**Chapter 15**

**Computer Networks**

*Lesson 15.1:* Computer Network Fundamentals

*Lesson 15.2:* LAN and WAN

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***Lesson 15.1***

***Computer Network Fundamentals***

**15.1.0 Objectives**

*On the completion of this lesson, you will know:*

* *Types of computer networks and their characteristics*
* *Types of Transmission media*
* *Different types of Network devices*
* *Network architecture*

**15.1.1 Introduction**

A computer network is a system of interconnected computers. The computers of a network communicate with one another and share applications, data, voice, video and hardware components. There are three main types of computer networks, they are:

* Local Area Network (LAN),
* Wide Area Network (WAN), and
* Metropolitan Area Network (MAN).

LAN is an individual network which usually spans over a small area, providing high speed communication services and applications to people within a common organization structure such as a single business, campus or region. LANs are usually owned and managed by a single organization.

A WAN spreads over a large geographical area and may connect computers within a country or cover many continents. WAN may be provided by telephone and telegraph organizations. It may be private to a single organization or may be operated by a group of organizations. Traditionally, WANs have been implemented using circuit switching and packet switching techniques. A WAN can connect a number of LANs. The Internet is a popular example of a WAN.

MANs cover an area of a city. They offer a simple and fast way to link different sites of an organization for exchange of information. MANs use technologies similar to LAN technologies.

Computer networks provide many benefits. Major uses of computer networks are:

* Simultaneous access to programs and data.
* Sharing peripheral devices like printer, scanners etc.
* Personal communications using email.
* Making backup of information.
* Aiding communication by teleconferencing and video-conferencing.
* Accessing information from websites.

**15.1.2 Transmission Media**

Three main transmission media for LANs are: metallic cable (usually copper), optical fiber and wireless. The metallic cable includes twisted pair and coaxial cable. Optical fibers include single mode and multimode fibers. Wireless media include microwave and infrared.

The physical connection that connects two nodes is called a link. A link may be through a pair of wires or a coaxial cable or an optical fiber or through wireless or through a satellite. The data transmission rates of the links are expressed by Kbps (Kilo bits per second), Mbps (Mega bits per second), Gbps (Giga bits per second) or Tbps (Tera bits per second),

Table 15.1.1 shows the name of media and the corresponding maximum speed.

**Twisted pair:** Two types of twisted pair cables are UTP (unshielded twisted pair) and STP (shielded twisted pair). Twisted pairs having different characteristics have evolved over the years. The most modern type is the Category 5 (Cat 5) UTP which is used for high speed LANs. Twisted pair wiring extensively used in home and office telephone systems. Figure 15.1.1 shows a STP.

**Table 15.1.1 Different types of media and speed.**

|  |  |
| --- | --- |
| **Media** | **Maximum speed** |
| Twisted pair (UTP and STP) | 2 Mbps to 100 Mbps |
| Coaxial cable (baseband/broadband) | 264 Mbps to 550 Mbps |
| Microwave (satellite/terrestrial) | 100 Mbps |
| Wireless radio (for LAN) | 3.5 Mbps |
| Infrared (for LAN) | 4 Mbps |
| Fiber optic cable | 3 Gbps |



**Figure 15.1.1**: Twisted pair

**Coaxial Cable:** A coaxial cable, or coax, is an electrical cable with an inner conductor surrounded by a flexible, tubular insulating layer, surrounded by a tubular conducting shield, as shown in Figure 15.1.2. The most commonly used coaxial cables are thick-net and thin-net. Coaxial cables allow much higher speed data transmission compared to twisted pair cables.



**Figure 15.1.2**: Coaxial Cable

**Fiber Optic Cable:** An optical fiber is a thin, flexible, transparent fiber that acts as a waveguide, or "light pipe", to transmit light between the two ends of the fiber. Two types of mostly used fiber optic cables are multi-mode and single-mode cables. The multi-mode has a core diameter of 62.5 microns (1 micron=10-6 meter) and a cladding (glass surrounding the core) diameter of 125 microns. The single-mode has a core diameter of 8.3 micron and a cladding diameter of 125 microns. Currently available fiber optic cables can carry data at transmission rate of several gigabits or more. Figure 15.1.3 shows an optical fiber cable.



