Real Time Systems
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Lecture 48
Basic of Real – Time Communication

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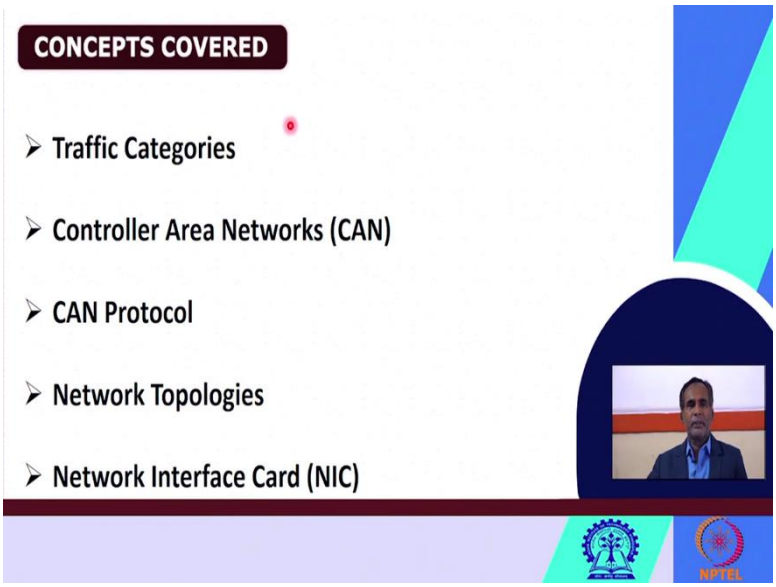

Good afternoon to all of you, today we will discuss some basic concepts of real time communication. We will cover first the different traffic categories, then the something about the controller area networks, the protocol for controller area network, different network topologies and network interface card.

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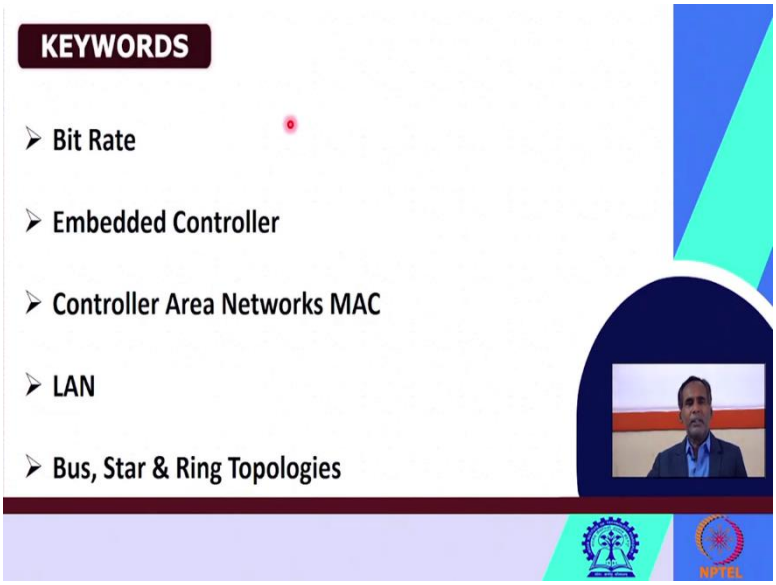

We will use these keywords bit rate, embedded controller, controller area networks MAC and LAN the different topologies such as bus, star and ring.

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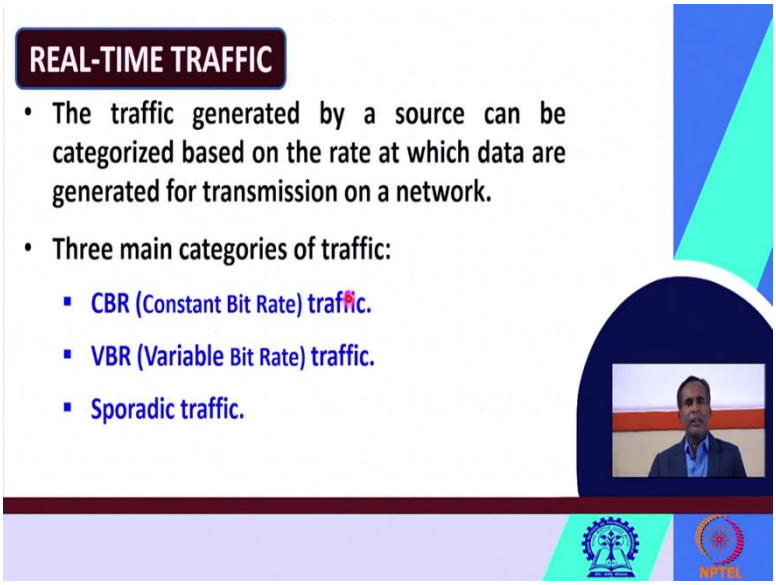

Let us, start with the real time traffic. So, normally the traffic generated by a source it can be categorized into three important classes based on the rate at which the data are generated from a source for the transmission on a network. Let us, see what are those are three improtant classes. So, the three main categories of traffic based on this classification are as follows. Number one, the CBR traffic or constant bit rate traffic, then VBR traffic or variable bit rate traffic, then sporadic traffic.

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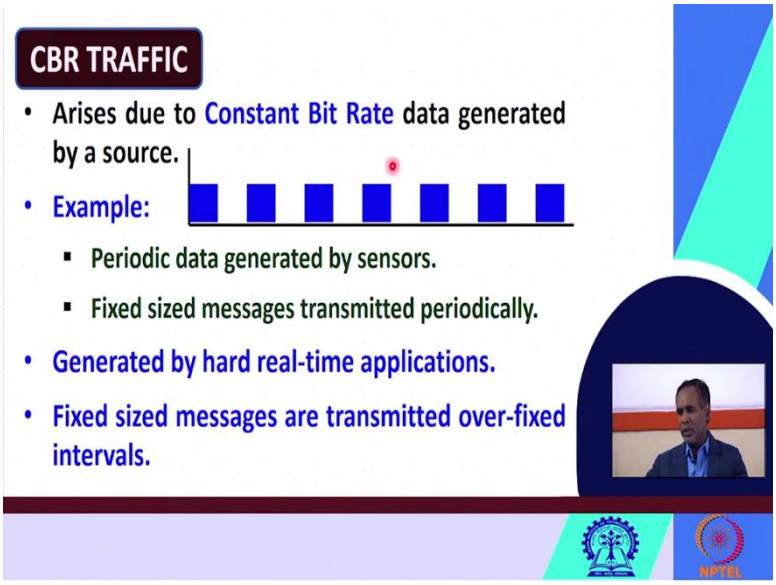

Let us, start with this CBR traffic. As its name suggests the CBR, CBR stands for constant bit rate, so traffic it arises due to the constant bit rate data generated by a source. So, I am repeating again that CBR traffic how do they arise? They arise due to the constant bit rate data which are generated by a source, so here the data those are generated are of constant bit rate, example we will see where CBR traffic they are used like you see the periodic data generated by us with the sensor.

Suppose there is a temperature sensor, it is what sensing the temperature of environment so here the periodic data that is generated by a sensor maybe example of the constant bit rate, similarly another case where messages they are transmitted periodically and those messages are of fixed size. They are also the examples of constant bit rate traffic. So, two examples I had given, the periodic data generated by the different sensors maybe temperature sensor or pressure sensor etcetera, then the fixed sized messages which are transmitted periodically.

So, these CBR traffic they are generated normally by the hard real time applications, I hope so you have already known what is the hard real time application, soft real time application and firm real time application. So, the CBR traffic they are normally generated by the hard real time applications. The fixed messages size they are transmitted over fixed intervals. So, as I have already told you in an example here fixed message sizes they are transmitted periodically, how they are transmitted? These fixed size messages in CBR traffic they are transmitted over fixed intervals.

So, here the intervals are of fixed type. We will take see the example like this year, see here the data generated periodically and you see the here the bit rate is constant see almost we see

how this is constant here, so and they are genetic just periodically, first say this is supposed one millisecond then again something is vacant, idle, then again one millisecond, then again idle like this, so here the data generated by maybe a sensor they are periodically generated and the what you can see this bit rate is constant, this is the example of CBR traffic.

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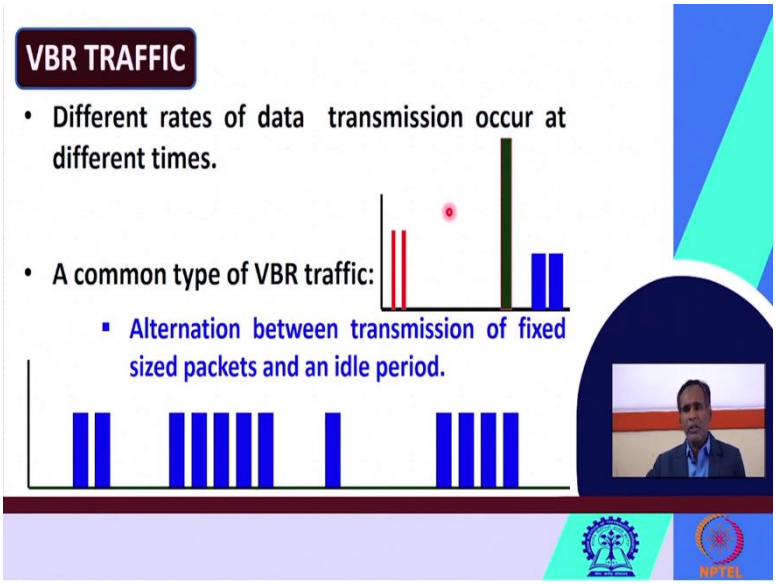

