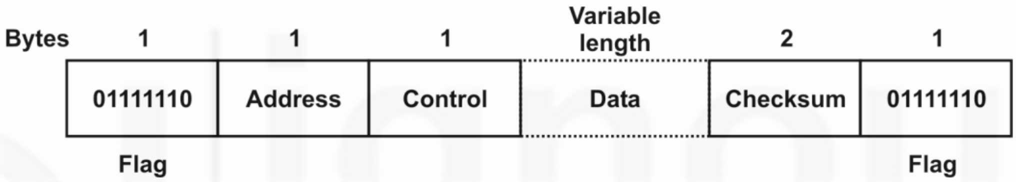

Fig. 15.5: Frame format for bit-oriented protocols

The ADDRESS field is primarily of importance on multi-drop lines, where it is used to identify one of the terminals.

The CONTROL field is used for sequence numbers, acknowledgments, and other purposes.

The DATA field may contain arbitrary information. It may be arbitrarily long, although the efficiency of the checksum falls off with increasing frame length due to the greater probability of multiple burst errors.

The CHECK-SUM field allows detection of any error occurring in data transmission.

The frame is delimited with flag sequence (01111110) on either side. On idle point-to-point lines, flag sequences are transmitted continuously.

3. The Network Layer

Subnet is an identifiably separate group of machines within a network. These machines can be connected to the Internet with a single shared address.

The network layer is concerned with controlling the operation of the subnet. A key design issue is determining how packets are routed from source to destination. Routes could be based on static tables that are *wired into* the network and rarely changed. They could also be determined at the start of each conversation, for example a terminal session. Finally, they could be highly dynamic, being determined anew for each packet, to reflect the current network load.

If too many packets are present in the subnet at the same time, they will get in each other's way, forming bottlenecks. The control of such congestion also belongs to the network layer.

Since the operators of the subnet may well expect remuneration for their efforts, there is often some accounting function built into the network layer. At the very least, the software must count how many packets or characters or bits are sent by each customer, to produce billing information. When a packet crosses a national border, with different rates on each side, the accounting can become complicated.

When a packet has to travel from one network to another to get to its destination, many problems can arise. The addressing used by the second network may be different from the first one. The second one may not accept the packet at all because it is too large. The protocols may differ, and so on. It is up to the network layer to overcome all these problems to allow heterogeneous networks to be interconnected.

Example: X.25 Connection Establishment

X.25 (layer 3) manages connections between a pair of DTEs. Two forms of connection are provided: virtual calls and permanent virtual circuits. Here connection is established, data is transferred, and then the connection is released. In contrast, a permanent virtual circuit is like a leased line. It is always present, and the DTE at either end can just send data whenever it wants to, without any setup. Permanent virtual circuits are normally used in situations with a high volume of data.

Connections (virtual calls) are made as follows. When a DTE wants to communicate with another DTE, it must first set up a connection. To do this, the DTE builds a CALL REQUEST packet and passes it to its DCE. The subnet then delivers the packet to the destination DCE, which then gives it to the destination DTE. If the destination DTE wishes to accept the call, it sends a CALL ACCEPTED packet back. When the originating DTE receives the CALL ACCEPTED packet, the virtual circuit is established.

At this point both DTEs may use the full-duplex connection to exchange data packets. When either side is through with information transfer, it sends a CLEAR REQUEST packet to the other side, which then sends a CLEAR CONFIRMATION packet back as an acknowledgment and the connection is closed.

The three phases of an X.25 connection are shown in Fig. 15.6.

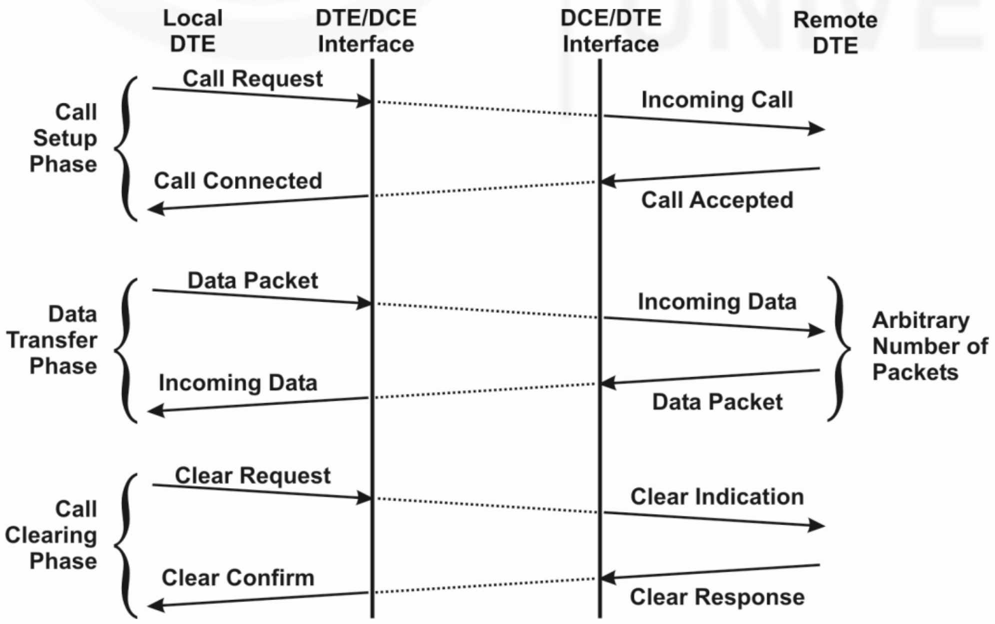

Fig. 15.6: The three phases of an X.25 connection

4. The Transport Layer

The basic function of the transport layer is to accept data from the session layer, split it up into smaller units if need be, pass these to the network layer, and ensure that all the pieces arrive correctly at the other end. Furthermore, all this must be done efficiently and in a way that isolates the session layer from the inevitable changes in the hardware technology.

