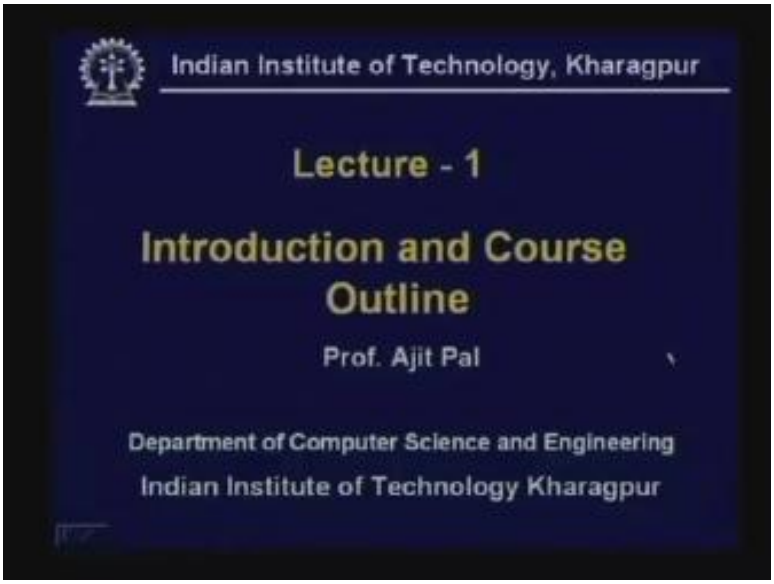
Data Communications
Prof. Ajit Pal
Department of Computer Science & Engineering
Indian Institute of Technology, Kharagpur
Lecture # 01
Introduction and Course Outline

Hello viewers welcome to the video lecture series on data communication. It is the first lecture of the 40 lecture series and in this lecture I shall give an introduction and course outline.

(Refer Slide Time: 00:01:16)



First let me introduce myself, my name is Ajit Pal I joined IIT Kharagpur in 1982 the day ASIAD started in Delhi and I am currently professor in the Computer Science and Engineering Department of IIT Kharagpur. I received M. Tech and PhD degrees from the Institute of Radio Physics and Electronics, Calcutta University in the year 1971 and 1976 respectively.

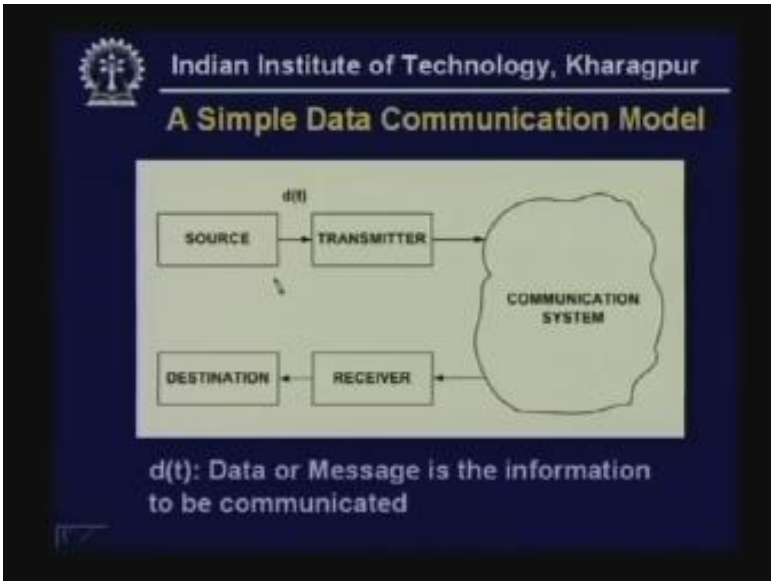
(Refer Slide Time: 1:20)

My research interests include embedded systems, low power VLSI circuits and computer networks. I am fellow of the IETE India and senior member of the IEEE USA. If you want to send email address to me here is the email address: apal@cse.iitkgp.ernet.in.

Before I discuss about the various topics that will be covered in this lecture first I shall give a very over simplified model of data communication system and that will put you in proper perspective. So here is the over simplified model of data communication model system.

You have got a source, source is essentially where the data is originated. Source can be a computer, peripheral, it can be some communication equipment like cell phones, PDAs and so on so any system which can send data which can process data and which can receive data can be source. Then we will require a transmitter, a transmitter is the device which converts the data sent by the source into a suitable form for transmission through the medium.

(Refer Slide Time: 5:20)



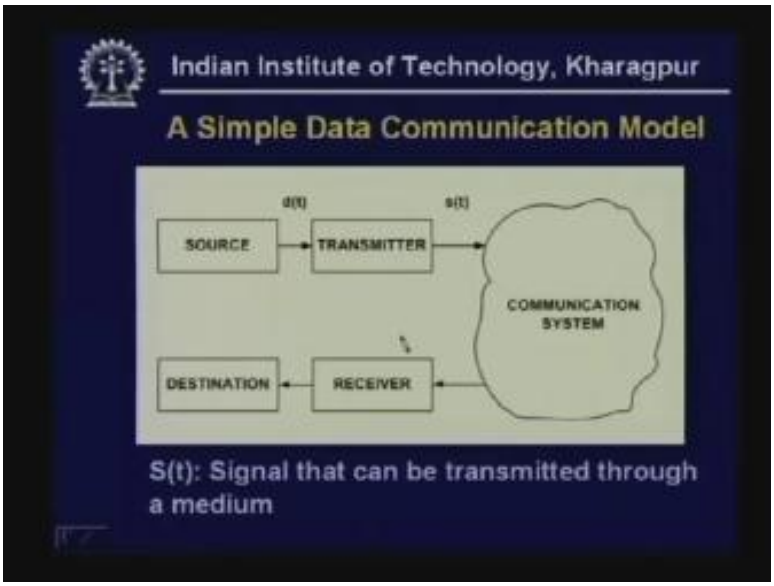
(Refer Slide Time: 2:55)

As we shall see the source generates data and transmitter will convert it into a suitable form which can be sent through the communication system. So the third component is the communication system the medium through which signal is sent. Now the medium can be very simple a piece of wire or a pair of wire like a shell cable, twisted pair of wire or it can be optical fiber or it can be Local Area Network, it can be Wide Area Network so by communication system we mean that it can be a very simple system like a pair of wire or it can be very complex system like LAN, WAN or internet. So we shall consider different types of communication systems.

Then comes the receiver which receives the signal and converts it into data or message. So here again you see you require a receiver which will receive the signal coming through the communication system and then it will do some processing and then after converting the signal into data it will send to the destination. Destination again can be a computer, can be peripherals or it can be communication equipments or whatever. The source and destination equipments can be of same type. Now let us consider what we mean by data.

This source is generating some data or message is the information to be communicated. What do you mean by data? Data is something which conveys some meaning to the receiver that is what we call data. And, data can be analog in nature, can be digital in nature so here d(t) means data it can be analog or it can be digital which is sent from the source to the transmitter.

(Refer Slide Time: 5:55)



Now the transmitter as I said will convert it into a signal so data is transformed into signal. As such the data cannot be sent through the communication system. Data has to be converted into some electromagnetic signal which can be transmitted through a medium. The signal can be electrical in nature, electronic in nature or optical in nature which can be sent through the communication system.

Before we discuss about the communication system and other things let us first consider what we mean by data and signal.

First of all we shall discuss about what we mean by data, analog and digital data types, analog and digital data. Then as I mentioned the data has to be converted into signal again the signal can be analog or digital in nature it can be either of the two types.

(Refer Slide Time: 7:00)

So we shall discuss about two different types of signals analog and digital both types will be considered. And as we shall see the signal can be periodic in nature, can be a periodic in nature and in fact a signal which is not periodic in nature can be considered as a combination of some periodic signals. So we shall first discuss the periodic signal characteristics and then we shall see how periodic signals can be used to non-periodic signals. And as we shall see the signal can have two different types of representation; one is time domain representation, another is frequency domain representation. We shall discuss about the time domain and frequency domain representations and in this context we have to discuss the spectrum of the signal and bandwidth of the signal. We shall discuss about both of them and also see the relationship between the two.

And obviously when a signal is generated it has to be propagated and obviously whenever it goes from say transmitter to the receiver the signal has to go through the communication system and depending on the distance and medium used there will be some propagation time and obviously the wavelength of the signals that can be sent will depend on the medium that is being sent. So we shall discuss in detail the data and signal. Then comes the impairments that take place as the signal goes through the signal. As the signal passes through the transmission medium it suffers some impairment and that impairment can be in the form of attenuation.

We shall see how attenuation occurs and also the unit of attenuation decibel or db which is universally used. We shall discuss about the attenuation of different types of media and the unit of attenuation. And also in this context we shall consider the bandwidth of the medium, the signals which can be sent through the medium and for different types of mediums the signal can be of different types. Then as I said the impairments will take place, one reason is attenuation and second reason is distortion. The distortion will occur

in two forms. These two forms are known as delay distortion and also the time distortion and obviously these two distortions are to be taken care of at the receiving end.

