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

Module - 10
DLL Layer
Lecture - 46
CSMA/ CA

So, continuing our discussion on this career sensing and then associating what we can do according to the underlying channel. So, we have, what we have so far seen that, if we have the underlying channel which is wired be it optical or be it coaxial we have already seen what we can do. For optical, because carrier sensing collision detection all were impossible.

So, we had to come up with a centralized protocol, where we have seen we connected a tree network where there was a master-slave protocol going on and the centralized controller was administering every user ok.

So, that was the case whereas, for coaxial cable, we could see it can be still done in a distributed fashion, of course, distributed will be favored, because if it is distributed then we are not dependent on a single node to control everything. If that node fails then the entire network gets inaccessible. Whereas, if it is distributed one node failing does not affect the other nodes to transmit ok.

So, that is why probably distributed will be facilitated in optical of course we were not able to do that. There are possibilities of doing it in research people have done that, but probably that is too complicated and not scalable. So, those are things we will skip. Whereas, for coaxial cable which is a more popular access technology probably over the years Ethernet has been probably one of the most popular access or land technology. So, there both CSMA/ CD means collision detection and carrier sensing were possible.

Now, from there what will try to see? The third part of media, popular media probably where people have used that as a common media for accessing networks. So, that is the wireless media. So, today what we will try to do is in wireless media what happens, how the protocol gets changed or modified and what are the salient feature of that particular

media which has to be taken inside the protocol? So, that is something will try to understand ok?

So, let us try to see in wireless what happens.

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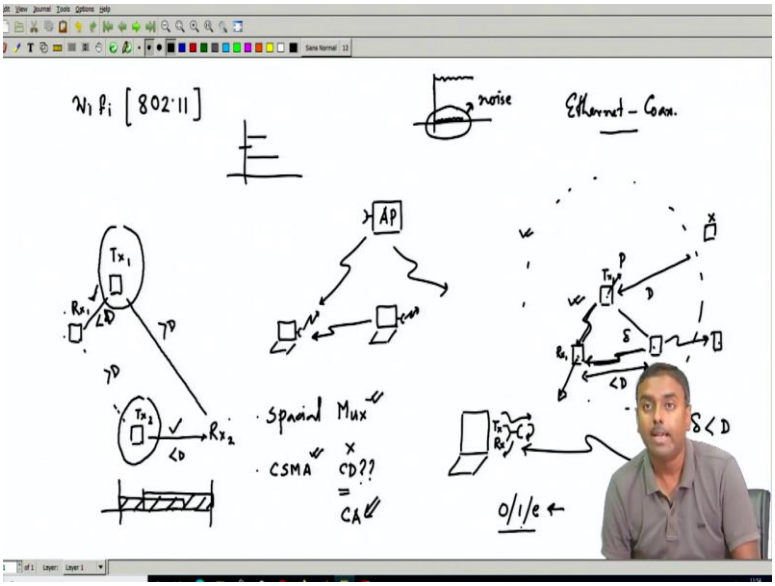

So, in wireless generally, you have heard about this Wi-Fi or it is called 802.11 that is the I triple e standard ok. It has multiple standards after 802.11 a came, then b came, then means g, then n you had other standards also which are whether the frequency band has been shifted to a millimeter wave.

So, all kinds of things are happening over there, but we will just talk about the very basic protocol MAC layer most of the time remaining similar. So, we will talk about that. So, what happens over there? You all are aware that there will be an access point you call AP which is a kind of OLT that is the local hub probably where everybody gets connected. And through wireless media basically. So, it has its own antenna, its omnidirectional antenna when people first started it at 2.4 gigahertz ism band or even 5 or 11 gigahertz.

So, they basically started with a particular omnidirectional data. So, it was not directional no MIMO and all those things. So, initially, it was an omnidirectional antenna that was there and then all users. So, let us say your laptops or something had their own antenna, and they were connecting through wireless media. So, that is used to happen. So, all the

users were connected to this access point or sometimes the access point was facilitating things.

But over there what people thought that this wireless media with the same frequency band actually, over here you generally do not do FDM frequency division multiplexing is not the case over here, either single frequency or band of frequency being used, but they are used with FDMA or they might be used for spread spectrums, but that is all separate.

