Real Time Systems
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Lecture 49
Basics of Networking

Good afternoon to all of you. Today we will discuss again some of the basics of the networking in real time communication. Last class I have already told you there are three types of networks, they are suitable for real time communication. Number one, Controller Area Network or CAN. Then Local Area Network or LAN and another is internet, internet or you can say which is coming under packet switch network.

So, out of this we have already discussed Controller Area Network or CAN. We have seen some of the scheduling topologies, some of these topologies under LAN like ring topology, star topology, etcetera we have seen. So, today we will continue with those of the topologies and more about LAN. And next class we will discuss about the third category that is a packet switching network or this with the one of the example is the internet. So, that we will see in the next class.

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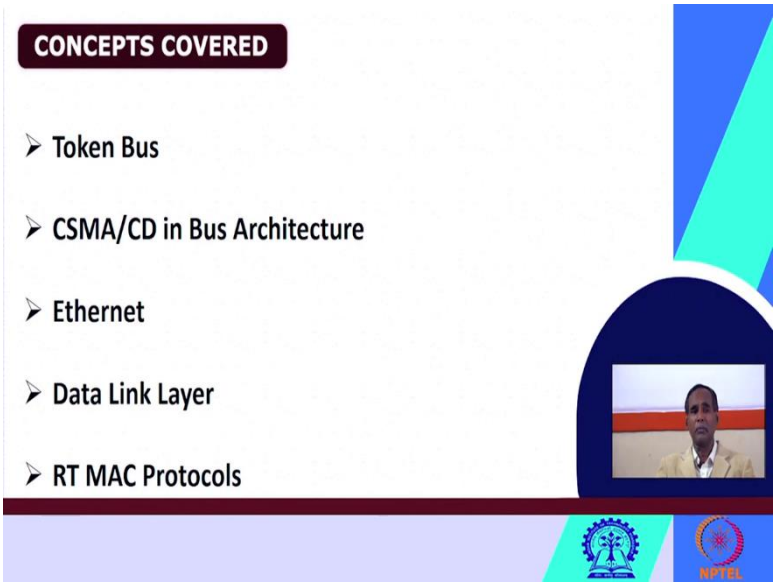

So, some of the common concepts today we will cover. The drawbacks of the ring topology and how can we overcome using token bus. Then you will see this CSMA CD in bus architecture. We will discuss ethernet, Data Link layer and some of the protocols under data link layer that is here we will especially see MAC protocols and MAC protocols for real time or real time MAC protocols.

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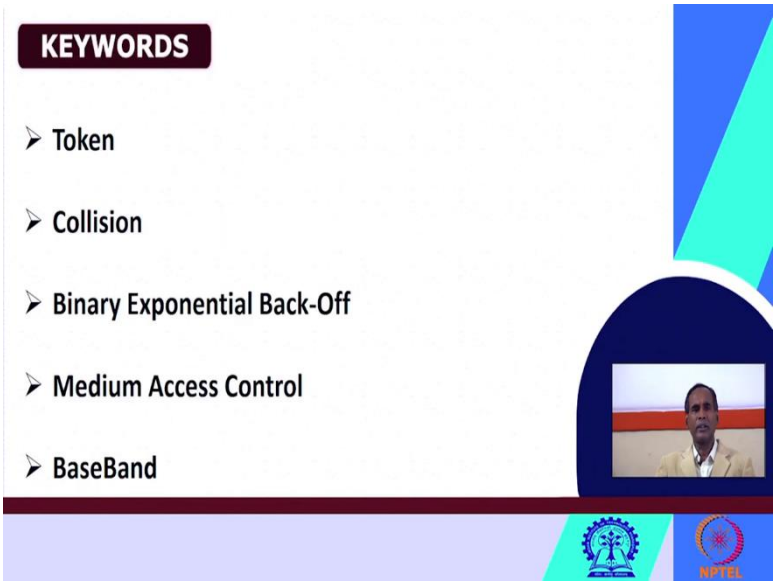

So, these are the key words we will use.

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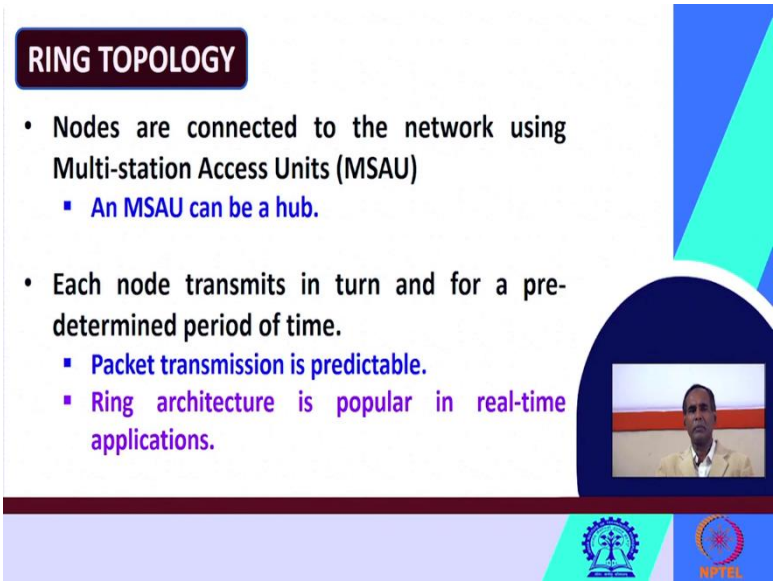

Now let us see this ring topology I have already discussed in the last class and I have already told you that in ring topology the nodes are connected to the network using some access unit called Multi Station Access Units and this multi station access unit can be a hub this we have already discussed in the last class. In ring topology each node can transmit in turn, is not it?

In topology each node transmits in turn and for a specific period of time and for a predetermined period of time and in the ring topology this packet transmission is predictable you can predict about the details of this packet transmission so in the ring topology packet transmission is

predictable in most of the current real time applications ring architecture is becoming very much popular.

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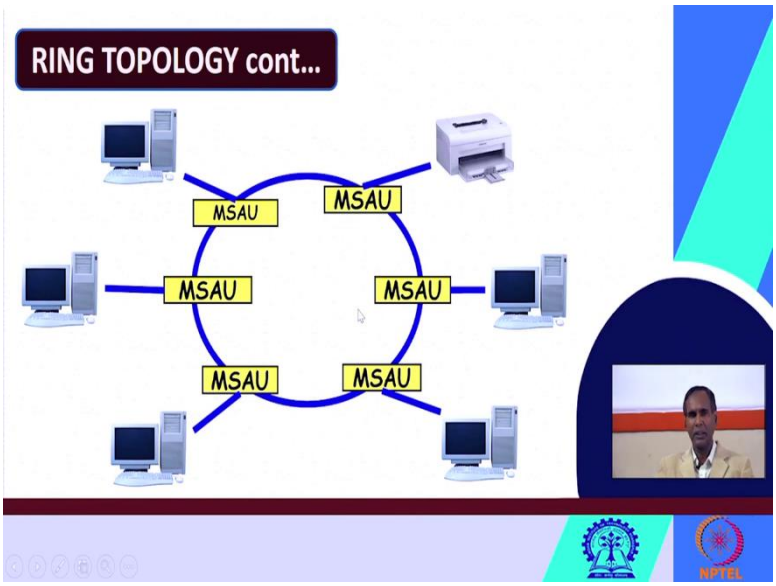

How does the ring topology look like I had already shown in last class this is how these the nodes arranged in ring topology they may look like this. So, here there are servers and printers etcetera. They are just arranged in the form of a ring.

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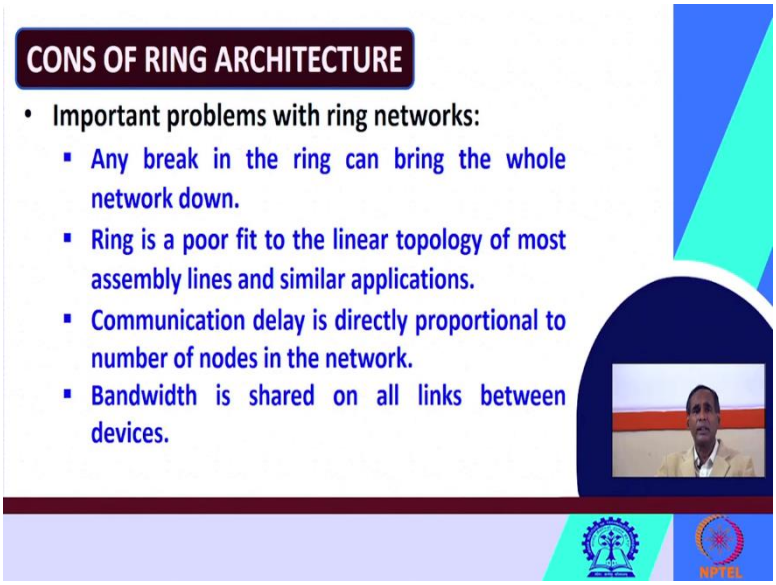

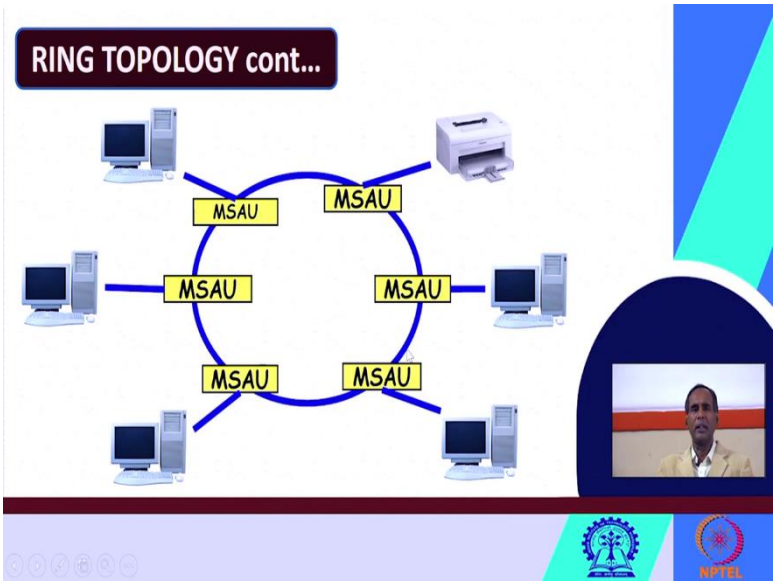

Now let us see what is the problem? What are the limitations? What are the limitations of ring architecture? First, the important problems with the ring network are as follows. First drawback, any break in the ring can bring the whole network down. You see if any node is broken, is faulty, then what will happen? The whole ring will fail. So, any break in the link can totally bring the whole network down.

So, if there is any single break in the ring, the whole ring will break down. So, any break in the ring can bring the whole network down. This ring architecture is not suitable to the linear topology of most assembly lines and similar applications. So, for the linear topology, of most of the assembly lines and similar applications for them ring topology is not suitable at all.

Similarly, in case of ring topology the communication delay is directly proportional to the number of nodes in the network. So how many number of nodes are there in the network the communication delay in this ring architecture is directly proportional to the number of nodes in the network. That means if the number of nodes in the network it is the more the communication delay will increase.

So, the communication delay directly proportional to the number of nodes in network. Similarly, the bandwidth is shared on all links between the devices. So how many links are there? So, so this the ring network so how many links are there the total bandwidth is shared on the links between the devices. In case of link architecture, the whole bandwidth is shared on all the links between devices. So, these are some of the drawbacks of this ring architecture. Now let us see how this can be overcome. Any solution exists does any solution exists?

