Computer Network and Internet Protocol

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Lecture – 48
Data Link Layer-Ethernet

Hello, we will continue our discussion on Computer Networks and Internet Protocols and last couple of lecture, we were talking about data link layer as we know that link layer 2 in the OSI stack also in TCP IP stack also it is in the layer 2 in some of the TCP IP stack, if we put physical layer and data link layer together nevertheless it is a in a layer 2 devices right.

So, we have also discussed that the switches or layer 2 switches has this property is that it can open up packets up to layer 2 and take a call based on the things right and also in the layer 2, we understand that it is a it divides the (Refer Time: 01:02) and domain, but still work in the same broadcast domain and another point that any routing protocol. Once the route is specified when the routing path is found out by this routing protocol then, this then when the packets moves up to hub to hub, it need to resolve the next location or the next hub destination by resolving.

The IP to this layer 2 address or MAC address right and also we have seen that there are 2 predominant, we can sub layer or we can divide into sub layer 1 is the LNC, which takes care of the connectivity with the upper layer or the negotiation with the layer and another major part is this MAC medium access control, which basically takes care of the connectivity with the media and there is a unique addressing of MAC address some also known as hardware address also known as network address which comes with the network interface card.

So, today what we will be discussing is one of the predominant protocol in the layer 2, which is more or less omnipresent across the across the all networks in the world that is the predominant protocol of Ethernet right. So, initially we may talk about this some other that allow a protocol or 1 or 2 slides, then we will go to the Ethernets basic features.

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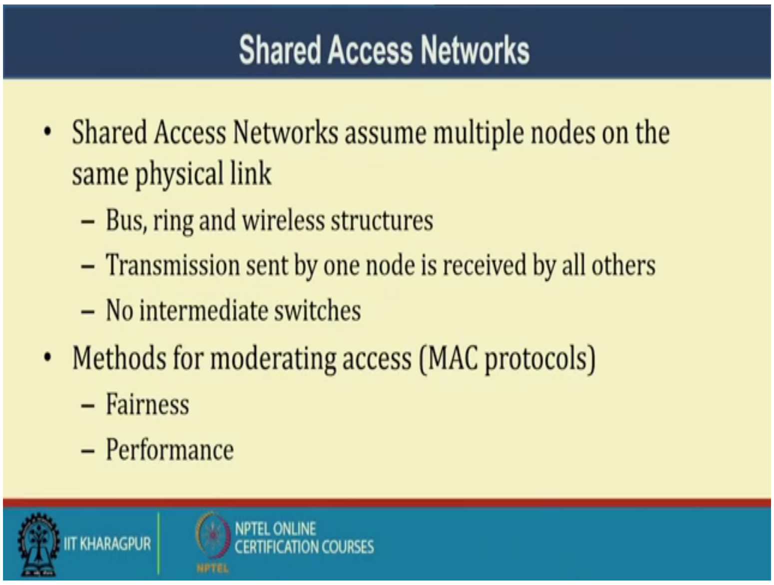

So, what we are talking about shared network address right. So, that means, shared network access assume multiple nodes on the same physical link right, it can be bus, ring, wireless structure, whatever so, but we on a physical link there are several networks transmission sent by one node is received by all others nodes right no intermediate switches are required. So, that is within that what we say reach of all the nodes and received by all the nodes as we are telling that is in the same broadcast domain. So, method of moderating the access is the, is through the MAC protocols and which primary look as the fairness and the performance.

So, it is pair to all nodes and it able to utilize this is means band width in a appropriate way and also we know that it should be somewhat simple to implement otherwise putting onto devices with low resources etcetera we cannot put resource (Refer Time: 03:36) and those type of things.

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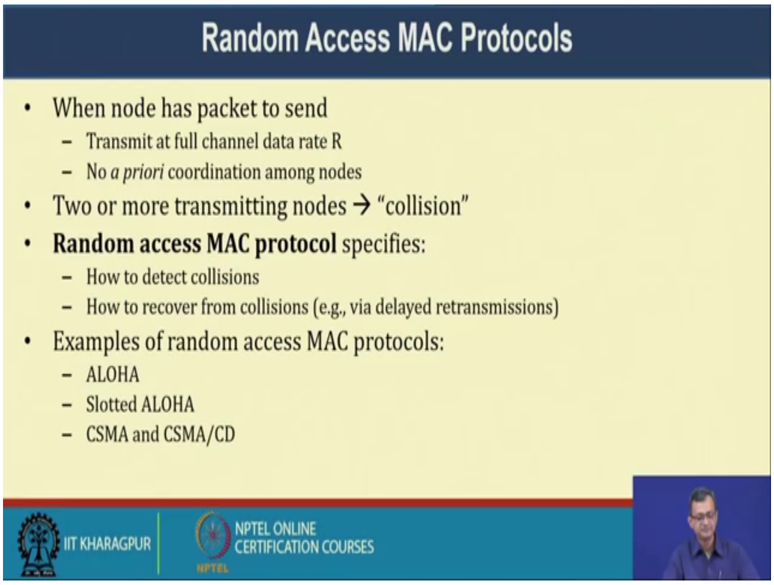

Now, if you look at the random access MAC protocol, when node has packet to send transmit at full channel rate R. No a priori coordination among the nodes. So, whenever the; it needs to send, it sends on a full rate right, no coordination things. So, randomly access the channel two or more transmitting nodes if there are there are the same time there may be a possibility of collision.

Once the collision is there should be a mechanism should come up and if there should be a retransmission or whatever some action needs to be taken. So, random access MAC protocol specifies how to detect collision. So, there should be a way to detect collision and how to recover from collision right may be via one of the popular thing is that delayed retransmissions. So, (Refer Time: 04:28) transmission after sometimes.

So, and examples of random access MAC protocols one that from long back like sixties or in early seventies is Aloha. There is a variant of these of slotted Aloha and this days, what we look at is CSMA or CSMACD right or rather we have more things on the things never the less what we see is the Ethernet is predominately (Refer Time: 04:59) predominantly ruling the whole networking and it is sees on CSMA CD.