But it is actually you can logically think that it is the same band being used by all the users in a time-shared fashion and all that you have to do is somehow that same channel they are trying to access you have to control the access of those channel done by multiple users, possibly in a distributed fashion. It has also both distributed and centralized protocols.

So, we will talk about that later. But initially, we will start talking about the distributed version of it. So, first of all, if it is a distributed version it is not much different from our means wired land version or Ethernet version in coaxial cable. So, it is almost similar.

So, let us try to see whenever you transmit it actually gets radiated over the air by its omnidirectional antenna. So, if a particular transmitter is there. So, let us say is transmitting. So, we can just see if the media is taken to be homogeneous in every direction and all those things, it does not have similar kind of fading and all those effects in every direction.

Or if you just take only the path loss component over here. So, we know that it is just radiated in every direction, and we can decide radius D up to which the signal is detectable. That means, it sits beyond its noise load probably or noise plus interference flow, but generally over here we will not discuss interference it is mostly noise. So, basically up to this signal strength is good enough to be still detected beyond this if the station is over here, he will not be able to detect this.

That means we can say that up to this radius, only people can hear each other ok or if he is transmitting all the stations which are within this radius ok or within this circular disc, they are able to listen to all other users they cannot listen to him this is what will be happening and it is always seen from the transmitter perspective. So, one transmitter

along with that with some D, D will be given already it is a system parameter probably depending on the amount of power you inject.

So, of course, this D depends on the amount of power you inject. So, if that power I take to be constant. If I take the means fading and everything is homogeneous in every direction if we take that way and it's similar ok. So, then we can say up to D distance this circular disc up to this everybody can listen to him, beyond this stations are not communicable among each other ok. So, that assumption will be taken.

So, this is one of the assumptions that will be taken. So, over here what happens whoever is there, so in his vicinity where the distance let us say it is defined by delta. So, the delta is less than D if that is the case, they can listen to each other does that also means that they can collide with each other transmission. Now this collision again we have to be very careful. Collision always as I have told collision always happens in a receiver. So, we have to see where their intended receivers are.

So, for this transmitter let us say the intended receiver is over here. So, he is within the D., therefore, he can transmit to him with no problem. So, this is his intended receiver. So, transmitter 1 let us call that receiver 1.

Now, if he starts transmitting at that same time towards some other guy who is also within D. So if this distance is within D. So, he will be able to transmit to him, but what happens whenever he is transmitting because it is an omnidirectional antenna? So, it will also get linked over here if this distance is also below D.

So, if this is less than D then he can potentially create interference at this point or we can say here we would not be talking about interference that is the collision scenario. If simultaneously both of them are transmitting, so this guy is transmitting this guy also is transmitting then there is a collision.

So, collision always we have to see from the perspective of the receiver and we have to see we have to ensure that his intended transmitter is within D, but if the collider is also within D we have to do something. So, that we avoid this collision. So, that part of the protocol will be trying to design over here.

See wireless media is the problem or that might be also advantageous for us as you can see, sometimes simultaneous transmission is still possible in wired media we have not talked about that thing. Why it is possible? Because of the separation of the distance. So, if you see it immediately I just redraw this diagram. So, let us say I have a transmitter over here that is transmitting to a receiver that is within distance D.

So, this distance is less than D ok capital D, and then I have another transmitter. So, let us say he is another transmitter there, he is above D. So, therefore, he cannot actually create interference, and then I have another receiver. So, this is transmitter 1 receiver 1, I have transmitter 2 another receiver I put receiver 2. So, he is transmitting to him that is less than D ok. If this transmitter to this receiver is also greater than D then both this transmission and this one can simultaneously go on. This is actually called special multiplexing.

So, we have this added flexibility, we can actually still do simultaneous transmission which was not possible in wired media, be it optical or be it Ethernet cable simultaneously we were assuming that, everybody transmits others can receive because it is a guided media ok?

So, because the other one can receive their simultaneous transmission this special multiplexing was not possible. Over here they are using the same time and same frequency band, but they can simultaneously still transmit without colliding the data at the receiver because their corresponding receiver is more than D distance way away from the corresponding interfering transmitter.

So, this transmitter which is the interfering transmitter for receiver 1, and this transmitter which is the interfering transmitter for receiver 2 both of them are above D distance away. So, they cannot listen to each other and that is why, this particular things phenomenon which is called spatial multiplexing is possible.