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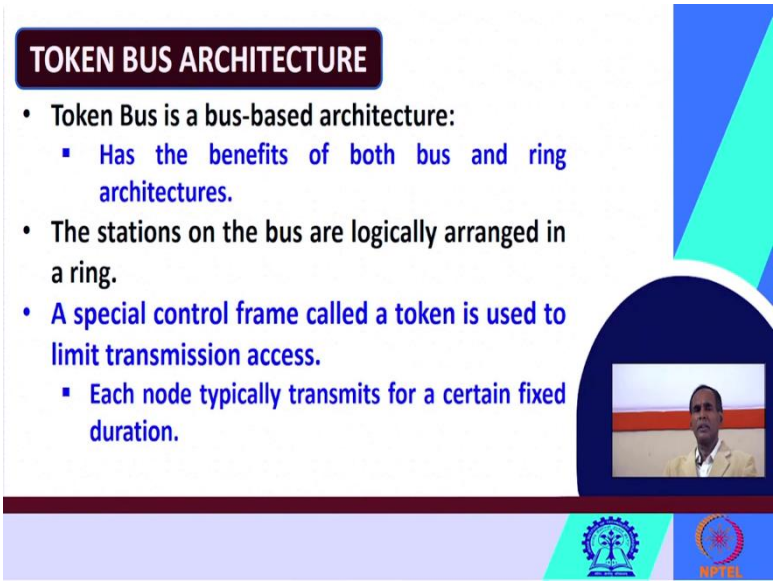

Yes, we can take another architecture which may overcome some of these drawbacks of ring architecture. So, we can take the example of token bus architecture. So, this may overcome some of the drawbacks that we have seen earlier. This token bus, as its name suggests, token bus, so token bus is a bus-based architecture. So, token bus is a bus-based architecture. This architecture has the benefits of both ring architecture as well as bus architecture.

Bus architecture only what we have discussed in the last class. So, this token bus architecture it has the advantages of both the bus architecture as well as the ring architecture. So, in case of the token bus architecture the stations on the bus they are logically arranged in a ring. In case of token bus architecture what happens the stations on the bus they are logically arranged not may not be physically.

The stations on the bus they are logically arranged in a ring. Now, how this transmission takes place a special control into token bus architecture, a special control frame called as the token it is used to limit the transmission access. In token bus architecture a special control frame which is called as a token that token is used to limit the transmission process to control the transmission process.

Each node typically transparent transmits for a certain fixed duration, so every node it can transmit to only for a specific duration only for a certain fixed duration. So, I am repeating again in token bus architecture how this transmission takes place? In token bus architecture, a special control frame called a token and it will be used to limit or to control the transmission access, every node typically transmits only for a certain fixed duration or only for a specific duration.

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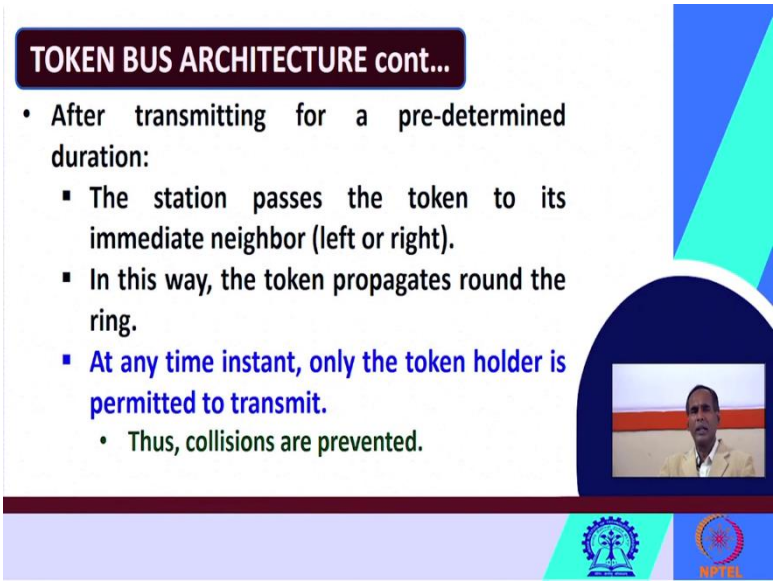

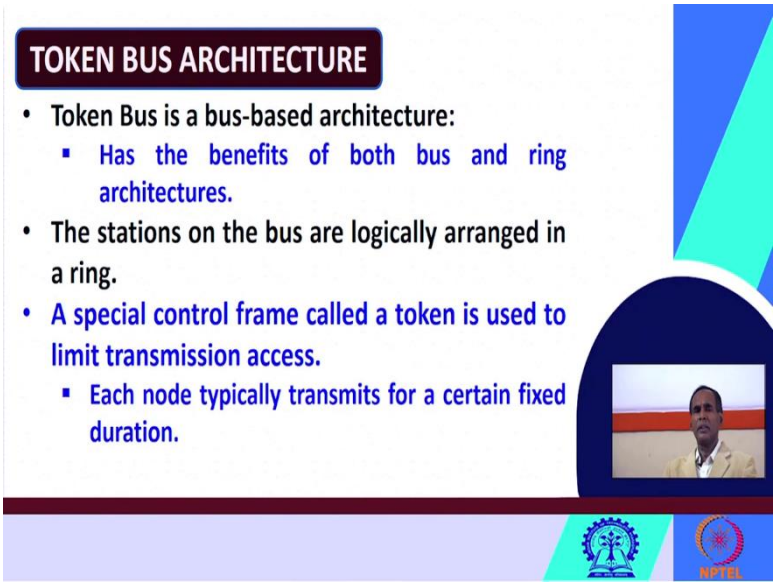

So, after transmission for a predetermined duration the station passes the token to the immediate neighbour. So, when I have already told you here each node uses a certain fixed duration. So, now after transmitting for that pre-determine duration for that specific duration then this station what does it do? Then this station passes the token to whom? To its immediate neighbour that immediate neighbour may be on the left-hand side or on the right-hand side.

So, in this way, the token it propagates around the ring. So, in this way the token the token propagates through the whole ring around the ring. At any instant, at any time instant only the token holder is permitted to transmit, not always everybody can transmit. At a particular point of time, which station holds the token only that station or that node can transmit. So, at any

time instant only the token holder this station or the node who is holding the token it is permitted to transmit.

Thus, by following this constraint by following this restriction, collisions are prevented. So, collisions are prevented, in this way collisions can be avoided in token bus architecture.

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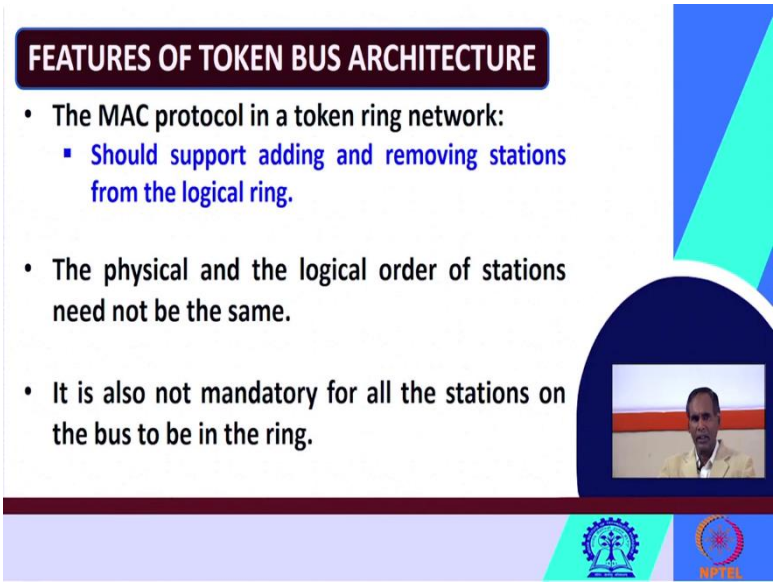

So, some of the features of token bus architecture you can see. So, in case of token architecture, the MAC protocol in the token ring network it should support adding and removing station from the logical ring. So, I have already told you in token bus architecture the stations maybe arranged in the form of a logical ring. The MAC protocol in case of a token in network it should support adding and removing stations.

How this distance can be added? How can be removed? So it should support adding and removing the stations from the logical ring. Please remember that the physical and the logical order of the stations in the ring may not be the same. The physical and the logical order of the station need not be same. It is also not mandatory for all the stations on the bus to be in the ring it is in token bus architecture it is not compulsory that all the stations they must have to present in the ring that constraint is not there. You can see an example.

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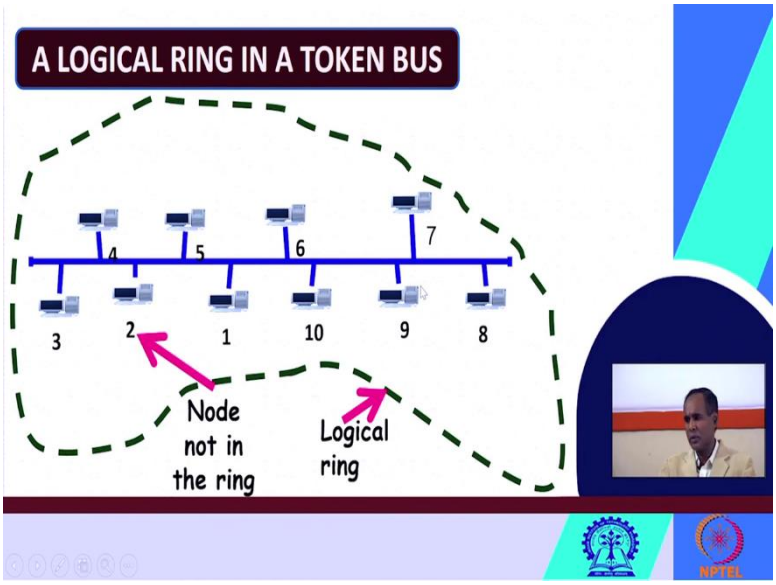

See here I have a just shown a token bus architecture you can see a logical ring is formed, you can just a little bit of what, the my diagram is not correct like this 7 is here it is present in the ring. Similarly, can see actually this ring is not, this logical ring is a little bit mistake I have while I have drawn, so like 3 it can be there, but you see 2 it is not there in the ring.

So, the point of speaking is that in a token bus architecture, some of the nodes can be present on the ring some of the nodes may not be present on the ring. But for example you see 2 is not present, similarly you can see 5 it is not present in the rink, but you can see here 7 is almost present on the ring like that you can construct the ring so that it is not mandatory that all the nodes have to be present in the ring.