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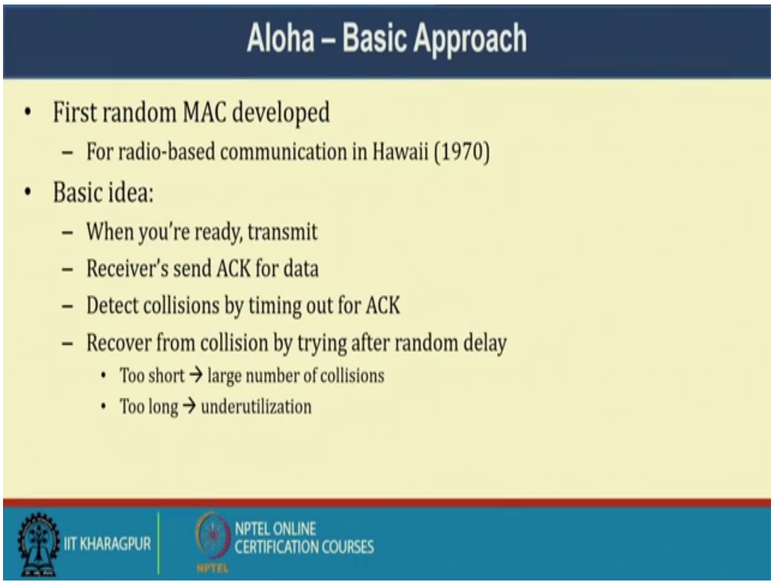

So, Aloha basic approach is the first random MAC developed for radio based communication in Hawaii in 1970 all right early, I means late sixties and early seventies 19 seventy. So, basic idea when you are ready transmit; so, there is no question of looking at the Chennai Aloha, whether it is busy or somebody is using receiver sends a acknowledgement for data detect and collision by timing out of timing out of technology.

So, if you do not receive the acknowledgement in time. So, there is collision or there is a loss of the packet, recover from the collision is by trying to trying after random delay. So, too short large number of collision if it is too long underutilization channel. So, these are the basic over all philosophy of the thing.

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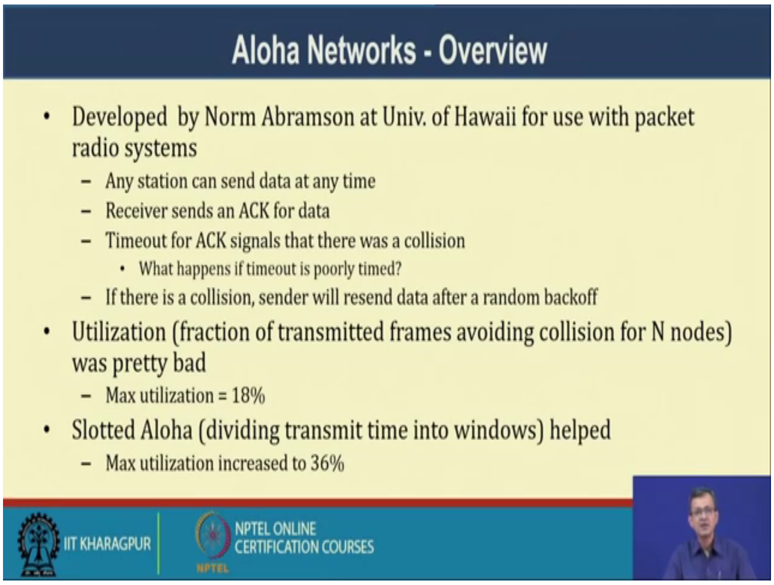

And if you look at the network Aloha network developed by Norm Abramson at university of Hawaii to use with packet radio network. Any station can send data at any time receiver sends an acknowledgement same thing, if there is a collision sender will resend the data after a random back-off all right. So, utilization; that means, how much channel is utilized fraction of transmitted frames avoiding collision for N nodes, it is pretty bad correct or pretty low. So, maximum utilization is 18 percent right. So, it is if you if you will at some point of time, you try to look at the calculations or rough calculations to see that.

So, it is around 18 percent whereas, slotted Aloha dividing transmit time into windows help so, maximum utilization. So, if we in the case of certain Aloha the utilization time increases little bit to 36 percent, but better than Aloha. So, this was the first card thing, but we need to remember it is there in 1970 right late sixties 1970. So, those type of (Refer Time: 07:08) was there and what we see that our present day thing, what we came up later on is based on this basic philosophy.

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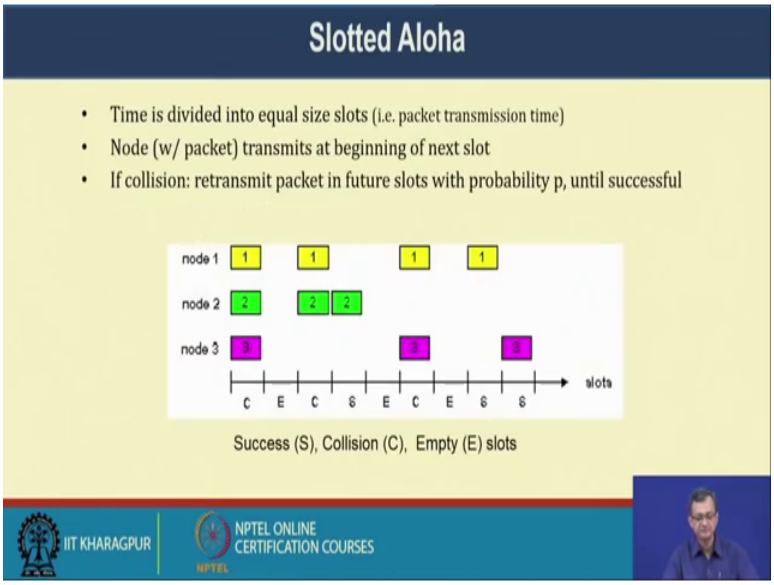

So, in case of slotted Aloha time is divided into equal size slots that is packets transmission time right. So, slots node without packet transmit at beginning of next slot right. So, the node, which want to sends with packets in nodes to have the packets to be send and beginning of the next slots. So, it is on the slots it transmits; if collision retransmit packet in future slot with probability p until successful. So, it is it is not like that any time transmission it is on the on the slotted. So, there are it is divided in to slot and whenever the things comes it node transmit on that particular slot.

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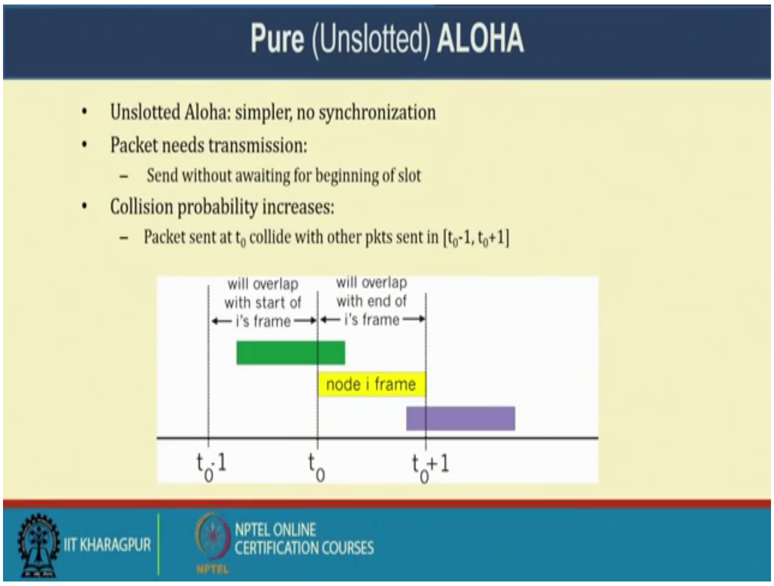

So, in case of pure Aloha, un-slotted Aloha: simpler, no synchronization. So, when we look at the pure Aloha, there is no synchronization; that means, no slotting or type of things packets needs transmission send without awaiting for the beginning of slot or anything like that once, it goes it goes on the things. So, collision probability; obviously, increases much packets sent at t 0, you see at this in this figure collide with other packets send in t 0 minus 1 t 0 plus 1 right. So, it can collide with the other packets at sending at other time interval also right. So, there is a in case of pure Aloha it is once ready send it type of things, if there is a collision wait for some time and retransmit.