Under normal conditions, the transport layer creates a distinct network connection for each transport connection required by the session layer. If the transport connection requires a high throughput, however, the transport layer might create multiple network connections, dividing the data among the network connections to improve throughput. On the other hand, if creating or maintaining a network connection is expensive, the transport layer might multiplex several transport connections onto the same network connection to reduce the cost. In all cases, the transport layer is required to make the multiplexing transparent to the session layer.

The transport layer also determines what type of service to provide to the session layer, and ultimately, the users of the network. The most popular type of transport connection is an error-free point-to-point channel that delivers messages in the order in which they were sent.

The transport layer is a true source-to-destination or end-to-end layer. In other words, a programme on the source machine carries on a conversation with a similar programme on the destination machine, using the message headers and control messages.

Many hosts are multi-programmed, which implies that multiple connections will be entering and leaving each host. There needs to be some way to tell which message belongs to which connection. This information is put in the transport header.

In addition to multiplexing several message streams onto one channel, the transport layer must take care of establishing and deleting connections across the network. This requires some kind of naming mechanism, so that the process on one machine has a way of describing with whom it wishes to converse. There must also be a mechanism to regulate the flow of information, so that a fast host cannot overrun a slow one. Flow control between hosts is distinct from flow control between switches, although similar principles apply to both.

5. The Session Layer

The session layer allows users on different machines to establish sessions between them. A session allows ordinary data transport, as does the transport layer, but it also provides some enhanced services useful in some applications. A session might be used to allow a user to log into a remote time-sharing system or to transfer a file between two machines.

One of the services of the session layer is to manage dialogue control. Sessions can allow traffic to go in both directions at the same time, or in only one direction at a time. If traffic can only go one way at a time, the session layer can help keep track of whose turn it is.

A related session service is token management. For some protocols, it is essential that both sides do not attempt the same operation at the same time. To manage these activities, the session layer provides tokens that can be exchanged. Only the side holding the token may perform the critical operation.

Another session service is synchronisation. Consider the problems that might occur when trying to do a two-hour file transfer between two machines on a network with a one hour mean time between crashes. After each transfer was aborted, the whole transfer would have to start all over again, and would probably fail again with the next network crash. To eliminate this problem, the session layer provides a way to insert checkpoints into the data stream, so that after a crash, only the data after the last checkpoint has to be repeated.

6. The Presentation Layer

The presentation layer performs certain functions that are requested often to warrant finding a general solution for them, rather than letting each user solve the problems. In particular, unlike all the lower layers, which are just interested in moving bits reliably from here to there, the presentation layer is concerned with the syntax and semantics of the information transmitted.

A typical example of a presentation service is encoding data in a standard, agreed upon way. Most user programmes do not exchange random binary bit strings. They exchange things such as people's names, dates, amounts of money, and invoices. These items are represented as character strings, integers, floating point numbers, and data structures composed of several simpler items. Different computers have different codes for representing character strings, integers and so on. In order to make it possible for computers with different representation to communicate, the data structures to be exchanged can be defined in an abstract way, along with a standard encoding to be used *on the wire*. The job of managing these abstract data structures and converting from the representation used inside the computer to the network standard representation is handled by the presentation layer.

The presentation layer is also concerned with other aspects of information representation. For example, data compression can be used here to reduce the number of bits that have to be transmitted and cryptography is frequently required for privacy and authentication.

7. The Application Layer

The application layer contains a variety of protocols that are commonly needed. For example, there are hundreds of incompatible terminal types in the world. Consider the plight of a full screen editor that is supposed to work over a network with many different terminal types, each with different screen layouts, escape sequences for inserting and deleting text, moving the cursor, etc.

One way to solve this problem is to define an abstract network virtual terminal for which editors and other programmes can be written. To handle each terminal type, a piece of software must be written to map the functions of the network virtual terminal onto the real terminal. For example, when the editor moves the virtual terminal's cursor to the upper left-hand corner of the screen, this software must issue the proper command sequence to the real terminal to get its cursor there too. All the virtual terminal software is in the application layer.

Another application layer function is file transfer. Different file systems have different file naming conventions, different ways of representing text lines, and so on. Transferring a file between two different systems requires handling these and other incompatibilities. This work, too, belongs to the application layer, as do electronic mail, remote job entry, directory lookup, and various other general-purpose and special-purpose facilities.

SAQ 2

Spend 4 *Min.*

What is the difference between the Physical layer and the Data Link layer?

15.3.2 TCP/IP Reference Model

TCP/IP stands for Transport Control Protocol / Internet Protocol. It is a protocol suite used by most communications software, especially in the U.S. It came out of the work on ARPANet (predecessor to Internet). It is not so much of a model, but a base set of protocols. It comprises of four layers as shown in Fig. 15.7.

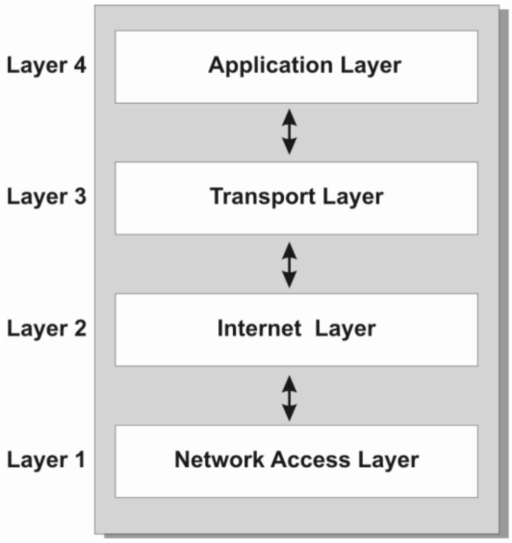

Fig. 15.7: TCP/IP Layers

In comparison with TCP/IP, OSI is not widely accepted. The major reason is that TCP/IP has been a fine working model and most of the companies have invested heavily in TCP/IP. Also there are some other criticisms about the OSI model:

- It would be better if all layers were of roughly equal size and complexity – in practice, the session layer and presentation layer are absent from many existing architectures.
- Some functions – addressing, flow control, retransmission – are duplicated at each layer, resulting in degraded performance.
- The initial specification of the OSI model ignored the connectionless model, thus leaving much of the LANs behind.
- The OSI model has too many layers the data has to travel through, which will impact the performance.