**Figure 15.1.3**: Optical fiber cable

Table 15.1.2 shows the comparison between coaxial cable and optical fiber.

**Table 15.1.2** Comparison between coaxial cable and optical fiber

|  |  |
| --- | --- |
| **Coaxial cable** | **Optical Fiber** |
| 1. Data rate in Mbps relatively low in comparison of Optical Fiber | 1. Data rate in Gbps. |
| 2. High attenuation | 2. Low Attenuation. |
| 3. Transmission through electro-magnetic waves . | 3. Transmission through light pulse. |
| 4. Possibility of cross talk. | 4. No Possibility of cross talk. |
| 5. Best suited for Cable distribution and large LAN’s . | 5. Best suited for LANs where high quality of facilities is required. |

**Wireless Media:** It can be divided into wireless radio and wireless infrared. Wireless radio is extremely useful in situations where running cable is prohibitively expensive or not possible. Office LAN can use radio signals to transmit data between nodes in a building. Laptops with cellular modem allow users to connect to the wireless network when they travel. Infrared communication covers relatively short distance, requires a clear line of sight and is used for indoor LAN. Figure 15.1.4 shows a mobile station is receiving data from a mobile base station through a wireless media.



**Figure 15.1.4:** Wireless Media

**15.1.3 Network Devices**

Networks rely on intermediary devices to provide connectivity and to ensure data flows across the network. These devices connect the individual hosts to the network and can connect multiple individual networks to form an internetwork. Examples of intermediary network devices are :

* Network Access Devices (e.g., Hubs, switches, and wireless access points as shown in Figure 15.1.5)
* Internetworking Devices (e.g., routers as shown in Figure 15.1.5)
* Security Devices (e.g., firewalls)

**Network Access Devices**

**Hub**: An Ethernet hub or hub is a device for connecting multiple twisted pair or fiber optic Ethernet devices together and making them act as a single network segment. Hubs work at the physical layer of the OSI model. The device is a form of multiport repeater. It is relatively slower because it broadcasts the packets it receives to all nodes attached to its ports.

**Switch**: A switch is the most common device for interconnecting LANs. It reads the outermost section of data (called hardware address) on the data packet, to tell where the message is going. Thus it reduces the amount of broadcast traffic. Switching occurs at the data link layer of OSI model, which means it, cannot read IP addresses, but can read the hardware address of the packet. A two port switch which connects two LANs or LAN segments is called bridge.

**Internetworking Devices**

**Router** : A router is used to route data packets between two networks. It reads the information in each packet to tell where it is going. Routing occurs at the network layer of OSI model. They can connect networks with different architectures such as Token Ring and Ethernet. Routers do not send broadcast packets or corrupted packets. If the routing table does not indicate the proper address of a packet, the packet is discarded. Wireless router is a specific type of router often found in home networks.



**Figure 15.1.5:** Network Access and Internetworking Devices

**Security Devices**

**Firewall:** A firewall is a device or set of devices or software designed to prevent unauthorized user’s transmissions based upon a set of rules while permitting legitimate communications to pass. Personal computer’s operating system includes software-based firewall to protect against threats from the public Internet. Many routers that pass data between networks contain firewall components and, conversely, many firewalls can perform basic routing functions. Figure 15.1.6 shows a LAN is connected to a WAN via Firewall.



**Figure 15.1.6:** Connection of a LAN to a WAN via Firewall

**15.1.4 Network Architecture**

On a LAN, computers share files, programs, or printers. LANs providing these types of services are typically set up either as client-server or peer-to-peer LANs, or perhaps as a combination of the two.