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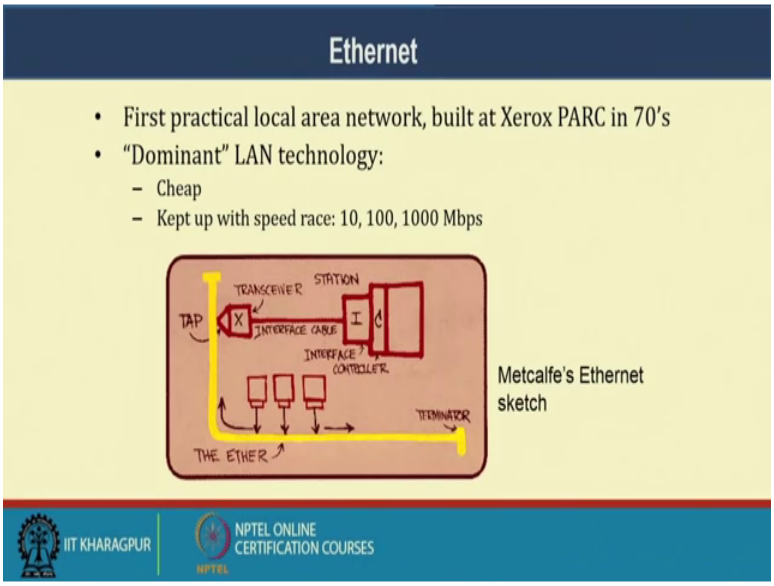

Now, we come to that our Ethernet. So, this is the very first hand-drawn figure of Ethernet sketch of Metcalfe. So, the first practical local area network built at Xerox PARC in 1970's right in 70's, dominant LAN technology, it is cheap kept with a speed race 10, 100, 1000 mbps. So, 10 Mbps, 100 Mbps and 1 gbps Ethernet and started in 19 seventies, there is a, this is a very popular picture, you will find in several books and other several resources internet resources and type of things. So, this was the initial sketch of the thing, the query interfacing a particular stage interface controller a trans receiver connecting or tapping to the that backbone of the ether and there can be several other devices, which is connecting to the things. So, there is a there are terminator and anybody can means, any of the device can connect to this particular backbone of the ether right. So, that was the philosophy and make a big change because, now you have a shared media on a on a single bus or ether.

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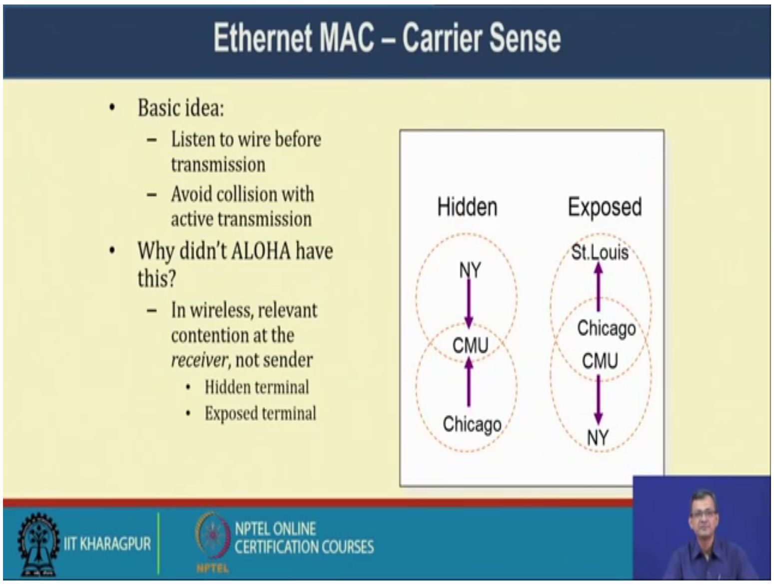

So, one issue with the Ethernet MAC is the carrier sense. So, basic idea is the listen to the where before you transmit right, whether somebody is there avoid collision with active transmission right. So, avoid collision with active transmission, if there is things.

So, why what was not in Aloha, the primarily Aloha is a packet switch network. So, in wireless relevant contention at the receiver is not on at the sender right. So, at the receiver end;so, there can be a problem of hidden terminal in this case, where the one terminals are hidden or it can be exposed terminal, this both terminals are exposed and get the things. So, there can be a hidden terminal problem or exposed terminal problem and it may not be feasible to have all those, you can listen and before transmit.

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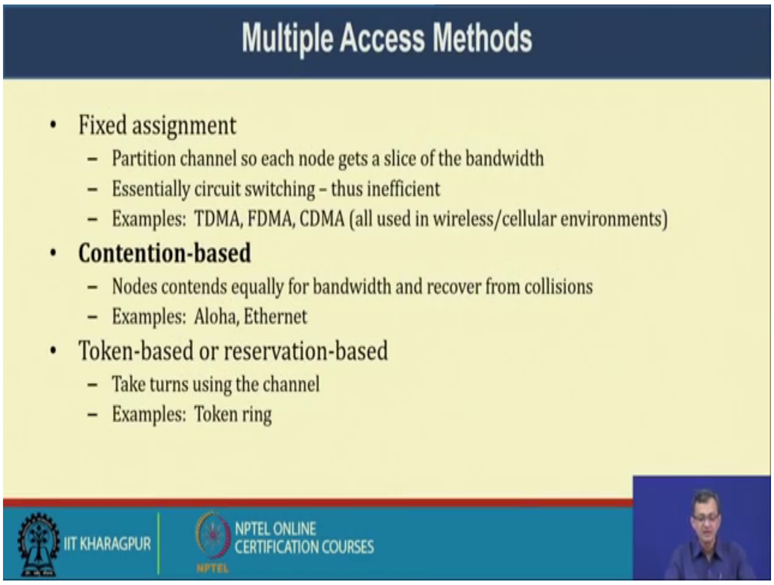

So, multiple access method;so, when what there are approaches, one is the fixed assignment like partition channel into each node gets a slice of the bandwidth. So, I the channel is partitions. So, it has it node has his own partition essentially some sort of a circuit switch, thus inefficient like if you if you are not transmitting then also it is the slot is allotted and type of things.