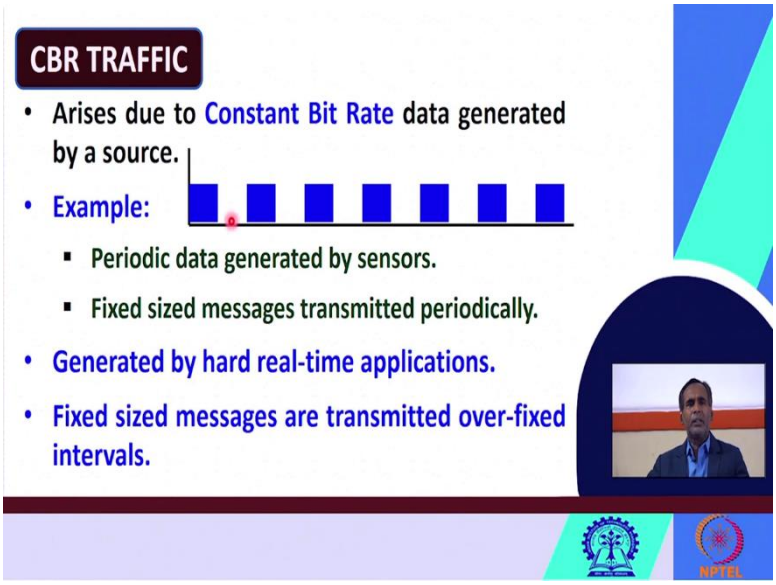

Now, let us quickly see about this VBR traffic, as its name suggest VBR transfer, a variable bit rate traffic, here is just in case of CBR, these arises to what? Constant bit rate data. So, here these here the data the different rates of data transmission occur at different time. So, here the different rates of data transmission occurs, so here fixed rate data transmission, here different types of data transmission, variable rates of data transmission occur at different times.

So, when VBR traffic different types of data, or what variable rates of data or variables size of data transmission occur at different times. So, we can take a small example, a common type of VBR traffic is the alternation between transmission of fixed size packets and an idle time. So, some for some time what will happen? Some fixed size packets they will be transmitted and then again for some time the period is idle, you can see an example here I am showing.

So, here like this first say for 2 milliseconds say what you can see some data transmitted and again see for again for some period this time is idle. Then again for some period again what some data is transmitted, then again it is idle, then again some data transmitted then idle, so like these different rates of data transmission occur at different times, so that is why we say that this is of variable bit rate, and the common example that I have shown here alternation between transmission of fixed size packets and the idle type idle time period.

So, here see data packets are fixed, but you can see that alteration, for sometimes these fixed data size packets are transmitted and some other times you see these white places means they are of idle period. This is an example of VBR traffic. Now, let us quickly see this is another example I am showing here that this is also variable traffic, so you can see first to this red color signal say that some data is transmitted, then say for a long period this is what this is the idle period.

Again in the next some time period maybe one millisecond or so, again some data of different sizes, some data of different size is transmitted, again some period of vacant, again some what less size of data rate that bit rate variable bit rate again, so here the data that is transmitted of its size is different. So, this is not constant, so that is how you say that this is a variable bit rate traffic. So, here different rates of data transmission occurr at different times.

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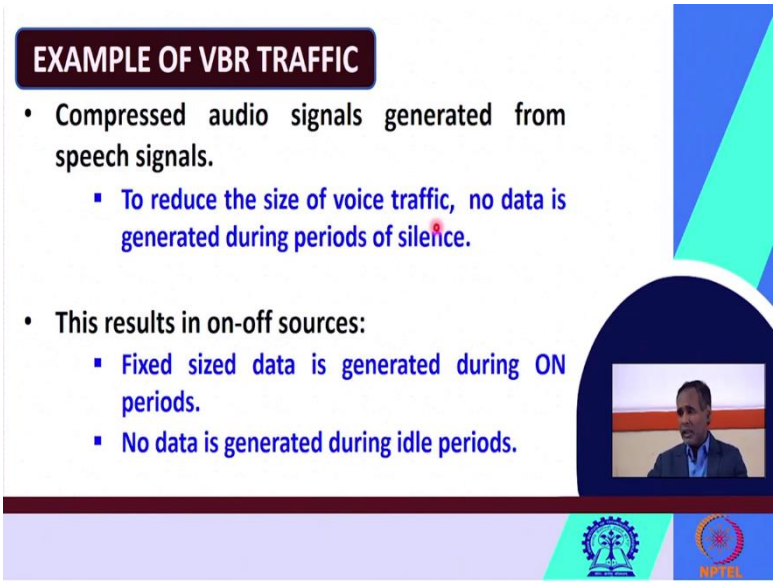

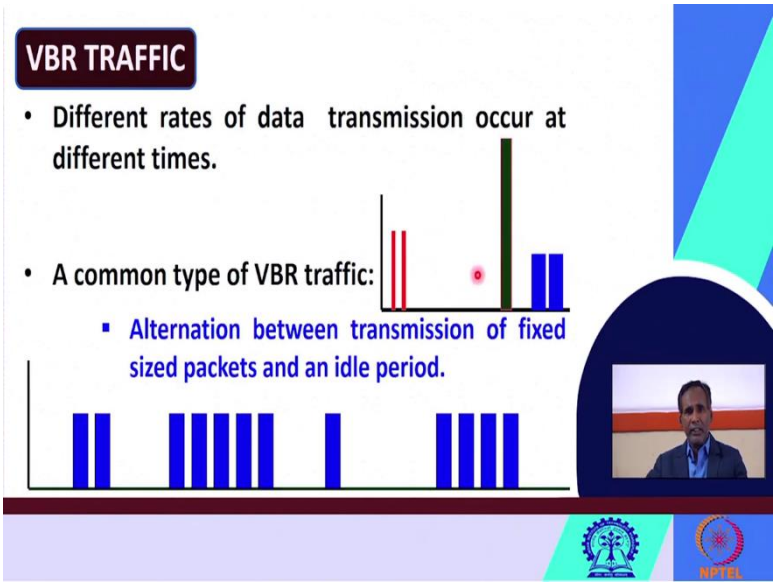

So, where we can find the application of VBR traffic let us see some examples. So, the examples are like the compressed audio signal generated from speech signals. So, you see when somebody is talking maybe you are recording about how this what some speech like one speaker is delivering a speech you are recording it and then you will what delivery it so here the compressed audio signals generated from the speech signals here are to reduce this idea of the voice traffic no data is generated during periods of silence.

So, in order to reduce the size of the voice traffic deliberately what is being done, no data is transmitted during the silence period, you can see here this is this period is the silence period, this period is the silence period, so during this period no data is transmitted, why? In order to maintain in order to reduce this size of voice traffic. So, in case of compressed audio signals,

which are generated from speech signals, so in order to reduce the size of the voice traffic no data is generated during the period of silence.

This results in on-off sources, so if that means for some time you will transmit data and for some time you have to remain silence, you have to maintain idle period. So, this results in case of on-off sources, let us see in on period what you will do and off period what is being done. So, in case of on period fixed size data is transmitted is generated. So, during the on period fixed size data is generated, so fixed size data is generated during on periods and in the idle period what is happened? No data is generated during the idle period. So, these type of cases they may result in on-off sources.

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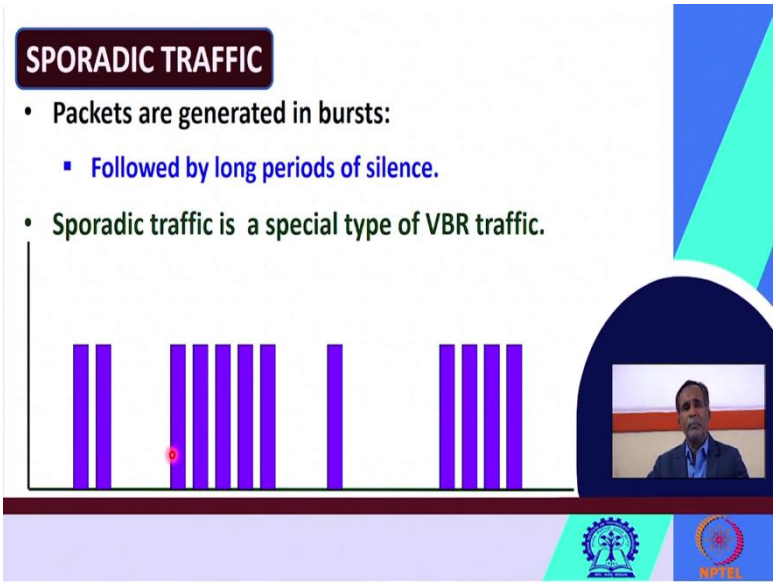

Then you will see the third category that is sporadic traffic, I hope you have already known three types of events earlier periodic events or periodic task, aperiodic task or aperiodic events and sporadic taxes, sporadic events. So, in case of this sporadic traffic the packets are generated in burst, here the data packets they are generated in burst and followed by long periods of silence.

And then it is remained silent for a very long period, and you can see that the sporadic tropic is a very special case of what VBR traffic, we can take a simple example, you know that this is a case of this VBR traffic where for some time some data is transmitted in burst, see like this you are continuously some data transmitted, then for some time it is remaining idle.

Similarly, again for 1 millisecond so data is transmitted, then for a long period no data occurs no data transmission occurs, no packets are generated. So, then it is remaining idle. So, in this

case we say that the packets are generated in burst and followed by long periods of silence for a long period of time no data are generated, no packets are generated.

