Module (Tutorials))

Tutorials and Detailed Discussions on Special Topics

e-Business Applications, Architectures, Integration

MODULE (APPLICATIONS): e-Business Strategies and Applications:
Chapter 1: e-Business - From Strategies to Applications
Chapter 2: e-Business Applications (CRMs, ERPs, eMarkets, SCM, ASPs, Portals)
Chapter 3: From Strategies to Solutions -- A Planning Methodology
Chapter 4: IT Infrastructure -- Overview of Enabling Technologies
Chapter 5: Applications State of the Practice, Market, and Art

MODULE (ARCHITECTURES): Solution Architectures Through Components
Chapter 1: Solution Architecture Overview
Chapter 2: Enterprise Application Architectures -- Component-based Approach
Chapter 3 Enterprise Data Architectures in Web-XML Environments
Chapter 4: Implementing Architectures -- Concepts and Examples
Chapter 5: Architectures State of the Practice, Market, and Art

MODULE (INTEGRATION):Enterprise Application Integration and Migration
Chapter 1: Integration with Existing (Including Legacy) Applications -- An Overview
Chapter 2: Enterprise and Inter-Enterprise Application Integration (EAI/eAI)
Chapter 3: Data Warehouses and Data Mining for Integration
Chapter 4: Migration Strategies and Technologies
Chapter 5: Integration State of the Practice, Market, and Art

The Enabling IT Infrastructure

MODULE (PLATFORMS): Platforms for Mobile and EC/EB Applications
Chapter 1: Mobile Computing Platforms -- Mobile Application Servers
Chapter 2: e-Commerce Platforms for C2B Trade-- The Commerce Servers
Chapter 3: B2B Platforms and Standards -- The B2B Servers
Chapter 4: Platforms for Multimedia and Collaboration
Chapter 5: Platforms State of the Practice, Market, and Art

MODULE (MIDDLEWARE) : Application Connectivity Through Middleware
Chapter 1: Middleware Principles and Basic Middleware Services
Chapter 2: Web, XML, Semantic Web, and Web Services
Chapter 3: Distributed Objects: CORBA, J2EE, .NET, SOAP, and EJBs
Chapter 4: Enterprise Data and Transaction Management
Chapter 5: Middleware State of the Practice, Market, and Art

MODULE (NETWORKS): Network Services and Network Architectures
Chapter 1: Principles of Communication Networks
Chapter 2: Network Architectures and Interconnectivity
Chapter 3: Wireless and Broadband Networks -- Next Generation Networks:
Chapter 4: IP-based Networks and the Next Generation Internet
Chapter 5: Networks State of the Practice, Market, and Art

Background and Management

MODULE (OVERVIEW); The Big Picture
Chapter 1: e-Business and 3G Distributed Systems
--From Strategies to Working Solutions

MODULE (EXAMPLES); Case Studies & Examples
Chapter 2: Case Studies and Examples

MODULE (MANAGEMENT): Management and Security
Chapter 1 e-Business Management in Practice
Chapter 2: Management Platforms for Network and Systems Management
Chapter 3: Security Management - Approaches and Technologies
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MODULE (TUTORIALS): Tutorials and Detailed Discussions on Special Topics

Chapter 1: Network Technologies -- A Tutorial
Chapter 2: Object-Orientation, Java, and UML -- A Tutorial
Chapter 3: Database Technologies and SQL -- A Tutorial
Chapter 4: Web Engineering and XML Processing
-- A Closer Look
Chapter 5: CORBA -- A Closer Look

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MODULE (Tutorials)

Tutorials and Detailed Discussions on Special Topics

This Module presents tutorials on special topics that cover networks, databases, Web, and object-orientation. The main goal of these tutorials is to provide background information and overviews of technologies to support the topics discussed in other modules of the handbook. For example, the network tutorial (Chapter 1) can be used for an overview of networks before reading the Networks Module. In addition, some tutorials discuss technical details that do not quite fit in the chapters of the modules. For example, the CORBA and Web/XML tutorials (Chapter 4 and 5) are intended for people who need more technical details on the topics. These tutorials can also be used to augment discussions on related topics. For example, the database tutorial can be used to support data architectures and the object-orientation tutorial can be used to support discussions on distributed objects.

1 - Network Technologies – A Short Tutorial

Note: : This is a very short tutorial intended to introduce the main network concepts and terms. For a detailed discussion, see the Networks Module.

1.1 Introduction

A ***communication network*** is a collection of equipment and physical media, viewed as one autonomous whole, that interconnects two or more stations. At the lowest level, a communication network consists of three components (see Figure 1-1):

- **Stations (data sources/sinks).** These entities generate and receive the data handled by the communication network. Examples of the data are voice, computer bits, and TV patterns. A station is effectively an end-point (source/sink) in a communication network. Examples of stations are terminals (text and/or graphics), telephones, sensors (temperature, security), TVs, facsimiles, diskless workstations, personal computers, workstations, minicomputers, or mainframes.
- **Data/signal converters**. These devices convert the data to signals for transmission on one end and back to data at the other. Data is propagated from one point to another by means of signals which are electromagnetic representation of data. An example of a converter is a modem which converts data bits to continuous signals which are transmitted across a network. Converters basically translate different formats of data and signals (modems are digital to analog converters and codecs are analog to digital converters). In some networks, called baseband networks, the conversions are bypassed by "pressing" the data directly against the communication wire. In these cases, data and signals are the same.
- **Transmitting facilities**. These facilities deliver (transport) the signals across a network. This transport involves finding a path for the signals, sending the signals over the path, and dealing with signal attenuation and distortion over long transmission paths.The transmission facilities themselves consist of:
- **Links (communication links)** refer to the physical media that is used to interconnect stations in a communication network. Examples of links are telephone lines, coaxial cables, and fiber cables.
- **Intermediate systems**, also sometime referred to as nodes, serve as intermediaries in a communication network. Example of a node is a router which is used to direct traffic from one point to another .

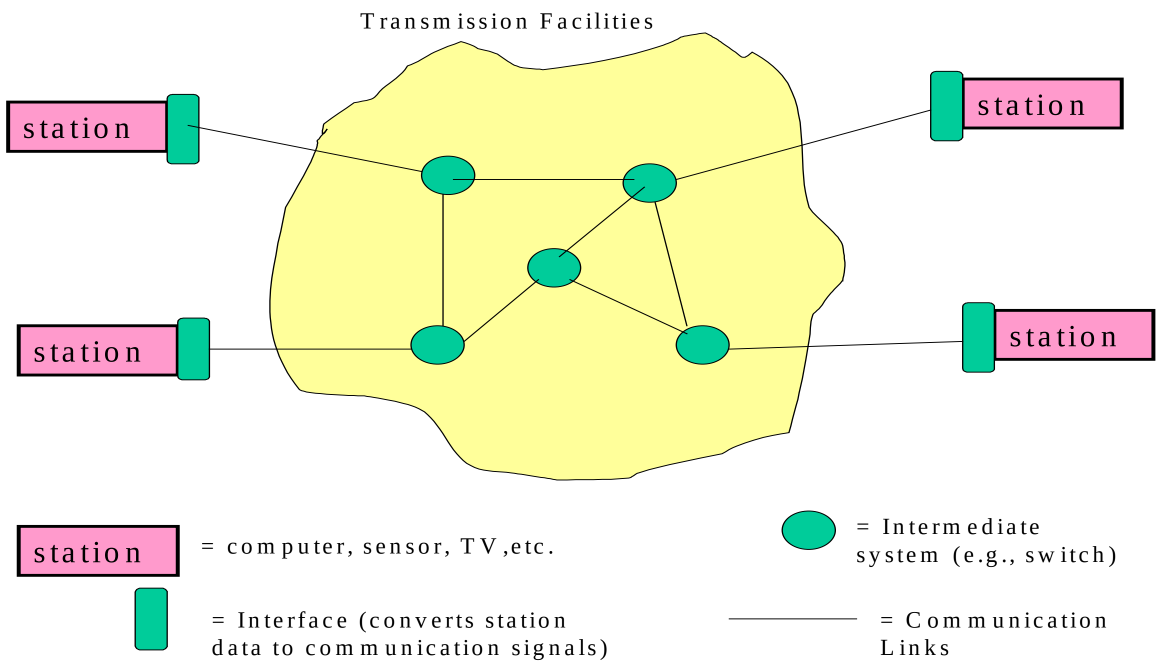


Figure 1-1: Conceptual View of Networks

A communication network may use analog (continuous) or digital (discrete) data for its inputs and outputs. In digital communication systems, all data is digital (it either comes from digital data sources or is converted to digital format). These systems are increasingly being used in most of the current and future distributed applications.

