Communication Networks
Prof. Goutam Das
G. S. Sanyal School of Telecommunication
Indian Institute of Technology, Kharagpur

Module - 09
Media Access Control Protocol
Lecture - 42
Effect of Physical Media

Ok. So, so far we have discussed about Media Access Control Protocol which is the layer two protocol and we started seeing the historical development through analysis. So, first Aloha came then Slotted Aloha then from Slotted Aloha we started analyzing the stabilization of how to make it stable and then we could see that there are two other options that are coming into the picture carrier sense multiple access and collision detection.

So, this means seeing all these things there is another detour that we might have to take basically we now have to really see where what kind of things we can do; which means depending on the physical media can we do collision detection, can we do carrier sensing, what is possible, what is not possible and if something is not possible what kind of alternative we can think about in terms of the media access control protocol.

So, this is something we might have to do before we again restore our final state of analysis for CSMA what is the benefit of CD if we employ what is the benefit in wireless there is something called CA what is the benefit? So, we will see all those things, but before that probably it is really required that we rigorously discuss the media and the effect of media and its influence on designing protocols.

So, today we will try to do that let us see what kind of media we have. So, whenever we talk about this physical media. So, physical media can be as we have already discussed earlier.

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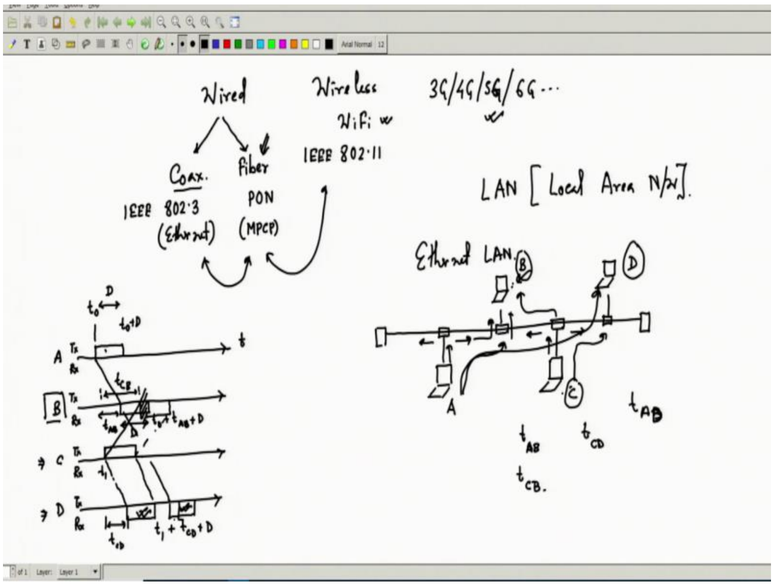

So, it can be divided into two parts. One is wired and the other one is wireless. Among wired probably there are two kinds of media that have been over the years. So, one is a coaxial cable and the other one is fiber, wireless is wireless that is fine. So, with coaxial cable the corresponding protocol that has been popularized is called 802 dots 3 or is popularly known as Ethernet with the fiber it is PON, and the corresponding protocol is MPCP we will talk about that Multi-Point Control Protocol.

Wireless is one of the access technologies, of course, this Wi-Fi and the corresponding protocol is 802 dot 11 this is I triple E standard actually. These are all I triple E standards where the standard actually describes the protocol ok. So, these three kinds of media we can talk about and you will see later on that all these three media has their means potential differences, and accordingly the protocol also has means hugely they differ from each other. So, that is there.

In wireless there is also another access that is now becoming more popular, it is more like I mean with infrastructure kind of thing and know with infrastructure wireless provisioning. So, that is like 3G, 4G, 5G, so, all those things, and then it is going towards 6G and so on, it just keeps on going. So, that is another thing, but that is also wireless protocol ok.

So, this is more distributed probably this is probably more centralized we will talk about that and this will have more infrastructure, but anyway predominantly if we see it from the protocol perspective probably these three are the ones we have to discuss and their comparison is the major thing even in our analysis also will be most probably bringing these three things because they are only the most of the innovation in protocol has been proposed depending on the media.