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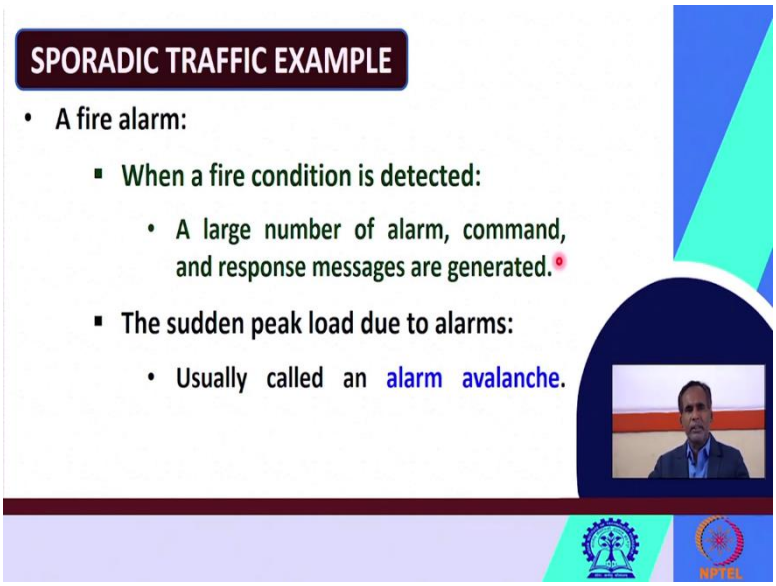

You can take the example, good example of the fire alarm system those are put in multi storied buildings. So, how does the fire alarm works? So, when a fire condition is detected, then what happens? A large number of messages are generated, for example, a large number of alarms, large number of commands and large number of response messages are generated because a fire condition a smoke is detected.

And then as soon as this what fire is extinguished, then what will happen? Then again it will come to this normal position, then the sudden peak load it becomes idle, then no data is generated, because no fire is detected, no smoke is detected. So, this sudden peak load due to the alarms is usually called an alarm avalanche. So, in this case what happens?

Only when some fire condition is detected or smoke is detected then a large amount of data large amount of packets will be generated otherwise it is remaining idle, no data is generated for a long period of time. So, till the what smoke or this what fire condition is detected. It is a very good example of sporadic traffic example.

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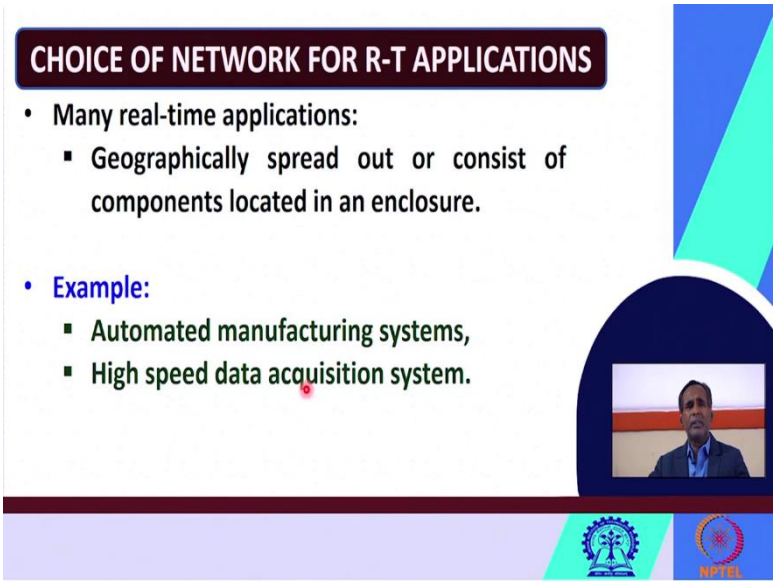

And see then the choice of network for R-T applicants, for real time applications how do we select which type of network we will use. So, normally many real time applications they are geographically spread out or consist of components located in an enclosure, is not it? So, normally these real time applications they are geographical spread out, they spread out to different geographical places or they may consist of different components which are located in an enclosure.

Examples of real time applications already I have told in the last class like this manufacturing automated company, then this internet banking and internet telephony etcetera here also I have given two more examples, automated manufacturing systems, high speed data acquisition systems, so here are these real time applications or real time communication they are applied here. And now we will choose for these real time applications what type of network can you use.

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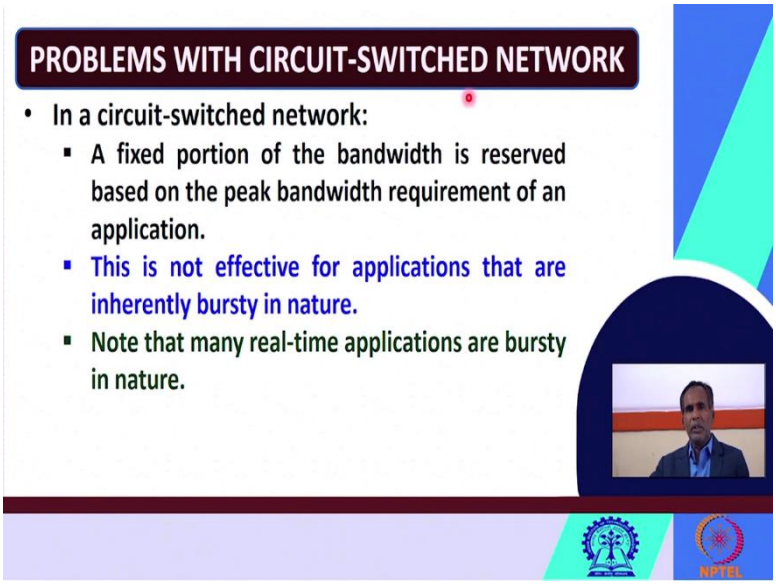

You know traditionally there are different types of network like packet switch network, circuit switch network, end to end wiring et cetera, let us see about if we will use a circuit switch network, what problem will occur? So, the problem with circuit switch network are as follows. In a circuit switch network, a fixed portion of the bandwidth is reserved based on the peak bandwidth requirement of an application.

So, as its name suggests circuit switched network, so what does it do? In a circuit switch network, a fixed portion of the bandwidth, what is the total bandwidth? A fixed portion of the bandwidth is reserved; it is reserved based on what? It is reserved based on the peak bandwidth requirement of an application because the bandwidth may not be required equally at all the time, sometimes you might require a high value of bandwidth that we call as peak bandwidth that may occur at the peak time.

So, a fixed portion of the bandwidth is reserved based on the peak bandwidth requirement of a particular application, but this is not effective for applications that are inherently bursty in nature. So, the applications which are bursty in nature, burst means what? At a time suddenly a high volume of data will come. So, this is not effective for applications that are in the bursty in nature. And you have known that most of the real time applications they are bursty in nature. So, since the many of the real time applications are bursty in nature and this circuit switch network cannot be applied to those what are those types of applications.

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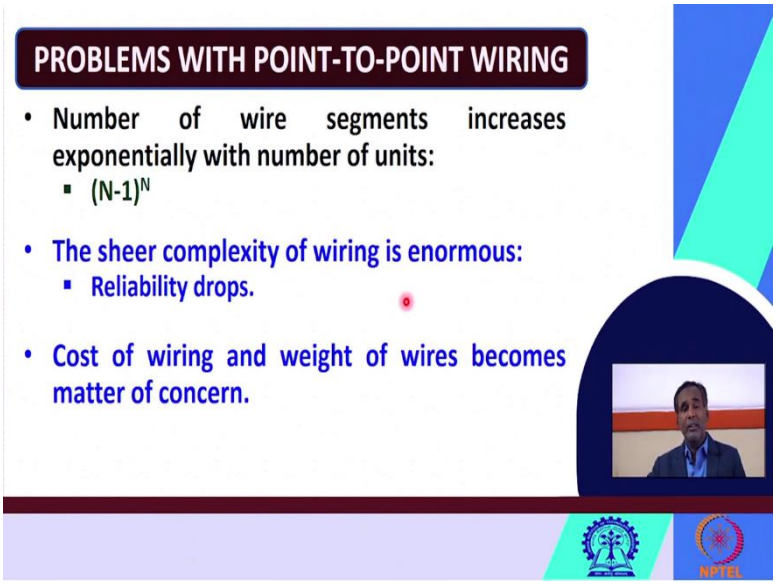

Next we will say another type of network maybe point to point wiring, so in this case what will happen? Why it cannot be applied to the real time communication? Because you see in case of point to point wiring the number of wire segments, it increases exponentially with the what? With the number of units. So, if the number of units grow exponentially, if the number of units grow, increase, then the number wire segments that also increases exponentially.

For example, if there are n number of units, then how we will compute the number of wire segments? It can be computed at $(n-1)^n$, this shows that it increases exponentially with the number of units, and here the drawbacks is that the sheer complexity of wiring is enormous, so the sheer complexity of this wiring is enormous and for this the reliability may drop drastically. Also the cost of the wiring and the weight of the wireless it may become a matter of concern for the real time communications. So, a problems with point wiring, point to point wiring may not work in this real time communications.

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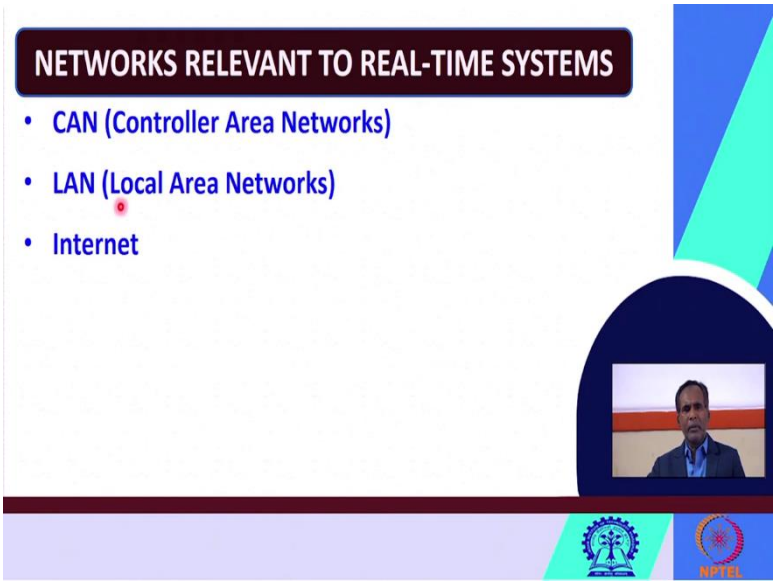

So, then what type of networks we can use? Three important types of networks they are very much relevant to real time systems, they can be used in real time systems, one is CAN, that stands for controller area network, another is LAN local area network, another is internet, you have more or less known about LAN and internet in your computer networking subject, so today I will highlight mostly about the CAN, and then a little bit about the LAN.