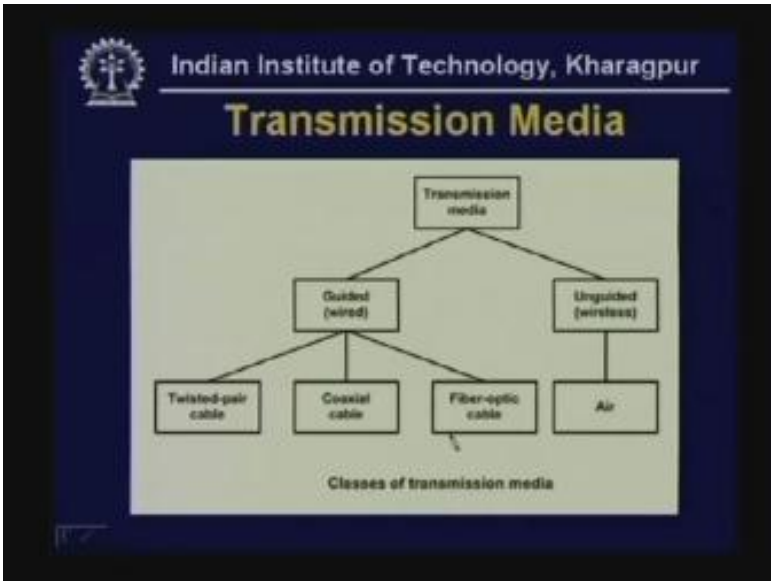
(Refer Slide Time: 11:17)

And the rate at which data can be sent will be dependant on the medium and as we shall see there is some data rate limit which can be sent through a medium and which is characterized by Nyquist bit rate. Depending on the bandwidth of the medium the Nyquist bit rate will be decided. We shall we shall discuss in detail about this Nyquist bit rate which is the highest data rate that can be transmitted through the medium.

Another important concept is the baud rate. As data is sent it is converted into a signal and actually the rate at which data is sent and the rate at which the signal elements are sent through the medium is different and that leads to two different concepts like bit rate and baud rate. We shall discuss about both of them in detail and the relationship between the two. And apart from attenuation, distortion there is another source of distortion which is noise. We shall discuss about various noise sources and see how they affect both the analog and digital type of signals.

A signal can be analog in nature or it can be digital in nature so let us see how these two different types of signals are affected because of noise. And we shall also discuss in the subsequent lectures about whenever in presence of noise how the bandwidth of the signal or the channel capacity changes that is resided by the Shannon capacity in a noisy channel.

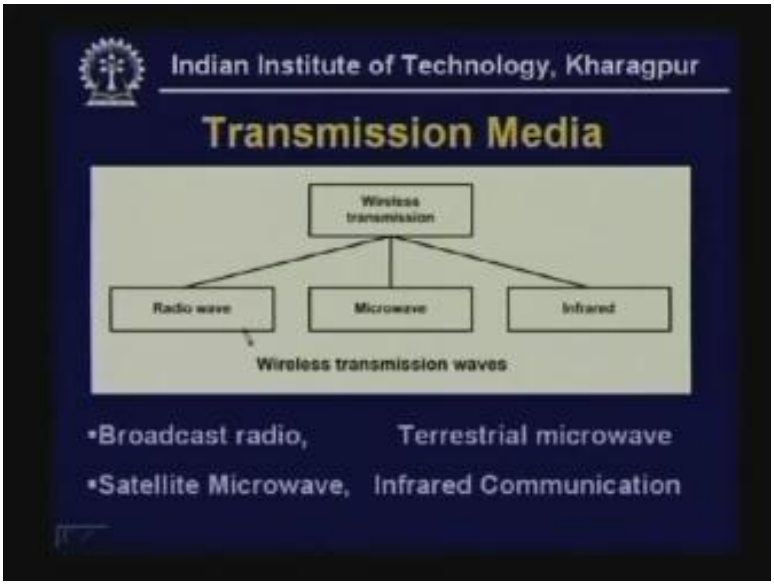
(Refer Slide Time: 11:43)



As I said the signal has to be sent through some transmission media. We shall discuss about two different types of transmission media. In fact the transmission media can be broadly divided into two types; one is guided and another is unguided. In case of guided transmission media there are three popular types; twisted pair, coaxial cable and fiber optic cable.

We shall discuss about the characteristics of these three types of guided transmission media and also we shall discuss about the transmission of signal through unguided media or through air. In that case of course as we shall see there are three mechanisms of sending transmission in the wireless form. One is radio wave, another is microwave and another is infrared. So there are three different forms in which the wireless transmission occurs. Some examples are broadcast radio the AM FM radio that we hear, then the terrestrial microwave, satellite microwave and infrared communication.

(Refer Slide Time: 12:28)



So these are the four different types of transmission media in the context of wireless communication and we shall discuss about all of them in detail.

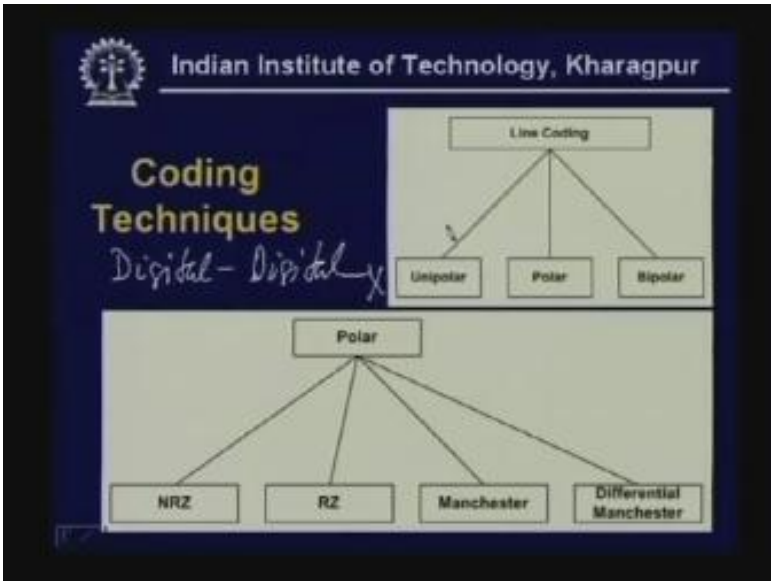
(Refer Slide Time: 13:05)

Then as I said this signal data has to be converted into signal for transmission through transmission media and depending on the data and the signal as we can see various approaches that can be used first of all if the data is digital in nature here the data is digital in nature so the signal can be also digital in nature and in that context we call it encoding. Whenever we transform digital data to digital signal the approach that is followed is known as encoding. And as we shall see there are various encoding

techniques. Then if the data is analog in nature such as voice, video and converted into digital form then also we have to do encoding. So in general whenever the signal is digital in nature or when we do digital transmission the conversion process is known as encoding.

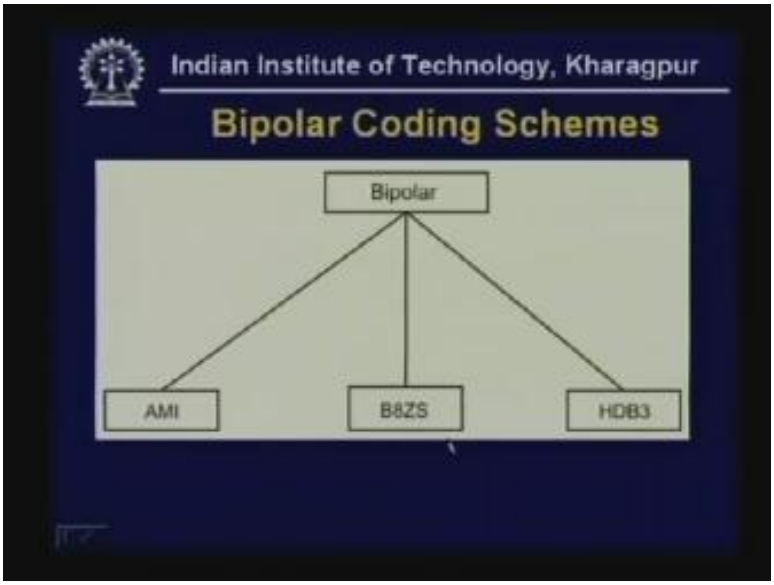
On the other hand whenever the signal is analog in nature whether it is analog data or digital data we call it modulation that means the technique is known as modulation. And obviously the type of signals we will use will be dependent on the situation and bandwidth and obviously of the transmission media that we are using.