So, now let us try to individually characterize the media. So, in coaxial cable what happened? So, this was probably the first kind of access network that was proposed as LAN or Local Area Network ok? So, what was the proposal? So, in the local area network, they had different kinds of topology, so we have to discuss topology. So, because it is infrastructure-based or it is it is a wired media.

So, basically, whatever it is up to the end user there will be wire wired connectivity. And over here the media is a coaxial cable which has a comparatively lower bandwidth compared to the fiber of course, fiber will be having it is modulated at the optical signal and it is having a huge bandwidth whereas, this mostly takes baseband signal and has a low pass characteristics which cannot go beyond a very high value.

So, bandwidth-wise fiber is much higher of course, and coaxial cable is lower. Fiber has a carrier. So, basically, it is modulated it is at optical frequency. So, it is quite high frequency in the terahertz range whereas, Wi-Fi ok, will be in some gigahertz 2.4 gigahertz, or 5 or 11 gigahertz. So, that kind of range ok that is the carrier and it has reasonably high bandwidth, it is not very high probably.

So, let us try to see the media itself. So, for LAN, the first LAN that was proposed is called Ethernet LAN ok. So, in Ethernet LAN first of all it is a media access control protocol. So, the media has to be shared. So, let us try to see what was the initial sharing techniques.

So, in initial sharing techniques, there are few topologies actually; one was the bus topology. So, you had this coaxial cable running everywhere there will be a tap and from that tap, another coaxial cable will go to the system that you are trying to connect to. So, there will be a terminator at both ends which will be exactly impedance matching. So, that the reflection and all those things are reduced. So, all those things are properly being done ok.

So, again there will be machines over here connected. So, like this, it used to be. So, it is it is a bus, a bus means, a particular length of coaxial cable that runs everywhere with the tab you are tapping power ok? So, basically, it is a common medium because this bus is shared among users.

So, whoever wants to transmit actually launches power over here that flows into both directions and then it reaches its destination. At the same time, others can launch power over here that will also flow in both directions. So, if they are means simultaneously transmitted, they will collide. So, suppose this guy wants to transmit to this receiver and there is another receiver that is connected over here and this guy also wants to transmit to him.

So, there will be a collision, and remember always the collision happens in the intended receiver because when you are receiving then only the collision will generally happen. So, you have to mean whenever you talk about collision a lot of timing is involved.

If it happens that some of the intended receivers are receiving both packets simultaneously while he is receiving them because it is a common media, everybody's data goes to everybody. So, his data also will be going over here, his data also will be going through this tab over here they will superimpose.

If in the time they have this one transmission time then only there will be a collision and that has to be happening from the perspective of the receiver. So, let us try to understand that. Let us try to understand and analyze this collision. So, let us say station A, station B, station C, and station D are ok.

Now, I am drawing the timing diagram where the sense of global time is there. This is for station A, this was station B, this is station C, and station D ok. So, now, station A suppose at time equals to t start transmitting this packet, it will take some amount of time. So, if this is t 0, so, t 0 plus if his packet size is D. So, up to t 0 plus D he will be transmitting. So, his transmitter will be occupied.

Now, he is intending towards B. So, this will be there is a distance between A and B; however, small that is there. So, there will be a propagation delay. So, whenever A transmits, if I say this is his transmitter and this is his receiver, so, above I put transmitter below I put receiver.

Similarly, for A also above transmitter, below receiver same thing over here. So, now, if you carefully see A's transmission with some propagation delay let us call that as t AB. After that, the first bit will be received. So, basically, A's propagation delay will be this t AB after that this packet will start getting received and it will be received in D amount of time.

So, this point will be definitely t 0 plus t AB plus D that is what will be happening. Now at the same time let us say C wants to transmit something to D ok. So, C will be transmitting his thing, let us say he starts over here. Let us say he also transmits for a D amount of time.

So, his overall whatever data rate is there how much packet he has same amount of packet same similar kind of data rate and with that, it comes down to be to D amount of time it requires to transmit the whole packet. So, let us call it t 1. So, at a later time probably C has started transmitting. So, C will have a different propagation delay which is let we call C t CD.