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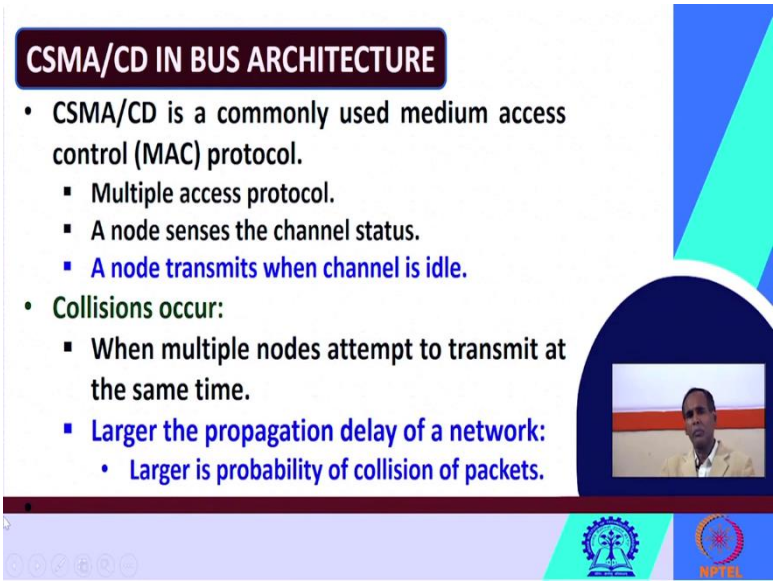

Then let us see about this CSMA CD in bus architecture. I hope you have known what the CSMA CD please I again request those who have forgotten this computer networking fundamentals of computer networking please read that paper because this is a prerequisite for these classes or this chapter. So, CSMA CD you have already known earlier in computer networking.

Now, let us see CSMA CD in a bus architecture. The CSMA CD is a commonly used the medium access control protocol. We have already known MAC protocol. So, the CSMA CD is a commonly used medium access control protocol. So it is a multiple access protocol. So, the CSMA CD it is a multiple access protocol. Here a node senses the channel status. In case of this CSMA CD here a node it can sense what is the channel status.

A node transmits when the channel is idle. So only when the channel is idle at that time a node can transmit. So, in CSMA CD the collisions may occur when the multiple nodes attempt to transmit at the same time. So, when more than 2 or more than 2 nodes they try to transmit at the same time then collisions may occur, but here larger the propagation delay of a network larger is the probability of collision of packet.

So, if the propagation delay in the network is increasing then there is increase in the probability of the collision of the packet. So, if so, larger the propagation of a network delay then of course obviously larger is the probability of collision of packets. Yeah, there is a, there is a probability that you will get what more number of collisions of packets.

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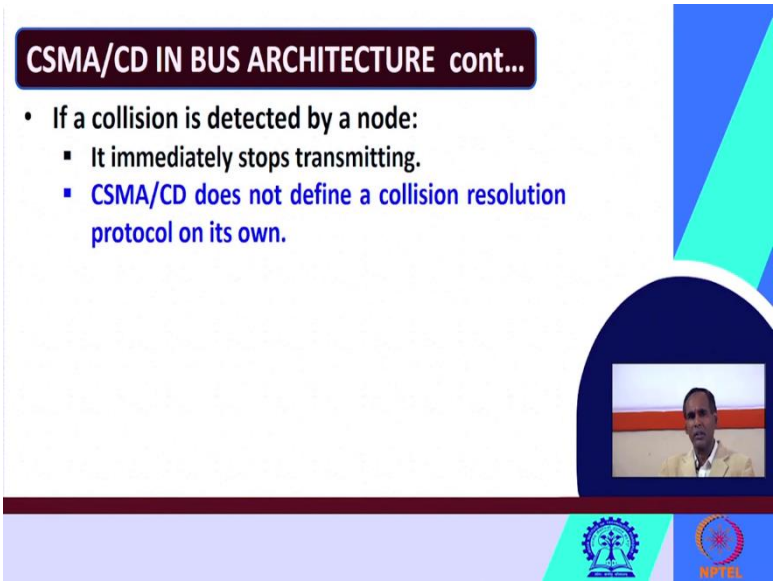

So, if we will see that if a collision is detected by a node, then what it will do? So, when in CSMA CD it detected that if a collision is detected by a node, then what happens the node immediately stops transmitting. The node it stops the transmitting process then CSMA CD does not define a collision resolution protocol on its own.

Please remember it is only what CSMA CD we have already known earlier, in case of CSMA CD, it does not define a collision resolution protocol on its own. Here on its own it does not define how to perform resolution of the collisions. How to solve the issues? So, CSMA CD does not define a collision resolution protocol on its own.

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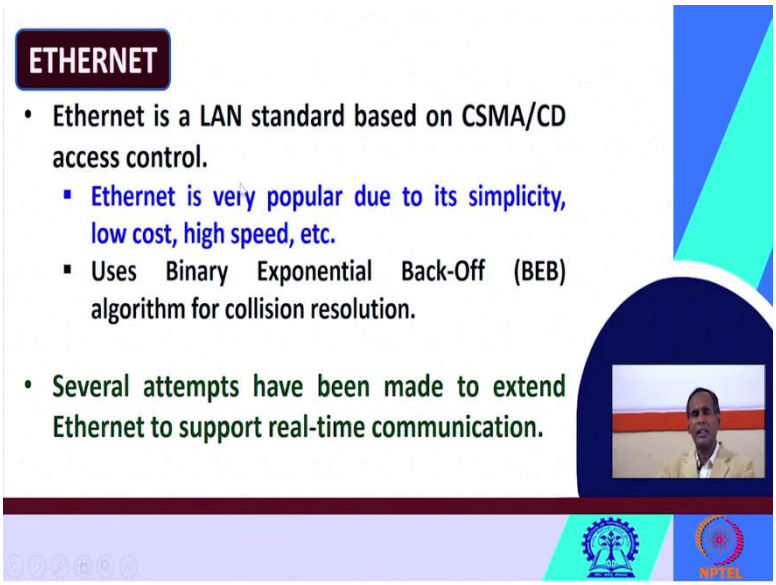

Now, let us see about little bit about ethernet. Ethernet is your LAN standard based on CSMA CD access protocol. So, ethernet is a local area network standard based on the CSMA CD access control. So, normally ethernet is very popular nowadays you have already used you have already seen. So, ethernet is very popular due to some of its advantages features such as its simplicity, low cost, high speed etcetera due to these features ethernet becoming very much easy.

So, this Ethernet it uses an algorithm called as binary exponential backup or in short, we shall call it as BEB algorithm for collision resolution. So, in ethernet how collision is resolved? How collision resolution takes place? In ethernet, the collision resolution takes place by using an algorithm called as binary exponential backup or BEB algorithm. So, there are several attempts have been made to extend ethernet to support real time communication.

We will see, so many researchers have attempted to extend this Ethernet to support real time communication. Initially you have non ethernet is LAN standard based on CSMA CD access control, but these people have already tried to extend this ethernet to support real time communication. We will see that is why I will keep the details on ethernet.

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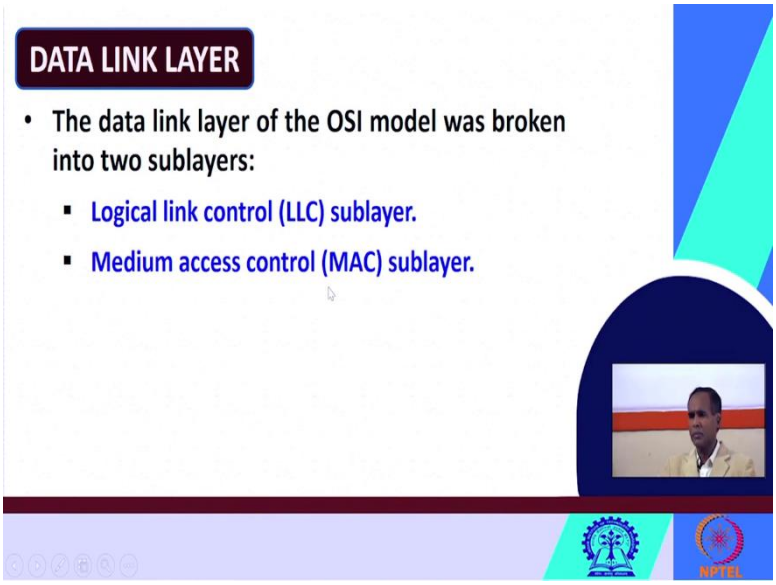

Before going to the details of the ethernet let us quickly look at this data link layer you know that OSI model it has 7 layers starting from the at bottom you can see physical layer, data link layer then like that and the topmost layer is the application layer. So, in data link layer, the data link layer of the OSI model was broken into two sub layers. So, I have already told you after this physical layer then this data link layer.

This data link layer of the OSI model was divided into two sub layers; one is LLC sub layer another MAC sub layer. LLC stands for logical link control sub layer and the MAC stands for medium access control sub layer. So, we will see on details of this MAC sub layer.

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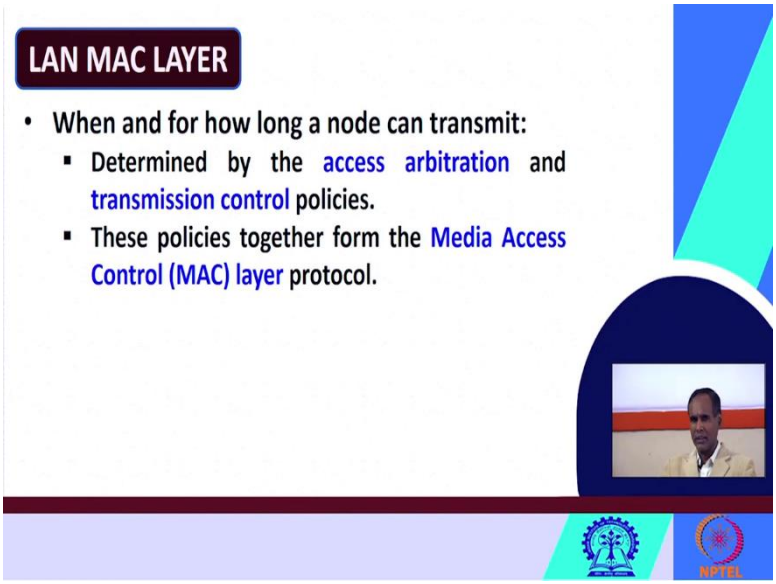

So, we will see that LAN MAC layer, so, when and for how long a node can transmit so in a LAN for what period of time a node can transmit and when it can start transmission how to decide. So, this thing is decided is determined by two important policies, two important processes; one is access arbitration policy another is transmission control policy. When a node can transmit and for how long duration a node can n transmit this can be determined by the access arbitration by two policies.

One is access arbitration policy; another is transmission control policy. So, these two policies access arbitration policy and transmission control policy they together form the media access control layer protocol or MAC layer protocol.

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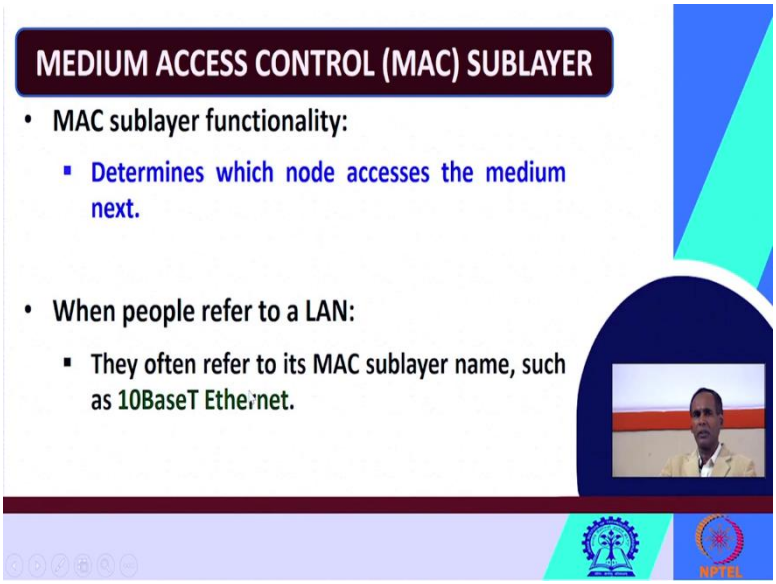

We will see about the details of this MAC sub layer protocol. So, this MAC sub layer functionality, what is it do or MAC protocol what does it deal with? The MAC sub layer functionality, it determines which node accesses the medium next, that is why the name is the medium access; please see. The MAC sub layer functionality, what does it determine? It determines which node accesses the medium next, so that is why the name is medium access control protocol.