(Refer Slide Time: 15:10)



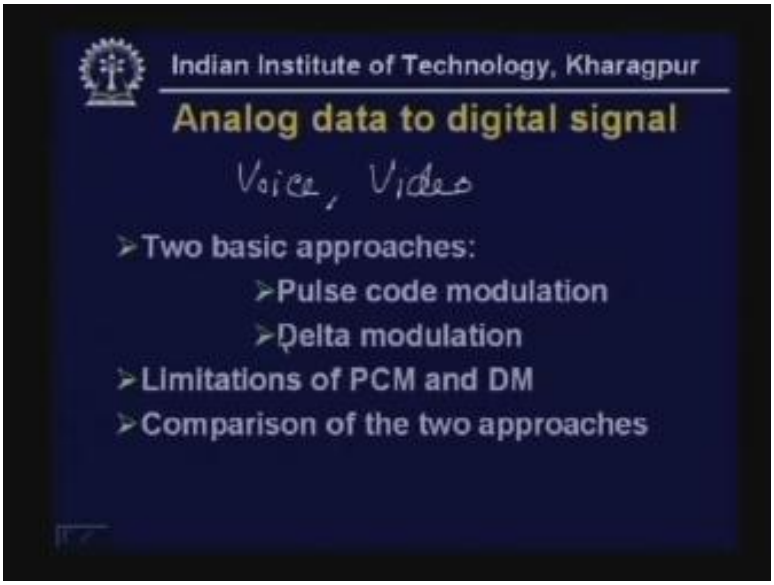
Let us look at the conversion techniques, coding techniques first. Here we have mentioned about the various techniques for digital to digital conversion. That means here we are doing encoding. The encoding can be divided into three types. This is known as line coding (Refer Slide Time: 15:04) so unipolar, polar and bipolar. Unipolar is not that popular because of its various limitations. We shall discuss about the limitations of unipolar transmission. And the polar where the signal has two different levels has got a number of varieties such as non return to 0 NRZ, return to 0RZ, Manchester encoding, differential Manchester encoding and so on. So these are the four popular polar techniques for line coding and we shall discuss about each of their advantages, disadvantages, bandwidth required etc in detail in the subsequent lectures.

(Refer Slide Time: 15:50)



So far as the bipolar techniques are concerned they have some advantages such as AMI Amplitude Mark Inversion then B8ZS and HDB3. These are the three popular bipolar encoding techniques and we shall discuss about these three techniques in detail.

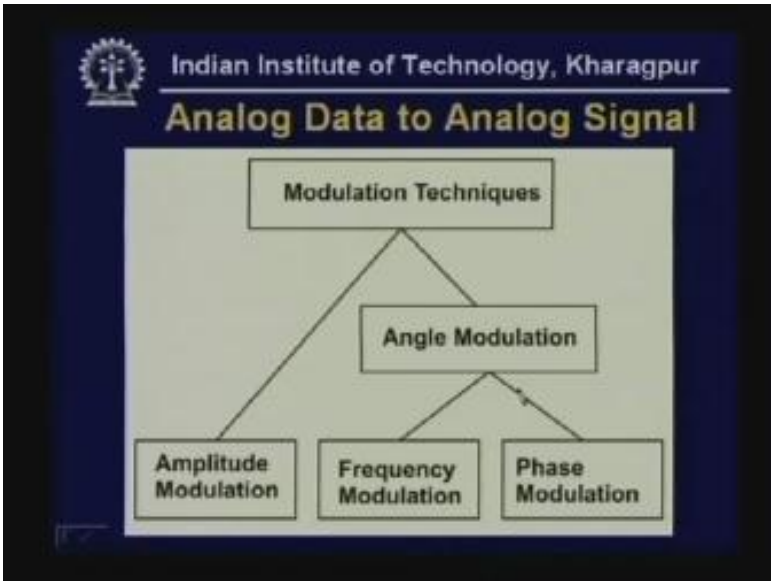
(Refer Slide Time: 16:23)



Coming to analog data to digital signals where data is analog in nature such as voice, video etc in such a case you have to convert the analog data into digital form and there are two basic approaches; one is know as PCM Pulse Code Modulation and second one is known as Delta Modulation.

We shall discuss about these two techniques and obviously we shall consider the limitations of both PCM and Delta Modulation technique and compare these two approaches in detail in subsequent lectures.

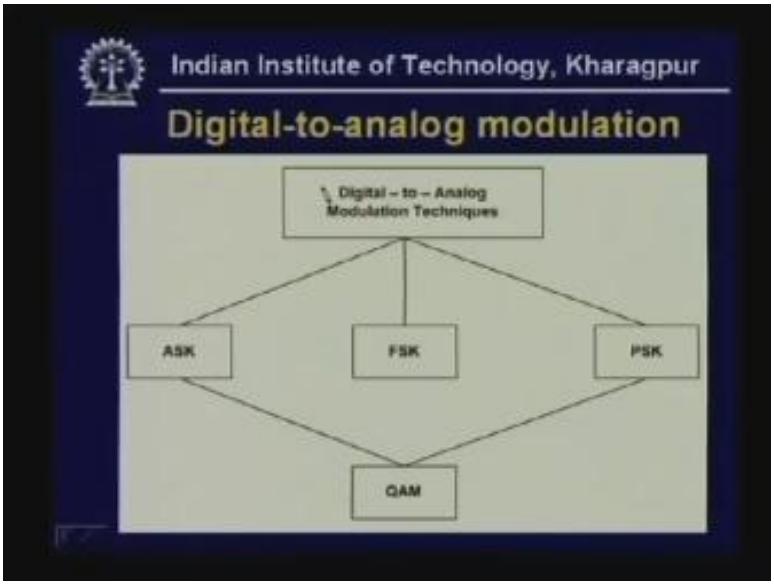
(Refer Slide Time: 16:50)



Coming to the modulation techniques where we are generating analog signal and if the data is analog in nature we have three different modulation techniques which can be broadly divided into two types; amplitude modulation and angle modulation. And again angle modulation has got two different components frequency modulation and phase modulation. When we discuss about data and signal we shall see that the analog signal has got three important parameters; amplitude, frequency and phase and any one of the three parameters can be modified or changed to embed some signal and actually this has lead to three different modulation techniques like amplitude modulation, frequency modulation and phase modulation.

We shall discuss about these three modulation techniques in detail, their advantages, disadvantages, the bandwidth required for transmission to the media, the immunity to noise and so on.

(Refer Slide Time: 18:04)



Coming to digital to analog modulation where the data is digital in nature and the signal is again analog in form in such a case again we have got three different techniques known as amplitude shift keying, frequency shift keying and phase shift keying and of course these two can be combined to form another modulation technique known as QAM Quadrature Amplitude Modulation. So we shall discuss about these four modulation techniques which are used for converting digital data to analog signal and these QAM and PSK are particularly used in many applications. ASK is used in transmission of signal through optical fiber so all these modulation techniques we shall consider in detail.

(Refer Slide Time: 19:03)

Whenever the bandwidth of the medium is very high it is possible to send several signal simultaneously and the technique that can be used is known as multiplexing. And in this lecture we shall discuss about the basic concepts of multiplexing and there are two different forms like frequency division multiplexing and wavelength division multiplexing rather three different forms frequency division, wavelength division and these two are essentially the same thing representing two different phase and then Time Division Multiplexing.

Again Time Division Multiplexing has got two different forms synchronous TDM and asynchronous TDM. We shall discuss about both of them and compare their advantages and limitations and as we shall see nowadays another technique that is being used is known as inverse TDM. So, when we discuss multiplexing techniques we shall discuss all these topics in detail.

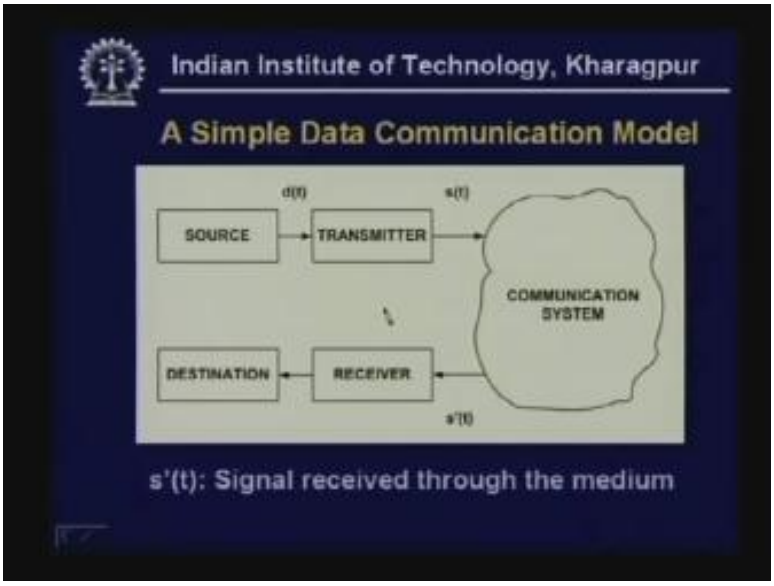
(Refer Slide Time: 21:45)

Of course the multiplexing has got very wide applications. and in this lecture series we shall discuss about four important applications and four important applications are telephone system which are used in our day to day life and we shall discuss how using multiplexing technique two different types of services known as analog services and digital services are provided.

And nowadays it is possible to have a broadband service using the telephone system known as DSL technology digital subscriber line technology and it has got three different types or three different variations like ADSL, SDSL and HDSL rather four different types ADSL, SDSL, HDSL and VDSL. We shall discuss about all the four one after the other and we shall discuss the multiplexing application. then we shall discuss about cable modem where the standard cable TV network can be used for transmission of data which is possible by using a technique known as Hybrid Fiber Coaxial network or HFC network and we shall see how multiplexing technique is used not only to send the TV signals but also to send data which can be used for internet access.