The transmission facilities consist of a wide range of hardware components and software modules. Design of transmission facilities raises questions such as what communication medium to use, how to interconnect the various components (network topology), what methods to use for communication between various components, and what techniques to use for data compression and encryption. .

Network facilities are generally classified into three categories based on the geographical area covered

- **Local area networks (LANs)** which do not use common carrier facilities over short distances with speeds up to 100 Mbps. LANs are commonly used to interconnect computers within the same building and organization. See section 1.2 for details.
- **Wide area networks (WANs)** which use common carrier facilities over long distances commonly with speeds in the range of 1.5 Mbps. WANs are used to interconnect remotely located sites and equipment. See section 1.2.2 for details.
- **Metropolitan area networks (MANs)** are essentially large LANs which cover an entire metropolitan area (a city, a suburb, etc.). The evolving metropolitan area networks can be used to interconnect LANs within a metropolitan area. See section 1.2.3 for details.

Communication networks needed for the physical transmission and recognition of data between interconnected devices are moving toward digital communication systems. These systems receive digital data which is regenerated over long distances by eliminating noise. A hierarchy of digital services, known as the T carriers are widely in use. Digital communications are increasingly being used for transmission of data, voice and video in communication systems. ISDN (integrated system digital network) is an example.

1.2 Local Area Networks, Wide Area Networks, and Metropolitan Area Networks

1.2.1 Local Area Networks

Simply stated, a local area network (LAN) is a network of data communication devices within a small area (typically 100 to 1000 meters). The main characteristics of local area networks, also called local networks, are:

- **Private ownership**. The LAN equipment, including the communication media, are privately owned. A legal restriction in the US does not allow individuals to string cables over public property (underground cables are allowed). All above ground communication facilities are provided by the common carriers (AT&T, MCI, Sprint, Regional Telephone Companies, cable TV companies, etc). Thus if you want to communicate between two houses located across a road, you must purchase the common carrier facilities, i.e., you do not privately own the communication medium. This leads to an interesting way to look at a LAN: a LAN is independent of the common carriers. If you happen to own a city, then your LAN may cover the entire city. For the rest of us, our LANs may not go beyond a room.
- **High data rates**. The data rates of LANs are much higher than the common wide area networks. For example, most wide area networks use data rates ranging from 56000 bps (bits per second) to 1.54 Mbps (million bits per second), while most local area networks use data rates between 10 Mbps to 100 Mbps.
- **Low error rates**. The error rates in LANs are much lower than the typical wide area networks. This is mainly because of the short distance and the use of simple communication devices in LANs.

- **Broadcast services**. LANs typically broadcast the messages to receivers in contrast to WANs which usually select a receiver before sending a message. Broadcasts, if misused and disregarded, can cause many administrative problems.

Figure 1-2 shows a typical LAN in which many computing devices are connected together through communication media such as twisted pair cables, coaxial cables, or fiber optic cables. At the basic level, a LAN consists of a *LAN segment* (a physical cable) that is connected to various *hosts* such as personal computers, laptops, terminals, printers, TV sets, and/or sensors. A LAN segment may use a bus, ring or tree topology. Larger LANs are formed by interconnecting several LAN segments. A LAN "server" is a computer on the LAN which provides a set of services for sharing common resources. A server may be a personal computer, a workstation, a specialized computer, or a minicomputer. From an end-user point of view, a LAN server allows a user to access remote resources l(e.g., printers, disk drives, files, and databases located on the LAN. Common examples of services provided by the LAN servers are as follows:

- **Printer sharing services**. The computers and terminals on a LAN need to share high quality (e.g., color) printers. A LAN provides access to a common printer (say, LPT2) in addition to a local printer such as LPT1 (see Figure 1-2).
- **Disk sharing services**. Many LANs are configured so that one computer (LAN server) has a large disk on which many packages are installed. Many small computers with limited disk storage access the server to retrieve the needed software. The LAN server provides another drive (say drive n) which can be accessed by any computer on the LAN (see Figure 1-2).
- **File/database sharing services**. One file/database may be shared by several LAN users. The file/database server coordinates the data access for integrity control. For example, the server may lock the data resource at the file level (if one user is updating the file, then no one can access the file) or at a record level (deny access to the record being updated).

Keep in mind that a “server” is not a hardware device – in fact, server is a function that may be imbedded in a software module or in an ASIC (application specific integrated circuit) chip. In most cases, print server, disk server, and file server are sofware modules that are installed on more powerful computers, thus giving rise to the notion of “server” computers. Typically, a single computer on a LAN houses the print, disk, and file/database servers (e.g., the Novell Netware Server). It is also possible to assign the servers to many computers on a LAN.

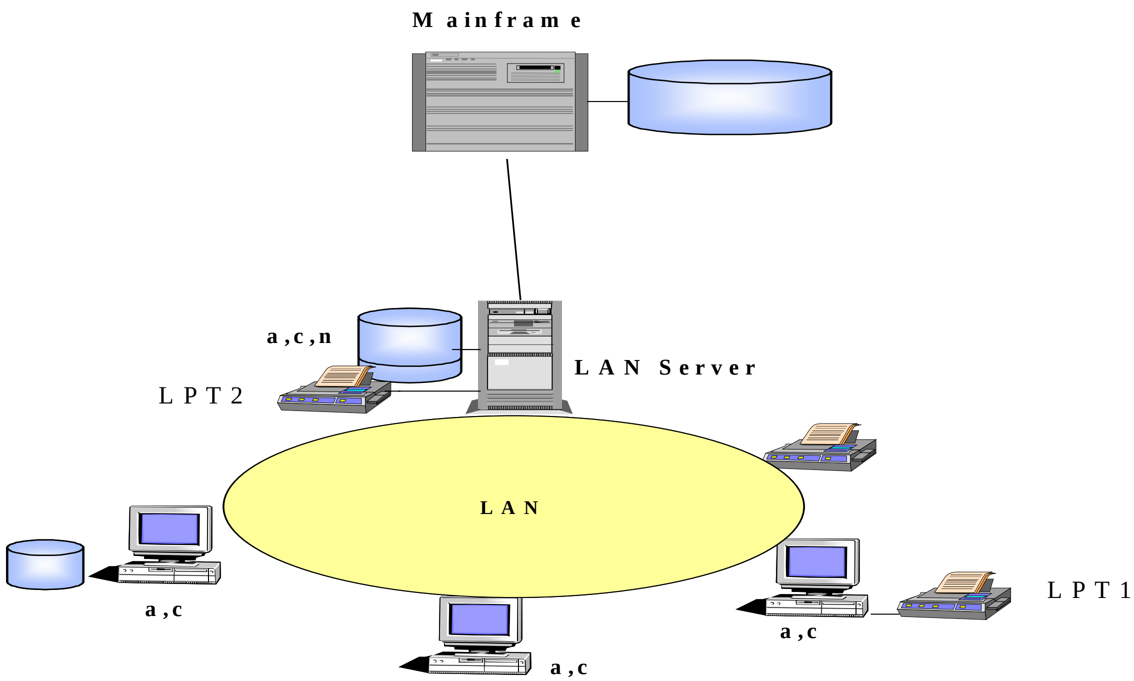


Figure 1-2: A Typical Local Area Network

LANs were introduced in the marketplace in the early 1980s. In the early stages, there was no agreement on LAN technologies and many LAN vendors were pushing proprietary solutions. For example, in the early 1980s, more than 50 vendors were marketing LANs on different devices, using different communication media, protocols, and topologies. The IEEE (Institute of Electrical and Electronics Engineers) 802 Committee on LANs was formed in 1980 to develop standards for LANs[1]. Thanks to the work of this committee and market pressures for interoperability and minimization of interfaces, the LAN landscape has simplified considerably with only a few surviving vendors and technologies. We will primarily present a review of the current and future technologies and will not dwell on history, unless of value.

Two techniques for message transmission and recognition are of significance at present (e.g., token passing and CSMA/CD). These techniques, accepted by the IEEE 802 Committee, are called data link control techniques. When a LAN package is purchased, it may need a) cables to interconnect computers; b) adapter cards which connect the cables to the devices; c) LAN server software which is used for sharing the resources (printers, disks, files); and d) station software which is installed at each computer attached to the LAN.