The four layers of TCP/IP are:

1. Network Access Layer

The Network Access Layer (also called the Network Interface Layer) is responsible for placing TCP/IP packets on the network medium and receiving TCP/IP packets off 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 acknowledgment 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 acknowledgment of packets is the responsibility of the Transport Layer.

2. Internet Layer

The Internet Layer is responsible for addressing, packaging, and routing functions. 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.

3. Transport Layer

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. 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.

In *connection-oriented* communication a connection is established before any data can be sent (just like a phone call).

In *connection-less* communication it is not necessary to establish a dedicated connection. The data packets are just sent out on the network paths.

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

4. Application Layer

The Application Layer provides applications the ability to access the services of the other layers and defines the protocols that applications use to exchange data. There are many Application Layer protocols and new protocols are always being developed.

The most widely known Application Layer protocols are those used for the exchange of user information:

The Hyper Text Transfer Protocol (HTTP) is used to transfer files that make up the Web pages of the World Wide Web.

The File Transfer Protocol (FTP) is used for interactive file transfer.

The Simple Mail Transfer Protocol (SMTP) is used for the transfer of mail messages and attachments.

Telnet, a terminal emulation protocol, is used for remote login to network hosts. Additionally, the following Application Layer protocols help facilitates the use and management of TCP/IP networks:

The Domain Name System (DNS) is used to resolve a host name to an IP address.

The Routing Information Protocol (RIP) is a routing protocol that routers use to exchange routing information on an IP internet work.

The Simple Network Management Protocol (SNMP) is used between network management console and network devices (routers, bridges, and intelligent hubs) to collect and exchange network management information.

15.3.3 Comparison between OSI and TCP/IP

Both OSI and TCP/IP reference models are based on the concept of a stack of independent protocols. The functionality of the layers is roughly similar. In both models the layers through and including the transport layer are there to provide an end-to-end network-independent transport service to processes wishing to communicate. The layers above transport are application oriented users of the transport service.

The two models have many differences as are evident from Fig. 15.8. An obvious difference between the two models is the number of layers: the OSI model has seven layers and the TCP/IP has four layers. Both have (inter)network, transport, and application layers, but the other layers are different. OSI uses strict layering resulting in vertical layers whereas TCP/IP uses loose layering resulting in horizontal layers. The OSI model supports both connectionless and connection-oriented communication in the network layer, but only connection oriented communication in the transport layer. The TCP/IP mode has only one mode in network layer (connectionless), but supports both modes in the transport layer. The protocols in the OSI model are better hidden than in the TCP/IP model, and can be replaced relatively easily as the technology changes. With the TCP/IP model, replacing IP by a substantially different protocol would be virtually impossible, thus defeating one of the main purposes of having layered protocols in the first place.

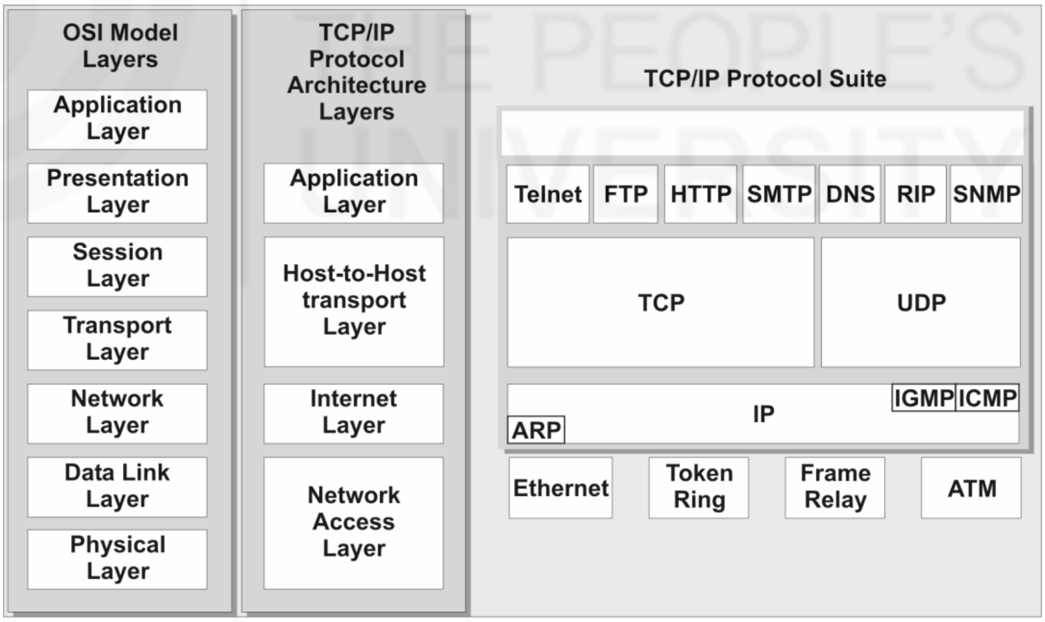

Fig. 15.8: Comparison of OSI and TCP/IP Models

The OSI reference model was devised before the protocols were invented. Consequently, the model was not biased toward one particular set of protocols, which made it quite general. The down side of this ordering is that the designers did not have much experience with the subject, and did not have a good idea of which functionality to put in which layer. With TCP/IP the reverse was true: the protocols came first, and the model was really just a description of the existing protocols; there was no problem of the protocols fitting the model. The only drawback was that the model did not fit any other protocol stacks.

15.3.4 Datagram Switching

Datagram switching describes how data is forwarded across an inter-network. The type of datagram switching that a service or application may use depends on how fast the data needs to be delivered. There are three main methods:

- Circuit switching
- Message switching
- Packet switching

a. Circuit switching

Circuit switching is a type of communication in which a dedicated channel (or circuit) is established for the duration of a transmission. The most ubiquitous circuit switching network is the telephone system, which links together wire segments to create a single unbroken line for each telephone call.