This is an added advantage. So, we have talked about frequency multiplexing or FDM time division multiplexing TDM we are now seeing in wireless new kinds of things which is called special multiplexing. So, whatever protocol you build you know that this is an advantageous thing that will enhance the throughput.

So, we have to somehow facilitate that this is very important, that something we should keep in mind. So, this is as I have been keeping on telling in every part of our courses or every part of our lectures that there are salient features of the media, you have to capture that and you have to try and take that inside your protocol description that is the most important part of protocol designing.

So, in a communication network, it is all about how you design the protocol or how you design the rules of transmission.

These rules of transmission if you see the media access control layer or layer 2 which is part of the DLL layer data link layer are the most important part is, how the physical media takes the salient feature of those physical media and incorporates them in your protocol designing so that you can enhance some of the criteria, either throughput or you can reduce delay or you can reduce back drop probability whichever it is you can somehow enhance your performance.

So, as you can see whenever we went to wireless media immediately we could see that spatial multiplexing is one of the features and we should include it in our protocol description. We will see how the protocol description has been done in a different manner so that we can include these particular things. So, that is one part. What is the second part? This was one very important part. Now let us try to understand the second part of the protocol. So, what is it?

In the second part of the protocol which we will be talking about, we will now try to see if can we suppose they are within the vicinity of something like this, something like this, this scenario. If they are within the vicinity then I need to know I cannot do special multiplexing.

So, I need to avoid collision ok. So, how do I do that? Like earlier also we are doing, for Ethernet we have done that. We have somehow meant all these binary backup algorithms we have talked about or Bayesian kind of these things to avoid simultaneous transmission of two nodes right?

So, that is something we have seen already, over here also we want to implement that particular part. So, that is the part that I will be trying to see right now.

Now, let us try to see what features can be done over here can I do CSMA? So, over here CSMA ok. So, CSMA we have to see whether that is something that is possible over here in carrier sensing. So, over here what we can see, unlike the optical version? If somebody is transmitting others can listen to it because of the omnidirectional antenna as long as they are within the vicinity of reception or within that distance D they will be able to listen to it, their receiver will be on and they will be able to listen to it.

So, basically, everybody has a pair of transmitter-receiver transceivers. So, the receiver will be on and they can listen to it, then they can immediately do the same thing. Again integrate up to some duration T D and they will be able to detect with a threshold if it is beyond the threshold after integration then you can detect the signal. So, CSMA is possible. What about CD collision detection is that possible? That is where there is a problem.

Collision detection means what? I will be transmitting, but at the same time, I want to detect if my transmission is being hampered by others, and whether others are also transmitting. So, this is something I want to know. If there is a collision immediately I detect the collision after detection I will avoid it like in the Ethernet coaxial cable we were doing after detecting the collision we were actually sending the jamming signal right.

So, while I am transmitting if I detect a collision, I put the jamming signal and that is it that is the end of the story I do not transmit any further I do not allow any others to transmit also that time and I end my collision slot. This is something that is not possible. Why it is not possible? Let us try to see in wireless what happens.

So, I have a station, which has a transmitter and a receiver. It generally has a antenna generally same antenna, which gets linked to the transmitter and receiver ok, the same antenna is used for transmission reception. Now when he is transmitting, he is injecting the power in the air. Now what is happening? Whatever power he is injecting because of the omnidirectional antenna, will also be cached by the antenna itself. So, that same power and that will be fed to his receiver.

Now, his own transmitter whenever he is transmitting, his receiver is almost in the media 0 distance, it is coexisting because the transmitted receiver is at the same location. So, what will be happening? A huge amount of power will be linked through this antenna

ok? It is almost like through the media there is no loss of power that is not getting dissipated, it is not getting lost and all those things are not happening. So, the power is getting immediately linked and a huge amount of power is coming to the receiver. Now if somebody else at a distant location is transmitting, through his antenna that will be dissipated through the channel, and there will be a huge either due to the distance traversed there will be 1 by distance square that power that will be linked over here plus there might be fading and all other channel effects.

So, due to that this power that will be linked over here will be very low. So, basically, if you try to see in the integrator what is happening, his own power level will be even if it is random be a very high level, whereas, the other level will be very low.