**Client - Server Network Architecture:**

A network architecture in which each computer or process on the network is either a client or a server. Servers are powerful computers or processes dedicated to managing disk drives (file servers), printers (print servers), or network traffic (network servers). Clients are PCs or workstations on which users run applications. Clients rely on servers for resources, such as files, devices, and even processing power.

In the client-server network architecture, the client initiates the connection with a request as shown in Figure 15.1.7. The server responds to this request, delivering the required service or resource. Most business-related networked applications operate on this model. Web browsers request web pages from web servers in the same manner. Client server was the only method of network communication until peer-to-peer networking was invented.



**Figure 15.1.7** Client-Server network architecture

Data transfer from a client to a server is referred to as upload and data from a server to a client as download.

**Peer to peer Network Architecture**

In a peer-to-peer (abbreviated P2P) network, two or more computers are connected via a network and can share resources (such as printers and files) without having a dedicated server. Every connected end device (known as a peer) can function as either a server or a client. One computer might assume the role of server for one transaction while simultaneously serving as a client for another. The roles of client and server are set on request basis. Figure 15.1.8 shows a P2P network where Peer 2 wants to print a document file via a network printer which is directly connected to Peer 1. Here Peer 1 acts as a print server and Peer 2 acts as a print client, whereas Peer 1 acts as a file client and Peer 2 acts as a file server.



**Figure 15.1.8:** Peer to peer Network Architecture

**15.1.5 Key points**

* A computer network is a system of interconnected computers.
* The physical connection that connects two nodes is called a link.
* The most commonly used media for computer networks are twisted pair, coaxial cable and optical fiber.
* Office LAN can use radio signals to transmit data between nodes in a building.
* Infrared communication covers relatively short distance, requires a clear line of sight and is used for indoor LAN.
* An Ethernet hub or hub is a device for connecting multiple twisted pair or fiber optic Ethernet devices together and making them act as a single network segment.
* A switch is the most common device for interconnecting LANs.
* A router is used to route data packets between two networks. It reads the information in each packet to tell where it is going.
* A firewall is a device or set of devices or software designed to prevent unauthorized user’s transmissions based upon a set of rules while permitting legitimate communications to pass.
* Client - Server Network is the most popular type of server based network where individual computers share the processing and storage workload with a central server.
* In a peer-to-peer (abbreviated P2P) network, both computers in a connection are equals, or "peers." Both computers in the connection are both clients and servers simultaneously.

**15.1.7 Practice Set**

**Multiple Choice Questions**

1. A network that connects computers in a building is called \_\_\_\_\_\_\_\_\_\_\_.
   1. LAN
   2. WAN
   3. MAN
   4. VAN
2. A device that connects two LANs is called \_\_\_\_\_\_\_\_\_\_\_.
   1. Switch
   2. Hub
   3. Router
   4. Repeater
3. In\_\_\_\_\_\_\_\_\_\_\_\_\_, each computer in the network can maintain a connection to more than one computer at the same time.?
   1. P2P
   2. Client-server
   3. IBM OS/2 Wrap Server
   4. None
4. A \_\_\_\_\_\_\_\_\_\_\_\_\_is a device or set of devices or software designed to prevent unauthorized user’s transmissions based upon a set of rules while permitting legitimate communications to pass.
   1. router
   2. hub
   3. firewall
   4. NIC

**Review Questions**

1. List the possible topologies for computer networks.
2. List common users of computer networks.
3. Distinguish among hub, switch and router.
4. Contrast and compare client-server and p2p network architecture.

**Analytical Question**

1. Name different types of computer networks and briefly explain their characteristics.
2. Explain different types of transmission media.
3. Explain different types of network devices.
4. With the help of an illustration briefly explain client-server and p2p network architecture.