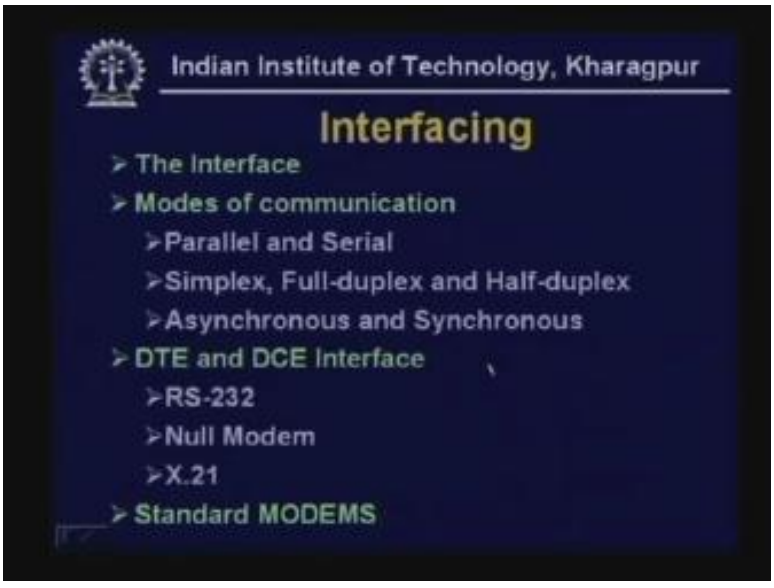
Then so far as the optical network is concerned we shall consider another important application of multiplexing known as SONET Synchronous Optical Network and Synchronous Optical Network provides you very high bandwidth. And we shall see how that bandwidth can be used and particularly the telephone system and SONET system can be integrated so that also we shall discuss in detail. So these are the four important applications of multiplexing. we shall discuss in detail in subsequent lectures.

(Refer Slide Time: 22:23)



Now we have discussed various techniques that is being used for sending signal through the communication system; the encoding techniques, modulation techniques and multiplexing techniques. And as the signal passes through the medium because of the various impairments the signal that is being sent S(t) is not same as it is received by the receiver. so signal received through the medium is different from what has been sent but what the receiver wants is a same thing now so we have to find out what kind of problem or what is the difference between the original signal and the received signal.

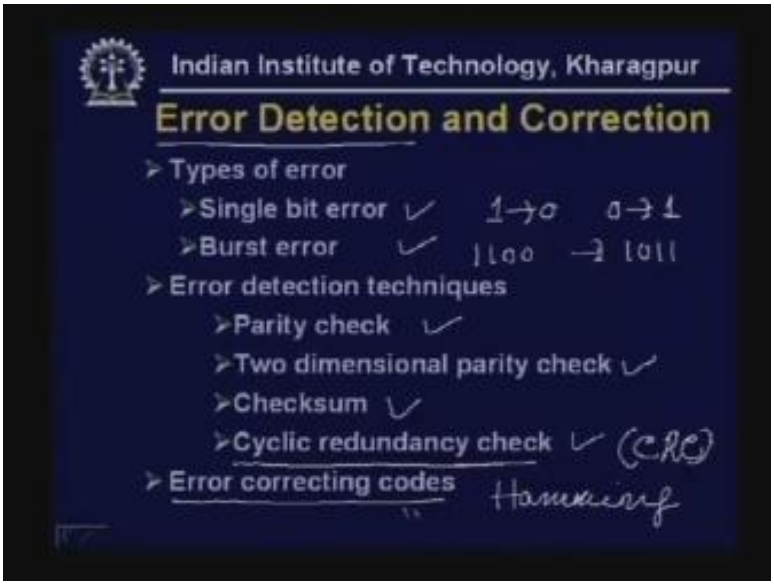
(Refer Slide Time: 00:23:13)



Particularly in this context we shall discuss first about how the interfacing to the medium can be done and for that purpose the various modes of communication we shall discuss like parallel and serial, simplex, full duplex and half duplex techniques. There are two approaches of serial communication and also parallel communication, asynchronous and synchronous we shall discuss about that, then DCE DTE interface that is being used for interfacing between the source and the transmitter and also for the destination at the interface. so these source and destination are known as the DTE Data Terminal Equipment and transmitter and receiver are known as DCE, so this interface will be discussed in detail known as RS – 232 and in this context there will be a concept known as null modem and X.21 also we shall discuss in detail.

And various types of modems or DCE being used will be discussed so that you can interface to the communication system. Then we have got another important concept. As we receive the signal we shall see that the data that is being sent by the source is different from the data that is being received so they are not same.

(Refer Slide Time: 26:45)



So in this context there is some problem and that problem is known as error. So, because of various types of impairments like attenuation, distortion and noise there will be error, error will be introduced in the signal, if it is a digital signal a 0 will become 1 and 1 will become 0 and obviously first we shall discuss about different techniques for detection of error and the various types of error that can occur. First of all we shall discuss about single bit error then burst error etc. In single bit error one bit gets changed from 1 to 0 or from 0 to 1.

On the other hand in the case of burst error a sequence of bits say 1 1 0 0 gets changed to 1 0 1 1 so this happens whenever a burst error occurs. We shall discuss about both of them and particularly various techniques that is being used for error detection such as parity check, two dimensional simple parity check where only one bit error detection is

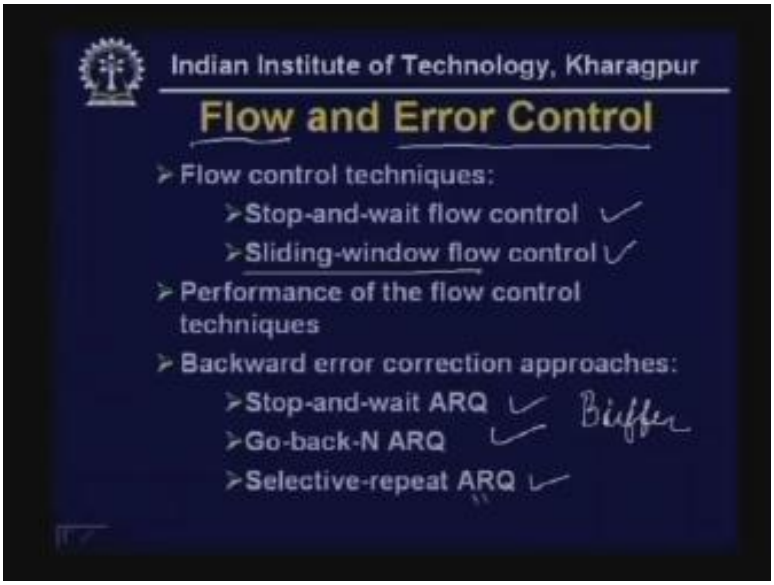
possible or odd number of error detection is possible, then two dimensional parity check, checksum and cyclic redundancy techniques. So these are the four different error detection techniques which are used for detecting both single bit error and burst error.

We shall learn about the cyclic redundancy check which is the most popular one which is known as CRC and possibly the most widely used technique. And apart from error detection techniques we shall discuss about error correcting codes which can be used to correct the error from the received data. This is known as forward error correction. So we shall discuss about how particularly by using hamming code the error correction can be done, we shall restrict our discussion to only single bit error correction.

However, in practice something else is done which is known as error control where actually a backward error correction technique is used instead of forward error correction. In backward error correction what is being done is if the received signal is found to be corrupted that means if there is error in it then the receiver sends a message to the transmitter to retransmit the data or message once again so it is based on retransmission and for that purpose there are several techniques. Apart from error control there is another technique which is known as flow control. Flow control is necessary whenever the transmitter and receiver are not of the same capability.

Suppose you have got a fast transmitter and a slow receiver, a server and a desktop system in such a case the transmitter can be sent at a very high speed but the receiver is not capable of receiving at that speed. So in such a case there will be over flow or the buffer of the receiver will become full so we have to overcome that problem and for that purpose the flow control technique is used.

(Refer Slide Time: 29:45)



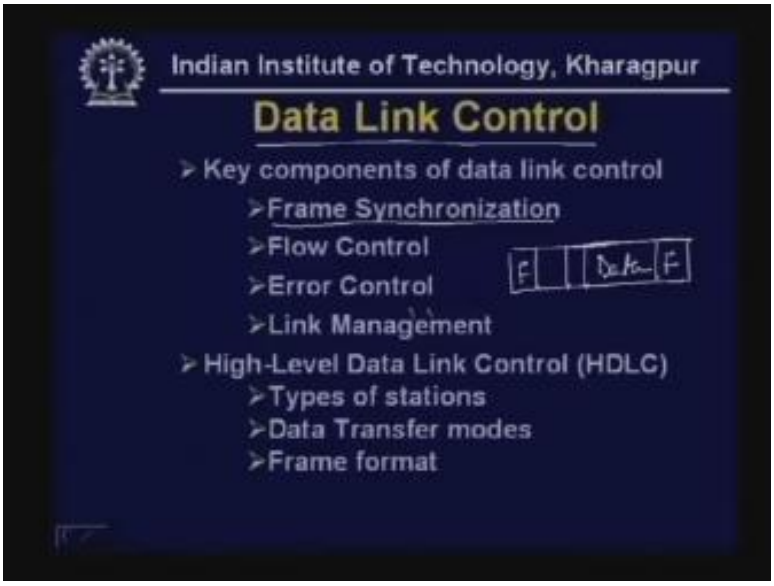
The first technique we shall discuss is the stop-and-wait flow control and also sliding-window flow control. So both these techniques will be used and as we shall see the performance of sliding-window flow control is better that's why it is widely used. And we shall see that these flow control approaches can be extended to perform error control or can be used for backward error correction and the technique which is used for this purpose is known as ARQ or Automatic Repeat Request.