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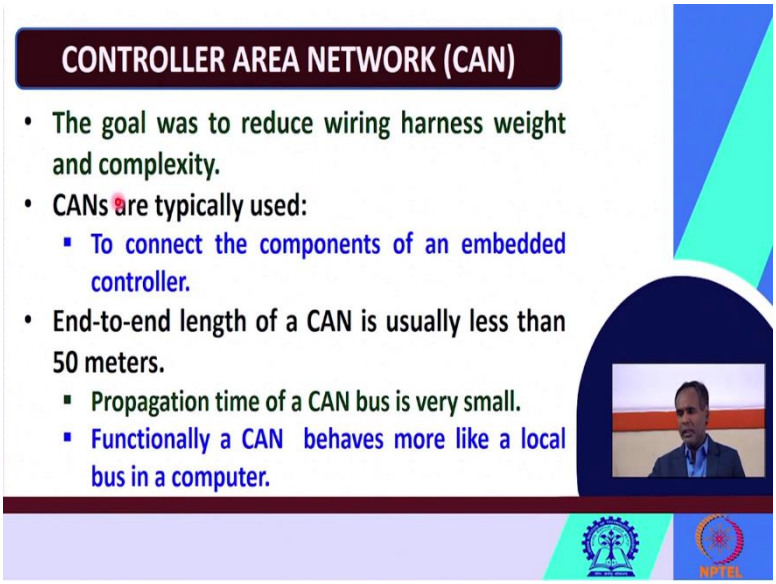

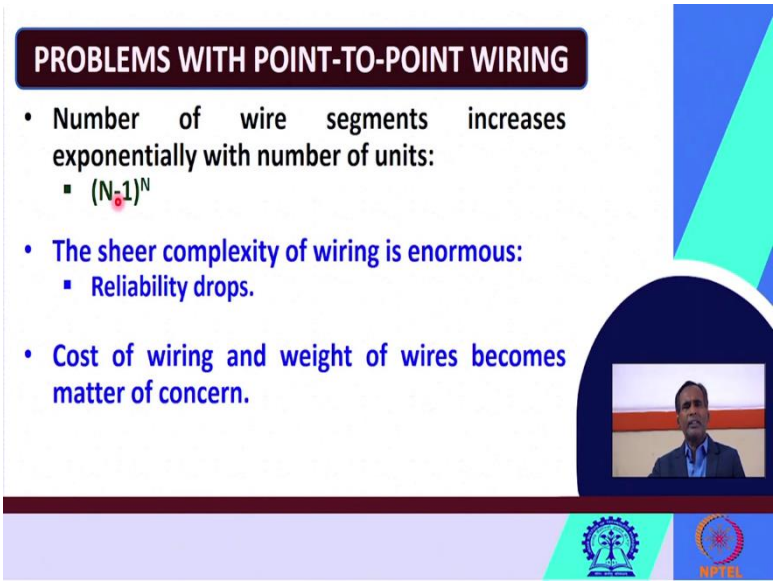

So, let us start with this controller area network. So, what is the goal of controller area network? The objective or the goal of controller area network was to reduce the wiring harness weight and complexity, I have already told you see in case of point to point varying the number of wire segments it takes it increases exponentially with the number of units, and the sheer complexity the it is becoming enormous.

So, and the cost of wiring and weight of wires, wires also become what a matter of concern, they are also becoming very high, they are also becoming very high, so in order to get this in order to overcome these drawbacks controller area network was proposed, so the goal of controller area network was to reduce the wiring harness weight and the complexity of this wiring approach, so here we can use the CAN as a solution.

So, normally CANs are typically used to connect the components of an embedded controller. So, controller area network are normally they are typically used for what? To connect the different components of an embedded controller. The end to end length of CAN is usually less than 50 meters, if we consider the end to end length, the end to end length of a controller area network is less than 50 meters normally.

So, the propagation time of a controller area network bus is very small, here the propagation time is also very small, so but we can remember that the CAN functionally it behaves in a similar way more or less like a local bus in a computer, we have already seen in your networking course local bus in case of a computer, so this controller area network it behaves more or less just like a local bus in a computer.

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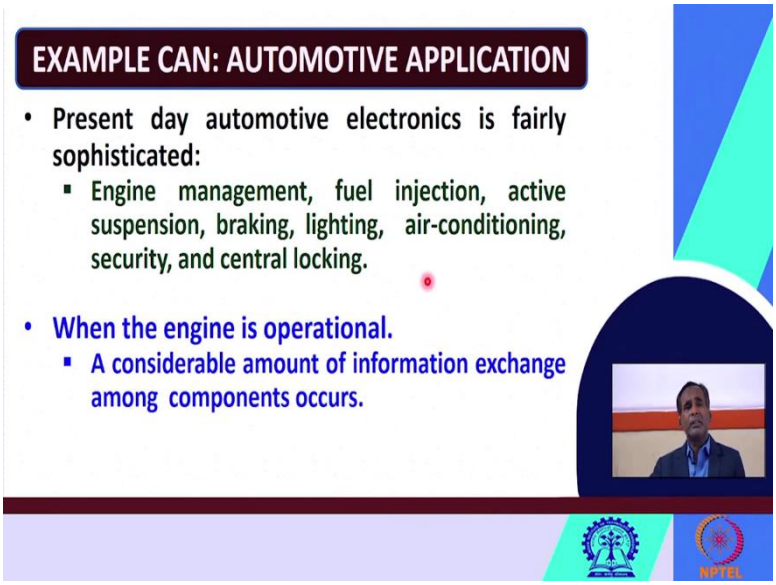

One example we can see, this automotive application you will see, so present the automotive electronics is purely sophisticated, you see the cars right now people are riding so here so all the different components you see, in particular the electronic components they are very sophisticated for example, the engine management, fuel injection, active suspension this automatic braking, lighting and air conditioning security and central locking these are the some of the important features of the recently or the modern automotive vehicles or the modern vehicles such as the modern cars and these are very, these components these are very fairly sophisticated.

So, this is these are the examples here this CAN can be used, so for example, when the engine is operational you are running the car, when the engine is operational a considerable amount of information exchange among the component occur, so there are different components may be breaking part, then the air conditioning, then what the windows parts, engine part etcetera, so when the engine is operational, considerable amount of information exchange occurs takes place among whom? Among the different components such as these doors, glasses, brake, etcetera. So, in this cases also you can use CAN.

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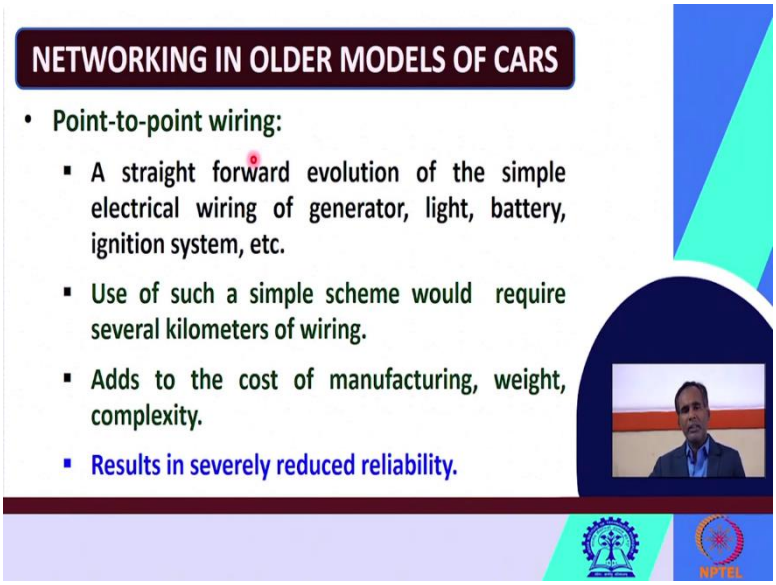

So, now let us see in the older models of the cars how the networking was used. So, mostly they were using point to point wiring the in the older models of the cars. So this point to point wiring it is a straightforward evolution of the simple electrical wiring of the generator, light, battery in ignition system et cetera they have used this simple or straightforward evolution of this electrical wiring.

So, but this simple wiring cannot be used in the modern models of the cars, because use of such a simple what wiring scheme it will require several kilometers of wires. So, it will use such a simple straightforward my wiring scheme then it will require several kilometers of wires. So, also it adds to cost of manufacturing weight and complexity.

So, it will use huge kilometers of wires in this wiring process obviously the cost of this manufacturing it will be increased the weight of the vehicle will be increased and the complexity will be increased. So, this will result in several reduced reliability, also the reliability of this system will be drastically reduced. So, this point to point wiring method is not used, this scheme is not used this current models or the recent models of the cars.