[1] 802 indicates February of 1980, the date when IEEE 802 Committee was formed.

1.2.2 Wide Area Networks

Wide area networks (WANs) are the oldest form of communication networks. WANs use the telecommunication facilities of common carriers (telephone companies) to exchange data between end-devices (computers, telephones, sensors, TVs). We briefly review the telecommunication networks (networks owned by the telephone companies) before describing the WAN components, switching systems, and WAN design issues.

Since the first telephone patent by Alexander Graham Bell in 1876, more than 600 million telephones had been installed throughout the world by the mid 1980s [Datapro 1987]. Since then, this number has jumped dramatically, more than doubled, thanks to the increase in cellular phones. This growth in the telecommunications industry, expected to continue at 6% annually, has led to large telecommunications networks with a variety of terminating equipments (e.g., telephones, computer devices), transmission facilities (communication lines), and switches. The telecommunication networks are designed to minimize the cost of end-to-end connections. For example, to fully connect 100 phones directly with each other, we would need about 5000 lines. Naturally, the number of direct lines between 1 billion telephones would be more than a normal human being would like to imagine.

Figure 1-3 shows a typical telecommunications network design. Most of this network is owned by the common carriers (telephone companies). On the customer premise (an office, a house), the user interacts with telephone equipment and computing devices which are connected to the local central office through a subscriber loop. A customer premise may also include other equipment such as local area networks and a private branch exchange (PBX). A PBX, also called a computerized branch exchange (CBX), routes the customer premise calls internally without going to the subscriber loop. The PBX provide the telephone extensions in office buildings (if you call an extension within your office, the PBX in your building routes the call to another phone in the building). A PBX/CBX may be used for all voice and data communications within an office.

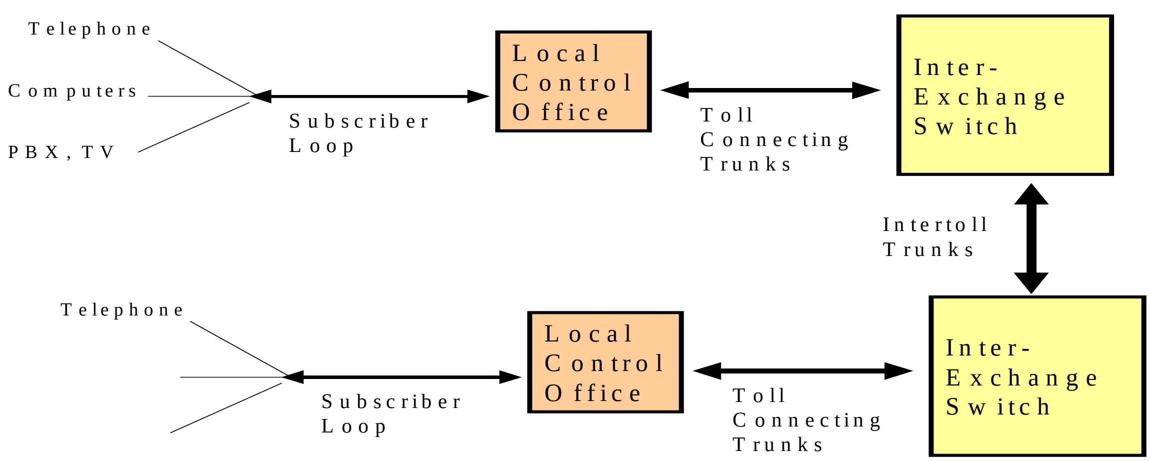


Figure 1-3: A Telecommunications Network

The subscriber loop, also known as the local loop, consists of the wires, poles, conduits and other equipment that connects the customer premise equipment to the telephone company's central office.

Before deregulation, the telephone companies had a monopoly on the local loop. At present, customers can use cable TV or wireless systems to bypass the local loop.

The local central office, often called an end-office, is the point where a local loop terminates. In a metropolitan area, many local central offices are located based on the population densities. A switch at the end-office routes the call to another end-office either by directly connecting to the end-office (if within the same area code) or through the interexchange switch. The telephone companies divide their service areas into exchanges where an exchange roughly refers to a city or part of a city. The inter-exchange switches route calls between exchanges over trunks. These trunks are called toll trunks because they connect outside the free calling areas. The toll trunks are fast transmission facilities, at present almost all digital.

WANs, as shown in Figure 1-4, are quite complex. The computing devices such as terminals (dumb, smart, and/or programmable), printers, sensors, appliances (e.g., TVs, telephones), laptop/desktop computers, minicomputers, and mainframes are the end-points in a WAN and are interconnected through telecommunication lines and an array of intermediate devices such as switches and routers. These lines may be switched (dial up) or leased (permanently connected) between the end points. Packet switching systems that breakup your messages into small packets and then route them over the WAN are much more popular for the reasons we will see in the next chapter. .

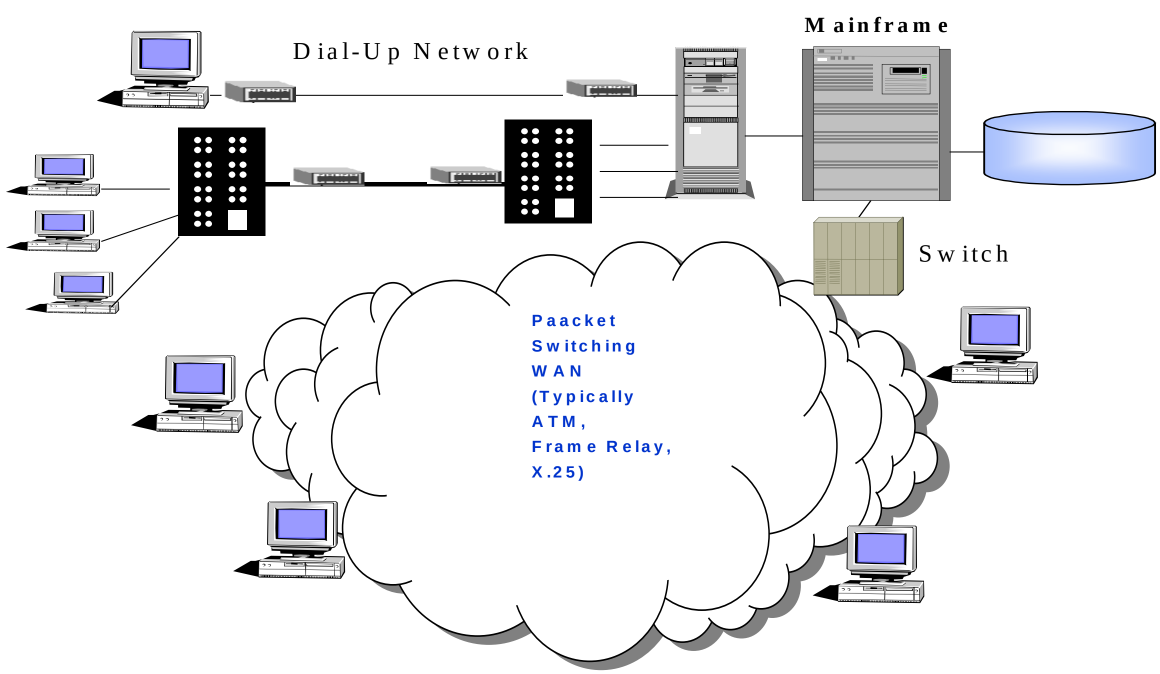


Figure 1-4: Common Wide Area Network Configurations

1.2.3 Metropolitan Area Networks

The metropolitan area networks (MANs) extend the scope of local area networks beyond the customer premises to cover a geographical area (e.g., a city or a county). A common definition (there are many slightly varying definitions) is that a MAN is a large LAN under the control of one authority and using a shared transmission medium. The origin of MANs is the cable TV industry that provides connectivity between users within a metropolitan area. The MANs are connected to the WANs for sewnding information to far off places through the Internet. This is the foundation for cable modems – they connect your computer to a MAN that in turn is connected to several WANs. A MAN typically covers 50 Km diameter and operates at data rates above 50 Mbps. .