There are three different variations of error control techniques. First one is known as stop-and-wait ARQ based on stop-and-wait flow control. We shall discuss about the stop-and-wait flow control in detail. There is another technique known as go back n ARQ which is based on sliding-window flow control approach. However, here error and lost frame is also taken into consideration. So we shall discuss about both stop-and-wait ARQ and go-back-N ARQ in detail.

However, go-back-N ARQ has some extra overhead because of retransmission of some frames which are not really necessary and that can be overcome by using selective repeat ARQ and we shall discuss about this selective repeat ARQ and particularly the buffer requirement in all the three cases and also the requirement of the number of bits that is required for numbering the frames so frame numbers are to be given so that this ARQ technique can work.

So number of bits required is again an overhead. That we shall discuss in the context of all these three techniques.

(Refer Slide Time: 31:00)



Now whenever we are sending signal through a communication system it is necessary to have synchronization at three different levels; at the bit level, word level and frame level. So whenever the data link control is performed essentially we are interested in frame synchronization. A sequence of bits or sequence of characters are being sent and

obviously in this context you have to identify when a particular frame is starting and when it is ending so to do that you have to use some kind of framing or a format has to be used such as it will have some flag at the beginning then you will have some addresses then the data and at the end also there will be some flag and also it may require some information for flow control, error control etc.

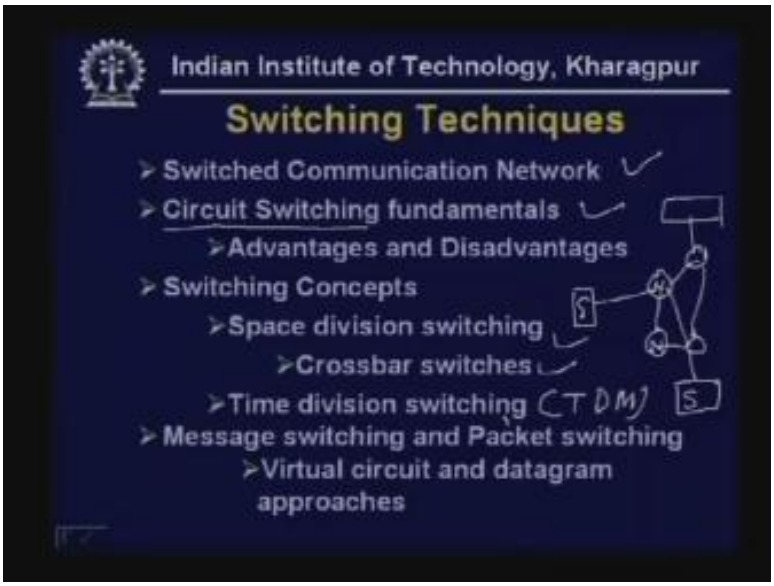
We will also discuss how the flow control and error control techniques are being used in data link control. And also it will be necessary to perform link management to initiate a link to continue the communication of messages and terminate the session so this is known as link management and in this context there is a standard which is widely used known as High Level Data Link Control or HDLC. Not only HDLC is widely used but also some limited versions of HDLC in some other forms are also used. And particularly we shall discuss HDLC in detail particularly some of the following important parameters of HDLC such as types of stations, data transfer modes, frame formats all these things we shall consider in detail in the context of HDLC.

For example, in the previous cases in case of say HDLC we are assuming that there are two stations here you have got one station and here you have got another station (Refer Slide Time: 00:32:30) and there is a direct link between them and they are communicating with each other that is the case of data link control. But it maybe necessary that a large number of stations or equipments may want to communicate with each other so in such a case this kind of simplified direct link cannot be used and in such a case we have to go for data communication through Wide Area Network and we have to use the switching techniques.

(Refer Slide Time: 00:33:00)

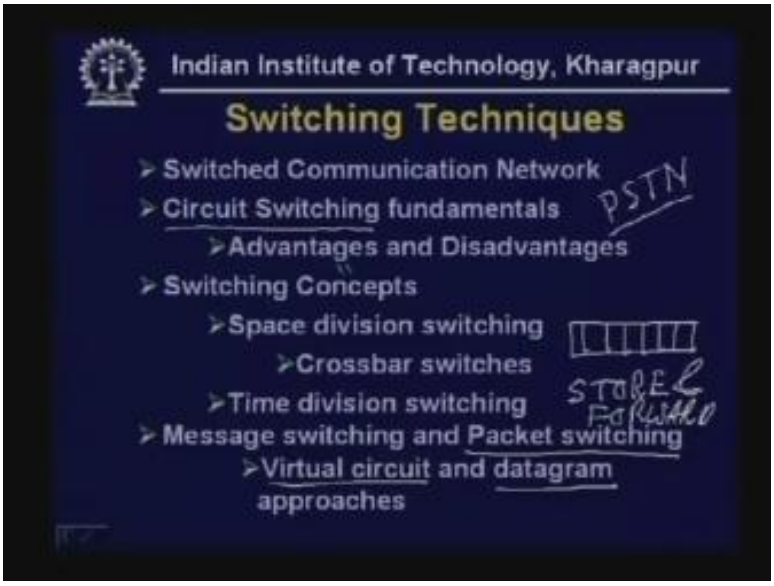
For example, there are different types of switching techniques and we shall discuss about switching techniques like circuit switching and in one lecture we shall discuss about the circuit switching techniques in detail after introducing the switch communication network and we shall see that in a switch communication network you will have a number of intermediate nodes through which signals are sent. So you will have some kind of stations and there is a number of intermediate nodes and these are essentially equipments which are used for communicating data to a number of stations and stations are connected to such nodes and that leads to a scenario known as Wide Area Network because these stations maybe located far away and they are connected with the help of nodes and in that context there are several switching techniques that is being used and the most popular one is known as circuit switching technique. We shall discuss about the circuit switching fundamentals, its advantages and disadvantages and how these circuit switching is implemented.

(Refer Slide Time: 34:48)



As we shall see there are different concepts like space division, switching using crossbar switches and time division switching like say it uses TDM Time Division Multiplexing. And we shall discuss about how space division and time division switching are combined to form a single switching technique. Then we shall discuss about message switching and packet switching. And in the context of message switching we shall see how a message can be sent through a switch communication network and what are the limitations of a message switching technique and particularly as we shall see whenever a long message say several gigabytes are sent through a network it monopolizes the network, it increases the probability of error and as we shall see whenever a weak message is sent the probability of corruption increases that's why messages are usually sent in terms of a number of packets. That means a single message is divided into a number of packets and each of them is sent separately and that is known as packet switching. We shall see that packet switching is very efficient compared to messages switching.

(Refer Slide Time: 37:25)

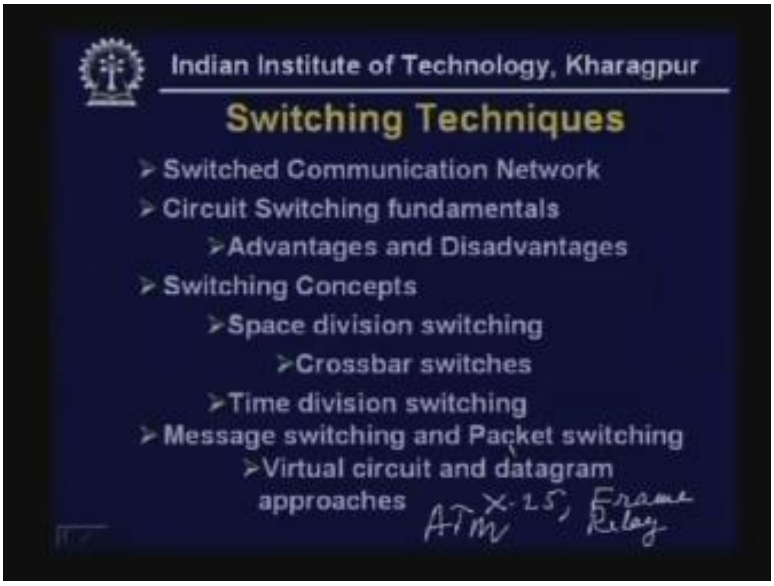


We shall discuss about various packet switching techniques such as virtual circuit packet switching and datagram circuit packet switching and we shall compare the virtual circuit packet switching and datagram circuit packet switching in detail and see how they are compared with each other and what are their advantages and disadvantages.

Circuit switching is essentially similar to the telephone network where you have to establish a link then do the communication. On the other hand packet switching is very similar to the postal system where we can send a letter and drop it in the letter box and then it can be sent to the next post office and so on. Essentially it is based on store and forward.

We shall discuss about the packet switching and circuit switching techniques in detail and particularly the application of circuit switching that is being done in Public Switch Telephone Network PSTN network where the circuit switching has the biggest application. Then we shall discuss about some important applications of packet switching in different types of network such as X.25, frame relay and also in ATM.