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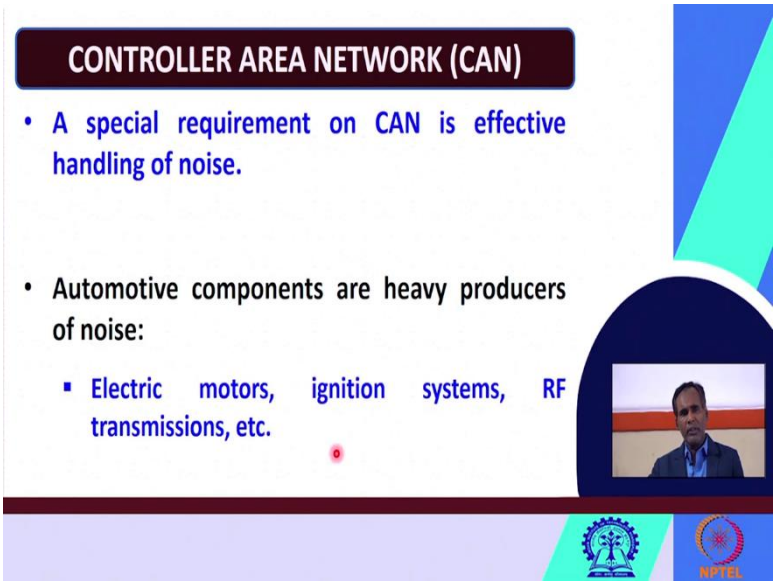

Let us, see one of the particular requirement of CAN, a special requirement on CAN is effective handling of noise. So, a good controller area network should effectively handle the noise those are coming around the system. So, for example in automotive components, these automatic components are heavy producers of noise, you see if you take out the case of the buses or the cars and if you will not use those sophisticated electronic devices you will get heavy noise.

So, as we have already known the automotive components they are heavy producers of noise due to the presence of the electric motors, ignition systems, RF transmissions etcetera, so due to these the automotive components are they are heavy producers of noise, and we should use CAN, so that or CAN should be used in such a way that it should effectively handle the noises those are arising out of these electric motors, ignition systems or RF transmissions etcetera. So, this is a special requirement of CAN that it should effectively handle the noises those are coming out of the system.

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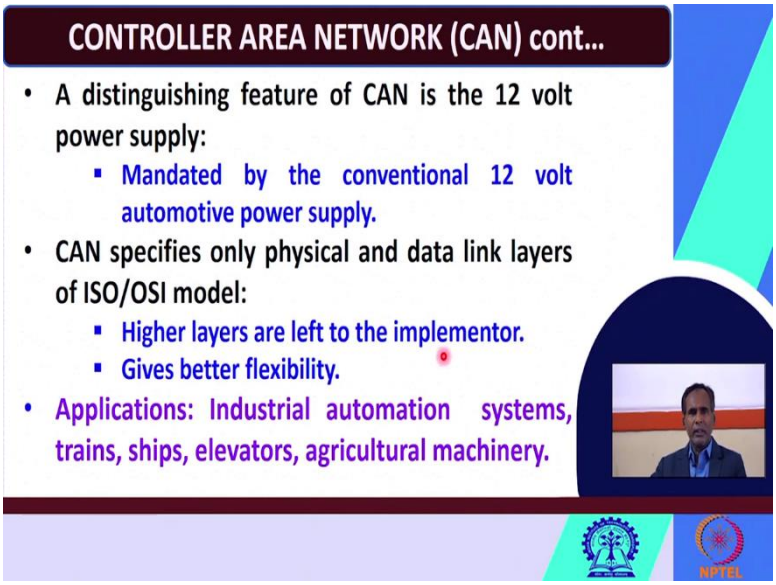

A distinguishing feature of CAN is the 12 volt power supply. Another distinguishing feature of CAN is that it should use 12 volt power supply, why? Because this is mandated by the conventional 12 volt automotive power supply, if we will see the traditional cars or traditional those automotive vehicles it mandates that 12 volt automatic power supply it mandates this that means a 12 volt automatic power supply required, so that is why so these CAN it has a feature or it uses the 12 volt power supply.

The CAN specify only physical and data link layers of ISO OSI model. You know that in the ISO OSI model, there are many layers? There are 7 layers, it starts from this physical layer, then data link layer and so on. And the top one is the application layer. So, this CAN specify it the controller area network it specifies only the physical and data link layers.

So, other higher layers they are left to the implementer. So, it does not emphasize it is not so much strict about the other higher layers, the other higher layers are left to the implementer, so this thing it gives better flexibility, because it only specify the physical and data link layer the bottom layers, all other higher layers they are left to the implementer, this gives better flexibility.

You can see where this controller area network can be applied or this CAN can be applied, for example industrial automation systems, trains, ships, elevators, agricultural machinery, office automation systems, these are some of the applications where this CAN can be applied, or where the CAN is used.

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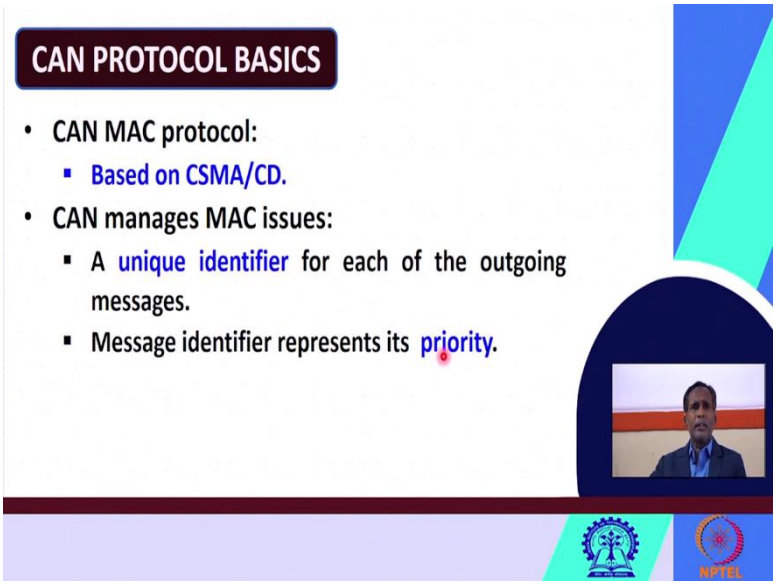

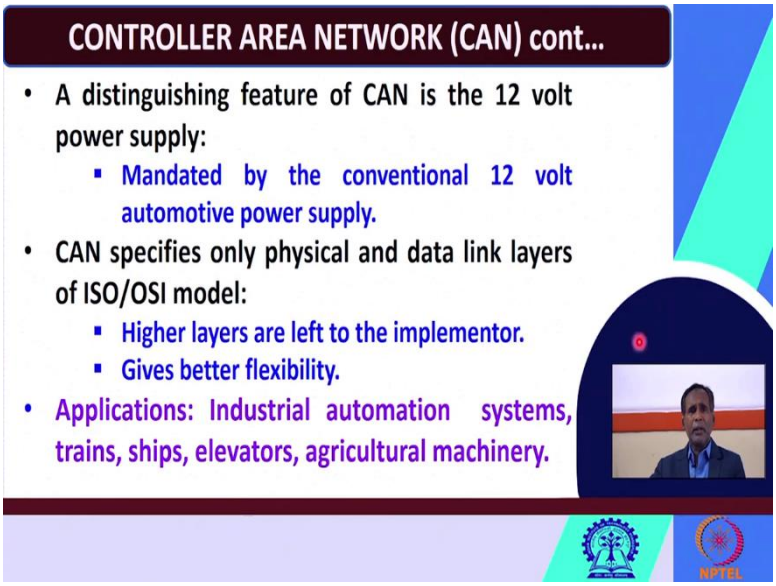

Let us, see what is the protocol of the CAN we will see only the basics, so the let us see the basics of CAN protocol, CAN MAC protocol based on CSMA CD, I have already told you CAN is applied where in physical and data link layer, you have already known in data link layer that is one protocol called the MAC protocol, this CAN MAC protocol it is based on CSMA CD, so MAC you have already known, medium access control protocol, this CAN MAC protocol it is based on CSMA CD, I hope MAC and CSMA CD etcetera you have already known in your computer network paper.

So, this CAN it manages the MAC different MAC issues. How does it manage? CAN manages the different MAC issues as follows. So, here a CAN unique identifier for each of the outgoing messages is maintained, for each of the outgoing messages, a unique identifier is maintained,

the message identifier represents its priority. So, what is the identifier assigned to the message, it represents its priority, what is the priority of the message? That is represented or that can be determined from its identifier.

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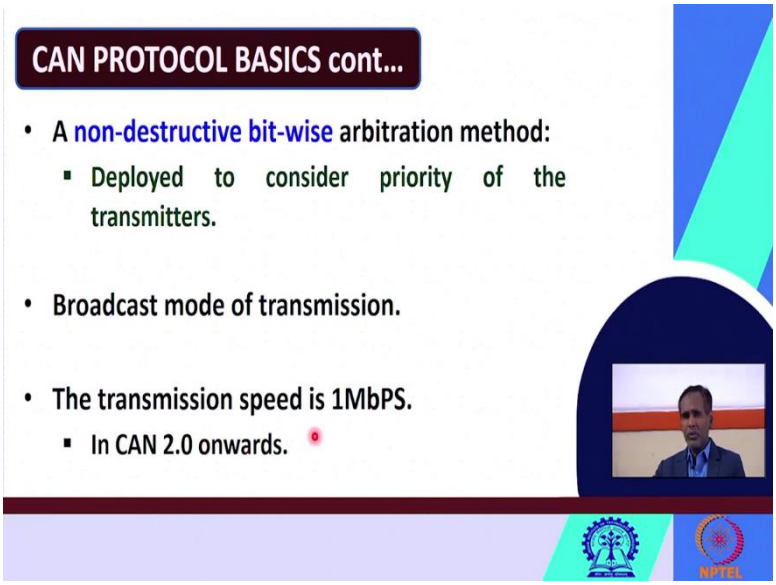

So, in CAN also what happens, it uses an arbitration method, what type of arbitration method it use? It uses a non-destructive bit-wise arbitration method. So, CAN it uses a non-destructive that means normally which is not destructed a non-destructive bit-wise arbitration method it is deployed, why a non-destructive bit-wise operation method is used in CAN? So, in non-destructive bit-wise arbitration method is deployed in CAN in order to consider the priority of the transmitters, which transmitter will be given first priority, which transmitter will be given the next priority like this.