So, with that delay let us say this time is t CD then this would be received. So, that time will be t 1 plus t CD plus D or something like that, but when he is because it is the common media. So, when he is C sends the packet to D it also goes towards B ok, the other unintended receiver who is receiving A's data. So, let us call that C to B propagation t CB ok. So, that might be a little larger also it might happen.

So, it will take some amount of time which is from here to here that is CB. So, this is to CB. So, from here he will start receiving the other data nonintended data. As you can see this is the region of vulnerability that is where there will be a collision, if you do not resolve the collision in some other manner ok.

So, that is where they might have a collision. So, always remember that collision is from the perspective of B. So, B is actually trying to receive A's data and at the same time, C is transmitting something for D which is being received because of the common media being received by B. And they have a collision. Similar things also will be happening.

See A's data also will come to when C is transmitting to D, and A's data also will come to D. So, if it happens that t AD is much bigger t AD is much bigger then this will come at a later point probably ok. This comes at a later point so this will not create a collision on this one. So, as you can see the same thing is becoming collision from the perspective of B who is one of the receivers who was receiving data from A.

But that might, depending on the timing direct that might not be a collision for another receiver D who was receiving data from C. So, he has received his data intact, but later on some more data means that spurious data which he is not the intended recipient for that he will be receiving it. At that time if somebody else is also transmitting to him then probably that will be colliding.

So, it is very important that whenever we propose this protocol we have a clear picture of this timing diagram, who is transmitting when, and where exactly the collision is happening that will be a very interesting perspective to be kept in mind while designing the protocol. So, once we have understood this particular part now let us try to see how can we whatever collision avoidance and all those things we were talking about how we can do that.

So, this is as we have said this is one of the protocols ok sorry one of the architecture.

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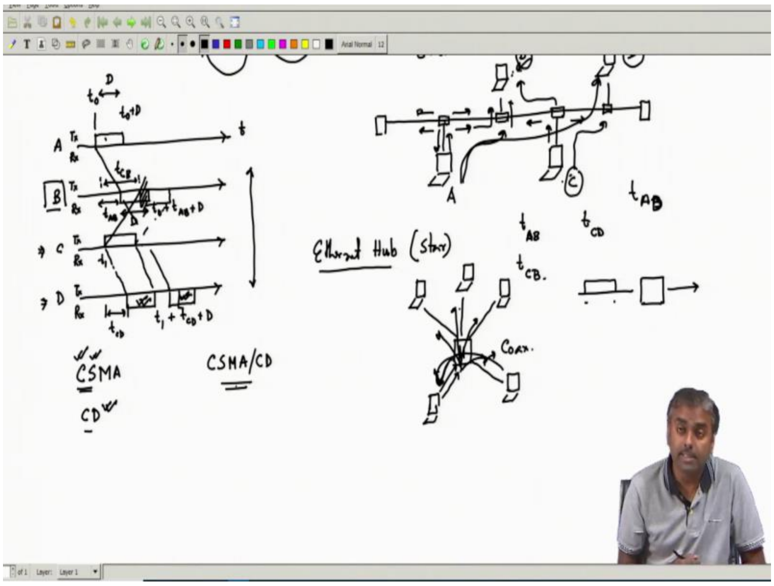

There might be another architecture which is called Ethernet hub architecture, which is kind of a star architecture. What happens? Over there you put a hub-like system. I will talk about its functionality. Every station is through a coaxial cable is connected to that hub.

So, something like that. It is a star-like connectivity and these are all coaxial cables. And what is the functionality of the hub? Hub actually does the broadcasting. So, what it does? Suppose he has transmitted a signal to a packet. So, what hub does? From whichever port he has got he again takes that makes multiple copies as many ports he has and in every this one he retransmits that packet ok.

So, basically, this will be transmitted everywhere and it will also come back to him. So, basically, hub is a broadcaster kind of thing. It takes the packet and remembers it is not it is not a kind of active device that completely stores the packet and then forwards it. So, packets can be forwarded in a different manner. If it is switched, it is like this. So, the switch actually first receives the entire packet. So, what will be happening?