Advantages of Circuit switching are:

- No congestion (because the link is dedicated)
- Almost no channel access delay

Disadvantages of Circuit switching are

- Inefficient use of the media
- Possible long wait to establish a connection

b. Message switching

With message switching, the data is sent from device to device in whole across the network. This is also known as store and forward. Devices must store all the information as it is sent whole. The media is used more efficiently with this method, and congestion can be controlled. Priorities on information can be set hence important data arrives first. This method will not work with real-time applications such as voice or video.

c. Packet switching

The other common communications method is packet switching. It is a combination of circuit switching and message switching. Here messages are broken into packets (small pieces) before they are sent. Each packet is then transmitted individually and can even follow different routes to its destination. Once all the packets forming a message arrive at the destination, they are recompiled into the original message.

Circuit switching systems are ideal for communications that require data to be transmitted in real time. Packet switching networks are more efficient if some amount of delay is acceptable.

Circuit switching networks are sometimes called connection oriented networks. Note, however, that although packet switching is essentially connectionless, a packet switching network can be made connection oriented by using a higher level protocol. The Internet is based on a packet switching protocol, TCP/IP. TCP makes IP networks connection oriented.

Most modern Wide Area Network (WAN) protocols, including TCP/IP, X.25 and Frame Relay are based on packet switching technologies. In contrast, normal telephone service is based on a circuit switching technology, in which a dedicated line is allocated for transmission between two parties. Circuit switching is ideal when data must be transmitted quickly and must arrive in the same order in which it is sent. This is the case with most real time data, such as live audio and video. Packet switching is more efficient and robust for data that can withstand some delays in transmission, such as e-mail messages and Web pages.

A new technology, ATM, attempts to combine the best of both worlds–the guaranteed delivery of circuit switched networks and the robustness and efficiency of packet switching networks. We will not be going into the details of this advanced technology in this course. Now we discuss the method of addressing the web pages.

15.4 ADDRESSING ON WEB

The cyber world is created by networking of a large number of computers situated at every corner of the world. In order to reach any particular computer on this network, it is necessary to know its precise address, just as we know a telephone number of a person in the form of country code, area code and local telephone number. In cyber world, the computers are identified by their unique IP (internet protocol) addresses. The IP address is a string of four numbers, separated by periods. Each number can be from zero to 255. For example 202.54.107.164 can be an IP address.

These numbers are not easy to remember for normal users. Hence these IP addresses are coded in the form of familiar strings of letters called domain names. For example the IP address in above example is remembered much easily as *www.ignou.ac.in*. These names map to unique IP numbers that serve as routing address on the Internet, allowing users to access websites on the Internet.

Domain names act as the first link between the physical world and cyberspace; they are a prerequisite for engaging in electronic commerce. Domain names allow users and search engines to locate business and other websites on the Internet.

15.4.1 Domain Structure

Domain names are constructed as hierarchies. They are divided into **top level domains** (TLDs) and **second level domains** (SLDs). In the domain name *unesco.int*, ".int" is the TLD and "unesco" is the SLD. In the beginning seven domains were identified as the top level domains which were generic in nature, classified by their application. They were called gTLDs (**generic Top-Level Domains**). They were .gov, .edu, .mil, .int, .net, .org, and .com. The Internet Assigned Numbers Authority (IANA) preserves the central coordinating functions of the Internet domain names.

Out of the seven gTLDS,

1. The .gov domain is reserved exclusively for the United States Government.
2. The .edu domain is reserved for post-secondary institutions accredited by an agency on the U.S. Department of Education's list of Nationally Recognised Accrediting Agencies.
3. The .mil domain is reserved exclusively for the United States Military.
4. The .int domain is used only for registering organisations established by international treaties between governments.
5. The .net domain is open to all.
6. The .org domain is intended to serve the non-commercial community, but all are eligible to register within .org
7. The .com domain is meant for commercial organisation.

Recently few new gTLDs have been added to this list, viz. .aero, .biz, .coop, .info .museum, .name, .pro, .cat, .jobs, .mobi and .travel.

The gTLDs fall into two categories: (i) the *unsponsored* gTLDs, which operate under policies established by the global Internet community directly through the Internet Corporation of Assigned Names and Numbers (ICANN) process; and (ii) the *sponsored* gTLDs, each being a specialised TLD that has a sponsoring organisation representing the narrower community that is most affected by the TLD.

There are also national or **country code top-level domains** (ccTLDs). At the ccTLD level, there are at present 243 ccTLDs, each of which bears a two-letter country code derived from Standard 3166 of the International Organisation for Standardisation (ISO 3166). These domains are not uniform in their management or policies; some are open in the sense that any person or entity may register in them, while others are restricted to persons or entities that satisfy entry criteria (e.g., domicile or business presence in the country). The administrative authority for each ccTLD, in principle, has autonomy to determine the policies for domain name registration within its domain. Some examples of domain names registered in ccTLD are: In India *ignou.ac.in*; in Switzerland *Webster.ch*; and in Britain *parliament.uk*.

Registering a domain name is simple, largely automated process that involves visiting a registrar online, checking to ensure that the desired domain name is available, and providing basic information such as your name and contact data and, normally, paying a basic registration fee. Domain names are registered on a first-come, first-served basis.

In India, Department of Information Technology (DIT) under the Ministry of Communications and Information Technology is responsible for administering *.in* ccTLD. Presently this administration is carried out by the National Internet Exchange of India (NIXI) Company under the supervision of DIT.

Before proceeding further, you may like to attempt an SAQ.

SAQ 3

Spend 2 min.

Some domain names belong to TLDs like .tv, .cc, .nu, .bz. What type of TLDs are these?

15.4.2 Format of Web Address

URL is the abbreviation of **Uniform Resource Locator**, the global address of documents and other resources on the World Wide Web.