So, in order to consider the priority of the transmitters, so this non-destructive bit-wise arbitration method is deployed in CAN. So, what mode of transmission is used in CAN protocol? So, in CAN protocol the mode of transmission is broadcast, it uses broadcast model mode of transmission. So, what is the speed of the transmission in case of CAN? The transmission speed in CAN is around 1 Mbps and this of occurs normally CAN 2.0 version onwards. CAN 2.0 onwards after that all other versions also in those cases the transmission speed is 1 Mbps per second.

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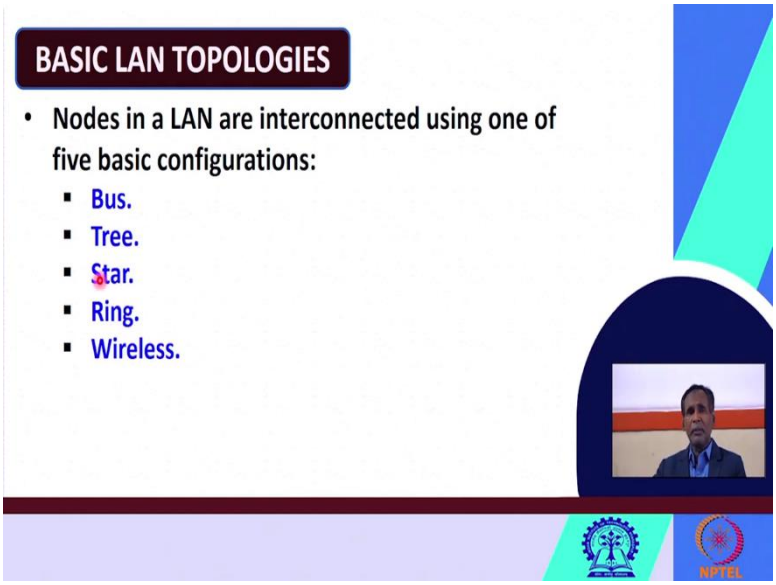

So, we have seen little bit or basics of this what your CAN, now let us see about some of the basic LAN topologies which are used in real time communications, you know that the nodes in the local area network they are interconnected using one of these basic configurations, you can use bus topology, you can use tree topology, star topology, ring topology or wireless topology, let us see about first this bus topology, I hope LAN already you have discussed in your computer network paper, these topologies you have already known, So, quickly I just escape those topologies with the brief hints only.

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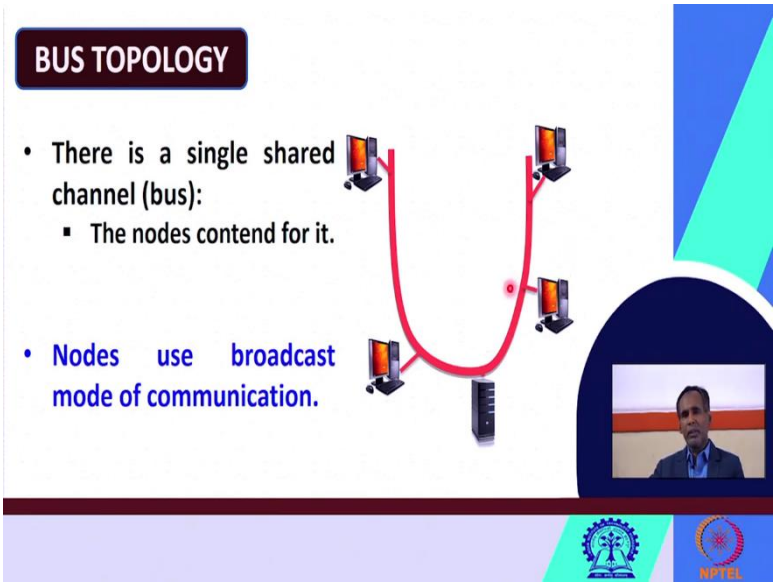

So, bus topology you know in case of bus topology there is a single shared channel or single shared bus and the nodes contend for it, is not it. In bus topology there is a single shared bus

or single shared channel that is present, the nodes they contend for it and you can see this like this, so there is a you can see there is a single shared channel or single bus and the nodes contend for this bus, the nodes how do they communicate among themselves? The nodes use the broadcast method of for broadcast method of communication among themselves, nodes use broadcast mode of communication among themselves. So, each of the node they send their message through some broadcasts, through the broadcasting.

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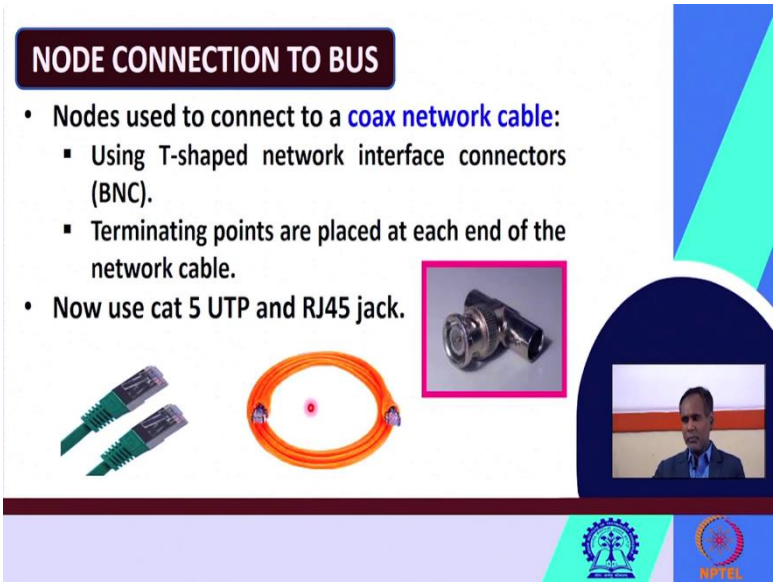

So, node connection to bus. Now, let us see how the nodes are connected, the nodes used to connect a coaxial network cable, normally the nodes used to connect throughout coaxial network cable so using T separate network interface connector, so while in order to connect the T shaped network interface connectors I will show the figure this we call as BNC connector.

So, the in case of this coaxial network cable which can be used to connect the nodes here among the terminating points they are placed at each end of the network cable. So, the terminating points they are placed at each end of the network cable and now normally the following things are used now for this the vendors use cat 5 UTP or RJ40 jack they are used for this purpose. So, this should be T shaped network interface connector, BNC and you can use also 5 UTP or the RJ45 jack for this purpose of connection.

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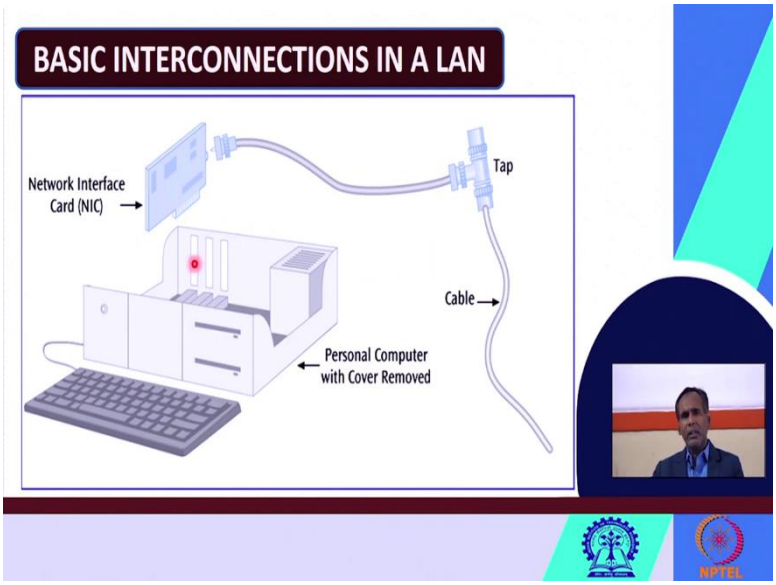

So, then you will see little bit your basic interconnections in network. So, this is easy figure showing the basic kernel interconnections in a LAN. So, this is the cable it is connected with a T shape here tap and this again it is connected to a card call as the network interface card. So, in this way the basic interconnections they appear in case of a LAN.

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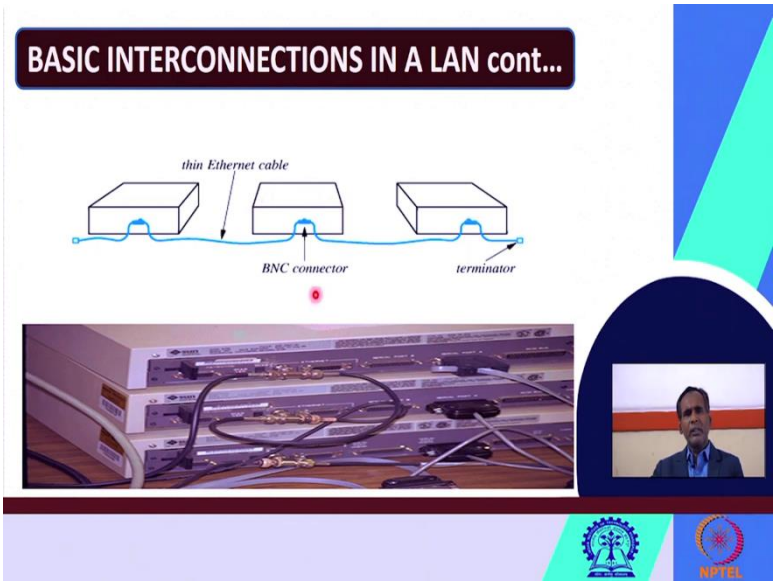