Suppose the packet is coming from the first bit to the last bit he will receive it, he will buffer that, and then after that, he will be forwarding that packet, and he will start again forwarding it. So, that is called store and forward. So that means, you first store the entire packet and then forward it. In active devices, this happens if you have a buffer and all those things, the hub does not have that. Hub what it does do?

Bit by bit it start broadcasting everywhere. Every other port including the port where it has been launched or it has come from; is the hub device. In there also you can see every packet will not only go to everybody it will also be received by this particular guy ok. So, it will come back.

Over here also we can think about a virtual hub kind of thing because from these ports they also come back. They go to these two ports and they all also come back in the same direction so that your receiver can receive it ok that has an advantage. We will talk about that. If your own packet you can receive that has some advantages, we will talk about that later on ok?

But this is what Ethernet has means proposed; two kinds of architecture and that is that is how the media is. Now, let us try to see what we can do with this. So, we had two technologies or two particular proposals that we have talked about 1 is CSMA and the major part is carrier sensing. Multiple access because you are doing media access control. So, that is some kind of time multiplexing you are doing or statistical multiplexing you are doing.

So, that is why multiple access, but the major part is carrier sensing ok and the other part is collision detection CD ok. Now, let us try to see this CSMA and CD, can we do it over here? So, the first thing, whatever heat everybody transmits gets broadcasted to everybody.

So, every node will be able to listen to the channel because they are capable of listening to everybody's transmission. So, carrier sensing is possible over here. The only thing is that we have to carefully take care of this delay we were talking about that is something we have to carefully take care and accordingly, the timing means carefully we have to design the timing in the protocol. We will see that later on ok. So, carrier sensing is possible.

Now, let us see collision detection. Suppose, who has to detect collision? Whoever is transmitting. So, suppose in the hub architecture whoever is transmitting is receiving his data, and if somebody else is also transmitting that data he will be receiving it. So, he can see this particular kind of means both the data or multiple users if they are sending data he will be receiving all these things.

So, in the case of just the presence of the carrier that means, only one guy present, so, the power level is whatever he will be getting of course, if multiple guys are present, so, all that power will be added and will be coming to his receiver. So, therefore, he has the potential to detect this by putting the two thresholds we have talked about can detect collision.

So, collision detection is also possible in Ethernet. So, that is why for Ethernet whatever protocol they have proposed that was having both the things; CSMA as well as CD. So, that is why famously it used to be called CSMA CD. Of course, the protocol details will be discussed later on. I am just now trying to see the physical media and correspondingly what can happen.

So, we can immediately see that both things can be done in this particular media. Now, let us try to see if from there go to optical media what will be happening. In optical media how things are being done? So, basically in optical media you launch power. So, it has a kind of tree kind of architecture ok.

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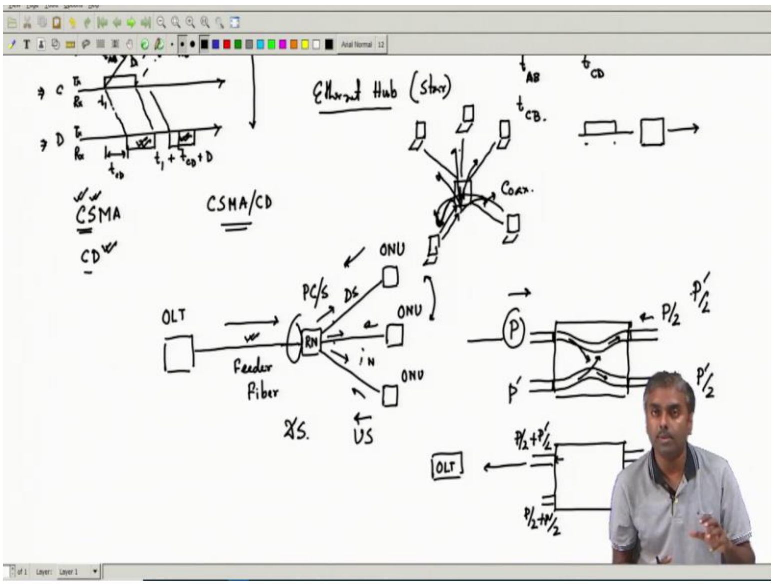

So, how that is being realized? So, you will have a central office they call an optical line terminal. From there the fiber, which is called feeder fiber goes to some remote node which is just a distribution center or distribution box, it is generally a passive device that will be just acting as a power combiner or power splitter.