So, it is a inefficient. TDMA, FDMA, CDMA all used wireless and cellular environments are examples of this type of fixed assignments, there is contention based nodes contends equally for the bandwidth and recover from the collision. So, this where our, this Aloha or Ethernet is based on and this is the thing. So, everybody contend for the channel and look for the means and whence it is free transmit, if there is a collision there is a process of recovering from the collision or retransmission of the data in to the channel. Token based or reservation based is another thing that is the take turns using the channels and that is that token ring is one of the example in previous lecture, we have discussed that, when the node which holds the token has the right to transmit, the or take charge of the channel type of thing. So, our main intention or main goal of the thing is look at the contention based or things. So, like which is the Ethernet.

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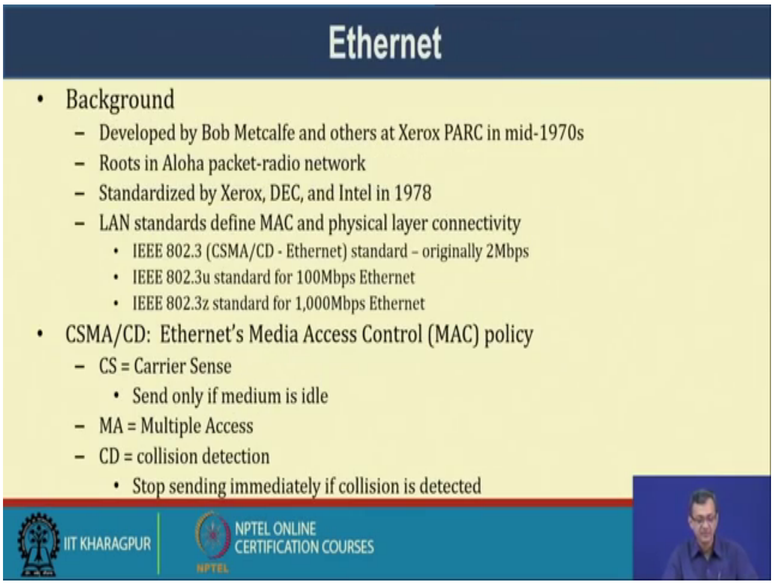

So, coming back to Ethernet; so, background is something developed on Bob Metcalfe on and others in Xerox PARC in mid seventies, roots in Aloha packet radio network that is primarily standardized by Xerox DEC and Intel in 1978 and LAN standards define MAC and physical layer connectivity right.

So, there are several standard we have already seen that is 802 dot 3 is the CSMA CD Ethernet that standard originally, it was 2 Mbps then we have that 10 mbps I triple E 208 dot 3 u is the 100 mbps Ethernet I triple E 802 dot 3 z is the one gbps of 1000 mbps Ethernet right and the basic protocol is CSMA CD Ethernet that media access and control MAC policy CS we as you know that CS is the carrier sense send only if, thus medium in idle. So, it sense, the carrier and see that whether the idle MA is the multiple access. So, carrier sense multiple access with collision detection stop sending immediately of if the collision is detection send a jam signal. So, that the other participating nodes understand, there is a collision and then go for a retransmission of the things.

So, that is the basic philosophy of this slotted Aloha, it is not sorry that is the CSMA CD sorry that, CSMA CD that is what we use in this Ethernet and this is the again the picture comes back the same picture.

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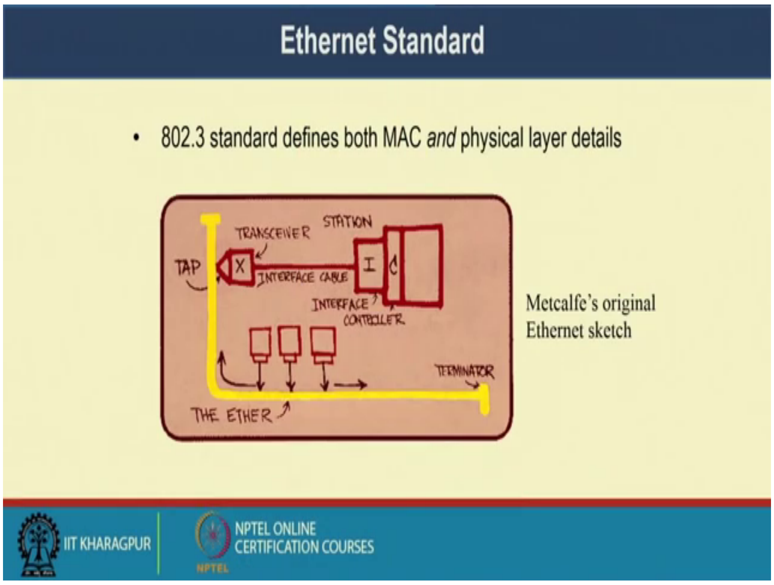

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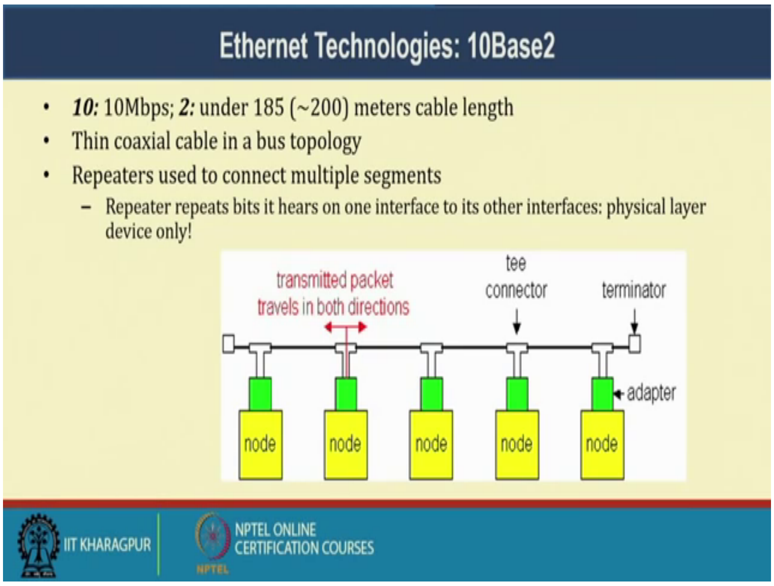

So, the Ethernet technologies that initial thing was the 10 base 2, 10 was that 10 mbps 2 is around less than 200 meters cable length is permissible. So, thin coaxial cable in a bus topology, it was their repeated used to connect multiple segments of such stable repeater repeats bits, it is here on the interface to the one other. So, it is a physical repeater is a physical layer phenomena layer 1 phenomena, which primarily increase the signal strength or in others terms, we can say it increases the (Refer Time: 15:43) signal to noise ratio.