So, when people they refer to a LAN, they very often refer to its MAC sublayer name, very common thing, please remember. Whenever the people refer to a LAN, that means they very often refer to MAC sublayer name. For example, they may tell us at 10baseT Ethernet or 100baseT Ethernet like that. So, we will see of course after a few slides, you will see about the different types of ethernet.

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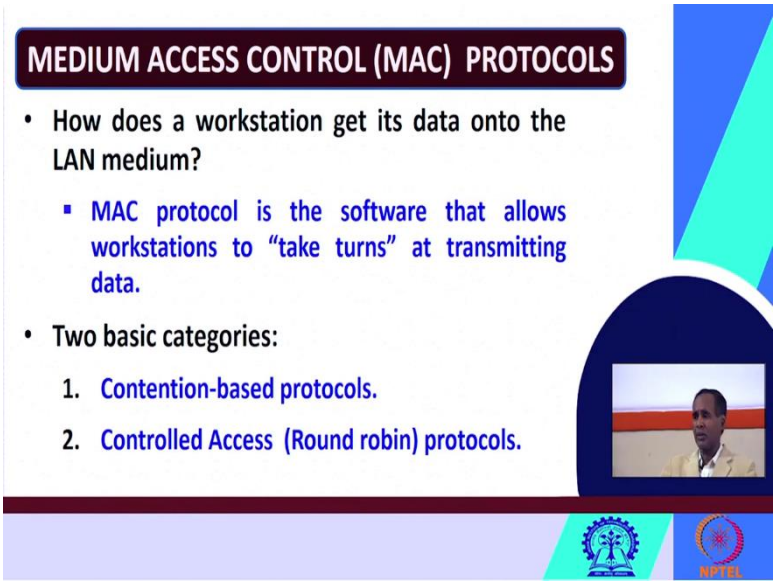

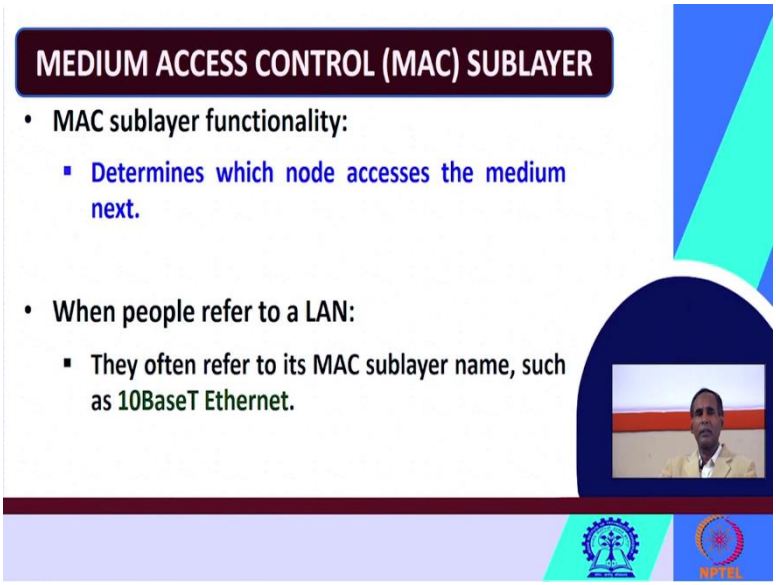

Now let us see first, a little bit more about the medium access control protocols. I have already told you so here in the functionality of MAC sublayer is that it determines which node accesses the medium next so how does a workstation gets its data onto the LAN medium? How does the workstation or a node gets its data onto the land medium? So, MAC protocol, by using the MAC protocol it can be done. So, how does a workstation gets its data onto the LAN medium?

The answer like this, the MAC protocol is the software which allows or that allows workstations to take turns at transmitting data. So, the answer is that here the MAC protocol it is the software that allows the workstations, that allows the nodes to take turns at transmitting data, there are two basic categories of these MAC protocols are there. So, one is contention-based you can say that the MAC based protocols can be divided into two major categories.

One, the contention-based protocols, another is the contention free protocols or control access protocols. You can see that we will see an example of the control access protocol those you have known TDM or these round robin protocols, they are coming under control access or contention free protocols.

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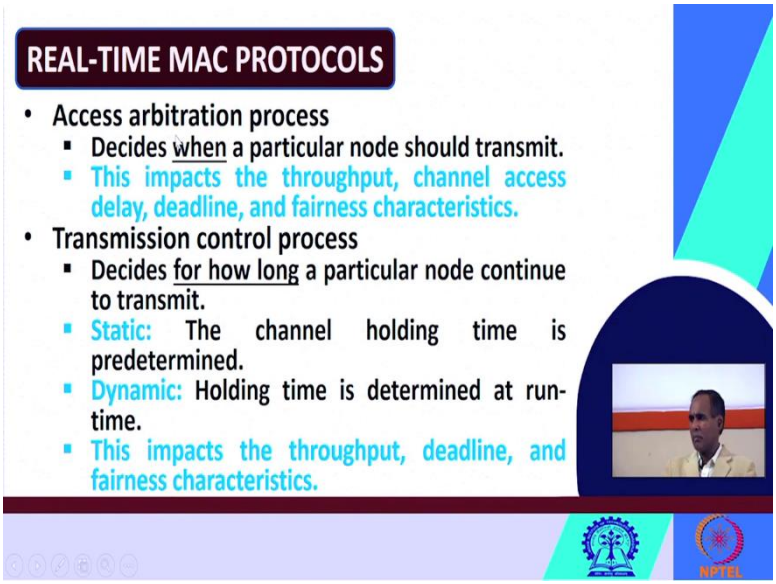

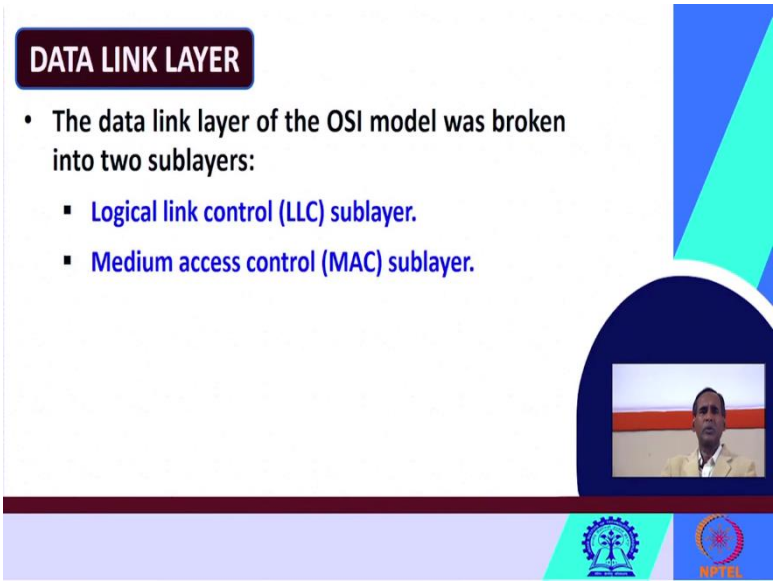

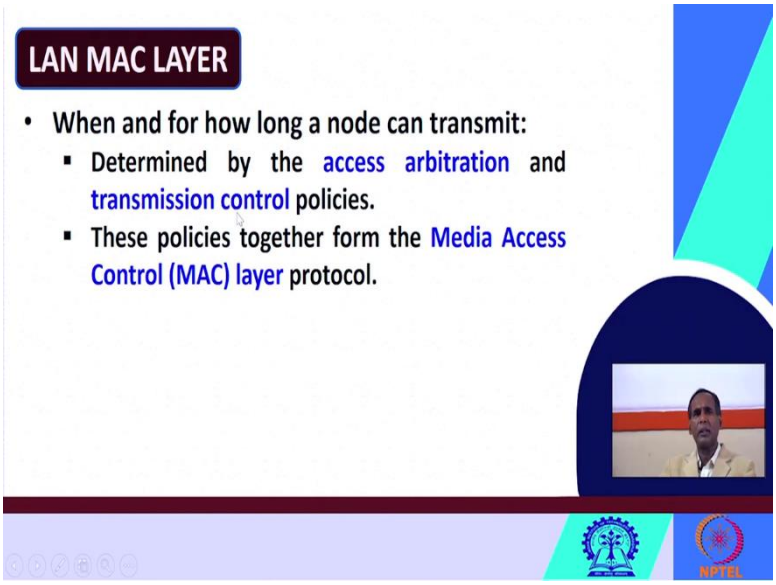

Now, let us look quickly look at these protocols. So, real time protocols, real time math protocols, what they do? I have already told you there are two important what schemes we use on this access arbitration process, another is this transmission process, is not it? I have told some errors. Yes. So, we have seen that this on this MAC layer, we have seen that there are two policies which form this MAC layer.

One is access arbitration; another is this transmission control policy. Now let us see a little bit about access arbitration and transmission control. So, this is the about access arbitration policy or access arbitration process. Access arbitration process deals with the following things this policy decides when a particular node should transmit. When a particular node can transmit, this is dealt with the access arbitration policy.

So, this will impact the throughput, channel access, the channel access delay, deadline and fairness characteristics and what does this transmission control policy does? What does it deal with? The transmission control process or this policy it decides for how long a particular node continue to transmit. So, when the nodes will transmit? The access arbitration policy will decide.

What or how long time a process a particular node should continue transmitting? It will be decided by the transmission control policy. There are two categories of this transmission control policies, one is static, another is dynamic. In static approach the channel holding time is predetermined. What is the channel holding time it is pre-determined? It is pre fixed that is why it is static and the dynamic here the holding time is determined at run-time.

You cannot turn pre determinate it, you cannot fix it earlier. In case of dynamic approach, the holding time the channel holding time is determined only at the run-time, only during the run-time. So, this will impact the throughput, deadline and fairness characteristics. So, this is how these two policies are accessed arbitration policy and transmission control policy they do their work in the real time MAC protocols.

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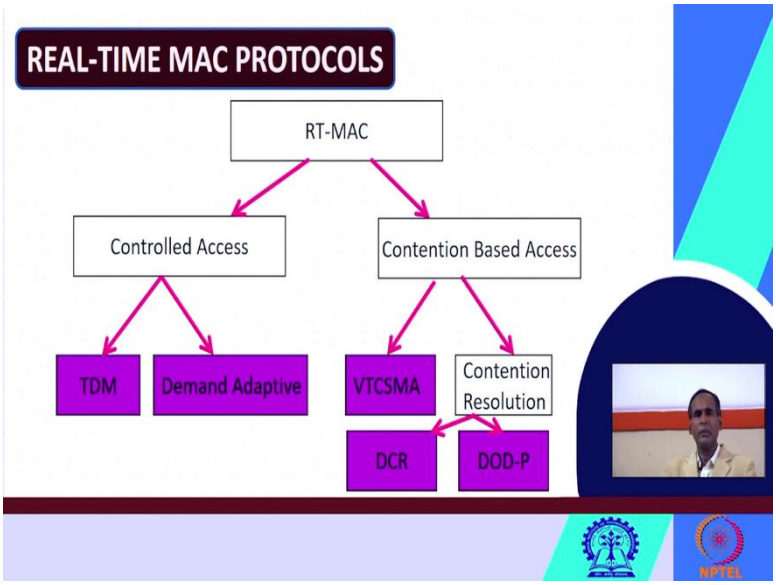

I have already told you real time MAC protocols can be divided into two categories; one is contention-based access; another is contention free access or controlled access. Under controlled access you can see the examples are TDM or round robin another is demand adaptive. And in contention-based access you can see that what categories are VTCSMA which is a variation of CSMA and another contention resolution.