So, it might combine and split power will see the device and then from there multiple fibers will be coming out. They are generally named as distribution fiber as many users you want to connect to and they will be terminated at the user premises because it is a wired infrastructure. So, up to the user, the wire will be running here fiber. So, this is called an optical network unit which terminates the light at the user's premises.

So, there might be an N number of such things depending on the split. Now, let us try to see how this is being realized, and what is the physical device involved in it. So, the physical device involved in it; suppose I want to just connect two ONUs, then what we can do? This device actually has one input fiber and multiple output fibers. So, I will draw a device for 1 cross 2. So, what happens? It will have two input fibers and two output fibers which are interfaced like this specially.

And then there will be a bend. So, you have a substrate over where you will be etching a waveguide ok which still works in total internal reflection; that means, the light will be guided through this waveguide and will be again relaunched into that fiber. Similar things you do over here. But because of this bend some amount of power will be leaked and that will be coupled over here. From here also some amount of power will be leaked and that will be coupled over here.

So, this bending can be very nicely engineered so that if you launch P amount of power over here, so, P by 2 will come over here and P by 2 will come over here that is why it is called a passive splitter; that means, it just split the power. Whatever modulation you will be putting over here whatever data you are carrying that same data we will be going in both directions with equal amounts of power.

There might be some insertion loss over here, but that is negligible. Some amount of loss 1 dB or so will be lost and because of this coupling also there might be some amount of loss, but those are very negligible. We can ignore that for the time being, of course, there will be some. Similar things will be happening. If you launch power P over here or P dash over here that P dash also will be now divided as P dash by 2 and P dash by 2.

So, if you launch power in both, the power coming in both of these fibers will be superimposed. If they have a signal they will be colliding. So, this will be happening. On the other direction, if you now try to see, so, in this direction if you connect this feeder fiber over here and launch P amount of power that will be subdivided. So, that is a splitter, but in the reverse direction if you try to see, what will be happening?

So, you have this connected to your feeder fiber to OLT, now if you launch let us say P power over here and P dash power over here. So, what will happen? This P power is because the device is symmetric, as you can see from the design device is symmetric output input can be exchanged. So, over here also if you launch P power that will be similarly leaked into both. So, P by 2 will be launched over here. P by 2 will go via this other fiber ok or other port.

Generally, because at the input only one port is there, only one port will be connected to this OLT, and the other port will be dangling. So, that power will be lost. Now, again simultaneously if you put P dash power that will also be launched over here P dash by 2 and P dash by 2. So, what is happening? Eventually, as you can see this is also acting as a combiner. So, whatever signal you put over here or over here they actually get combined over here. The only thing is that there is a power loss.

Of course, if it is 1 cross 2, there will be a means the power becomes half. If it is 1 cross 4, the power will be 1 by 4. So, for every means number of ports, there will be a means if it is 2, 3 dB power loss; if it is 4 then it will be 6 dB power loss and so on, it will go on like this ok. So, if it is 6 then 9 dB power loss. So, this kind of calculation will be happening. As many ONUs will be connecting that much power loss will be happening.

But what is happening over here? Whatever power you launch at OLT to ONU in this direction which we call as downstream direction ok, so, is getting broadcasted now, and it is going everywhere. Whatever you transmit goes to everybody. So, that is a broadcasting domain. On the other side, if you can see over here whatever you launch they are all getting aggregated over here in the feeder fiber.

So, that is the region in the upstream which is the reverse direction from ONU to OLT that is where power is getting combined. So, basically, what is happening You have a collision domain over here. The feeder fiber becomes the media where they are sharing things because they can each one of them can launch power, if they launch power simultaneously then there will be collision and the data will be lost.

So, this is a little peculiar compared to our Ethernet hub. What we will try to do in the next class? We will try to analyze this part and then try to see what is the capability of this particular protocol. Do we have really these collision detections, and carrier sensing all those things are available at the ONU, can we do those things? So, we will try to analyze that in the next class.

Thank you.