The first part of the address indicates what protocol to use, and the second part specifies the IP address or the domain name where the resource is located.

For example, the two URLs given below point to two different files at the domain *ignou.ac.in*. The first specifies a data file that should be fetched using the FTP protocol; the second specifies a Web page that should be fetched using the HTTP protocol:

ftp://www. ignou.ac.in /register.dat

http://www. ignou.ac.in /index.html

15.4.3 Search Engines

These special programmes search documents for specified keywords and return a list of the documents where the keywords were found. Although search engine is really a general class of programmes, the term is often used to specifically describe systems like Google, Yahoo, Alta Vista and Excite that enable users to search for documents on the World Wide Web.

Typically, a search engine works by fetching as many documents as possible. Another programme, called an indexer, then reads these documents and creates an index based on the words contained in each document. Each search engine uses a proprietary algorithm to create its indices such that, ideally, only meaningful results are returned for each query.

The first step to adding an Internet connection to your LAN is to add the TCP/IP protocol to your workstations. You also need a software that allows you to access and surf the net. This can be done by using the web browser.

15.5 WEB BROWSERS

A Web browser is the software programme you use to access the **World Wide Web (WWW)**, the graphical portion of the Internet. The first browser, called NCSA Mosaic, was developed at the National Centre for Supercomputing Applications in the early '90s. The easy-to-use click of the mouse interface helped popularise the Web, although few then could imagine the explosive growth that would soon occur.

Although many different browsers are available, Microsoft Internet Explorer and Netscape Navigator (refer to Fig.15.9) are the two most popular ones. Version 4.0 and later releases of either browser are good choices. (Both are based on NCSA Mosaic.) You can download Explorer and Navigator for free from each company's website.

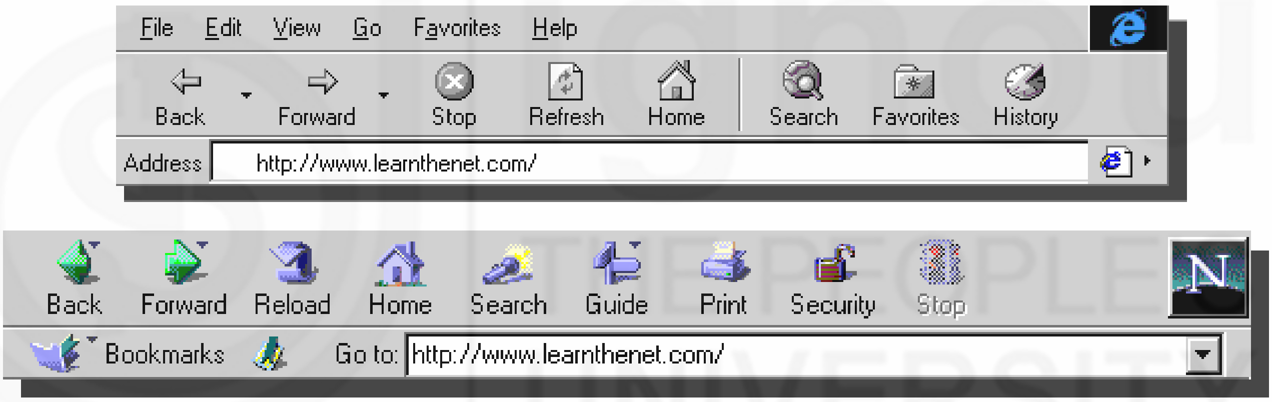

Fig. 15.9: Menus available on typical web browsers

When you first launch your web browser, usually by double-clicking on the icon on your desktop, a predefined web page, that is your home page, will appear.

15.5.1 The Toolbar

The row of buttons at the top of your web browser, known as the toolbar, helps you travel through the web of possibilities, even keeping track of the web pages you visited earlier. The toolbars for all web browsers usually have some common utility buttons to help you navigate the Web. These are:

The **Back** button returns you the previous page you have visited.

Use the **Forward** button to return to the page you just came from.

Home takes you to whichever home page you have chosen. (If you have not selected one, it will return you to the default home page, set by the web browser producing company).

Reload or Refresh loads the web page again. Why would you want to do this? Sometimes all of the elements of a web page are not loaded the first time, because the file transfer was interrupted. Also when you download a web page, the data is cached (pronounced cashed), meaning it is stored temporarily on your computer. The next time you want that page, instead of requesting the file from the web server, if you press <back> button on your web browser, it just accesses that page from the cache. But if a web page is updated frequently, as may be the case with news, sports scores or financial data, you would not get the most current information. By reloading the page, this updated data is loaded on your browser.

Print lets you make a hard copy of the current document loaded in your browser.

The **Stop** button stops the browser from loading the current page.

Search connects to pages that list a number of Internet directories and search tools.

Bookmarks or Favourites is where you can record the addresses of website you want to revisit. Once you add a URL to your list, you can return to that web page simply by clicking on the link in your list, instead of retyping the entire address.

15.5.2 Other Important Functions

Location Bar: Just under the toolbar, you will see a box labelled "Location," "Go To," or "Address." This is where you type in the address of a website you want to visit. An example of accessing IGNOU website is shown in Fig. 15.10.

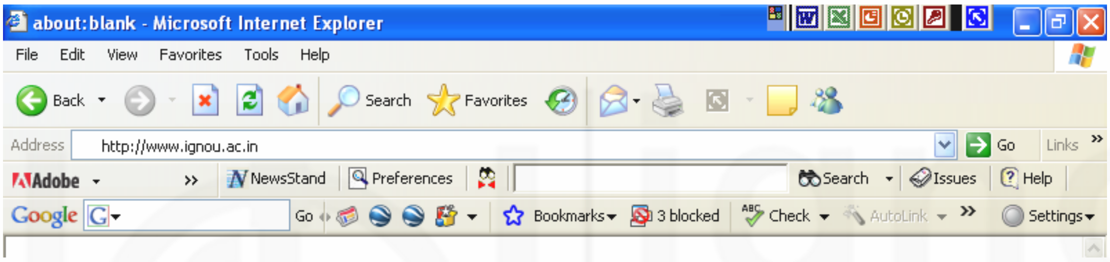

Fig. 15.10: Accessing a website via a location bar

After entering the address, press the Return or Enter key to access the site. Fig. 15.11 shows the accessed website.