Under contention resolution we will see again two categories DCR and DOD-P that I will see. So, those things so, in controlled access I think the bandwidth is reserved and in contention-based access bandwidth is not reserved. You can see the details from any book.

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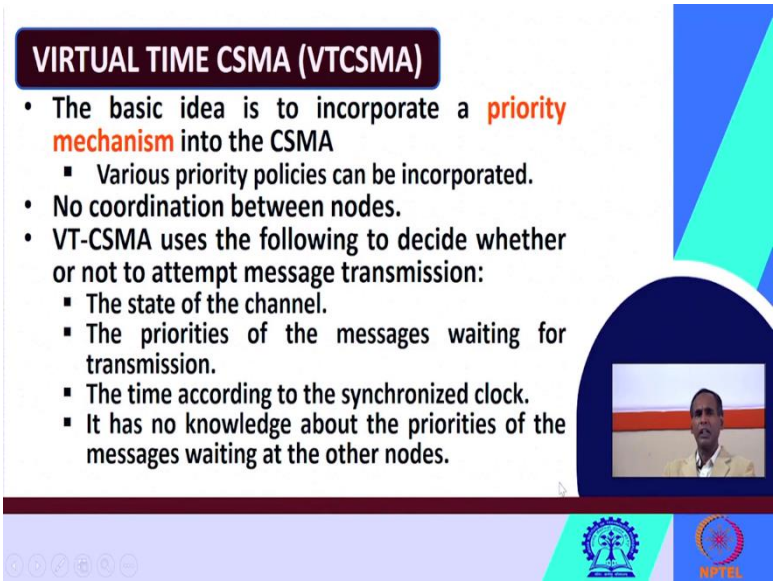

So, now let us see about the first one VTCSMA under contention-based approach. VTCSMA, it stands for what I can say V stands for virtual, T stands for time. So, this is virtual time CSMA. Here the basic idea is to incorporate a priority mechanism into the CSMA. Here the basic idea is to incorporate what? A priority mechanism. How to incorporate a priority mechanism into the CSMA?

So, various priority policies can be incorporated, we will not go into the deeper. So, in VTCSMA no coordination exists between the nodes. This protocol uses the following to decide whether or not to attempt the message transmission. So, while deciding whether to attempt the message transmission or not to attempt the message transmission, the VTCSMA uses the following issues like what is the state of the channel right now?

What are the priorities of the messages waiting for the transmission? Whether this is a low priority or high priorities? Similarly, the time according to the synchronized clock, so accordingly synchronize the clock at the time now? And also this VTCSMA it has no knowledge about the priorities of the messages waiting at the other nodes. Only knows the priorities or the messages waiting for the transmission at a particular node, at that node. But it does not have any knowledge about the priorities of the messages waiting at the other nodes.

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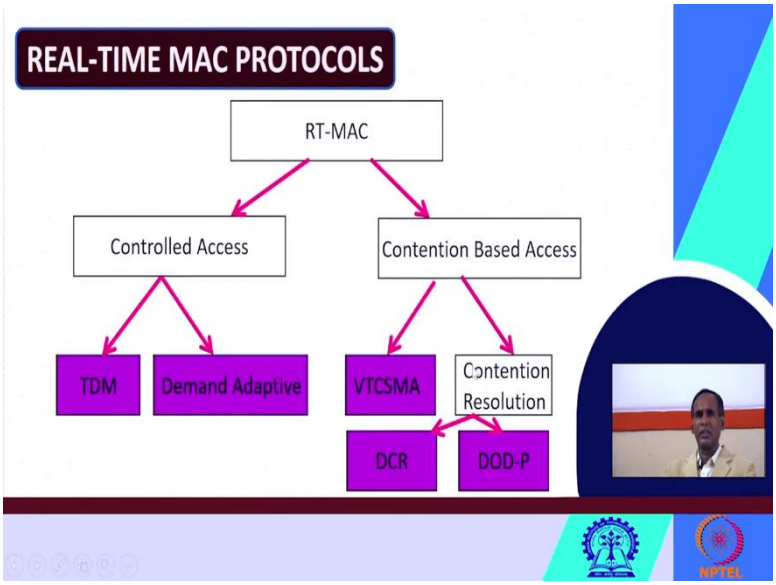

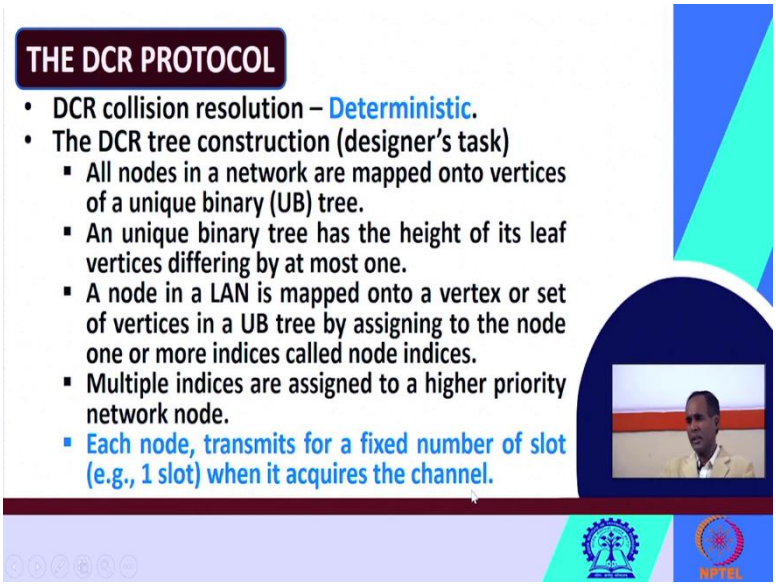

Then we will see the next category which is coming under this one contention resolution DCR and DOD-P. So, DCR stands for D stands for what deterministic, C, collision, R is resolution. So, DCR protocol it stands for deterministic collision resolution Protocol. So, basically DCR is a deterministic collision resolution protocol. Here in DCR a tree is constructed we call it as DCR tree.

So, in the DCR protocol first a tree called as the DCR tree is constructed which is the task of the designer. Tree means obviously some nodes will be there some vertices and some edges. Here all the nodes in the network they are mapped on to the vertices of a tree and that tree we call it a unique binary tree UB tree and this unique binary tree has the height of its leaf vertices differing by at most one, this is the specialty, this is the only feature in UB tree.

In an unique binary tree it is the height of what it has the height of leaf vertices differ by at most one. A node in a local area network is mapped into a vertex or set of vertices in a unique binary tree by assigning to the node one or more indices called us node indices. So, a node in a local area network is mapped onto a vertex or a set of vertices in this unique binary tree; how? By assigning to the node one or more indices, we call them as the node indices.

So multiple indices they are assigned to a high priority network node. So, when you want to give higher priority to the network node, so you can assign multiple indices. So, multiple indices are assigned to a higher priority network node. So, each node transmits for a fixed number of slot when it requires the channel. So, whenever a node requires a channel, it transmits for a fixed number of slots. So, each node transmits for a fixed number of slots. For example, one slot etcetera when it acquires the channel.

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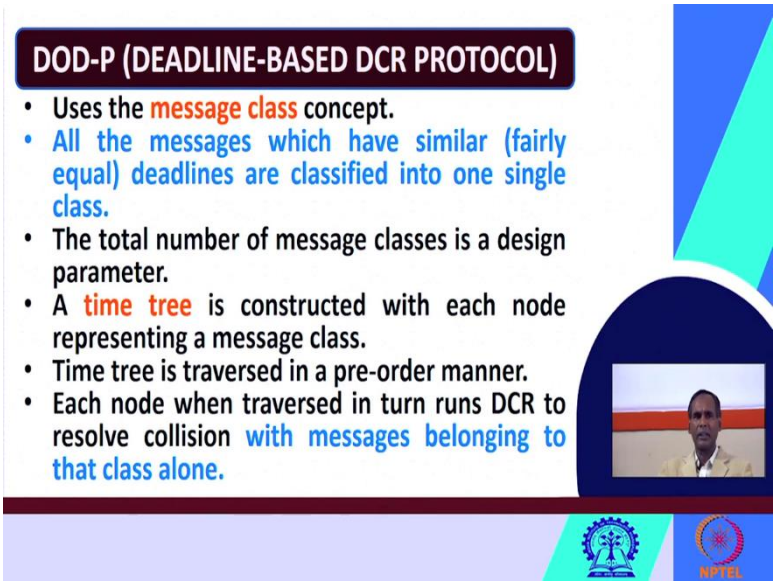

Then next protocol is DOD-P. So, it is the deadline based DCR protocol. It uses a concept called as message class. What do you mean by message class? So, here are all the messages which have similar deadlines, the messages which have similar deadlines. Deadlines are almost similar nearby they are classified into a single class. So as it is based on this message class concept here all the messages which have similar deadlines they are classified into one single class.

Here the total number of message classes is a design parameter. So, for designing the message class, you can consider the total number of messages, total number of messages classes as the design parameter. Here also a tree is constructed, we call as a time tree. Here a time tree is

constructed with each node representing a message class. So, here the nodes they will represent what? Message class.

Each node will represent a message class I have already told you DOD-P, it uses the message class concept, all the messages having similar deadlines they are considered as one single class. So here a tree is constructed called as time tree where each node represents a message class. Time tree is traverse in a pre-ordered manner, you know the different traversals, traversals like pre-order, post-order, any order, etcetera.

So, the time tree is traverse in a pre-ordered manner. So, each node when traverse in turn it runs DCR to resolve the collision. Now, let us see how in DOD-P protocol how this collision is resolved. So, each node when traversed in turn, it runs this desired protocol to resolve the collision with messages belong to that class one. I have already told you this based on message class that means this what message is having the similar deadlines they are classified into one class only.

So, in this protocol, each node when traverse in turn it runs the DCR to resolve the collision, how? With the messages belonging to that class only. So, this is something that class alone this is something a little bit or basic consists of DOD-P protocol.