So, if I now add these 2 powers this will be almost counted as noise ok or a very small amount of interference, which will not actually vary or increase the power level. What does that mean? What are my collision detection techniques? So, basically, 1 has a power level, 2 must have almost double power level and then I can put a threshold to segregate whether I have single things that are being transmitted or I have multiple things.

For collision detection, the power will be coming from sorry for carrier sensing, the power will be coming from some other source. So, I know that some amount of power will be coming I can still see as long as I am within distance D I can detect that there is something in the channel.

Whereas, for collision detection, I am getting saturated by my own transmitter, on top of that anything else that is coming will be almost noise and I would not be able to detect separately whether something extra is there or not, even if it is there and not there these two things will be almost indistinguishable. That is a problem then I cannot detect collision while simultaneously transmitting.

So, therefore, the CD is questionable over here. That is because of the wireless media and the way wireless structure is being put forward. So, therefore, collision detection I cannot do it, but that is an integrated part of our protocol design we have already seen, at least for Ethernet coaxial cable we have already seen that is an integrated part of our design.

So, therefore, I have to now take out this collision detection part, I cannot detect collision. So, if there is a collision then the entire time I will be transmitting I will be transmitting garbage because due to collision the data will be means it will be mixed up it will be superimposed with others' data and I would not be able to make sense of it. So, it will be garbage, but that garbage I will be transmitting for the entire duration of the packet.

So, both the stations that are transmitting, cannot detect collision. So, suppose in the time frame one is transmitting at this instant, another one starts at this instant and transmits for some duration. So, the entire duration of data transmission is garbage, because both the data are corrupted now. So, this is this will be a huge loss in the channel. What can we do? So, we now have to devise something, which is called collision avoidance or CA. We will see in the protocol how we really change these things and facilitate collision avoidance where collision detection is not possible.

We will, of course, do an indirect method of getting channel feedback we have talked about this channel feedback. Now we can we can again come back and revise our channel feedback mechanism. So, if you see Ethernet what was the channel feedback? As you can see from the channel, I can get feedback from CSMA; that means, whether others are present or not somebody else is transmitting before I transmit I can always sense the channel.

So, whether others are doing some transmission or not or whether the channel is idle or not, I can decide. Plus I had a CD; that means, when I was transmitting if somebody else was transmitting or not; that means, I could also detect whether there was an erroneous transmission or not.

So, basically, we have talked about this 0 1 e feedback from the channel that is all possible in the Ethernet case. So, the channel feedback is possible in the Ethernet case, we have talked about that earlier in a few classes back.

So, this 0 1 e feedback whether no transmission is going on the channel is idle that I can detect because CSMA, one transmission is going on against CSMA I can detect that somebody else is transmitting, if I am transmitting no collision has happened that also tells me that ok yes it is my transmission which is successful and no other guys are transmitting if I detect a collision then I can say I am transmitting and this is erroneous.

So, 0 1 e feedback I can immediately get from the channel or by the mechanism of this CSMA/ CD.

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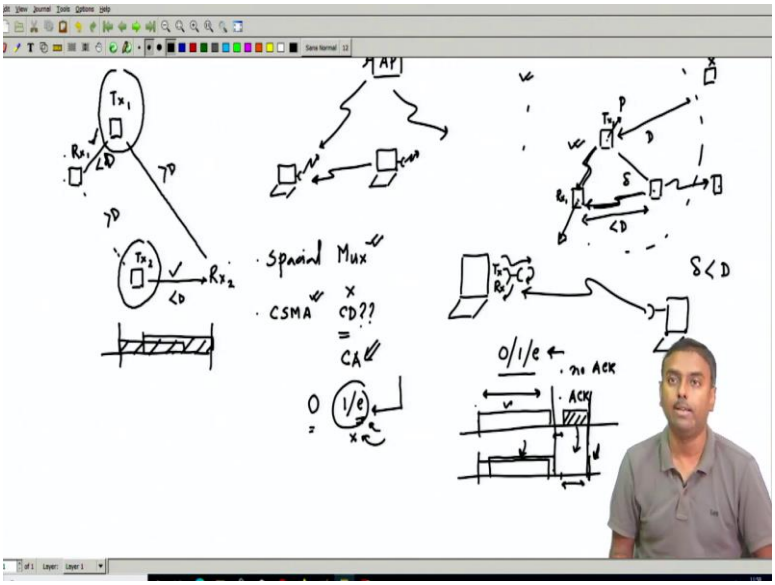

Now, over here can I get this feedback? What I can see this 0 whether the channel is idle or not that something I can decide, but whether 1 or e when I am transmitting I do not know these two are in confusion, I do not know whether it's successful or it is erroneous. This is something direct feedback I cannot get. So, the first thing I will have to devise I have to put a mechanism in the protocol. So, that I can get this feedback indirectly. How do I do that? That is something we have to now see.