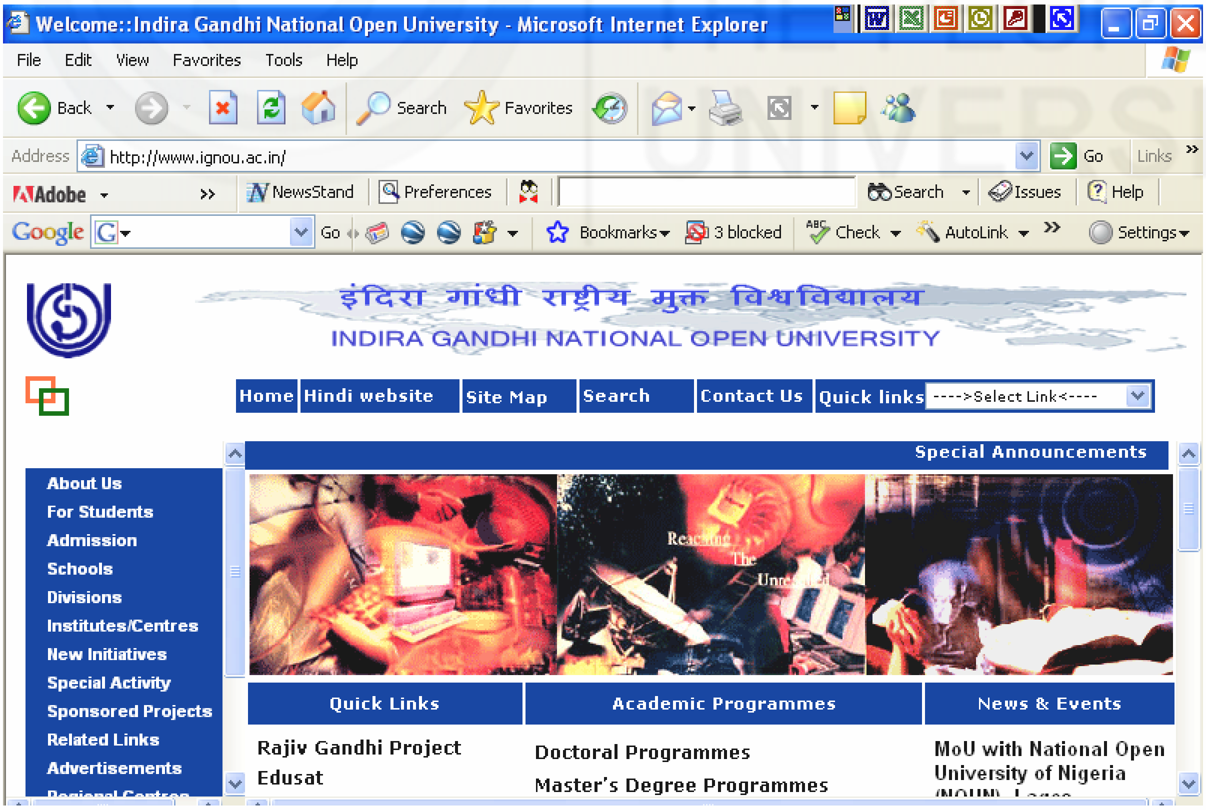

Fig. 15.11: View of a website accessed via a location bar

More information about a particular item in the web page can be obtained by clicking the mouse on the lists provided with hyperlinks.

By clicking the small triangle to the right of the Location box, you will get a drop down list of the most recent websites you have visited. To revisit a site, just click on the address.

The Menu Bar: Located along the top of the browser window, the menu bar offers a selection of things you can do with a web page, such as saving it to your hard drive or increasing the size of the text on a page. Many of the choices are the same as the buttons on the toolbar.

The Access Indicator: The web browsers have a small picture in the upper right hand corner of the browser. When this image is animated, it means that your browser software, (known as a *client*), is accessing data from a remote *server* computer. The server can be located across the town or on another continent. Your browser downloads these remote files to your computer, then displays them on the monitor screen. The speed of this process depends on a number of factors: your modem speed, your Internet service provider's modem speed, the size of the files you are downloading, how busy the server is and the traffic on the Internet.

The Status Bar: At the bottom of the web browser you will find a window known as a status bar. You can watch the progress of web page transactions, such as the address of the site you are contacting, whether the host computer has been contacted and the size of the files being downloaded.

15.5.3 Some Browsing Tricks

As with most softwares, there is more than one way to accomplish a task of getting web pages. Here are a few other features to help navigate efficiently.

- When you move from one page to another page and website to website, your browser remembers where you've been. Click the History button on the toolbar. There you will find a history of all the web pages you have visited during a specified period of time. To revisit a page, just click on the address.
- While text downloads quickly, images can really slow things down. There are two ways to speed things up: Since text appears first, after it loads, click the STOP button. The images would not appear, but should you want to look at an image, use the right mouse button to click on the image icon, and then select View Image. You can view websites in text-only mode by turning off the auto-loading of images function under the Options menu.

Spend
1 *Min.*

SAQ 4

What types of files are accessible by a Web browser?

After learning about the access to Internet, let us now discuss the intranet, which is a network used within an organisations.

15.6 INTRANET

Intranet is a network based on TCP/IP protocols belonging to an organisation, usually a corporation, accessible only by the organisation's members, employees, or others with authorisation. Intranet's Web sites look and act just like any other Web sites, but the firewall surrounding an intranet fends off unauthorised access.

Like the Internet itself, Intranets are used to share information. Secure intranets are now the fastest-growing segment of the Internet because they are much less expensive to build and manage than private networks based on proprietary protocols.