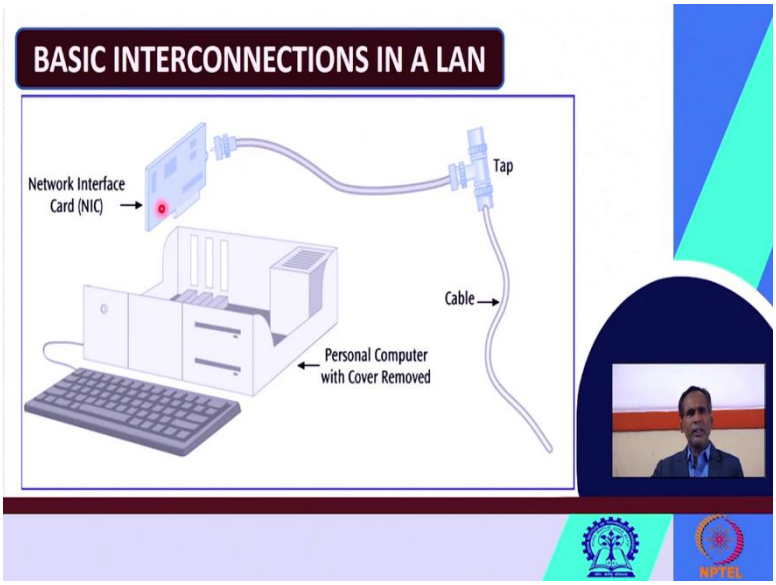

This is another example here, so here what happens? See in a computer center or in a building how they are connected. So, this is your thin Ethernet cable and this is the T shaped connector called as BNC and these are the terminators at because at each end terminators are used, so in this way the thin Ethernet connector is connected to the BNC connector on the terminator.

So, now let us see about it here I have already told you are using a what card called as NIC in this basic interconnection in your LAN you are using a network interface card or NIC let us see what is that NIC quickly we will look at this.

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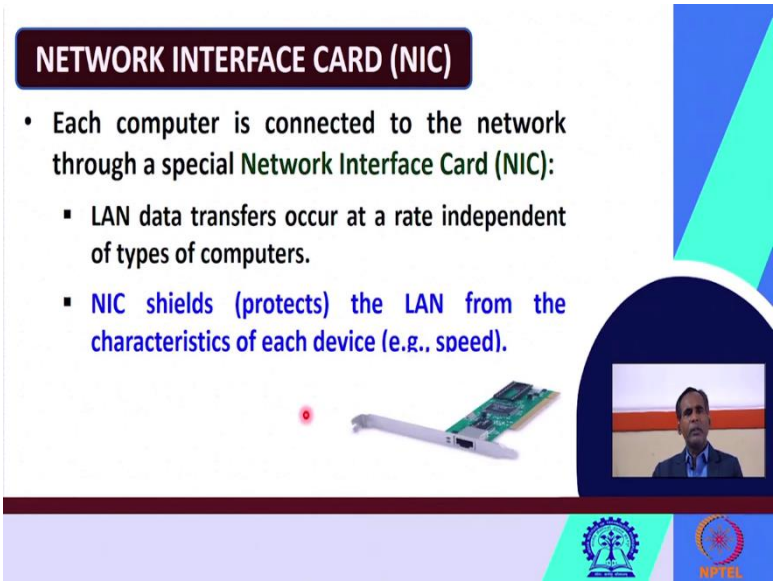

So, what is the NIC? This NIC the special card called as network interface card, each computer is connected to the network through a, through this card. Each computer is connected to the network through a special network interface card this happens in this bus architecture or bus

topology you are discussing, here each computer is connected to the network through a special network interface card called as NIC.

So, this LAN data transfer occurs how? This LAN data transfers they occur at a rate independent of the types of computers. The local area network data transfers they may occur at a rate which is independent of the different types of computers. So, this NIC network interface card it shields or it protects the LAN from what? It protects the LAN from the characteristics of each device for example speed.

Each device has a different speed, but I have already told you the LAN data transfers they occur at a rate independent of the types of computers, for example the speed maybe. So, NIC it shields or it protects the LAN from the characteristics of each device maybe speed etcetera. This is how a what an NIC look likes.

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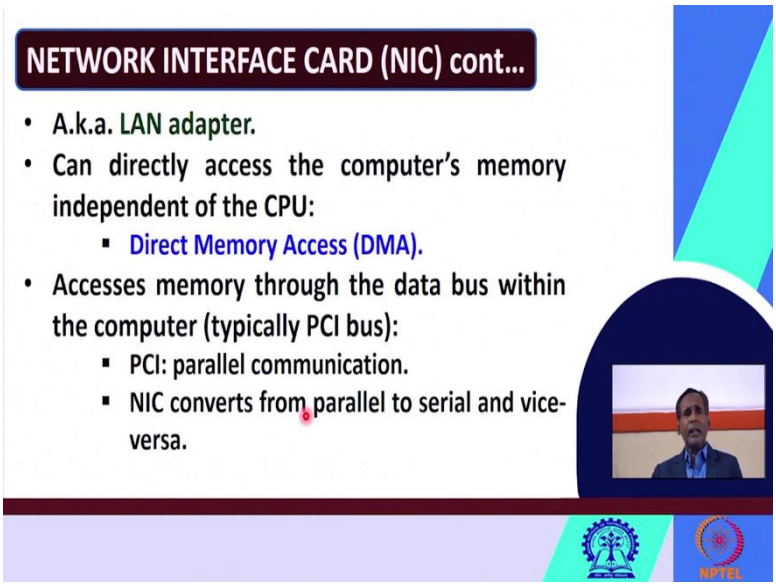

So, NIC the LAN adapter what it does, it can directly assess the memory of the computer independent of the CPU, using a technology call as DMA direct memory access, I hope you have already known direct memory access in your computer networking or in what some paper that you have already studied earlier.

This network interface card it accesses the memory through the data bus within the computer. This data bus can be typically PCI bus, where you know PCI, PCI stands for this parallel communication and NIC this NIC it converts what? It converts from parallel to serial as well as from serial to parallel.

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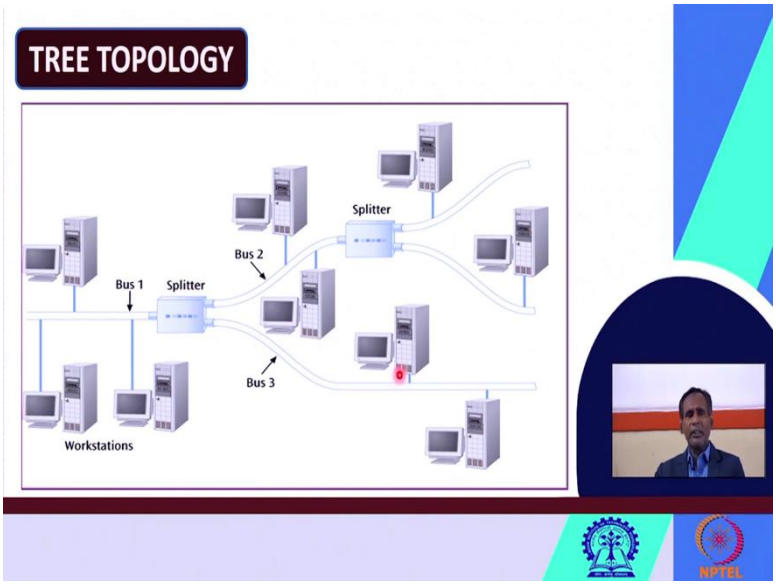

Then we will quickly look at the tree topology, you have already known tree topology earlier, this is a very good example of the tree topology where the different nodes they are arranged in the just like a different branches of a tree, whenever you require a branch you can use the splitter. So, in this way the tree topology looks like, this is very simple you have known you can read yourself, we will go to the next one.

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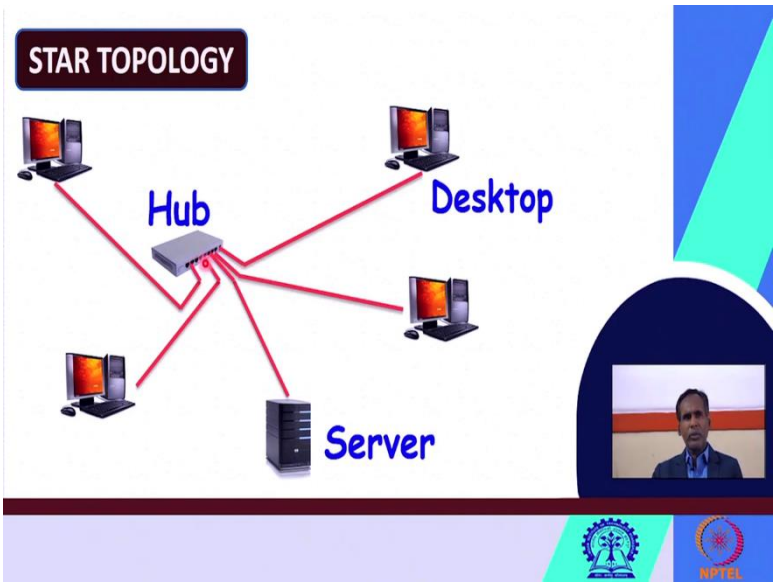

Star topology, here the different nodes are arranged just like a star, these are the different desktops or servers or workstations and centrally the hub is there, in this way the star topology looks like.