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***Lesson 15.2***

***LAN and WAN***

**15.2.0 Objectives**

*On the completion of this lesson, you will know:*

* *LAN topology*
* *Network interface cards and protocols*
* *Network software and Cabling equipment*
* *WAN characteristics*
* *Bandwidth and Switching*

**15.2.1Introduction**

A Local Area Network (LAN) provides interconnection of a variety of data communication devices within a small area. The key features of LANs are given below:

* Interconnection of multiple network devices and components,
* Computers are spread over a small geographical area,
* Channels are of relatively high capacity (Mbps to Gbps),
* Channels are relatively error free.

A WAN is a data communications network that covers a relatively broad geographic area and often uses transmission facilities provided by common carriers, such as telephone companies.  WAN technologies function at the lower three layers of the OSI reference model: the physical layer, the data link layer, and the network layer.

**15.2.2 LAN Topology**

LAN topology is the layout pattern of interconnections of the various elements (links, nodes, etc.) of a LAN. The basic LAN topologies are:

**Bus topology:** In the bus topology, all stations are attached through appropriate hardware interfacing (known as a tap) to a linear transmission medium, or bus. Figure 15.2.1 shows a bus topology. Full-duplex operation between the station and the tap allows data to be transmitted into the bus and received from the bus. A transmission from any station propagates the length of the medium in both directions and can be received by all other stations. At terminator, each end of the bus absorbs any signal, removing it from the bus. Low installation cost is the main advantage of bus topology where as the disadvantage is that the network is down if the cable breaks down.



**Figure 15.2.1** Bus topology

**Star Topology**: In the star topology, each station is directly connected to a common central node as shown in Figure 15.2.2. Each station attaches typically to a central node, referred to as the star coupler, via two point-to-point links, one for transmission and one for reception. In general, there are two alternatives for the operation of the central node. One approach is for the central node to operate in a broadcast fashion. A transmission of a frame from one station to the node is retransmitted on all of the outgoing links. In this case, although the arrangement is physically a star, it is logically a bus; a transmission from any station is received by all other stations, and only one station at a time may successfully transmit. Another approach is for the central node to act as a switching device. An incoming frame is buffered in the node and then retransmitted on an outgoing link to the destination station. The main advantage is that collision will be detected if two nodes transmit at the same instant.



**Figure 15.2.2** Star topology

**Ring Topology**: The ring topology (Figure 15.2.3) connects the nodes in a circular chain with each node connected to the next. The last node connected to the first completing the ring. Each node examines the data as it travels. If the data called token is not addressed to the node examining it, then it is passed to the next node. There is no possibility of collision as one packet of data travels the ring at an instant.

**Mesh Topology**: Mesh topology is designed over the concept of routing. It is the least used network topology and the most expensive to implement. In a mesh network all the nodes are connected to each other. The main advantage of mesh topology is that data can never fail to be delivered, if one connection goes down, there are other path to reach the destination. In order to connect four nodes six cables are required. Thus *n(n-1)/2* cables are required to connect *n* number of nodes. Figure 15.2.4 shows four routers are connected in Internet as mesh topology and it requires six connections to interconnect each others.



**Figure 15.2.3** Ring topology



**Figure 15.2.4** Mesh topology

**15.2.3 Network Interface Cards and Protocols**

A network interface card (NIC), or a LAN adapter, plugs into a slot on the motherboard to connect it to the LAN. The NIC serves a number of purposes

* It makes the physical connection between the computer and the network.
* It converts parallel data of the computer’s bus into serial data for the LAN.
* It boosts the strength of a signal sothat it can flow through the transmission link.

Only one computer is allowed to transmit in a LAN. Signals would interfere if there is more than one transmission at a time. For this reason, a LAN needs a medium access control (MAC) scheme to prevent overlapping of signals. The NIC determines the access method used by a network. The common medium access control methods are Ethernet, Token Ring, Fiber Distributed Data Interface (FDDI), Attached Resource Computer NETwork (ARCNET) etc. In case of wireless NIC, it establishes a link with wireless router via its antenna.