The main difference between the Internet and Intranet is the location of the information and who has access to it.

Internet is public, global and wide open to anyone who has an Internet connection. Intranets are restricted to people who are connected to the private organisation network. Other than that, they work essentially the same way.

15.6.1 Advantages and Disadvantages of Intranet

There are lots of benefits of Intranet, including:

- **Universal Communication -** Any individual and/or department on the Intranet can interact with any other individual/department and beyond to partners and markets;
- **Performance -** on inherently a high-bandwidth network, the ability to handle audio clips and visual images increases the level and effectiveness of communication;
- **Reliability -** Internet technology is proven, highly robust and reliable.
- **Cost -** compared with proprietary networking environments, Internet technology costs are surprisingly low.
- **Standards -** the adoption of standard protocols such as TCP/IP, FTP and HTML deliver a fast-track series of tools which allows infrastructures to be built, restructured and enhanced to meet changing business needs as well as allowing standards-based intercommunication between external partners, agencies and potential customers.

Of course, any approach to information systems has limitations. In the case of Intranets, the constraints include:

- **Performance limitations -** some applications that have been well optimised for conventional and proprietary systems create a heavy system workload while migrating them to an Internet platform or merging them with Intranet presentation; this problem will reduce with enhanced Internet technologies and continuing improvements in hardware price-performance.
- **Presentational issues -** some people whose experience is rooted in paper presentation want web pages (for example) to look like printed equivalents, and burden the systems and their users with unnecessary and sometimes tedious "graphics", which often get in the way of the information rather than making it more accessible and attractive.

15.6.2 Technology Components of Intranet

Main Technology Components of the Intranet are:

- **Communications Protocol -** with ability to connect and communicate between networks and individual desktop devices;
- **File Transfer -** between point-to-point locations;
- **Mail -** to provide direct point-to-point communications between individuals or groups;
- **Web Browsing -** to provide access to information on a one to many basis, on demand;
- **Terminal Emulation** – with ability to access existing infrastructure applications;
- **User Interfaces -** to deliver the increasing technical complexity to the desktop in a transparent, seamless and intuitive manner.

During the evolution of the Internet, a series of applications have been created to meet the specific needs of each component area. Within each of these areas the survival of the fittest has brought several specific best-of-breed applications and standards. For example, the FTP protocol standard for file transfer, the Netscape technology for web browsing, the MIMI standard for transparent distribution of all file formats, and HTML syntax as the language of the Web.

After learning about the wide access tools like Internet and limited access tool of Intranet, which essentially uses the basic modules well-proven for Internet already, let us now discuss the most common application of the Internet viz. e-mail.

15.7 E-MAIL

In its simplest form, e-mail is an electronic message sent from one computer to another. You can send or receive personal and business-related messages with attachments, such as pictures or formatted documents. You can even send computer programmes or executable files as attachments.

15.7.1 How does E-Mail Work?

It can take days to send a letter across the country and weeks to go around the world. To save time and money, more and more people are using electronic mail. It is fast, easy and much cheaper than the postal mail.

Let us say you have a small business with sales representatives working around the country. How do you keep in touch without running up a huge phone bill? Or what about keeping in touch with far-flung family members? E-mail is the way to go. It is no wonder e-mail has become the most popular service on the Internet.

Just as a letter makes stops at different postal stations along its way, e-mail passes from one computer, known as a **mail server** to another as it travels over the Internet. Once it arrives at the destination mail server, it is stored in an electronic mailbox until the recipient retrieves it. This whole process can take seconds, allowing you to quickly communicate with people around the world at any time of the day or night.

To receive e-mail, you must have an account on a mail server. This is similar to having an address where you receive letters. One advantage over regular mail is that you can retrieve your e-mail from a remote location. Once you contact your mail server, you can download your messages.

To send e-mail, you need a connection to the Internet and access to a mail server, which can forward your mail. The standard protocol used for sending e-mail on the Internet is called SMTP, for Simple Mail Transfer Protocol. It works in conjunction with POP servers. POP stands for Post Office Protocol.

When you send an e-mail message, your computer sends it to an SMTP server. The server looks at the e-mail address (like the address on an envelope), and then forwards it to the recipient's mail server. When the message is received at the destination mail server, it is stored until the addressee retrieves it. You can send e-mail to anyone who has an e-mail address, anywhere in the world. Remember, almost all Internet service providers (ISPs) and all major online services offer an e-mail address with every account.

Spend 4 Min.

SAQ 5

What makes the e-mail the most popular utility on the Internet?

15.7.2 Sending an E-Mail Message

Step -1

Open your e-mail programme and launch a new message window by clicking on the appropriate icon.

Step-2

In the <To> box, type in the name of the recipient. It should take this form: recipient@domain.tld. Make sure you enter the address correctly or the message will return to you.

You can send a message to more than one person by entering multiple addresses. Just put a semi-colon (;) between each address. You can also send a message as a carbon copy (cc) or blind carbon copy (bcc) to the receivers.

Your return address is automatically sent to the recipient.

Step-3

Type in the subject of the e-mail.

Step-4

Write your message in the message window. You can also copy text from a word processing programme and paste it into the window.

Step-5

You can attach any files that you wish to send with your mail.

Step-6

Click on the <Send> icon to send message; as shown in Fig. 15.12.