1.3 Enterprise Networks and Network Architecture

1.3.1 Overview

Enterprise networks comprise of many interconnected LANs. Internet, as we will see later, is a large network of networks. ***Network architectures*** needed to specify how these pieces fit together to form a functioning network – they define the components, the functions and the interactions/interfaces (protocols/standards) between the components of a network. A network architecture encompasses hardware, software, standards, data link controls, topologies, and protocols. These components may be very simple or quite complex depending on the size of the network and the nature of devices supported (mainframes, minicomputers, microcomputers, terminals). Network architectures provide a systematic approach to describe the various categories of networks and define exactly what components will be supported and how. A ***protocol*** is a set of precisely defined rules of behavior between two parties. As we will see, protocols in network architectures define the formats and the rules of interaction between peers. Protocols play a key role in integration and interconnectivity in distributed systems.

Figure 1-5 presents a simple network architecture model. In this figure, several computers are connected to the network. One or more user applications (e.g., order processing) may run on each computer. Application Support Services "connect" the applications to the network. Network Services provide exchange of messages between the computers.

The functions performed by the application and network services vary widely between the size and complexity of networks and the stations. In the 1970s, these services were viewed as layers where each layer performed a specific function. Different researchers, vendors and standardizing bodies have proposed different layers. For example IBM's SNA (System Network Architecture) uses 7 layers; Department of Defense's Suite, commonly referred to as the TCP/IP Suite, uses 4 layers; and the OSI Reference Model uses 7 layers.

Even though the number of layers differs between vendors, in all cases the lower layers provide low level (closer to the physical network) functions while the high level functions (application interfaces) are performed by the upper layers. For example, the first layer is physical link, the last is the application layer in most network architectures. In these layered systems, the data expands at source as it goes through different layers (additional pieces of information are added as headers in each layer) and shrinks at the sink (headers are removed successively). We will see this in Section 1.3.2.

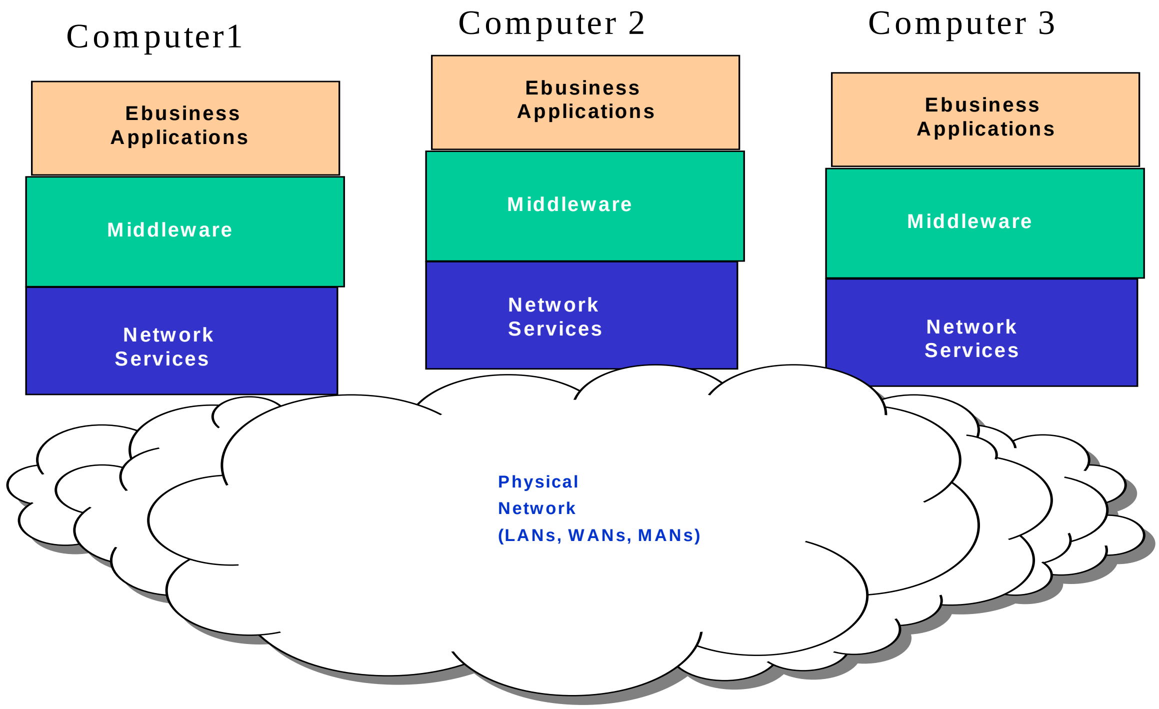


Figure 1-5: A Simple View of Network Architecture

1.3.2 The Open System Interconnection (OSI) Reference Model

The Reference Model for Open Systems Interconnection (OSI), commonly referred to as the OSI Model, was proposed by the International Standards Organizations (ISO) Committee 97 in March, 1977. This Model, published as ISO Document 7498, consists of 7 layers shown in Figure 1-6. The objective of the ISO subcommittee was to describe a hierarchical or layered set of generic functions that every network must fulfill. Such a generic definition makes it easier to develop interfaces between the growing number of different networks. The ISO subcommittee precisely defined the set of layers and the functions/services performed by each layer.

According to the conceptual framework in Figure 1-6, the first four layers (Physical, Data Link, Network, and Transport) are lower level layers which are responsible for the delivery of data between applications. These layers are responsible for connecting your devices to the physical network (e.g., a cable or a dialup line) and then delivering the messages between various applications and users on the network. Whereas the lower four layers are responsible for transport of information between applications, the upper layers support applications by providing services such as encryption, session establishment between remote applications and databases, etc. Collectively, these layers provide a conceptual way of categorizing the various functions that are performed when you access, for example, a remote web site from your browser or send an email to your friends in Singapore.

We will discuss the OSI model in detail in Chapter 3.

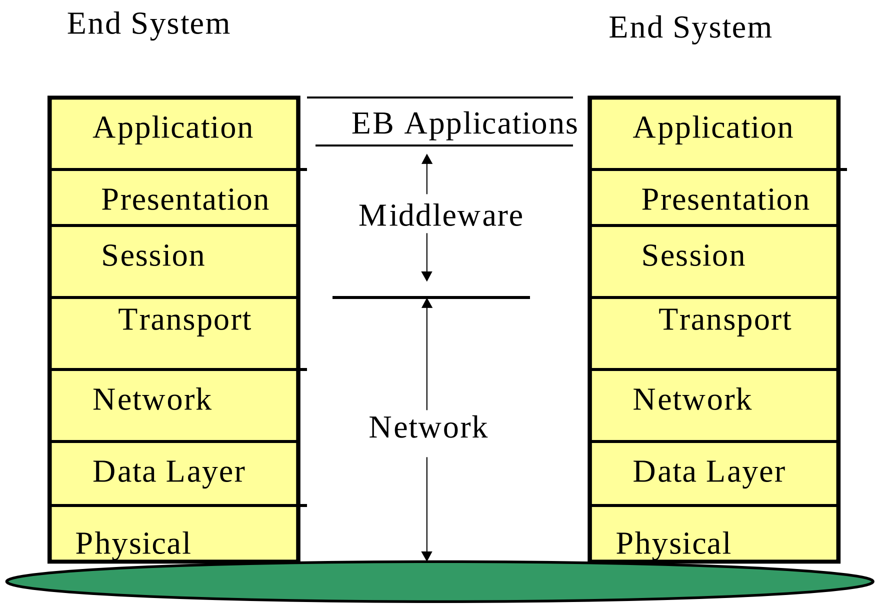


Figure 1-6: The OSI Model

1.3.3 Network Interconnectivity

Network interconnectivity is needed in large networks to provide interfaces and transport of messages between remotely located users, applications, databases, and devices. For example, if you access the Paris University Web site from Chicago, then many interconnectivity devices are used to get you from Chicago to Paris. The two principal network interconnectivity devices are:

- **Routers** find a path for a message in larger networks and then send the message over the selected path. Routers use very sophisticated routing algorithms and provide functionality such as "fire walls" for security checking.
- **Gateways** translate one type of protocol to another. In most large networks, protocols of some subnetworks need to be converted to protocols of other subnetworks for end to end communications. A gateway connects two dissimilar network architectures and is essentially a protocol converter. A gateway may be a special purpose computer, a workstation with associated software (e.g., a PC with gateway software), or a software module which runs as a task in a mainframe. An example of gateways for network interconnectivity is the TCP/IP to Novell LANs.