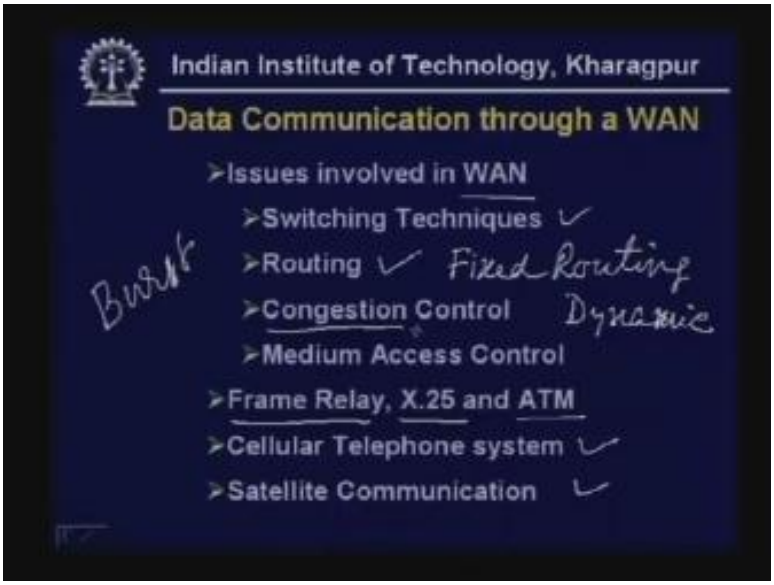
(Refer Slide Time: 37:50)



So we shall discuss about these three different types of networks where circuit switching and packet switching concepts are used and we shall see how data communication can be done through these networks. Then after discussing the various concepts of Wide Area Network there will be other techniques which I have not mentioned in the context of Wide Area Network. Particularly we shall be having a number of techniques. As I mentioned frame relay, X.25, ATM we shall consider and also we shall consider cellular telephone networks and satellite communication. We shall discuss about each of these networks in detail and also see how the various techniques have been used.

And in the context of Wide Area Networks we also have to use routing apart from the other switching techniques because these messages or packets have to be sent through a number of nodes so we need to know the route. We shall also discuss about the different type of routing techniques such as fixed routing, dynamic routing, flooding and so on.

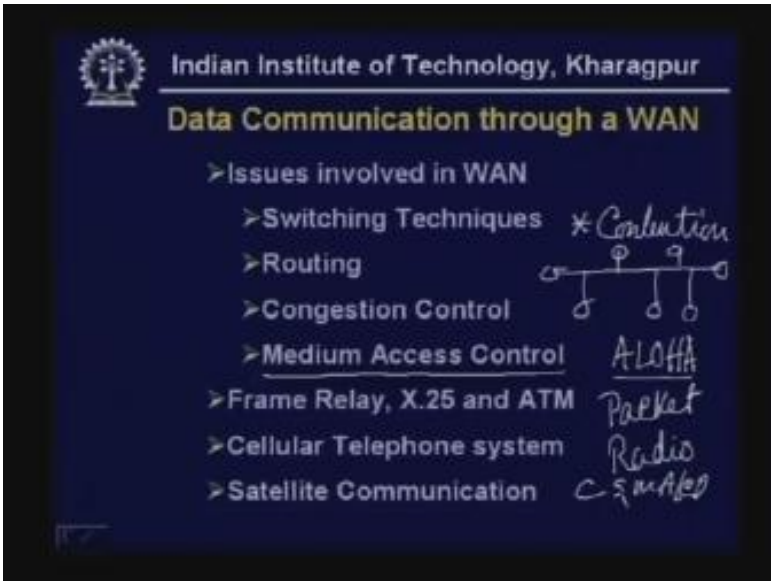
(Refer Slide Time: 40:20)



Another important concept in this context we have to discuss is known as congestion. The Wide Area Network can be considered as a network of packets. Now, whenever a large number of packets are sent through the network a problem known as congestion occurs. just like on the road whenever large number of cars come to the road traffic congestion occurs so similar to that congestion occurs in Wide Area Network whenever large number of nodes are sending packets. Particularly whenever a large burst of packets are sent it leads to congestion.

We shall discuss about various techniques by which we can first of all prevent congestion. So, congestion control can be done in two ways. First we shall consider how congestion can be prevented and second technique is whenever congestion occurs how we can come out of it. So we shall discuss about both the techniques like congestion prevention and also congestion control which we have to apply as whenever congestion occurs how we have to come out of that.

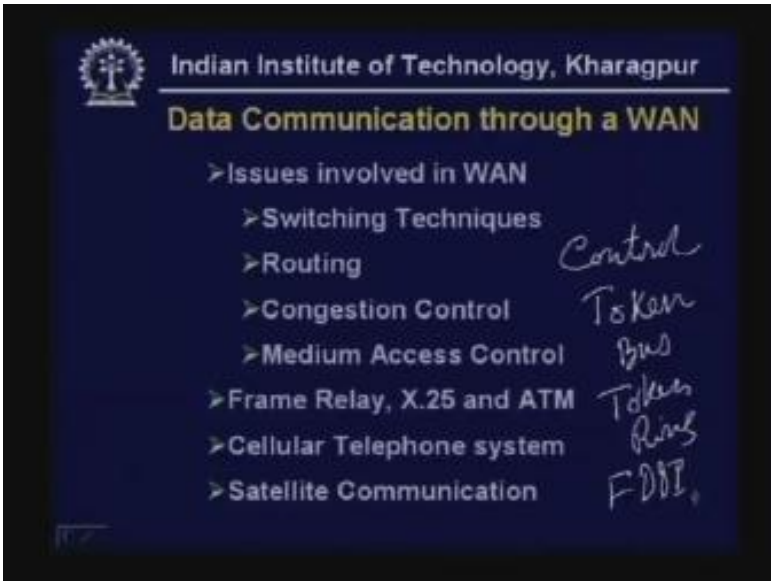
(Refer Slide Time: 42:22)



Then we shall discuss about the various Medium Access Control techniques. Medium Access Control techniques can be of different types. For example, it can be based on contention, contention based. That means you have got some kind of shared media and a number of nodes are connected and these nodes are having equal right to access the node. Then all these nodes are contending to get access to the network. So in such a case we have to use Medium Access Control technique based on contention and this contention based Medium Access Control techniques has a number of types.

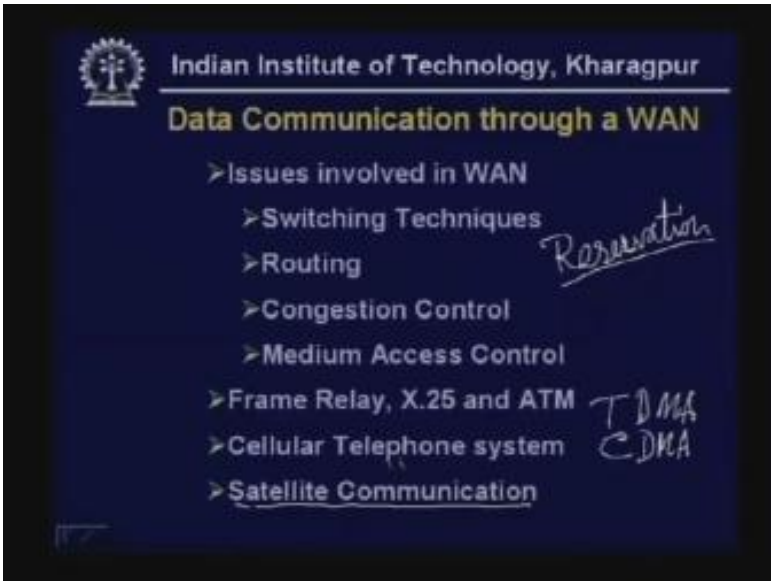
For example, it starts with ALOHA which is used in packet radio network so we shall discuss about aloha then there will be other techniques which are based on CSMA Carrier Sense Multiple Access which overcomes some of the limitations of aloha then we shall discuss CSMA CD Carrier Sense Multiple Access with collision detection particularly it improves the efficiency over CSMA. So apart from this contention based schemes we shall also discuss control based schemes based on token bus and token ring which is again based on sending tokens. That means whenever a number of nodes are there a station which is having that token will be able to send and this is how the contention is overcome.

(Refer Slide Time: 43:19)



So we shall discuss about this token parsing techniques in the context of Medium Access Control and this token parsing control techniques are popular in many applications for example in FDDI an important Local Area Network technique the token parsing technique is used for Medium Access Control. So apart from token parsing techniques the control access techniques there are other techniques which is based on reservation. There are many applications particularly which is used in satellite communications. You will see that neither the contention based schemes nor the token parsing schemes can be used because of the long delay. So in such a case we have to use a technique known as reservation scheme. So we shall discuss about the reservation techniques which is used in satellite communication. Reservation techniques are important whenever the delay is very large. We shall also discuss about the satellite communication and we shall see how reservation technique is used in satellite communication.