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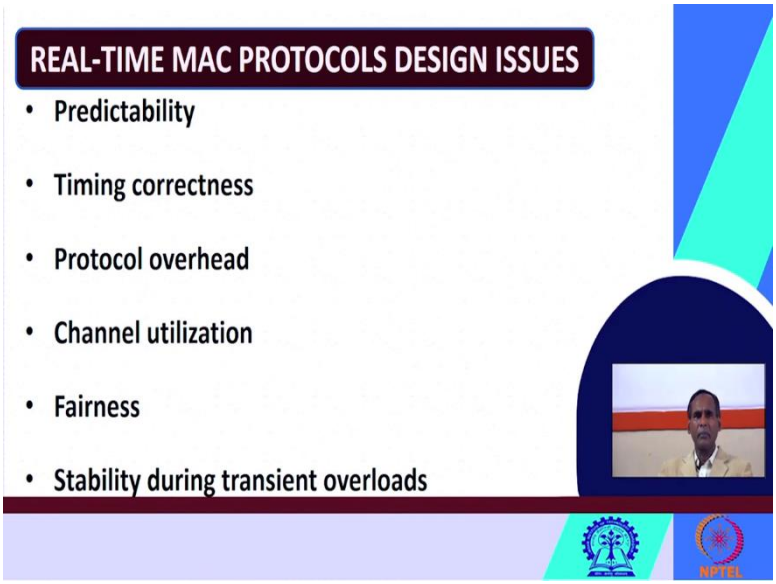

So, there are various design issues with real time MAC protocols such as what should be the predictability? How far the timing correctness will be achieved? What will protocol overhead? What will the channel utilization? The fairness property or this fairness issue, then stability

during transient overloads. These are some of the major design issues which you must take care while designing the real time MAC protocols.

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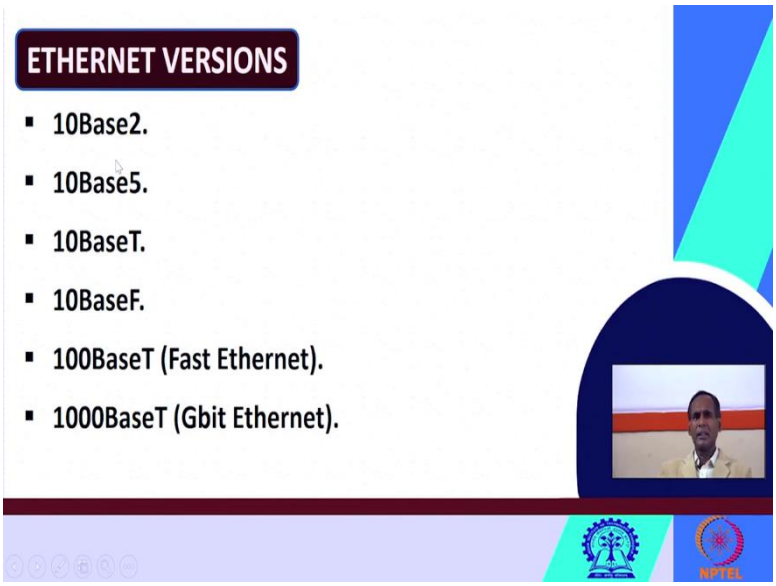

So, now we will come back to our original discussion. I have already told you ethernet is nowadays very much popular. Let us see some of these ethernet versions. Some of the popular ethernet versions are 10Base2, 10Base5, 10BaseT, 100BaseT, 1000BaseT, like this. This 100BaseT also known as fast ethernet and 1000BaseT is known as gigabit ethernet. Now let us say this 10Base2 what does it represent?

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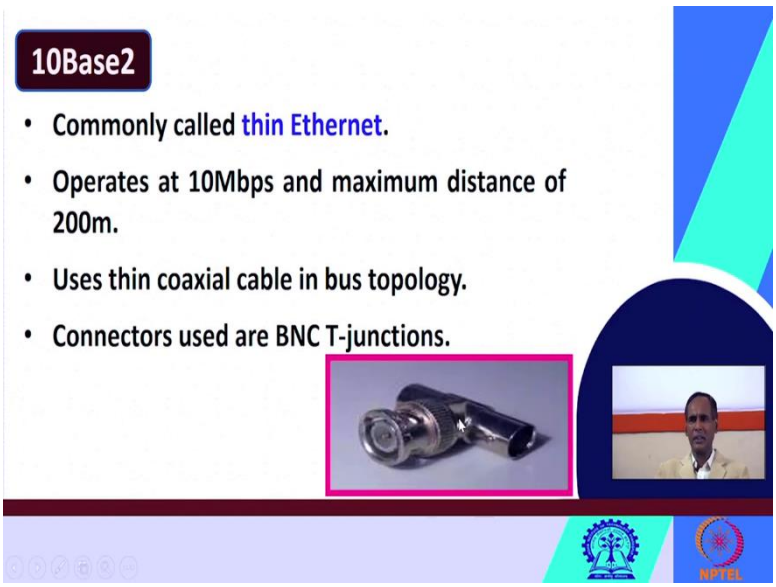

So, 10Base2 it is commonly called as thin ethernet and this 10Base2 this thin ethernet operates at 10 Mbps and its maximum distance and at maximum distance of 200 meter. Please remember this is very important. 10Base2 is known as thin ethernet. It operates at 10 Mbps speed and at maximum distance of 200 meters only. What does it use? It uses thin coaxial cable this 10Base2 it uses thin coaxial cable in bus topology.

We will see in some other cases we will see others will use. We do not use coaxial cable we will see what things we will use like twisted cable, etcetera, we will use we will see. Here in 10Base2 the connectors used are a BNC T-junctions. I already told you this T junction in earlier classes.

So, 10Base2 the what type of connectors are used? The connectors used are of BNC T-junctions types, the connectors it uses BNC T-junction connectors. Let us take a small example of this BNC T junction. This is very what this is an example of the BNC T-junction.

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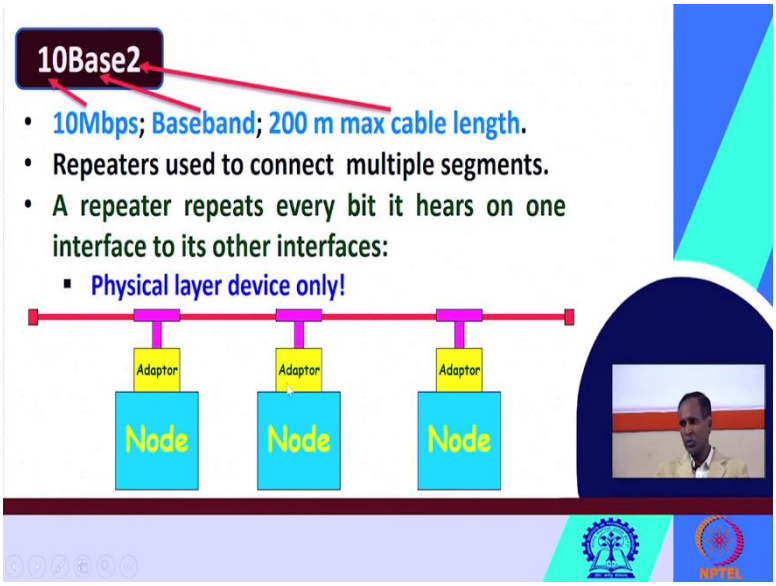

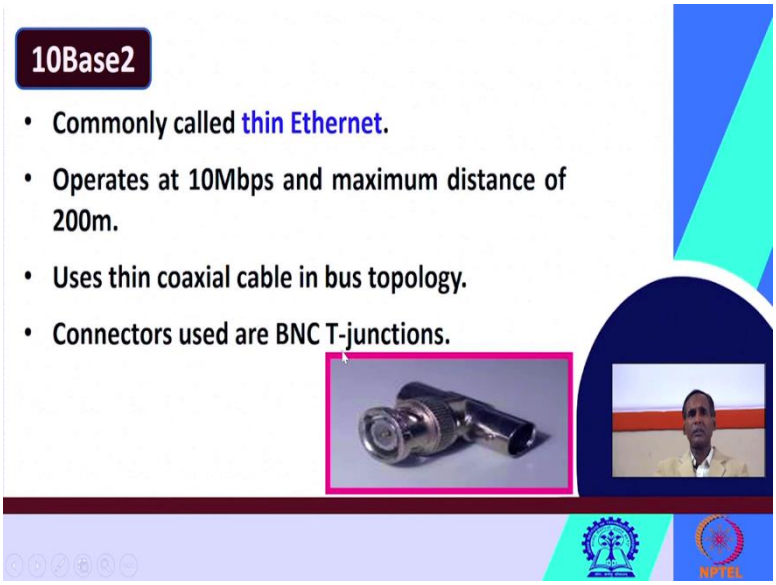

So, 10Base2 then what does these terms represent? When I am saying 10Base2, a 10 refers to this 10 Mbps. Base refers to this baseband, 2 refers to 200-meter maximum cable length. So, the cable length should be maximum 200 meter and here repeaters are used to connect multiple segments. So, if there are multiple segments it can use repeaters to connect them. So, what does these repeaters do?

A repeater it repeats every bit it hears. So, we use repeaters to connect multiple segments. What the repeaters do? A repeater it repeats every bit that it hears on one interface to its other interfaces. So, a repeater its job is to repeat it repeats every bit it hears on one interface to its other interfaces. Of course, it is a physical layer device only. So, similarly you can extend what is 10BaseT, 100BaseT, etcetera.

So, this is an example of 10Base2 ethernet you see how there uses this what is that junction, BNC T-junction. See these are the BNC T-junctions. These are nodes are connected through the ethernet and they are using BNC T-junctions to connect the segments. This is how the 10Base2 looks like.

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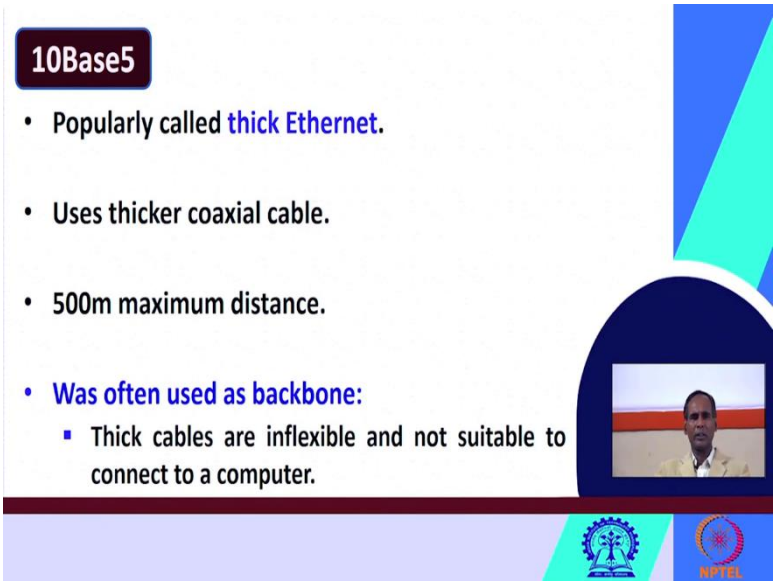

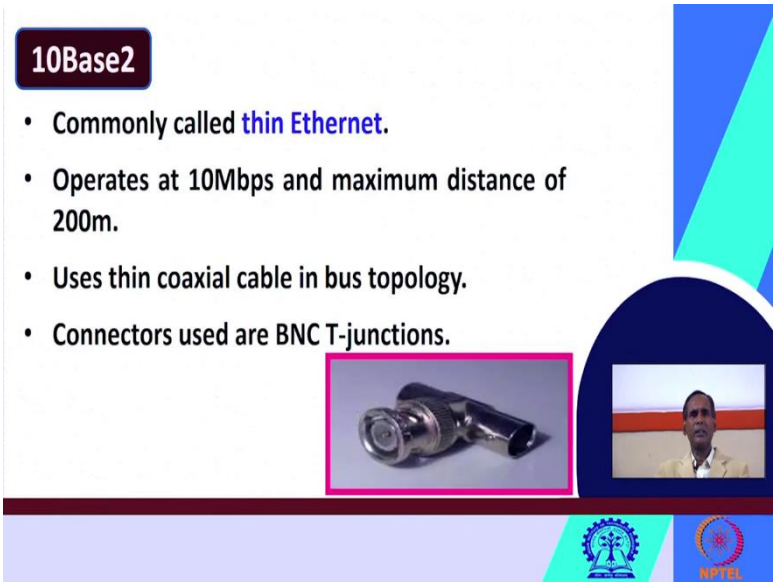

Similarly, you can understand yourself about 10Base5. So, 10Base5 it is popularly known as thick ethernet. 10Base2 is known as thin ethernet, 10Base5 is known as thick ethernet and it uses a thicker coaxial cable. So, 10Base2 uses thinner coaxial cable. But is uses a thinner coaxial cable, but it uses a, what? Thinner coaxial cable. But 10Base5 uses a thicker coaxial cable and the maximum distance is 500 meter here.