**15.1.4 Network Software**

Network Software is a set of primitives that define the protocol between two machines. The network software resolves an ambiguity among different types of networks making it possible for all the machines in the network to connect and communicate with one another and share information. The software that manages the resources of the network is often called the network operating system. Servers in LANs rely on network operating systems such as Novell Netware, IBM OS/2, Warp Server, Microsoft 2000/ NT Server etc. A server network operating system must meet stringent set of requirements than a client Operating System such as Windows, Linux, Mac and [Android](http://www.wisegeek.com/what-is-an-android.htm). A variety of communication software packages are available for microcomputers especially for Internet Web browsing like Microsoft Explorer, Mozilla Firefox, Google Chrome, Nestcase, Opera, Navigator, Microsoft Outlook etc. Several functions are commonly provided by communication software packages.

**15.2.5 Cabling Equipment**

The quality of the different types of network cable refers to distance and speed. For example, Cat5 can carry data up to 100 meters distance without attenuation and data can move at a speed of 100 Mbps. If a Cat5 cable is attached to a 10 Mbps hub, it will receive data at the rate of 10 Mbps. The most common types of network cabling equipments include:

**Ethernet**: It is the most commonly used cabling equipment. The original implementation of Ethernet used coaxial cable and was called 10Base-5 and 10Base-2. The most popular implementation of Ethernet used twisted pair cable and star topology and was called 10Base T. here the number 10 refers to transmission speeds up to 10 Mbps. Most new Ethernet technology use star topology with either twisted pair or fiber optic cables as the medium. With Ethernet, the collision is detected if two nodes transmit data at the same time.

**Fast Ethernet:** In the 1990s, several new 802.3 standards were established to describe methods for transmitting data over Ethernet media at 100 Mbps. These standards used different encoding requirements for achieving these higher data rates. 100 Mbps Ethernet, also known as Fast Ethernet, can be implemented using twisted-pair copper wire or fiber media. The most popular implementations of 100 Mbps Ethernet are:

* 100BASE-TX using Cat5 or later UTP
* 100BASE-FX using fiber-optic cable

Because the higher frequency signals used in Fast Ethernet are more susceptible to noise, two separate encoding steps are used by 100-Mbps Ethernet to enhance signal integrity.

**Gigabit Ethernet**: Gigabit Ethernet is used to describe Ethernet implementations that provide bandwidth of 1000 Mbps (1 Gbps) or greater. This capacity has been built on the full-duplex capability and the UTP and fiber-optic media technologies of earlier Ethernet. 1000Base-T is the most popular and affordable standard of Gigabit Ethernet.

**15.2.6 WAN Characteristics**

A wide area network connects computers across a wide geographical area. For example an organization may have its offices scattered over different cities and each office needs to share data with other officers as shown in Figure 15.2.5. In this case computers and LANs of different sites may be connected by public communication facilities (like telephone network) or private communication network to realize a WAN. A WAN for a particular organization is called enterprise-WAN. The internet is a popular example of WAN as it connects thousands of computers and LANs around the world.

Intermediate devices like gateways and routers and transmission facilities like telephone and data networks, fiber optic links, satellite are generally used for realizing WANs. The major features of WANs are listed below:

* Multiple computers are connected together.
* Computers are spread over a wide geographic area.
* A WAN usually interconnects multiple LANS.
* Communication links between computers are provide by telephone networks, public data networks, satellite etc.
* Links are of low capacity(i.e., low data rate).
* Bit error rate is higher (10-5) compared to that of a LAN.



**Figure 15.2.5: WAN**

**15.2.7 Bandwidth and Switching**

**Bandwidth:** Speed and capacity of computers and communication networks can be classified by bandwidth. Low speed local communication channels are typically used for transmission rates from 300 to 56000 bps, but can now handle up to several Mbps for Asymmetric Digital Subscriber Line (ADSL) connection. They are usually UTP lines commonly used for voice communication, but are also used for data communications by PCs, video terminals and fax machines. STP lines can be used for speed up to 100 Mbps for short distances. High speed broadband digital channels allow transmission rates from 256,000 bps to several billion bps; typically they are microwave, satellite transmission and fiber optic cables.