Many routers and gateways are used commonly in enterprise networks and the general Public Internet. For example, if a salesman in Detroit needs to access a customer database in New York, then a series of routers and gateways would be needed to find the path between the two cities. Figure 1-7 shows a realistic enterprise network that uses TCP/IP very heavily, except the IBM SNA network (an old network technology) at the mainframe. The routers are used between all TCP/IP network segments and gateways are used to convert the TCP/IP messages to SNA and the Novell protocol. . .

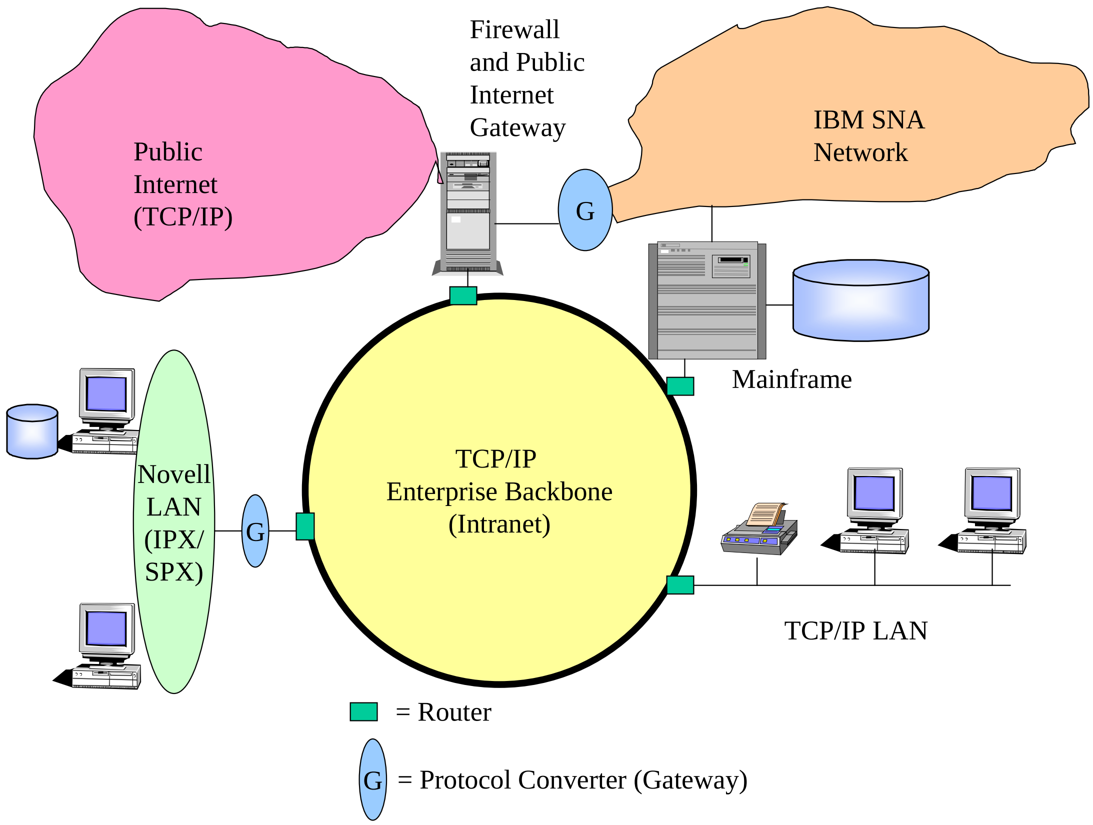


Figure 1-7: Network Interconnectivity in an Enterprise Environment

1.4 Broadband and Wireless Networks

1.4.1 Overview

The network communication technologies are advancing at a very rapid pace. In particular, we are witnessing growth of high speed, also known as ***broadband***, networks that exceed 100 Mbps data rates. Broadband is a general term that refers to "high speed" data communications, typically1Mbps, or higher. An interest in broadband communications has taken center stage over the past few years because broadband technologies represent the speed at which users can access the Internet In addition, we are also seeing an increased availability of wireless networks to support a variety of mobile users. The drivers for the growth of wireless and broadband services are:

- The Internet continues to be the primary driver for the communications industry. Internet traffic is doubling every year and is expected to keep growing in the future. The increased traffic is driving the need for networks that can handle the increased bandwidth levels.
- Increased use of cellular phones, palm pilots, PDAs, laptops, notebooks, and other handheld devices is driving the demand for mobile communications. "Wireless Internet" with mobile commerce has become highly desirable for "any information, anywhere, anytime" :
- The convergence of data and voice networks onto a single network infrastructure is also a driver of increased bandwidth needs. The converged networks must simultaneously support the highly interactive client /server applications and the voice/video applications (see side bar "Bandwidth Consumers").

- LAN Interconnectivity: Basically, LANs are fast but WANs are not. The demand for high speed LAN-to-LAN interconnection is driving high speed requirements (it is silly to connect high speed 100 Mbps LANs through a 56 Kbps WAN).

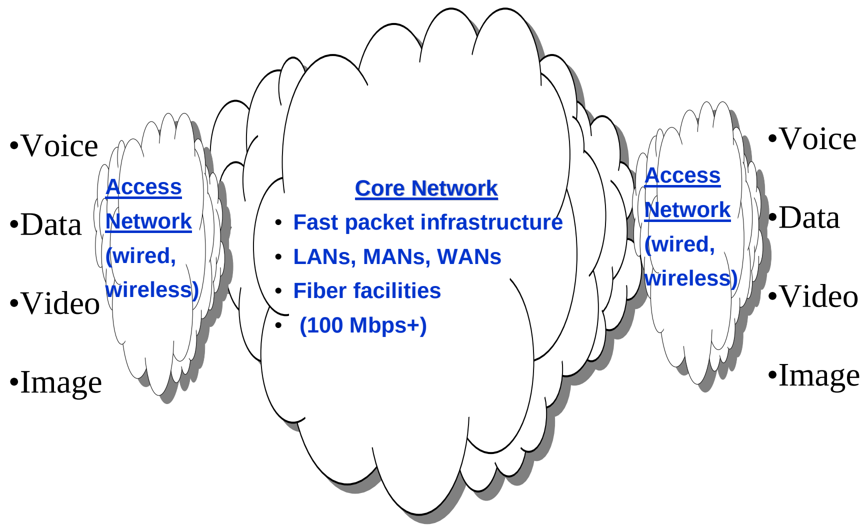


Figure 1-8: Conceptual View of "Next Generation Network (NGN)"

Figure 1-12 shows a conceptual view of a converged network that supports voice, data, and video over broadband and wireless services. Such networks are being referred to as ***"Next Generation Networks (NGNs)"***. The key players in NGN are:

- ***Core Network*** that provides the high speed short and long-haul capabilities to transfer information between end points. This network uses high speed transmission facilities.
- ***Access network*** that provides access from customer premise to the core network. This network, also known as the ***"last mile***" uses technologies such as DSL, Cable Modem, and other technologies for broadband services. Wireless networks are playing an important role in the last mile through the use of cellular networks, wireless LANs, and wireless local loops.
- **User Services** that support the voice, data, video, and image users. . Examples of these services are ecommerce/ebusiness applications, voice over IP, web-enabled call centers, and unified messaging. In addition, these services can support a variety of appliances such as IP phone, cellular phone, Fax, building temperature controller, alarm clock, facility sensor, coffee machines and the like.

This section briefly reviews the broadband and wireless networks. Detailed discussion can be found in Chapter 4 of this Module.

1.4.2 Broadband Networks

Currently, most people use modems that connect to the Internet at about 56kbp. Broadband access from home promises data rates around 1Mbps (1 million bits per second). A wide range of choices, such as cable modems and DSL, are available for broadband access from home.

Besides access from home (the last mile), broadband networks are used heavily in the core network. These networks use fast packet switching systems which move millions of packets per second over fiber networks to far off places. Fast packet switching systems, also known as ***fast relays***, have intelligent end-points which can deal with errors in transmission. Thus instead of checking for errors at every switch between New York and Los Angeles, it only checks errors at NY and LA. This considerably increases the throughput (number of bits transferred per second) of the network.

The most commonly used fast packet switching systems used at present are ATM (Asynchronous Transfer Mode) and Frame Relay. ATM is at present being used more commonly. The reasons for this are, as usual, not solely technical .