So, it is amplifies the signal. So, if you if the permitted length is 200 meters effectively around 180 meters. So, after that you require a repeater to increase the 6 signal strength. So, that it goes on the on the rest of the on the again, another segment of 180 meters or 200 meters right. So, and as we know that we are that that popular hub, which is also layer 1 device is primarily a multi port repeater. So, if it is hub is typically 4 port, 8 port, 16 port hub, but they have the same collision and broadcast domain. So, the effective bandwidth is pretty low. So, this worst case it is divided by the number of ports it is having right. So, that is the basic thing.

So, what we see that there is a cable here and these are all tapped right. So, thin coaxial bus repeater used to connect the multiple segment and there is a cable. So, there are node, there are several nodes, which are tapped into the thing. So, there are these are all tee connectors right, some of you might have seen, there are tee connectors right, where this cables are connected and this things are there. So, transmit packet travels in both directions. So, this, the tee connector and then we are the terminator at the end and there are adapter at the things. So, this adapter basically connects this machine or the node. So, that is the interface between these, this is the network adapter, which connects the things right.

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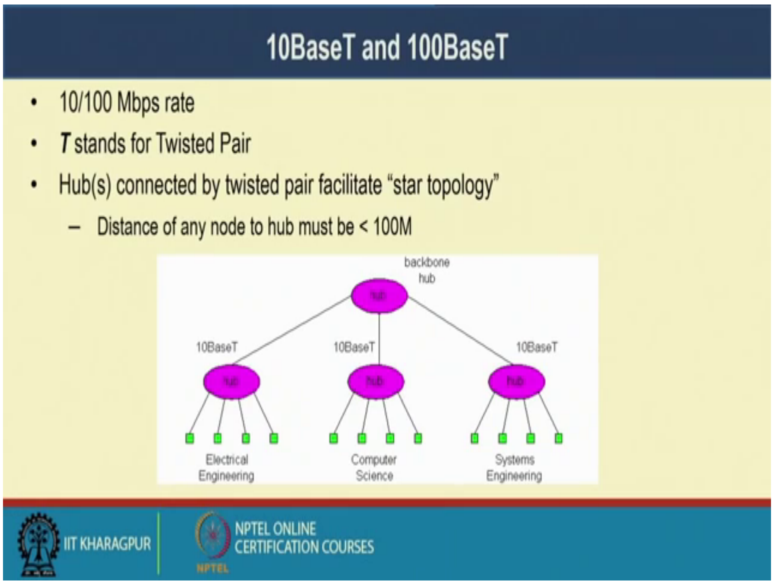

So, then it came that 100 10 oblique 100 mbps rate with twisted pair. So, initially if you see it is 10 base 2, this is 10 base T and 10 base 100 base T.

So, T stands for twisted pair hubs connected by twisted pair facilitate star topology type of things. So, there is a hub sorry, there is a hub and there are these are the different connections and again hub connectivity etcetera, the effective bandwidth goes on decreasing, but we can have a star type of topology right.

So, um. So, this is the structure by which that 10 base 2. So here, again 10 stands for the mbps and T is the twisted pair typical length of twisted pair is around not more than 100 meters another effective width is less, then 100 meter around 89 meters up to which this just twisted pair is can run.

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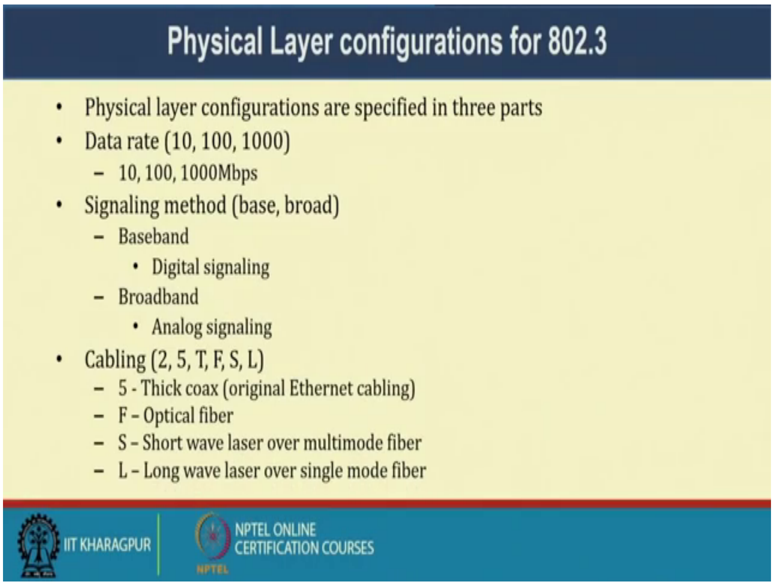

Will come to this physical layer, physical layer consideration letter, but has to have a continuity of 802 dot 3 physical layer configurations specified in 3 parts either data in data rate 10, 100, 1000 signaling rate, whether is a baseband or broadband signal, baseband is the digital signaling, broadband is analog signaling and this cabling right, there are difference specification 5 for thick coax coaxial cable, F for fiber optic, S for short wave laser through multimode channel L, for long wave laser to single mode channel and so and so forth all right and already, we have seen 2 and T what this stands for.

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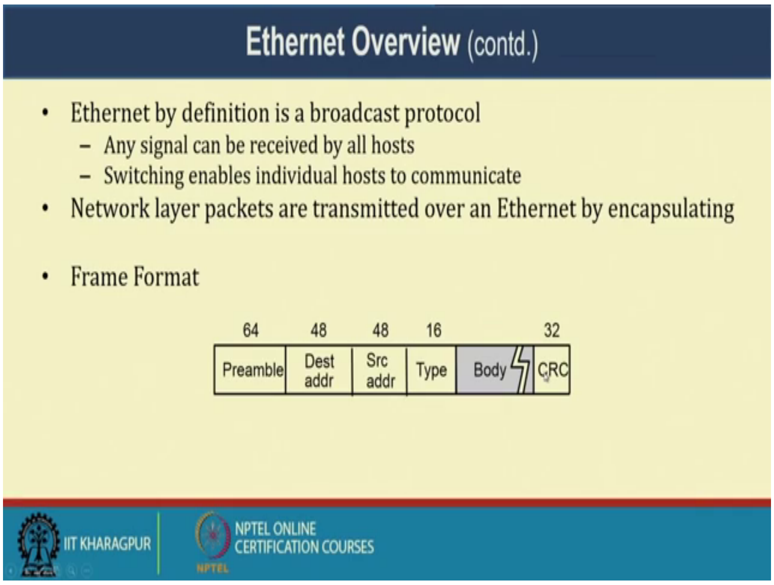

So, Ethernet is defined by a broadcast protocol, any signal can be received by all host. So, it is a same broadcast domain switched enable individual host to communicates.