**Switching:** The switching techniques used for WAN are:

***Circuit Switching*:** In circuit switching, a dedicated physical circuit is established, maintained, and terminated through a carrier network for each communication session. Circuit switching accommodates two types of transmissions: datagram transmissions and data-stream transmissions. Used extensively in telephone networks, circuit switching operates much like a normal telephone call. Integrated Services Digital Network (ISDN) is an example of a circuit-switched WAN technology.

***Packet Switching*:** In packet switching, network devices share a single point-to-point link to transport packets from a source to a destination across a carrier network. Statistical multiplexing is used to enable devices to share these circuits. Asynchronous Transfer Mode (ATM), Frame Relay, Switched Multimegabit Data Service (SMDS), and X.25 are examples of packet-switched WAN technologies.

**15.2.8 Key points**

* 15.2.9 Key points
* A Local Area Network (LAN) provides interconnection of a variety of data communication devices within a small area.
* A WAN is a data communications network that covers a relatively broad geographic area.
* In the bus topology, all stations are attached through appropriate hardware interfacing (known as a tap) to a linear transmission medium.
* In the star topology, each station is directly connected to a common central node called the star coupler.
* The ring topology connects the nodes in a circular chain with each node connected to the next.
* Mesh topology is designed over the concept of routing. It is the least used network topology and the most expensive to implement.
* A network interface card (NIC), or a LAN adapter, plugs into a slot on the motherboard to connect it to the LAN.
* A LAN needs a medium access control (MAC) scheme to prevent overlapping of signals.
* Network Software is a set of primitives that define the protocol between two machines.
* The quality of the different types of network cable refers to distance and speed.
* The most popular implementation of Ethernet used twisted pair cable and star topology and was called 10Base T. here the number 10 refers to transmission speeds up to 10 Mbps.
* 100 Mbps Ethernet, also known as Fast Ethernet, can be implemented using twisted-pair copper wire or fiber media.
* Gigabit Ethernet is used to describe Ethernet implementations that provide bandwidth of 1000 Mbps (1 Gbps) or greater.
* Speed and capacity of computers and communication networks can be classified by bandwidth.
* In packet switching, network devices share a single point-to-point link to transport packets from a source to a destination across a carrier network.

**15.1.9 Practice Set**

**Multiple Choice Questions**

1. Which is not a LAN topology?
   1. Ring
   2. Tree
   3. Bus
   4. VAN
2. In the bus topology, all stations are attached through appropriate hardware interfacing called \_\_\_\_\_\_\_\_\_ to a linear transmission medium
   1. Tin
   2. Tap
   3. Tail
   4. Tip
3. Mesh topology is designed over the concept of\_\_\_\_\_\_\_\_\_\_\_\_.
   1. switching
   2. repeating
   3. routing
   4. None
4. In \_\_\_\_\_\_\_\_\_\_\_ switching, network devices share a single point-to-point link to transport packets from a source to a destination across a carrier network.
   1. Circuit
   2. Virtual
   3. Message
   4. Packet
5. Which is not a network operating system?
   1. Novell Netware
   2. Windows NT server
   3. MS Work
   4. IBM OS/2 Wrap Server
6. Which is not the Internet Web browser?
   1. Opera
   2. Mozilla Firebox
   3. Google Chrome
   4. MS Excel

**Question for Short Answer**

1. List different types of LAN topology.
2. What do you understand by NIC?
3. List features of WAN.
4. Name any three servers and two client operating systems.
5. Distinguish between fast and gigabit Ethernets.

**Analytical Question**

1. Explain different types of LAN topology.
2. What is a NIC? Explain its characteristics
3. Explain the major functions of network software packages.
4. Explain different types of Network cabling.