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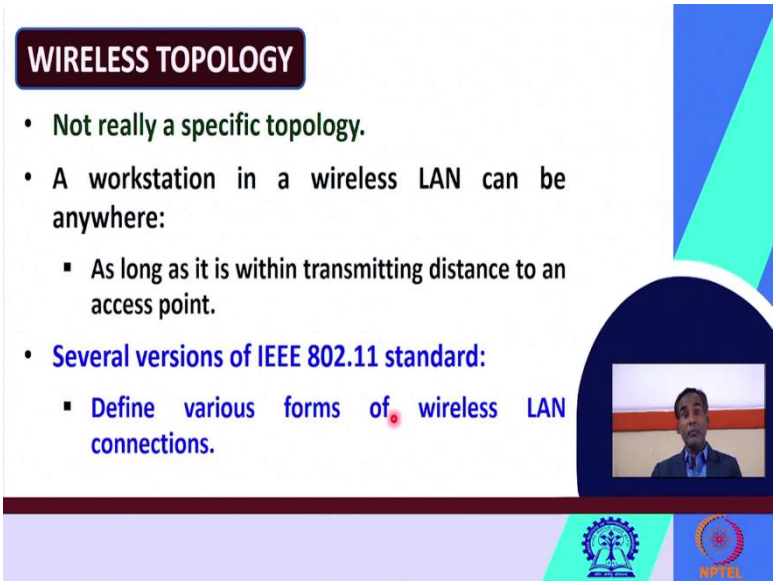

Then wireless topology actually, it is not really a specific topology, so here a workstation can be used anywhere else. A workstation in a wireless LAN it can be anywhere as long as it is within the transmitting distance to an assessment. So, as long as the workstation it is present within the transmitting distance to an assessment that workstation in this wireless LAN can be present anywhere else. So, several versions of IEEE 802.11 standard they are available, they define the various forms of the wireless LAN common connections. So, the IEEE standards they define the various forms of the wireless LAN connections.

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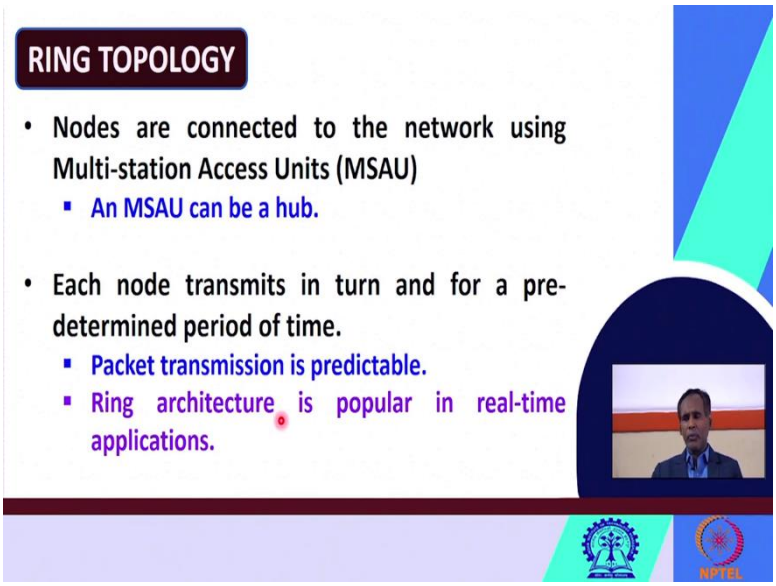

So, then quickly we will look at ring topology, here the nodes are connected to the network using multi-station access units, we call it MSAU, so what could be an MSAU? An MSAU can be any hub, so here each node transmits in turn, in ring topology what happens? Each node it transmits in turn and for a particular point for a particular duration of time.

So, here each node each computer transmits in turn and for a predetermined period time, for a specific duration of time. Here packet transmission is predictable you can predict the packet transmission, your packet transmission is predictable, so ring architecture is very much popular in real time applications or real time communication. So, in real time applications among the different architectures, different topologies, ring architecture or ring topology is popularly used.

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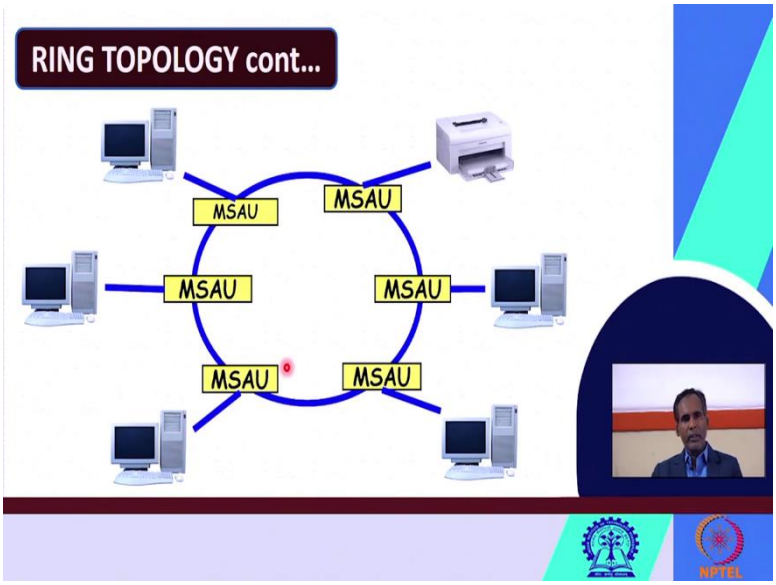

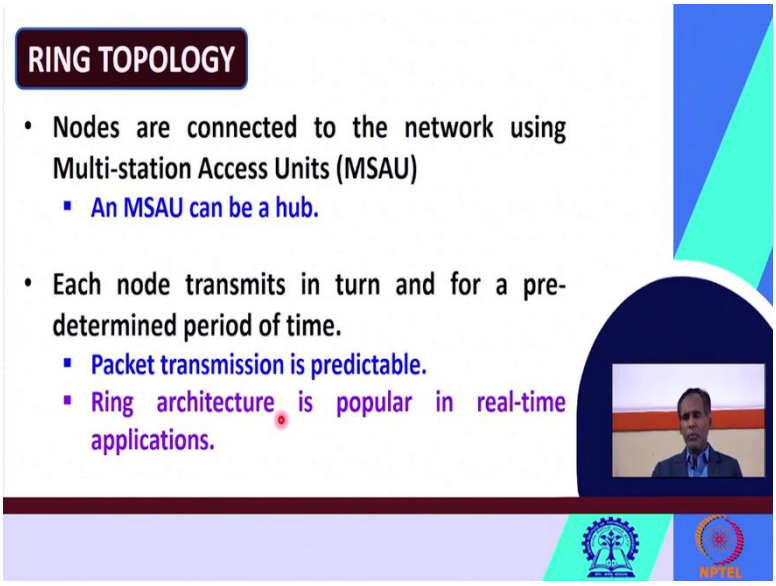

This is a very good example of a ring topology you can see, these are different MSAU's I have already told you MSAU you can be a hub, is not it, MSAU can be a hub, then see different nodes or different systems or maybe here see here different computers, workstations or even if a network printer they are connected to the MSAU's to the hubs, these nodes they are connected just like a ring so this is a very good example of a ring topology, this is how the ring topology will look like.

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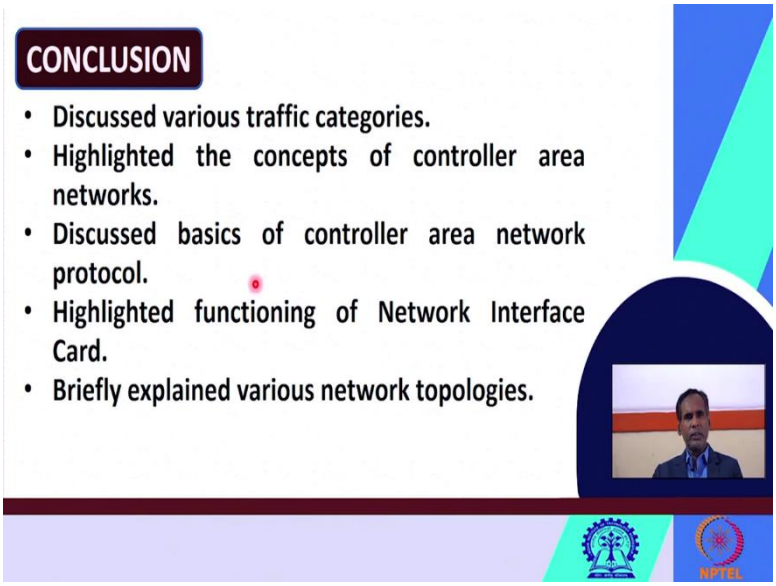

Today we have discussed the various traffic categories, CBR, VBR and sporadic traffic. We have also highlighted the concept of controller area network, we have discussed the basics of the controller area network protocol, we have highlighted how the network interface card it functions, we have also briefly explained the various network topologies such as the bus, ring, star topology, also we have discussed a little bit about the wireless topology.

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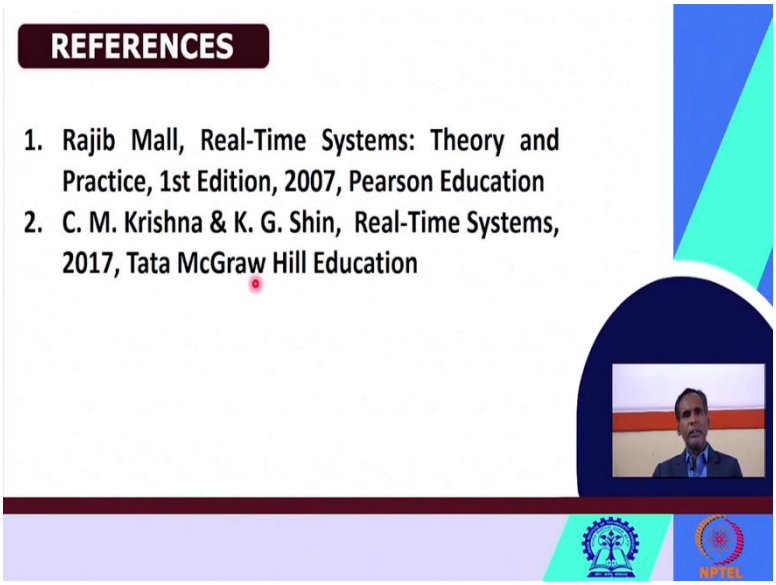

So, we have taken from these books. Thank you very much.