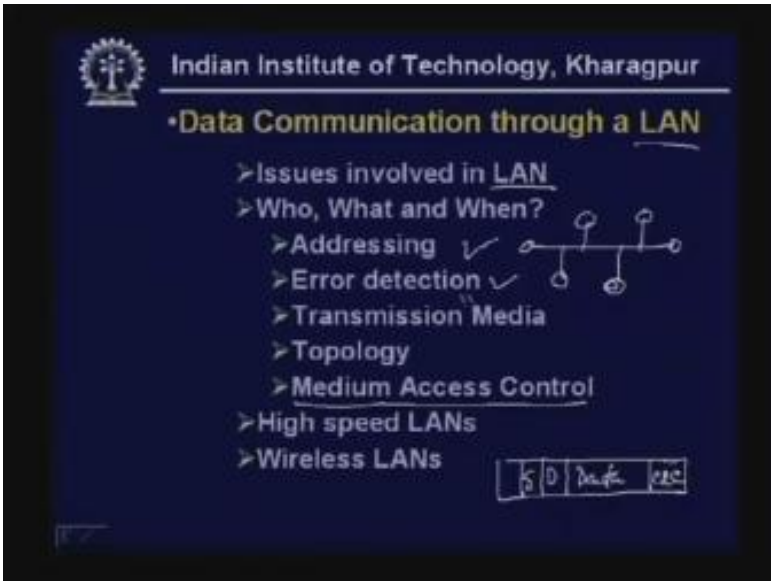
(Refer Slide Time: 44:33)



On the other hand the contention based techniques are used in LAN and also it is being used in cellular telephone system for example CDMA Code Division Multiple Access or TDMA Time Division Multiple Access. These techniques are used in cellular telephone systems so shall discuss how they are being used.

We shall see in cellular telephone systems not only multiplexing but also multiple access techniques are used and we shall see how they are combined to improve the efficiency of cellular telephone system. So, after discussing the WAN we shall discuss about the data communication through LAN Local Area Network. And the Local Area Network can be used whenever the geographic region is limited to few kilometers. We shall discuss various issues involved in Local Area Network like what it is sending information, to whom it is sending and when it is sending. suppose you have got a shared media which is being accessed by a number of users in that case the LAN technique has to decide to whom it should be sent, what will be sent which means what will be the size of the packet as to the minimum and maximum size and when it can send.

(Refer Slide Time: 46:53)

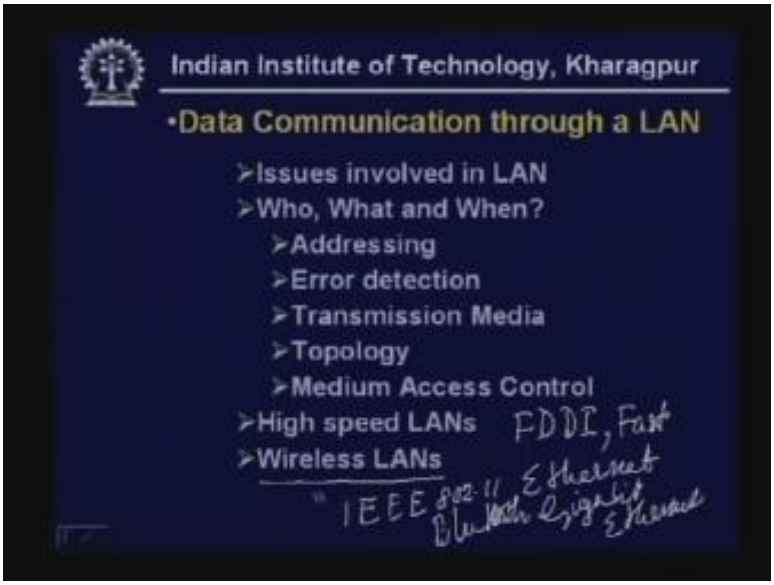


Obviously there will be several techniques. We have to use several techniques like Medium Access Control as I mentioned. Particularly in the context of LAN both contention bas based schemes and token parsing schemes are used. We shall discuss how they are used in various Local Area Networks.

So in the context of LAN we have to use some kind of addressing so that the sender and transmitter details will be recorded like who is sending the packet or frame and where it is going. That means the sender and receiver has to be identified and for that particular purpose addressing has to be used. So the address of the source and the address of the destination are to be sent which is known as addressing. We have to use error detection whenever the data is in a frame that is being sent and we shall see that there will be some address information, source address, destination address apart from data and also there will be some CRC check for detecting errors. Therefore error detection is used in the context of Local Area Networks.

Apart from the conventional legacy LANs like Ethernet, token ring or token bus we shall also discuss about high speed LANs such as FDDI Fiber Distributed Digital Interface, fast Ethernet and gigabit Ethernet techniques that is being used in high speed LANs.

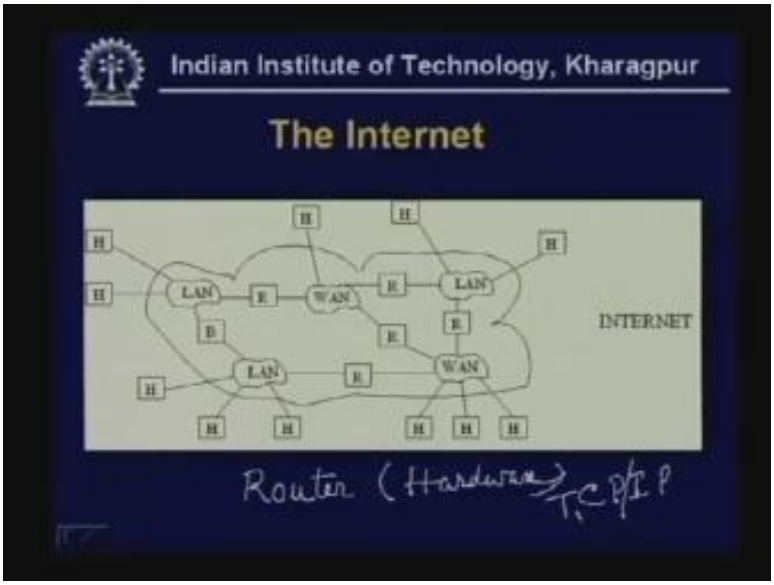
(Refer Slide Time: 00:48:15)



Nowadays the wireless Local Area Network is becoming very popular so we shall discuss about the Wireless Local Area Networks such as IEEE 802.11 based techniques and also we shall discuss about other techniques like Bluetooth that is being used in Wireless LAN. So we shall discuss about the legacy LANs like Ethernet and also about the high speed LANs and Wireless LAN in detail.

Then as we shall see apart from Local Area Networks and Wide Area Networks most of the people are communicating through internet, data communication is done through internet so we shall discuss about the internet. And as we shall see internet comprises a Local Area Network, Wide Area Network and they are bound together with the help of suitable software and hardware. So the basic objective of internet is to connect individual heterogeneous networks both LAN and WAN and distribute it across the world using suitable hardware and software in such a way that it gives the user the illusion of a single network.

(Refer Slide Time: 49:50)



So the single virtual network is widely known as internet which is essentially a network of networks. Question arises as what is the hardware and software that is needed.

As we shall see here apart from this host which is essentially the computers you have got LANs Local Area Network and Wide Area Network and there are other devices which is known as R essentially they are routers so you will require router that is the hardware that you require. So this is the hardware you require to link the various heterogeneous networks LAN and WAN. We shall discuss about the capability of router and how the routing is done. And also we shall discuss about the software the software that is being used in this context is known as TCP IP. So transmission control protocol and internet protocol is actually the software and that acts as a glue or which binds the various Local Area Network and Wide Area Network together so we shall discuss about TCP IP briefly.

Then whenever the data communication is done through internet we have to discuss about a number of techniques such as segmentation and reassembly. A particular packet may not be sent through a particular network because of the restriction and the maximum size so it has to be segmented or divided. We have to discuss about the segmentation and how the reassembling is done before delivering it to the destination. Also, we have to discuss about the encapsulation how the frames can be encapsulated, encapsulated to be sent through internet, how the connection control is done, how ordered delivery is been performed, how the addressing is done by using that internet address IP address and various types of IP addresses that is being used and how multiplexing is done through a single interface.

(Refer Slide Time: 51:29)

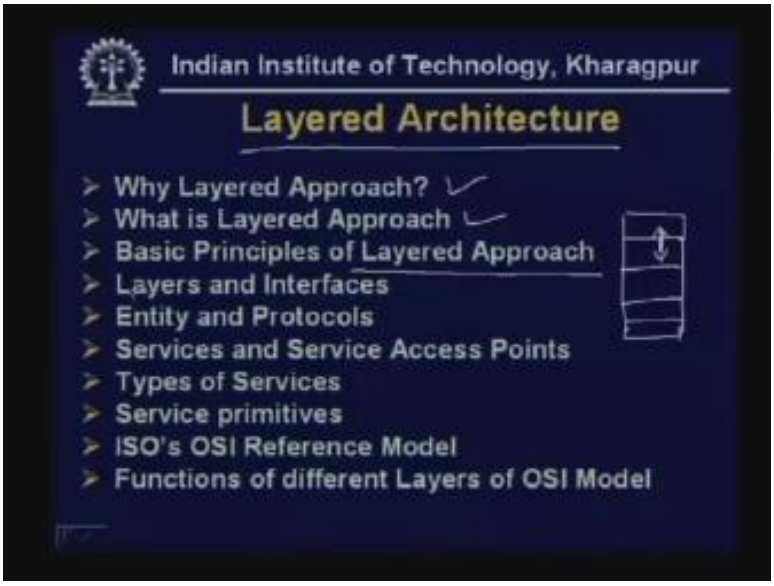
We can have access to multiple devices which is known as multiplexing and how these are all incorporated as part of TCP IP. We shall also discuss about the data compression that can be used for sending different types of signals through the mid transmission media for efficient communication and also we shall discuss about the data encryption techniques which is used for secrecy purpose or for the purpose of security and various types of transmission services as a priority grade of service and security.