So, that the collision domains is fragmented or divided and network layer packets are transmitted over and Ethernet by encapsulating by encapsulating so; that means, that this is our typical frame format, where we have a preamble of 64 bit destination address, 48 bit source address, 48 bit there is a type field of 16 bit, this is the body of the message and there is a 32 bits CRC check right. So, this a typical size of Ethernet, typical format of Ethernet a Ethernet frame.

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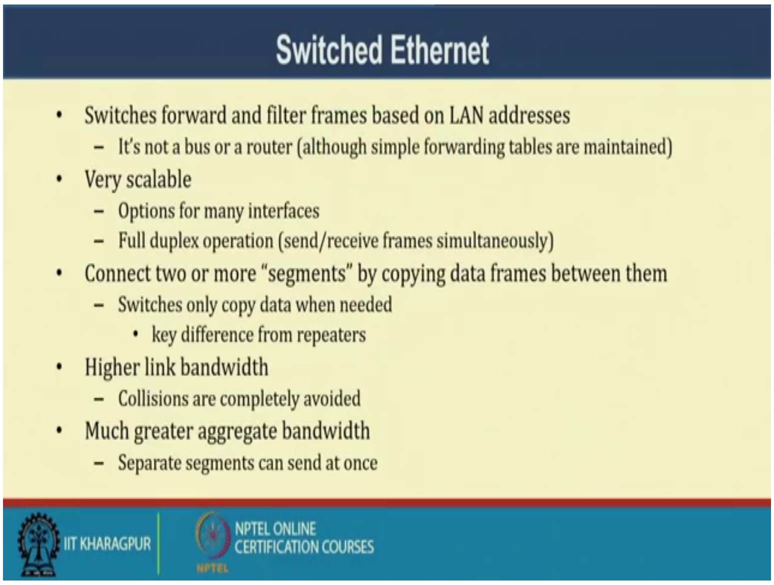

So, when we have a switch network there are several features or advantages right. Switches forward and filter frames based on the LAN addresses or MAC addresses or hardware address or network addresses whatever it is.

So, based on that switches forward and filters, the frames it is not a bus or a router although, simple forwarding tables are maintained. So, a switches has a layer 2 switch, what we are talking about layer 2 switch has a table and based on that. So, if I have a input switch then it is forwards packets based on the based on the data it is received, based on the destination input. So, in other sense the collisions are collision domains are divided or we are avoiding this collisions in this in when, we connected in the switch. So, it is very scalable like unlike hub, where the it is in the same broadcast and collision domain here, it is different collision domain very scalable of sense for many interfaces, full duplex operation send received frames simultaneously right. So, it can as a full duplex operation.

So, that I do not have those type of collision scenario. So, connect 2 or more segments by copying data frames between them right. So, I can even connect 2 or more segments with the switch right, switches only copy packets when needed key difference from the repeaters right. So, repeaters is primarily only signal enhancing or amplification of the signal. So, that it is transmitted, where as switch devise the collision domain. So, you can have different collision domain and that is why, the effective bandwidth is much higher than here and not only that scalability is there, you can connect cascade switch in a much better way than then hub or repeaters, higher link bandwidth, collisions are completely avoided.

So, you have a higher as you have talking about higher a link bandwidth or better utilization bandwidth, much greater aggregate bandwidth, separate segments can send at once. So that, I can have when, we aggregate the all these bandwidth then we have a much better aggregate bandwidth, when we have a separate segment connected over the switch.

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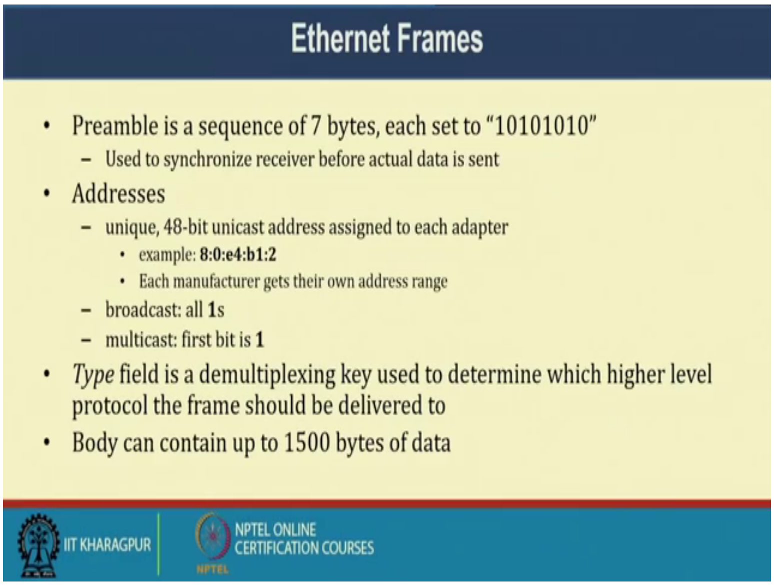

Now coming to the Ethernet frames; So, preamble is a sequence of 7 bytes and each set to 10101010. So, just to remind here; so, we have a this preamble of this used to synchronize receiver before actual data is transmitted and address is a unique 48 bit unique a unicast address assigned to each adapter right. So, of the form of x x though y x x colon x x colon x x and this form. So, we have a; so, 1,2,3,4 5. So, we have a total 48 6 into 8 that is a 1 early 1 is missing. So, it should be 1, 2, 3, 4, 5, 6, 6 into 8.

So, I have a 48 byte a 48 bit unicast address for each adaptor, each manufacture gets it is own address range so; that means, whatever adapter is manufacture is adapter or manufacture has a unique addresses; that means, ideally or whatever interface card, we are connecting with this our network has this separate addressing. So, all network interfaces or adapter across the world are unique though, there are issues of cloning of this adapter etcetera, we are not again as I am send earlier also we are not going to the those challenges complicacies, but we this is the basic philosophy right. So, broad in case of a broadcast all 1, in case of multicast first bit is 1 right. So, this is the way we look at it type field is a demultiplexing key used to determine, which level of protocol the frame should be delivered to right.

So, this is a which signifies that at which level of which higher level protocol, these particular frame will be delivered to, body can contained up to 1500 bytes like the payload can be after up to 40 1500 bytes and finally, we have a CRC of 32 bit.