So, one way to do that is always to expect the receiver to give me some acknowledgment before other transmission goes on. So, basically, my successful transmission window will be now decided like this. I first acquire the channel and transmit something, then after some time, I allow some amount of time receiver will respond with acknowledgment or no acknowledgment. So, these are the two decisions.

So, basically receiver might send this receiver, if he does not receive a proper packet he might not send this. So, this gives me and then only my transmission slot ends successfully sense slot ends, and then I start another one. If there is a collision what will happen in the same one? So, basically collision slot remains the same, if we see it right now. If there is a collision then one will be transmitting, another guy also will be

transmitted over here and then basically over here, no acknowledgment will be sent because the receiver has not actually received it properly.

So, if that is the case, immediately from here I will be able to if I received the acknowledgment properly or if I did not receive the acknowledgment properly, from there I can take this decision one more time, what was confusing then I can again say no no now I can get that feedback.

Because in the protocol I am telling the receiver to do this earlier for Ethernet, I was not doing that, I was not doing that because it was not required. I could do collision detection from there I could actually sense whether it is 1 or e over here I cannot do that.

So, therefore, I have to facilitate it in the protocol as you can now you can see, seeing the channel or seeing the property of the channel, I have to devise the protocol accordingly. I can possibly of course, we are wasting it wasting the channel a little bit this is the cost I pay because the channel does not facilitate me towards detecting collisions. So, therefore, I need to facilitate it in a different manner and that is exactly what we are doing through the protocol.

So, in the protocol, if the receiver has not received it; that means, my purpose of transmission has failed. So, that is erroneous, and irrespective of what was the cause of the erroneous transmission I can actually think that this error was caused because of a collision channel collision, this is another assumption I am taking over here ok?

So, the assumption is whatever happens most of the time, I will assume that it is because of the collision and I will give that feedback. So, the feedback you get might be sometimes erroneous feedback, earlier the feedback was not erroneous because from the channel directly I was getting feedback, if there was a collision I was getting it directly. But over here I get some feedback which might be erroneous; the feedback itself might be erroneous. What might happen?

Might be just because the channel might corrupt the data it might happen because due to the effect of the channel, due to the randomness of the channel, due to the fading that is already inherent in the channel, it might it is no longer interference or collision of data it is just due to channel fading condition we might get erroneous data, but still my

conclusion will be same as if two station or more than two stations were transmitting and there was a collision.

So, this is wrong feedback of course, due to that probably my protocol that back of binary backup and all those things will have a wrong conclusion, but we will have to take that because no other feedback can be possible over here.

So, in this feedback our assumption basic assumption is that we get the feedback from the recipient, if the recipient has received that signal properly it is good if he has not received that signal properly means if he has not received it then he will be telling me or he will not give me the acknowledgment. From there I will know that ok there is an error.

You can see potentially there is also another error that might be possible. Suppose the acknowledgment that he is sending becomes corrupted, he he has received it properly his acknowledgment due to the channel fading might get corrupted again.

So, there also I will again concluding that there was a collision in the channel which is all erroneous, but this error will of course, by some other means be minimizing errors you will see that, we can do channel equalization, we can do a lot of forward error forward error control means coding and all kinds of things we can do so that these errors are minimized. If there is a collision only then there will be no acknowledgement.

So, whatever it is that is the channel feedback we have been talking about. So, once we get this channel feedback now we are almost seeing that we can go back to our Ethernet-like channel feedback, but still, we cannot do collision detection. So, we have to waste this entire slot next we will be discussing, how to avoid this entire slot wastage at the same time special multiplexing how we facilitate it. So, that will be our next discussion.

Thank you.