All these sources will be discussed in detail particularly in the context of data communication through the internet. and by now you must have realized that the data communication is not a very simple technique it will involve a number of very complex techniques. we have already mentioned about a number of techniques and obviously we shall see that it becomes a very complex thing.

So, in such a case whenever we have to deal with a very complex system normally we use a layered approach. Layered approach is essentially a divide and conquer approach where a complex problem is divided into a number of simple problems and that each of these simple problems is solved independently and individually and that is being precisely used in layered architecture.

So, for the purpose of data communication we have to use layered approach and in fact the next lecture that we shall deal is on layered architecture where we shall discuss about what layered approach is and why layered approach is used and what are the basic principles of layered approach and how various layers for example a system is divided into a number of layers and each of these layers is responsible for performing different functions.

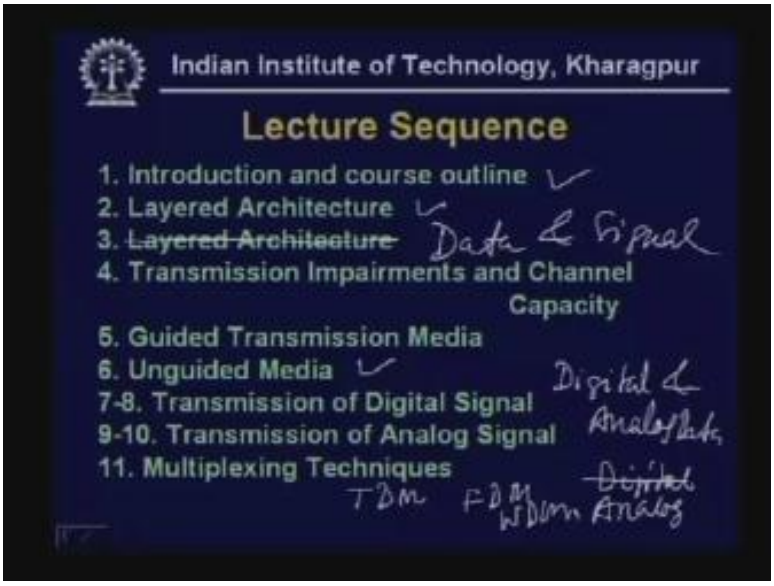
(Refer Slide Time: 53:52)



Obviously questions will arise as how these layers interact with each other. So in that context we shall discuss about layers and interfaces and we shall see the various functionalities that is being provided which can be hardware, software or a combination of them which is known as entity and how various protocols, protocols are essentially agreed upon rules and conventions that is being used for communication and how these protocols are used in a layered architecture.

And in the context of layered architecture we have to discuss about services and service access points, types of services, service primitives and particularly we shall discuss about the ISO's OSI reference model. International Standards Organization has proposed a open system interconnection reference model which is essentially a framework of standard and that is being widely followed. So in the next lecture we shall discuss about the ISO's OSI reference model and the functions of different layers used in version OSI model will be discussed in detail.

(Refer Slide Time: 57:33)



So, to summarize let me give you some idea about the lecture sequence.

First lecture that is being on now is essentially the introduction course outline which is this lecture. Then we shall discuss about the layered architecture, third will be essentially data and signal then the fourth lecture will be on transmission impairments and channel capacity, the fifth lecture will be on guided transmission media such as twisted pair, coaxial cable and optical fiber and the unguided medial will be covered in sixth lecture and there we shall discuss about those radio and other techniques that I have mentioned like the wireless communication techniques we shall discuss in detail.

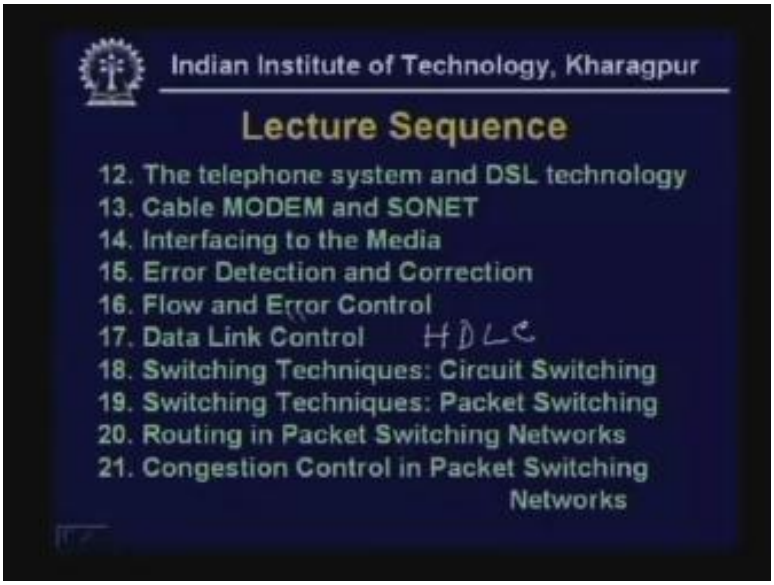
Then transmission of digital signal will be covered in seventh and eighth lectures that is essentially the encoding techniques that I mentioned those unipolar, polar and bipolar techniques that is used for converting digital and analog data into digital signal. Sso this will be covered in these two lectures seventh and eight lecture and ninth and tenth lecture will cover transmission of analog signal that means how the digital and analog data is converted not in digital form but in analog form by using different analog modulation techniques such as amplitude modulation, phase modulation and frequency modulation when it converts analog data to analog signal and also the ASK Amplitude Shift Keying, Frequency Shift Keying and Phase Shift Keying used for converting digital data to analog signal.

We shall discuss various multiplexing techniques in lecture 11 where we shall discuss about the Time Division Multiplexing, Frequency Division Multiplexing and in the context of TDM as I mentioned we shall discuss about synchronous TDM and asynchronous TDM and in the context of FDM we shall also discuss about the wavelength division multiplexing.

Then lecture twelve will cover the telephone system and DSL technology which are essentially the applications of multiplexing. Lecture 13 will cover cable modem and SONET, lecture 15 will cover interfacing to the media then lecture fifteen will cover various error detection techniques and error correction techniques by using hamming code and flow control and error control techniques will be covered in lecture number 16 where we shall discuss about stop-and-wait flow control, go-back-N ARQ techniques and so on.

Therefore various ARQ techniques and flow control techniques will be covered in lecture sixteen and data link control particularly that HDLC will be covered in detail in lecture number 17, then lecture number 18 will cover the switching techniques such as circuit switching and lecture number 19 will cover packet switching various characteristics and features of packet switching lecture number 20 will cover routing in packet switching networks.

(Refer Slide Time: 58:17)

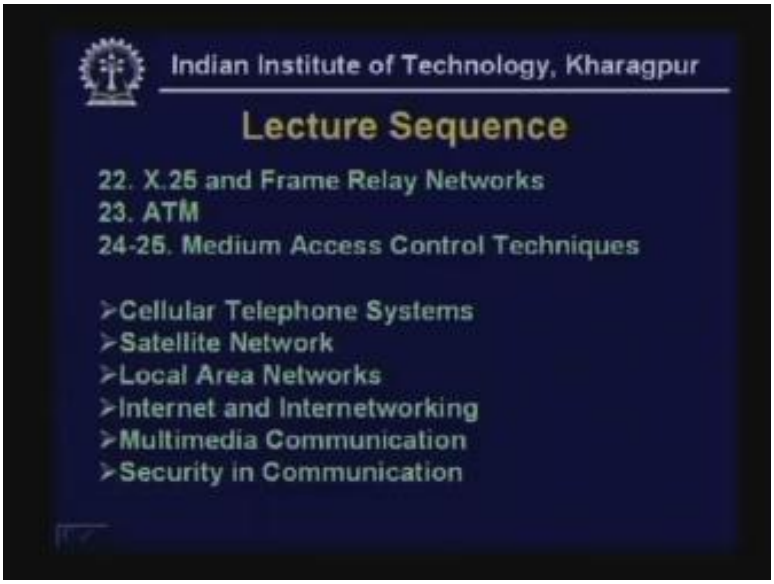


As I mentioned we have to use routing technique whenever we send packets through packet switching networks. Then congestion that happen in packet switching networks will be discussed in lecture 21 and lecture number twenty two will cover the Wide Area Network based on networks based on X.25 and frame relay, lecture twenty three will cover ATM the Asynchronous Transmission Mode and in lecture 24 to 25 we shall discuss about the Medium Access Control techniques such as contention based then token parsing based, reservation based all these techniques will be covered in lecture number 24 – 25.

And in the remaining lectures we shall discuss about cellular telephone network, satellite network, various Local Area Network including high speed Local Area Network and Wireless Local Area Network and we shall discuss about the internet and internet

working techniques and we shall also discuss about the multimedia communication where we have to use the compression and decompression techniques and we shall discuss about this security in communication where we shall discuss about encryption and decryption techniques where involve other techniques that will be in use. So this is the nut shell which will be covered in this lecture. So with this we come to the end of today's lecture the first lecture.

(Refer Slide Time: 58:50)



Thank you.