1.4.3 Wireless Networks

Wireless networks, as the name implies, interconnect devices without using wires -- instead they use the air as the main transmission medium. Wireless networks are enjoying widespread public approval with a rapidly increasing demand. The increase in the number of cellular phones, palm pilots, PDAs, laptops, notebooks, and other handheld devices is phenomenal. To meet this demand, mobile communications technologies are emerging with digital speech transmission and the ability to integrate cordless systems into other networks. In the meantime, researchers are developing the next generation of technologies for several years to come. Wireless networks, in a manner similar to the wired networks can be discussed in terms of wireless LANs, MANs, and WANs. .

Wireless LANs (WLANs) allow workstations in a small area (typically less than 100 meters) to communicate with each other without using physical cables. Several attempts to standardize Wireless LANs are underway. Examples are the IEEE 802.11 (for 11Mbps data rate), the HIERLAN (for 23.5 Mbps data rate) and the Bluetooth. LANs (for the data rates in the 700 kbps to 1 Mbps range). .

Wireless WANs (WWANs) provide wireless support over long distances. Traditional examples of wireless WANs are paging networks and satellite systems. However, a great deal of wireless WAN activity at present revolves around the cellular networks that provide support for cellular phones, handheld devices such as PDAs and laptops.

Wireless metropolitan area networks (WMANs) have been used in traditional packet radio systems often used for law-enforcement or utility applications. An interesting area of growth for wireless MANs is the wireless local loop (WLL) that is gaining popularity with long distance telephone companies. WLLs are ***fixed wireless networks*** where the devices being connected are stationary.

The wireless networks in the aforementioned categories are offering higher data rates than before. However, the wired networks are also offering higher data services. The following table summarizes the typical data rates in the wireless versus wired world. As you can see, the wireless technology is much slower than wired but it offers greater flexibility to the users.

Table 1-1: Wireless Versus Wired Networks

	Local Area Networks (LANs)	**Metropolitan Area Networks (MANs)**	**Wide Area Networks (WANs)**
Wired	Wired LANs Ethernet (10-100 Mbps, 150 to 500 meters) Token Ring (4 -16 Mbps, 200 to 500 meters)	Wired MANs FDDI (100 Mbps, 50 Kilometers)	Wired WANs Dial up (56 Kbps) DSL/cable modems (200 Kbps-1 Mbps) ATM (44 Mbps to 140 Mbps) Frame Relay (44 Mbps)
Wireless	Wireless LANs	Wireless MANs	Wireless WANs

	Bluetooth (1 Mbps, 10 meters) IEEE 802.11 LANs (2-11 Mbps, 100 meters)	wireless local loops (10 Mbps, 100 Kilometers)	Current GSM systems at 9.6Kbps, future 3G systems at 2 Mbps

1.5 Overview of Internet

1.5.1 What is Internet?

Technically speaking***, Internet*** is a network of networks based on the TCP/IP protocol stack. At present, the term Internet is used to refer to a large collection of TCP/IP networks that are tied together through network interconnectivity devices such as routers and gateways . The TCP/IP (Transmission Control Protocol/Internet Protocol), briefly introduced in chapter 3, was developed in the late 1960s and early 1970s by the Defense Advanced Research Projects Agency (DARPA). TCP/IP was developed for interconnecting many computers in the ARPANET (Advanced Research Projects Agency Network). ARPANET initially consisted of five protocols (indicated with * in the following list) that have been augmented with other key protocols (see Figure 1-9):

- *Internet Protocol (IP) for interconnecting and routing messages to a large number of physical networks
- *Transmission Control Protocol (TCP) for relaible information transfer
- User Datagram Program (UDP) for fast, but unrelaible, information transfer
- *File Transfer Protocol (FTP) for file transfer
- *Simplified Mail Transfer Protocol (SMTP) for email
- *Terminal emulator (Telnet) for terminal emulation
- Hypertext Transfer Protocol (HTTP) for Web applications
- Real Time Protocol (RTP) for audio and video applications

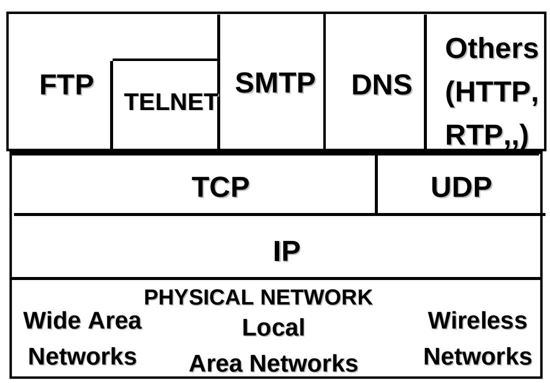


Figure 1-9: The IP Stack – Foundation of Internet

Although, the Internet at present uses TCP (i.e., higher level protocols and applications are based on TCP), this may not be true in the future since some future (especially real time) applications may be built directly on IP or newer alternatives to TCP. The main strength of IP is that it runs on top of a very diverse array of physical networks (wide area, local area, wireless) . In fact, IP supports almost all current physical network technologies and is expected to support most of the future high speed networks. We thus will use the following simple definition of the Internet:

Definition: Internet is a network of networks that is supported by the Internet Protocol (IP)

What does this mean? Basically it says that you need to have an IP network (or a gateway that translates to IP) to join the Internet. Once you have an IP network, then you can run almost any physical network under it and take advantage of voice, data, or video applications for your ebusiness that run on top of IP.

On the popular media side, the term cyberspace, first introduced through a science fiction book by [Gibson 1984], has been permanently transferred to our vocabulary. It represents thousands of computers and computer resources around the globe interconnected through the Internet. At present, the term Internet is used to symbolize a Public Internet that is not owned by any single entity -- it consists of many independent IP networks that are tied together loosely.

Transmission Control Protocol (TCP) and Internet Protocol (IP) are the best known protocols in the IP stack (they operate roughly at layer 3 and 4 of OSI). Over the years, the entire ARPANET Protocol Suite has become known as the ***TCP/IP Protocol Suite***. As stated previously, TCP/IP has dramatically grown in popularity in the last 20 years and is supported very widely. For example, TCP/IP can be used to transfer files between IBM, SUN, HP, IBM PCs and several other machines. IP, the lowest protocol in this Suite, can reside on a very wide variety of physical networks such as Ethernets, FDDI based fiber optic LANs, dial up lines, X.25-based packet switching networks, wireless networks, or ISDN digital networks. TCP, the layer above IP, supports a very wide variety of higher level (application) protocols which allow users to emulate terminals, transfer files, and send/receive mail between different computers ((see Figure 1-10):

Due to its popularity, the TCP/IP Protocol Suite continues to evolve. The TCP/IP Suite originally consisted of five basic protocols: IP, TCP, FTP, Telnet and SMTP. Later, Domain Naming Services (DNS) and Simple Network Management Protocol (SNMP) were added to the TCP/IP basic protocols. In addition, many other protocols and user applications have been developed around TCP/IP.The TCP/IP Suite addresses the layer 3 and above issues. The Application Layer of this network architecture provides a rich set of file transfer, terminal emulation, network file access and electronic mail services. It is important to note that a user application may choose to use any of the TCP/IP layers or may directly communicate with the physical network. Let us review the key protocols.

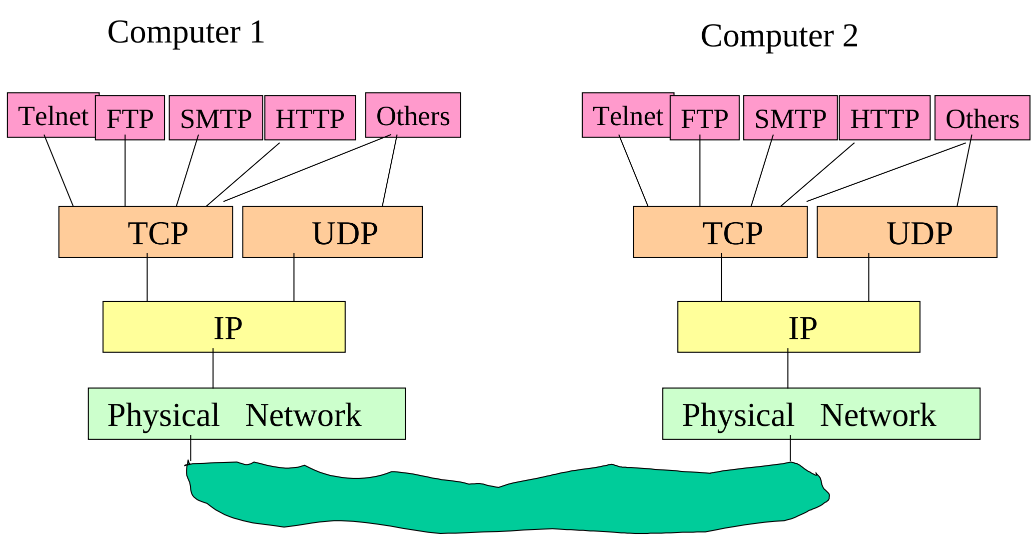


Figure 1-10: TCP/IP Network --- The Initial Stack

Initially, the public Internet was used to tie different university networks together. With time, several commercial and private networks have joined the public Internet. The computers on the public Internet have publicly known Internet Protocol (IP) addresses that are used to exchange information over the public Internet (we will discuss IP addresses later). The public Internet at present consists of millions of computers (PCs, Macs, Sun workstations, HP systems, IBM mainframes) that are interconnected through thousands of networks that use different underlying network technologies (ATMs, frame relays, Ethernet LANs, and wireless networks) in different parts of the world. All these computers and networks are tied together through a global IP network. .