So, this was often used as backbone. So 10Base5 previously it was used as a backbone and because you know, the thick cables are inflexible and they are not suitable to connect to a computer. These thick cables are very much inflexible and they are not suitable for connect to a computer they are previously they are used backbones.

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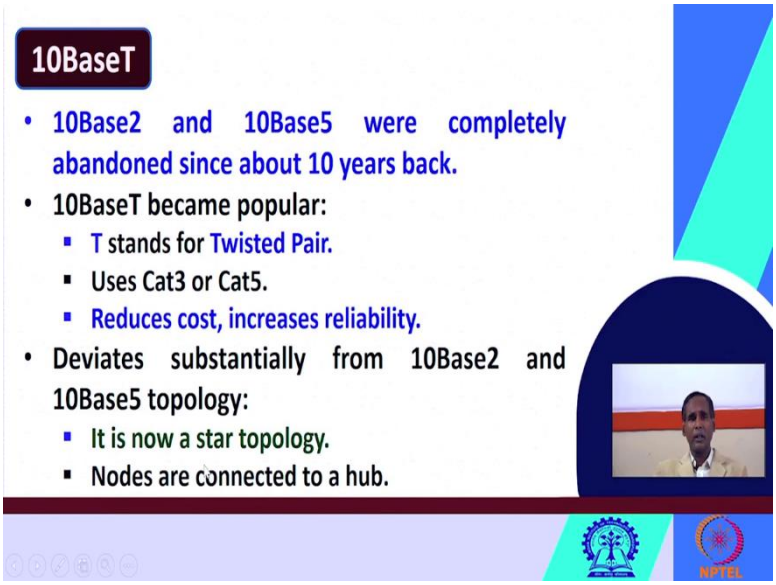

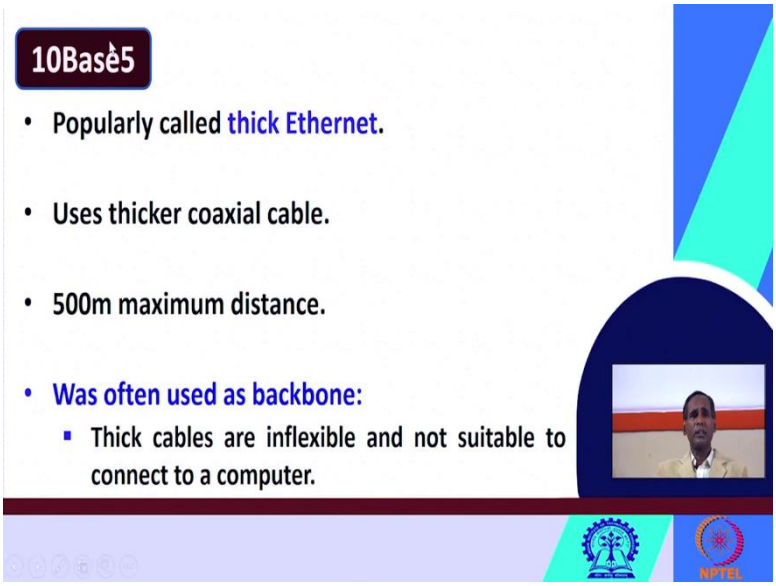

Now, let us see about the next version 10BaseT. Let us see what is the drawback of 10Base2 and 10Base5. So, these 10Base2 and 10Base5 they have similar drawbacks like 10Base5 I have already told you they these are inflexible and not suitable to connect to a computer. So, 10Base2 and 10Base5 which are completely abandoned since about last 10 years 15 years back. So nowadays this 10BaseT become popular.

So, in 10BaseT, T stands for what? T stands for twisted pair. It does not use a coaxial cable I have already told you this 10Base2 and 5 they use coaxial cable. But 10BaseT it does not use a coaxial cable, it uses a twisted pair that is why the term T is there. It uses Cat3 or Cat5. I hope you have already known what is Cat3 or Cat5, so, it uses Cat3 or Cat5 and this reduces costs and increases; this reduces costs and increases the reliability.

This 10BaseT it deviates substantially from 10Base2 and 10Base5 topology. Significant differences are there between 10Base2 and 10Base5. One significant difference I have already told you 10BaseT uses twisted pair, what 10Base2 and 10Base5 they uses? They use what coaxial, they use coaxial cable. So, and this is a 10BaseT it uses nowadays 10BaseT it uses star topology. The nodes are connected to your hub in 10BaseT the nodes are connected to a hub.

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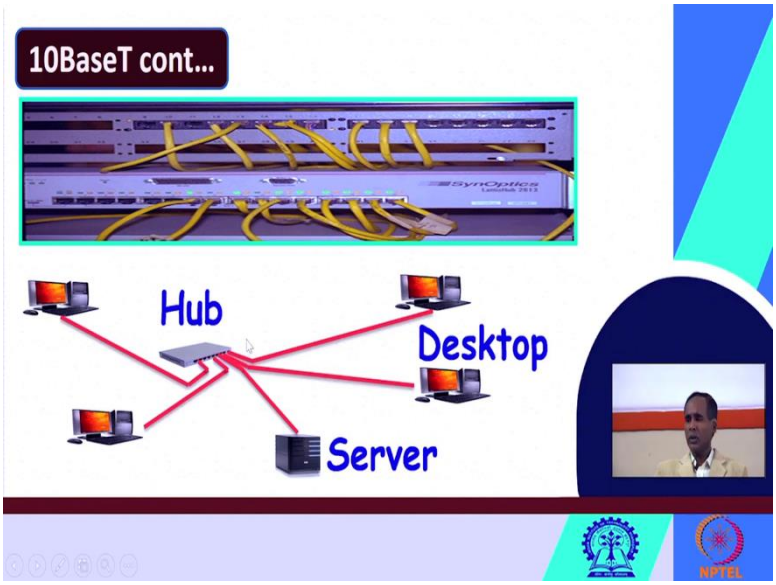

This is a sample figure of this 10BaseT you see all the nodes how they are connected to a hub. See all the servers, desktop, these are the nodes they are connected to a hub in 10BaseT ethernet.

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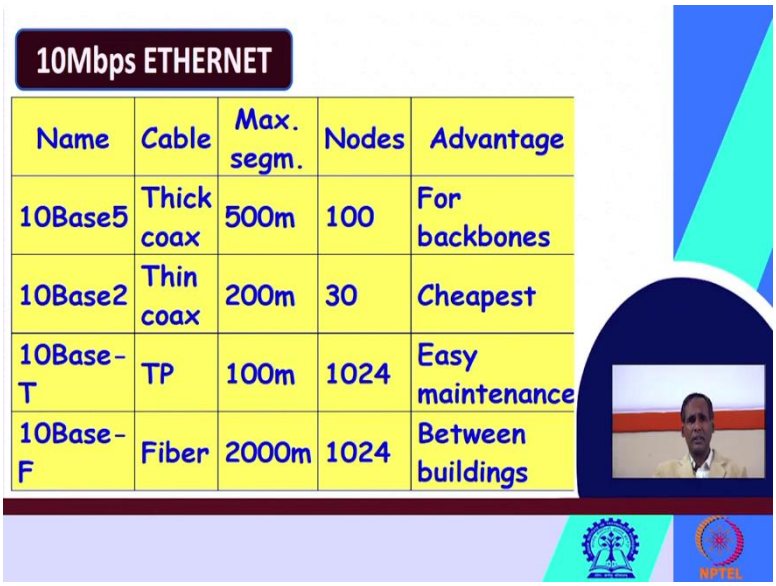

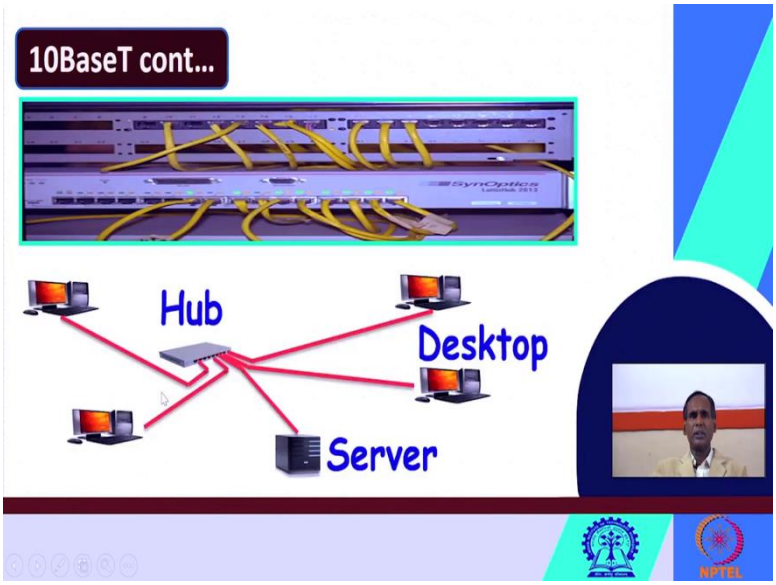

Next we will quickly go to this 10 Mbps ethernet. The difference variations I have already told you 10Base2, 10Base5, 10BaseT and similarly another is F. In 10Base5 we use thick coaxial cable, maximum distance is a 5-meter, number of nodes can be connected is 100 and advantage is it is used for backbones. In 10Base2 it uses a thin coaxial cable, maximum distance is 200 meter, number of nodes can be connected 30 and advantage is cheapest.

In 10BaseT instead of using thin coaxial cable, it uses what? A twisted pair, I have already told you it uses what? Twisted pair. 10BaseT, T stands for twisted pair. So, it uses this 10BaseT uses twisted pair, maximum segment is 100-meter, maximum number of nodes can be covered is 1024, advantage is easy maintenance.

Similarly, 10BaseF similar to 10BaseT but instead of using twisted pair it uses fiber, and distance covered is 2000 meters and number of nodes it can be connected to 1024 nodes and normally it is used to connect in between the buildings different in between or to connect 2 different buildings or for connection between buildings, this 10BaseF is used. These are the different variations of 10 Mbps ethernet.