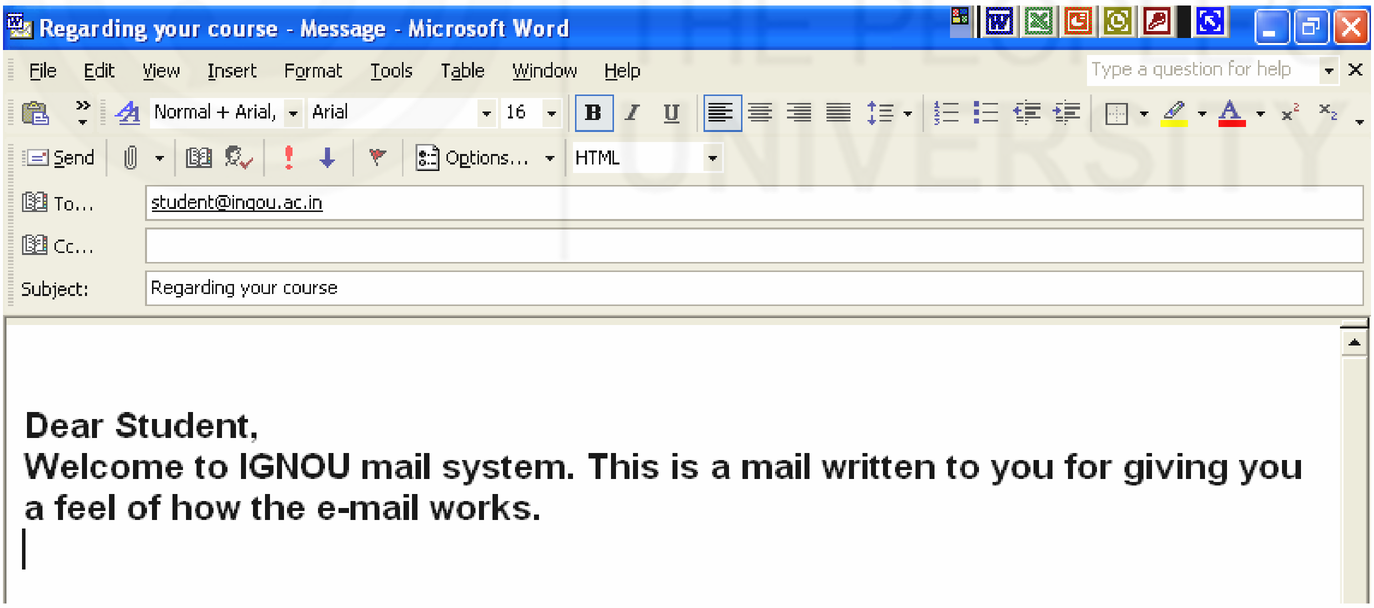

Fig. 15.12: Typical mail template

15.7.3 Understanding E-Mail Addresses

Internet e-mail addresses typically have two main parts:

bscph@ignou.ac.in

First there is the user name (coordinator of B.Sc. Physics) which refers to the recipient's mailbox. Then there is an axon sign (@). Next comes the host name (ignou), also called the domain name. This refers to the mail server, where the recipient has an electronic mailbox. It is usually the name of a company or organisation. Finally, there is a dot (.) followed by second and top level domains.

Let us now summarise the points you learnt in this unit.

15.8 SUMMARY

- The Internet evolved through the ARPANet.
- Internet can support various application protocols useful in information exchange like: web pages (HTTP), e-mail (SMTP), file transfer (FTP), remote access (Telnet).
- The networks use protocol which are designed in layered fashion. OSI and TCP/IP are the most widely used protocol reference models.
- OSI consists of 7 layers while TCP/IP has 4 layers. The network users are usually operating in the application layers, without being aware of the underneath layers facilitating the information transfer on net.
- The main switching technologies used in data transfer on net are: circuit switching, message switching and packet switching. Internet uses TCP/IP protocol with packet switching.
- To access Internet from a personal computer, it is necessary to have a modem and telephone line through which it is possible to establish a connection with an Internet Service Provide (ISP). It is also possible to access Internet through advanced mobile cellular phones.
- Large organisations prefer a dedicated high bandwidth lease line for Internet access.
- Computers attached to the Internet are assigned an IP address. These addresses are in the form of digits.
- IP addresses are also expressed as domain names, which are easier to remember than IP addresses.
- The domains are classified as top level domains (TLDs) and second level domain (SLDs).
- There are in all 14 gTLDs and 243 ccTLDs.
- Web browser software allows you to surf the net.
- Search engines help us in finding required information from the World Wide Web. They work on the principle of searching key words.
- For accessing e-mail on Internet, it is necessary to have an e-mail account on one of the e-mail servers.

15.9 TERMINAL QUESTIONS *Spend* 20 *Minutes*

1. What is hyperlink?

2. Compare the merits and demerits of circuit switching and packet switching.

3. On a web browser, what is the difference between *reload (refresh*) and *back* tools?

4. How can the performance of a search engine be judged?

15.10 SOLUTIONS AND ANSWERS

Self Assessment Questions

1. The costs will include subscription fees of the ISP and telephone bill depending on the duration for which the Internet is accessed from the dial-up connection.

2. The physical layer is concerned with hardware implementation of a network system which may include the voltage levels, clock intervals, pin configurations on connectors etc.

   The data link layer operates above the physical layer. It decides the format of data transfer frame, addresses destination terminal, detects errors in transmission. It also controls the data flow in order to avoid overflowing of data due to difference between the data transfer rates of transmitter and receivers.

3. These are all country code top level domains (ccTLDs).

   .tv: Tuvalu; .cc: Cocos Islands; .nu: Niue; and .bz: Belize.

4. Web browsers access the html (Hypertext Markup Language) files.

5. • The e-mail can be sent by using simple text editor and does not need any expertise like html proficiency. Hence any lay person can use it.
   - Fast transfer of e-mail messages is the most attractive part of e-mail.
   - Wide availability of mail service providers on Internet makes it easily accessible to anybody.
   - Cost of data transfer is much less than any post or courier service. (This is more prominent for long distance mails).

Terminal Questions

1. Hyperlink is a link to an address on Internet directing to the web page providing the relevant information related to the hyperlinked keyword.

2. Refer Sec. 15.3.4

3. Refer Sec. 15.5.1

4. A search engine is judged to be good if it returns maximum number of relevant documents in shortest possible time.

   The engines usually have a directory of web documents based on keywords. Whenever any keyword is typed, first this database is looked in and relevant document links are returned. Hence larger the database of a search engine, the better is its performance.

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