1.5.2 User View of Internet

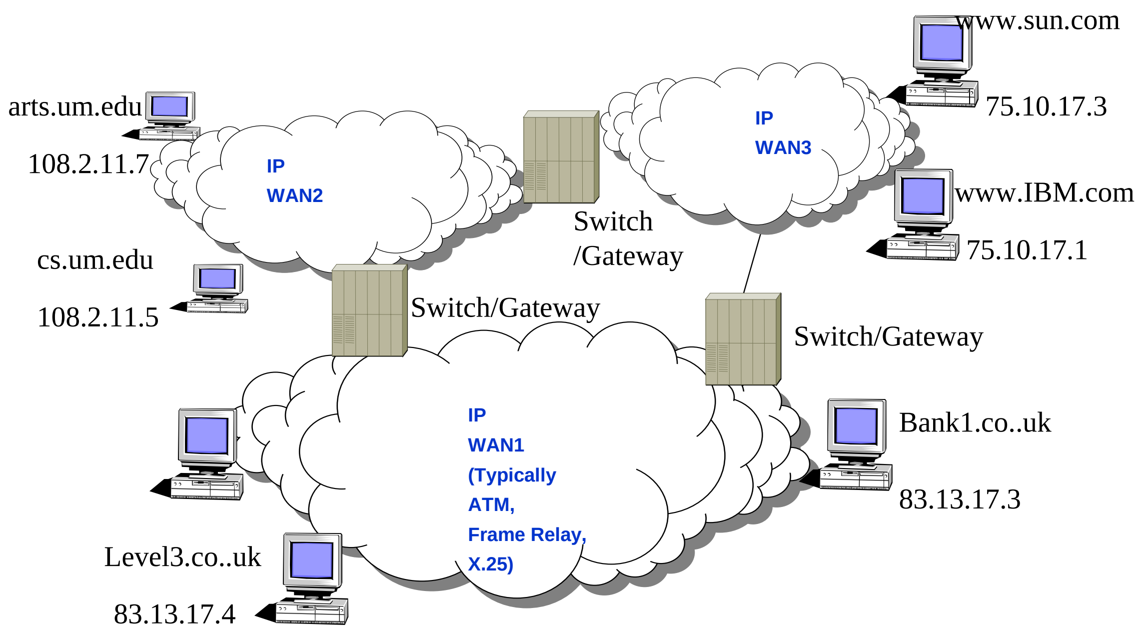
Before getting into the IP networking details, let us briefly review how the Internet is viwed by the users.

From an end user's point of view, Domain Naming Service (DNS) is of key importance because DNS helps the users to locate different resources in the is used in the Internet. DNS defines hierarchical naming structures which are much easier to remember than the IP addresses. For example, the machine with an IP address of 135.25.7.82 may have a domain name of shoeshop.com. A user "mills" may have an email address mills@shoeshop.com. The DNS naming structures define the organization type, organization name, etc. The last word in the domain name identifies an organization type or a country. Consider, for example, the following domain names:

telcordia.com = commercial company Telcordia
ibm.com = commercial company IBM
um.edu = educational institution University of Michigan
omg.org = organization OMG (Object Management Group)
waterloo.ca = waterloo university in canada
lancs.ac.uk = Lancaster University in UK
ansa.co.uk = ANSA consortium in UK
iona.ie = Iona Corporation in Ireland

The Internet uses a large number of domain name servers that translate domain names to IP addresses (the IP routers only understand IP addresses). Domain names are used in the Internet as well as the Web.

Figure 1-11 shows a conceptual and partial view of Internet. This Internet shows three networks (a university network with two computers, a commercial company network, and a network in UK). Each computer ("host") on this network has an IP address and also has been assigned a domain name. Internet is very heterogeneous (i.e., different computers, different physical networks.) However, to the users of this network, it provides a set of uniform TCP/IP services (TCP/IP hides many details). We will use this simple Internet to illustrate the key Internet capabilities.



•DNS (Domain Name Services) translates cs.um.edu to 108.2.11.5
•Telnet cs.um.edu = Telnet 108.2.11.5
•FTP cs.um.edu = FTP 108.2.11.5

Figure 1-11: Partial View of Internet

Since the Internet is based on TCP/IP, the applications and services provided by TCP are also available on the Internet. From an end-user point of view, the following services have been, and still are, used very heavily on the Internet:

- Email
- Telnet
- FTP

Electronic mail on the Internet is based on the **Simple Mail Transfer Protocol (SMTP)**. This TCP based protocol is the Intermet electronic mail exchange mechanism. Email is still one of the most heavily used service in the Internet. Users on the Internet have email addresses such as johnm@cs.um.edu, hevner@sun.com and howard@bank1.co.uk.

Terminal emulation is used to remotely logon to other machines. **Telnet** is used to provide terminal access to hosts and runs on top of TCP. Let us assume that a user "joe" on cs.um.edu needs to remotely logon to the bank1.co.uk machine to run a program "directory". The user would use the following steps (the steps are explained through comments in /* */):

```
> telnet bank1.co.uk            /* invoke Telnet. Could have typed " telnet    85.13.17.3".*/
bank1> enter logon: joe       /* prompt from  bank1 for logon ID. joe is ID */
bank1> password: xxxx         /* prompt from bank1 for password  */
bank1>  directory          /*  run the program "directory"   */
bank1> exit                   /* quit  telnet */
```

File transfer is used for bulk of data transfer over the Internet. The **File Transfer Protocol (FTP**) provides a way to transfer files between hosts on the Internet. Let us assume that a user "garner" on "sun.com" needs to transfer a file from the host arts.um.edu.The following steps would be used (the steps are explained through comments in /* */):

```
> ftp arts.um.edu              /* invoke FTP. Could have typed " ftp 102.52..10.7"*/
arts> enter logon: garner      /* prompt from arts.um for logon ID. garner is ID */
arts> password: xxxx           /* prompt from arts.um for password */
arts> get file1 file2          /* FTP file transfer command */
arts> exit (or quit)           /* quit FTP */
```

For many years, Internet had been used mainly by researchers, teachers, scientists, students, and programmers to transfer files and send/receive electronic mail. These users relied on text-based commands to do their job. WWW is a set of services that run on top of the Internet. The two main features of WWW are use of GUI and hypertext to make the life of Internet users easy and fun. We will discuss WWW in the next section in more detail.

1.5.3 Next Generation Network and Internet

The network communication technologies are advancing at a very rapid pace. In particular, we are witnessing growth of high speed, also known as ***broadband***, networks that exceed 100 Mbps data rates. Broadband is a general term that refers to “high speed” data communications, typically1Mbps, or higher. An interest in broadband communications has taken center stage over the past few years because broadband technologies represent the speed at which users can access the Internet In addition, we are also seeing an increased availability of wireless networks to support a variety of mobile users. The drivers for the growth of wireless and broadband services are:

- The Internet continues to be the primary driver for the communications industry. Internet traffic is doubling every year and is expected to keep growing in the future. The increased traffic is driving the need for networks that can handle the increased bandwidth levels.
- Increased use of cellular phones, palm pilots, PDAs, laptops, notebooks, and other handheld devices is driving the demand for mobile communications. "Wireless Internet" with mobile commerce has become highly desirable for "any information, anywhere, anytime" :
- The convergence of data and voice networks onto a single network infrastructure is also a driver of increased bandwidth needs. The converged networks must simultaneously support the highly interactive client /server applications and the voice/video applications (see side bar "Bandwidth Consumers").
- LAN Interconnectivity: Basically, LANs are fast but WANs are not. The demand for high speed LAN-to-LAN interconnection is driving high speed requirements (it is silly to connect high speed 100 Mbps LANs through a 56 Kbps WAN).