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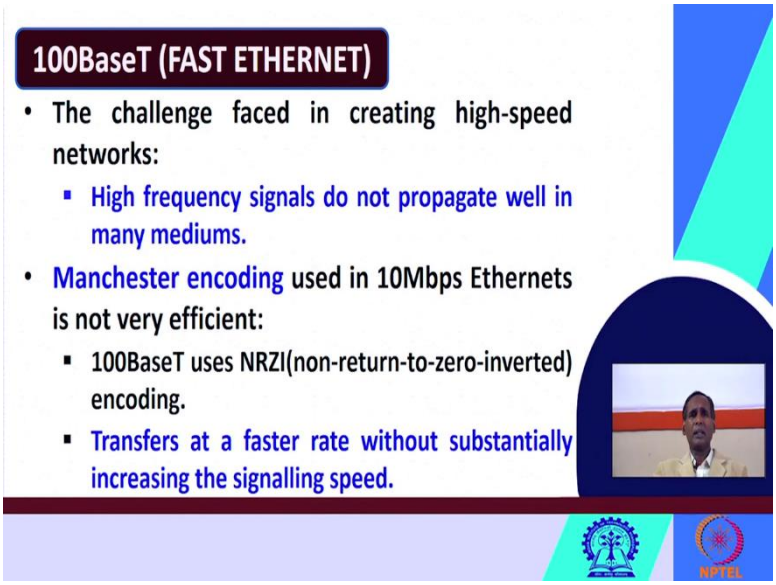

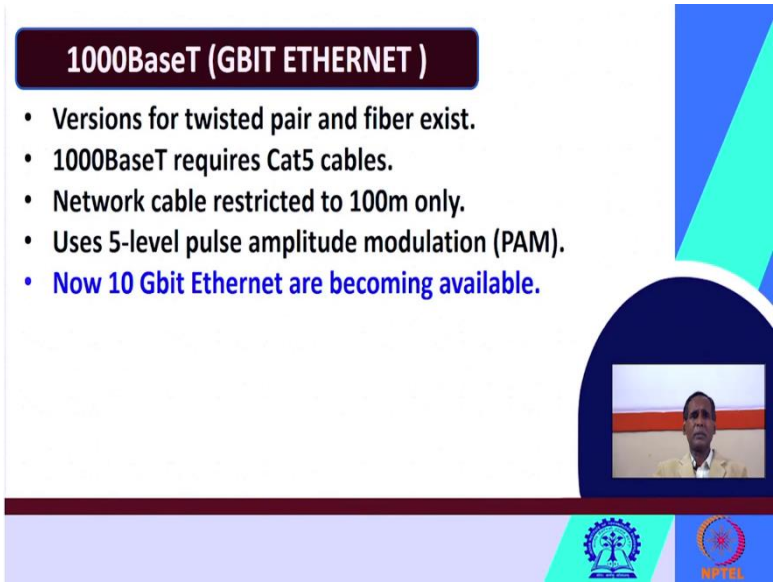

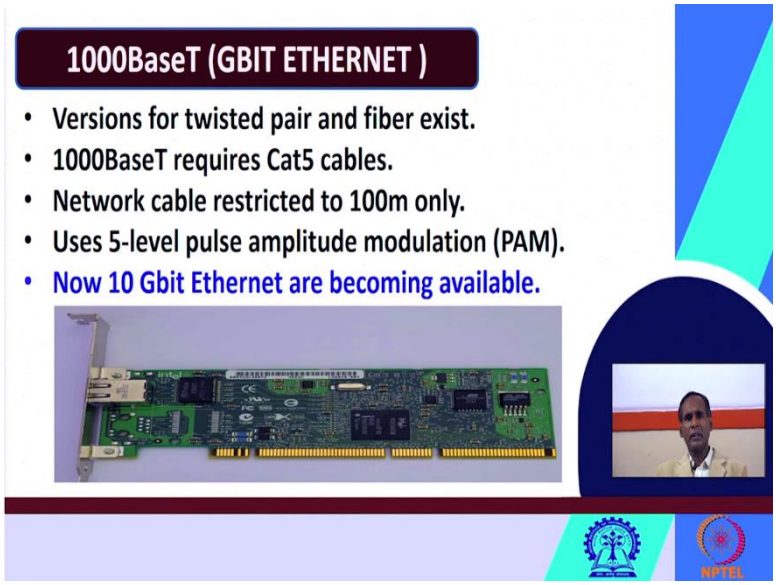

So 2 more are there, we will quickly see; one is 100BaseT, which we call as fast ethernet. Another is 1000BaseT, we call it gigabit ethernet. As its name suggests 100BaseT you can see here the speed is 100 Mbps and that is why we call that the fast ethernet. The challenge is faced in creating high speed network, so, when we are creating high speed networks the challenge faced is the following. The high frequency signals do not propagate well in the many medium. So, you will see many mediums the high frequency signals they do not propagate very well.

So, you know that in 10 Mbps different serial encoding techniques such as the Manchester encoding technique, another we will say that NRZI or simply RZ. So, these are the serial what encoding techniques. In 10 Mbps what happens, the Manchester encoding technique is used in 10 Mbps ethernets which is not very efficient, but in case of 100BaseT it uses NRZI; NRZI stands for what?

Non-return-to-zero-inverted encoding. We will not discuss those you can see from the book; how does it differ from Manchester encoding. So due to use of this NRZI technique, so, this 100BaseT it becomes more efficient. So, if this in this in 100BaseT it transfers at a faster rate without substantially increasing the signaling speed. So without increasing the signaling speed, this 100BaseT it transfers at a faster rate in comparison to this 10 Mbps ethernet. That is why you call as fast ethernet.

And last one is 1000BaseT it is stands for gigabit ethernet. The versions for twisted pair and fiber exists. So, that means 100BaseT of course T stands for twisted pair but the versions for fiber also it also exists in 1000BaseT. So, in 1000 base T or gigabit ethernet, versions for the twisted pair on fiber both exist. 1000BaseT requires Cat5 cables. So, we have seen that 100BaseT it may contain what maybe about in earlier versions we see cat3 or Cat5 but 1000BaseT requires only Cat5 cables.

Network cable is restricted to 100 meter and only. In 1000BaseT the network cable is restricted only to 100 meters. Please remember these things these things may be asked in the examination. It uses 5 level pulse amplitude modulation. You have known different types of modulation and particularly you know about different types of amplitude modulation in computer network paper.

So, this Gigabit ethernet it uses a 5-level pulse amplitude modulation. Now, 10-bit ethernet, 10 gigabit ethernet are also become available. So nowadays in the market 10-bit ethernet are also becoming available. If you will go to the market, you can easily see this is 10 gigabit ethernet

available that becoming very much available they are becoming very much popular. So, this is an example of this 1000BaseT or this gigabit ethernet.

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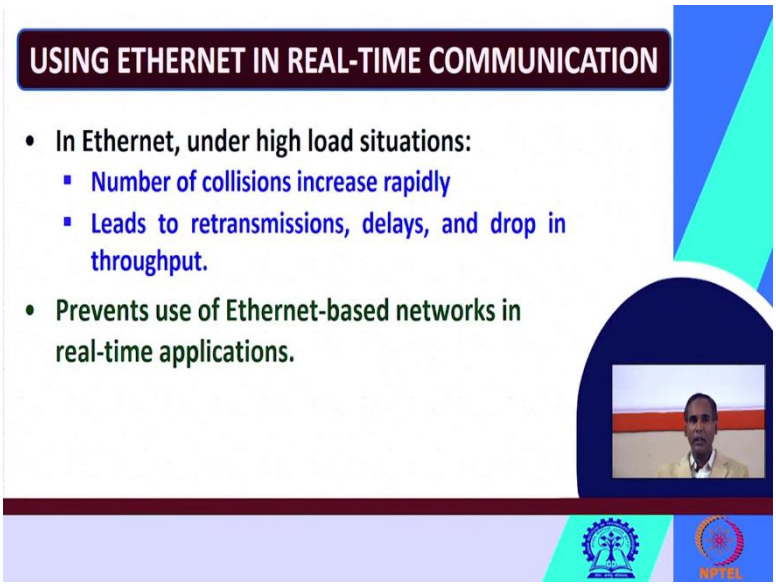

So, the now on the using ethernet in real time communication what is the drawback? How far it is suitable to be used in real time communication? In ethernet under high load situations the number of collisions they increase very rapidly. This will lead to retransmission and the delays and drop in throughput, I am repeating again what is the problem if you will use ethernet in real time communication.

In ethernet when there is a high load situation, under high load situations, the number of collisions it increases rapidly, this ultimately leads to retransmissions, delays and a drop in the throughput. This prevents the use of ethernet based networks in real time application. So, these drawbacks they prevent the use of the ethernet based networks in the real time applications.

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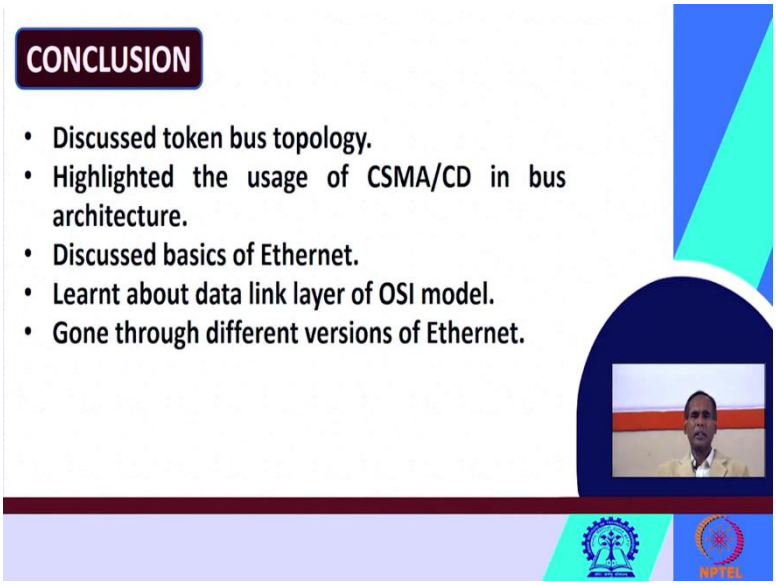

So, today we have discussed the token bus topology in detail. We have highlighted the use of CSMA CD in bus architecture. We have discussed the basics of ethernet and we have learned about the data link layer of OSI model particular the MAC layer protocols. We have also seen different versions of ethernet.

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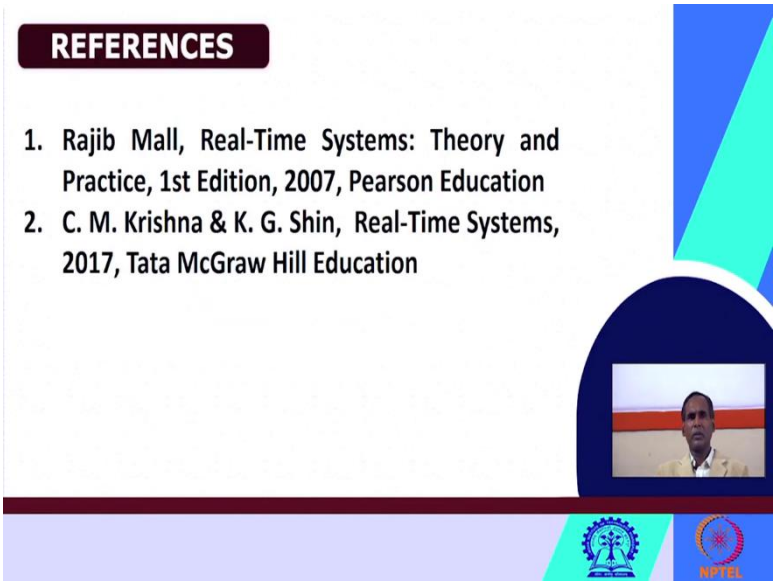

We have taken from these books, these contents. Thank you very much.