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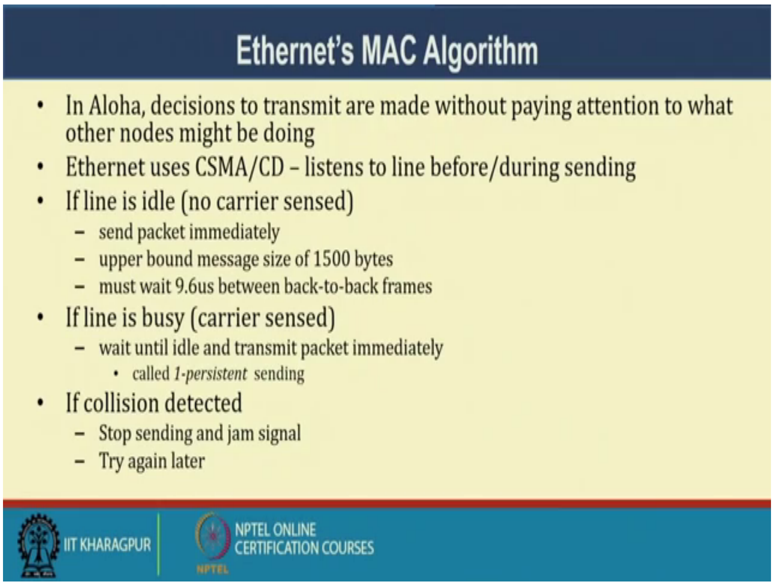

Now, in Aloha decisions to transmit are made without paying attention to what the other nodes might be doing right so; that means, you have once you are ready you transmit. Ethernet uses CSMA/CD listens to line before during sending the data right if line is idle no carrier is sensed right send packet immediately. Upper bound size is 1500 bytes must have 9.6 micro second between the back to back frames right. So, if the line is busy carrier sensed; that means, carrier is senses somebody is someone is transmitting wait until the transmit packet wait a wait until idle and transmit packet immediately, this is also known as one persistent sending. So, wait until the it is the is the idle and transmit packet immediately without looking at it, if collision detected stop sending and send jam signal try later again right.

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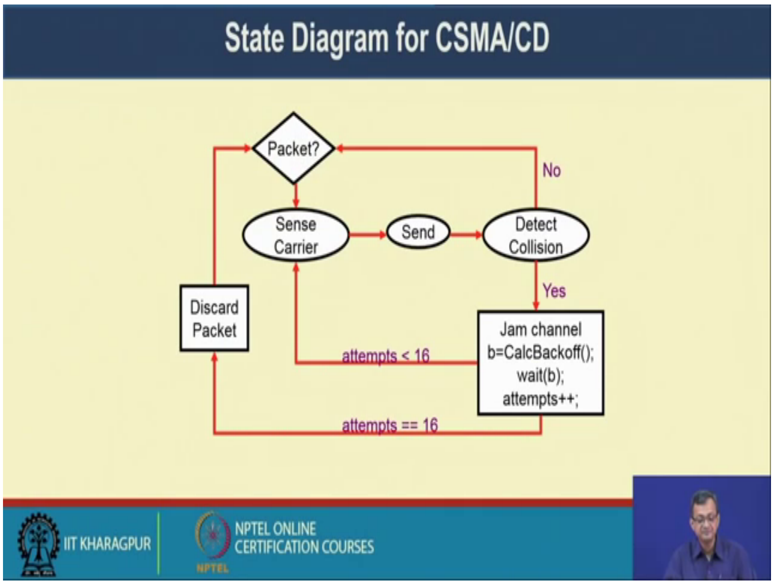

So, this is the basic philosophy. These some form we have seen earlier also that basic state diagram of CSMA/CD. So, the packet sense carrier if it is send if it is send yes then the jam signal calculate the back-off time wait for b and go on keep attempt is less than 16 again carrier sense equal to 16 discard packet and go on like this right. So, this is this is the way it goes on, if packet is there it is sense and type of thing. So, you sense the carrier and then go on transmitting the things right. So, this is the way to go on working on the thing right. So, first of all, if I want to send the packet sense, the carrier if the carrier is free send it, if there is a collision, if detected then wait for send jam signal wait for a back-off time, if attempt is less than 16 go an against the sense, the carrier if attempt is equal to 16 then discard the packet.

So, collisions are caused when 2 adapter transmit at the same time right, adapter sense collision based on the voltage differences. So, they voltage based on the voltage differences it sense that whether, is a collision or not.

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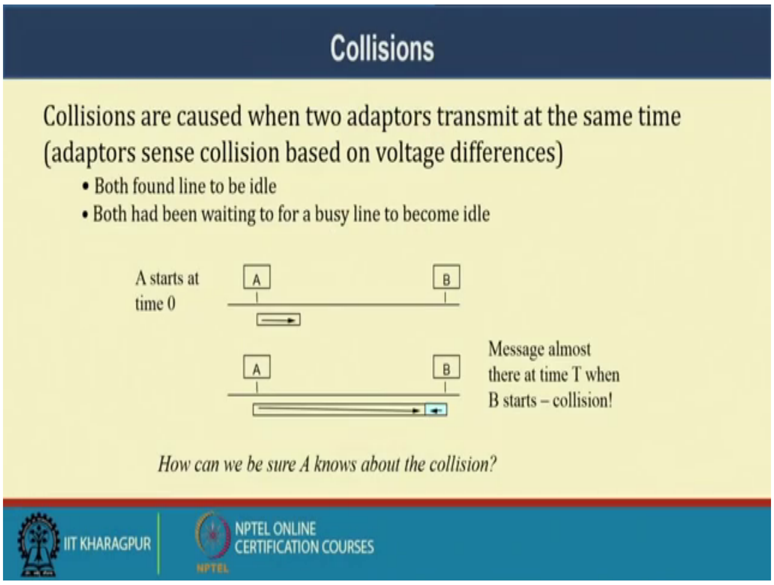

Both found line to be idle right, in this case AB both found that line to be idle at that time both had been waiting for a busy line to become idle and then they transmit A transmit at time 0, message almost there at time T B starts collision right. So, this is this is the way collision can happened and there should be a retransmitted, how can we be sure that A knows about the collision?