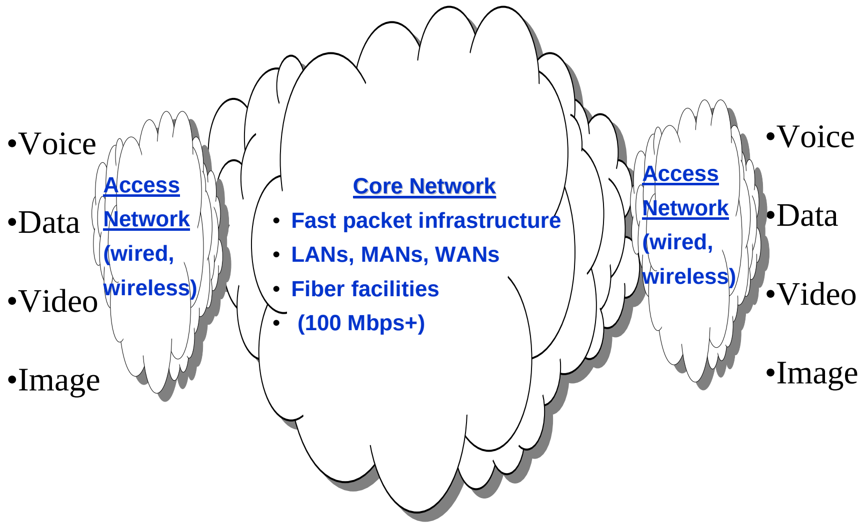


Figure 1-12: Conceptual View of "Next Generation Network (NGN)"

Figure 1-12 shows a conceptual view of a converged network that supports voice, data, and video over broadband and wireless services. Such networks are being referred to as ***"Next Generation Networks (NGNs)"***. The key players in NGN are:

- ***Core Network*** that provides the high speed short and long-haul capabilities to transfer information between end points. This network uses high seed packet switching systems (e.g., ATM, Frame Relay), fast LANs (e.g., Gigabit and 100 Mb/s Ethernet) over fiber facilities (e.g., SONET, WDM). Wireless technologies such as satellites are also increasingly becoming part of the core network.
- ***Access network*** that provides access from customer premise to the core network. This network, also known as the ***"last mile***" uses technologies such as DSL, Cable Modem, and ISDN for broadband services. Wireless networks are playing an important role in the last mile through the use of cellular networks, wireless LANs, and wireless local loops.
- **User Services** that support the voice, data, video, and image users. . Examples of these services are ecommerce/ebusiness applications, voice over IP, web-enabled call centers, and unified messaging. In addition, these services can support a variety of appliances such as IP phone, cellular phone, Fax, building temperature controller, alarm clock, facility sensor, coffee machines and the like.

The objective of this chapter is to present an overview of the core communication technologies that will support NGN. Figure 1-13 shows a layered view of the technologies of interest to us. Basically, the emphasis in this chapter is on the technologies below the IP layer (we will discuss IP in the next chapter).

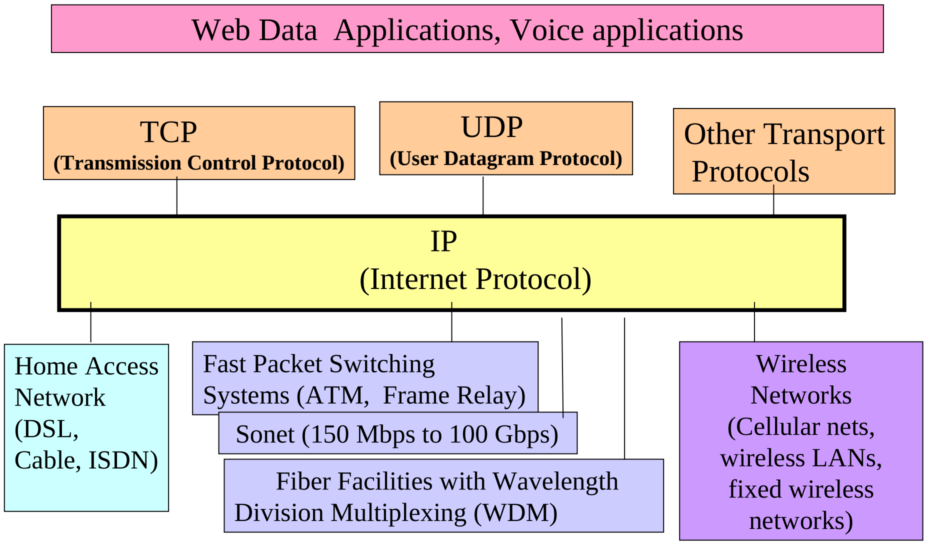


Figure 1-13: Technology Layers for Next Generation Networks

The home access network is also known as residential broadband. The two key technologies available to home users: DSL and cable modems. For wired access, the fiber optic digital technologies that typically reside at layer 1 (physical layer) of the OSI model are most common at present. SONET (Synchronous Optical Network) uses fiber optic to provide very high data rates that are in the several Gigabit per second. Growth in the use of fiber optics for local, wide and metropolitan area networks is unprecedented. Another technology, known as WDM (wavelength division multiplexing) allows multiple wavelengths representing different "colors" to be multiplexed onto a single fiber. This promises extremely high (10 gigabit per second and higher) data rates. Another development is the high speed packet switching technology being developed to run over fiber networks. Examples of fast packet switching systems are frame relay (variable sized packets) and ATM (fixed sized packets).

Due to the importance of mobile systems, wireless networks such as cellular networks, fixed wire networks, satellite systems, and wireless LANs have gained a great deal of momentum. The basic technical foundations of wireless networks (e.g., location services, frequency allocations, and multiple access) are also briefly reviewed. Most wireless networks (e.g., the fixed wireless networks, cellular networks, and wireless LANs) cover relatively small geographic areas but have many interesting applications. Satellites provide wireless support for long haul networks.

The key point about the network technology developments is that the Internet (TCP/IP) stack runs on top of all the emerging physical networks (wired or wireless). Thus the user does not need to know the underlying physical network.

1.6 Chapter Summary

Enterprise networks consist of many technologies, devices, protocols, and interfaces supplied by a multitude of vendors. Network architecture standards are needed for compatibility of inter-vendor and intra-vendor network products and services. This is an important issue because the advances in network technologies and facilities have led to an explosion of network related hardware/software products from many computer manufacturers, common carriers, software vendors and data communications equipment manufacturers. These products provide similar functions differently. Standards are needed to assure that all the products fit together to form a functioning network.

The Open Systems Interconnection (OSI) Model is widely acceptance as a framework for network architecture standards. The OSI Model presents a layered view of the network where each layer performs well defined functions. This functional model divides the network activities into seven layers. The high level layers of this model (Application, Presentation, and Session) are concerned with the issues related to the applications in different machines. The four lower layers (Transport Network, Data Link, and Physical) provide the transparent data exchange between computers.

Communication protocols play an important role in integration and interconnection. The discussion of protocols and the OSI Model in this chapter lays a good foundation for comparing different network architectures, defining and classifying network products and discussing levels of interconnectivity. We have also used the OSI Model as a framework for discussing, comparing and contrasting various network architectures such as TCP/IP, SNA, and LAN architectures. We have also classified and defined network interconnectivity products (e.g., routers, bridges, gateways, protocol converters).

1.7 Additional Sources of Information

Books

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Stallings, W., “ISDN and Broadband ISDN With Frame Relay and ATM”, Prentice Hall, 1998

Tannenbaum, A., "Computing Networks", Prentice Hall, 3rd., 1996

Magazines and Journals

For state of the art issues, the following magazines are recommended:

- Computer Networks and ISDN Systems
- Computer Communications
- IEEE Network Magazine
- IEEE Communications Magazine
- IEEE Transactions on Communications

For a state of the market and practice evolution, the following trade journals are recommended:

- Data Communications
- Business Communications Review
- Communications News
- LAN Technology
- LAN Magazine
- Byte Magazine (special issues on LANs and communications)
- PC Magazine (special issues on LANs and communications)