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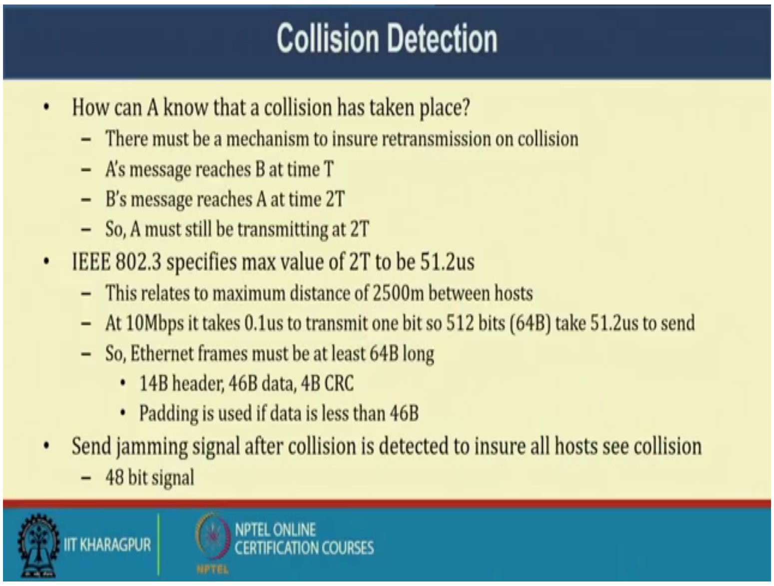

So, one way is that either that voltage difference and sort of things or if it is knows about the collision takes place, there must be a mechanism to insure retransmission on collision right A's message reaches B at time T. B's message reaches time A at time 2T right.

So,. So, A must wait till transmitting still B transmitting at time 2 T. So, after typically max time of 2 T comes to know whether, there is a collision or not. So, 802 dot 3 specify max value of 2T to be 51.2 micro second, these relates to a maximum distance of 1500 meters between the hosts right, if we consider that speed the speed of way when transmission. So, it is around 1500 meters between the hosts considering that cable etcetera, where you cannot get that whatever, in the vacuum also around 60 percent of the speed, you will be achieving. So, at 10 mbps it takes 0.1 micro second to transmit 1 bit. So, 512 bits that is 64 bytes takes 51.2 micro second to send right.

So, Ethernet frame must be at least 64 byte long, 54 byte header 46, yeah sorry 14 byte header 46 byte data and 4 byte CRC. So, there is the basic thing, if padding is use if that data is less than 46 byte correct. So, we have this thumb rule calculation. So, 8023s specify that the 2T to be 51.2 microsecond, this relates to 1500 meter between the hosts, if 10 mbps takes 0.1 microsecond to transmit 1 bit. So, at 10 mbps, it takes 0.1 microsecond to transmit 1 bit. So, 512 or 64 byte takes 51.2 microsecond to send right. So, Ethernet frame must be at the 64 byte long, 14 byte headers, 46 byte data and 4 byte CRC. So, if it is less than your, data is less than 46 byte then padding should be use. So, sending jam signal after collision is detected to ensure all hosts collisions are see the collision. So, it is a 48 bit signal, which is a jam signal is send.

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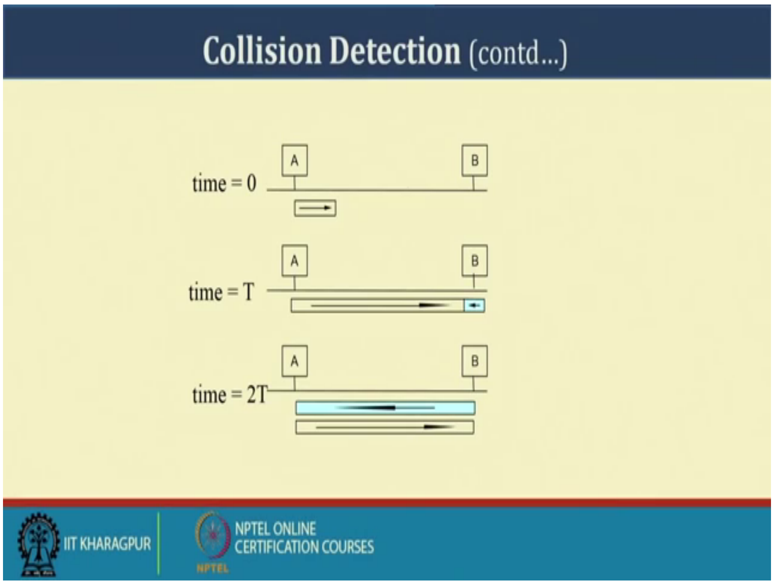

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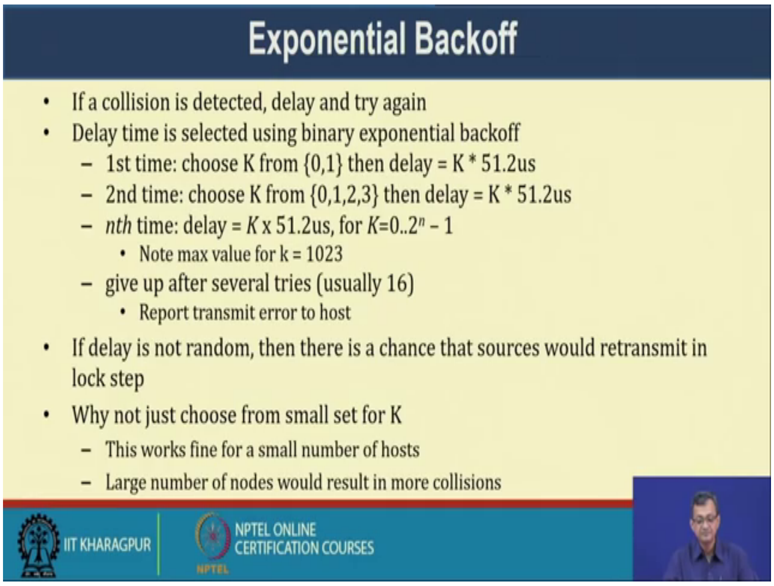

So, this is the collision detection after time 2T and then we have a exponential back-off, if collision is detected delay and try again delay time is selected based on the binary exponential back-off. First time choose K from 0, 1 and delay equal to K into 51.2 microsecond. Second time choose K from this side 0, 1, 2, 3, K into so and so forth and nth time choose from 0 to 2 to the power n minus 1. So, know the maximum value of allowable K is 1023 to give up after several tries usually 16 once, the trial is 16 gives a then report a error to the host, if delay is not random, then there is a chance that the source would retransmit in the lock step.

So, why not a choose small set of set for K, this fine it works fine, if the number of host are less. So, if you have a less number of host there is small k will work fine, if the number of host are pretty large then these there will be a chance of more collision. So, this is the basic philosophy of our basic Ethernet, which uses CSMA CD primarily and so, what we will what we have seen that that it is a carrier sense and detection and then retransmission after a back-off time, what it is doing. There are some base line what we say, arithmetic which tells are that what should be the size of the things, will continue our discussion in the next lecture with the Ethernet and other variation of this or on the data link layer. So, let us conclude our discussion for this particular lecture, and we will continue in the subsequent lecture.

Thank you.