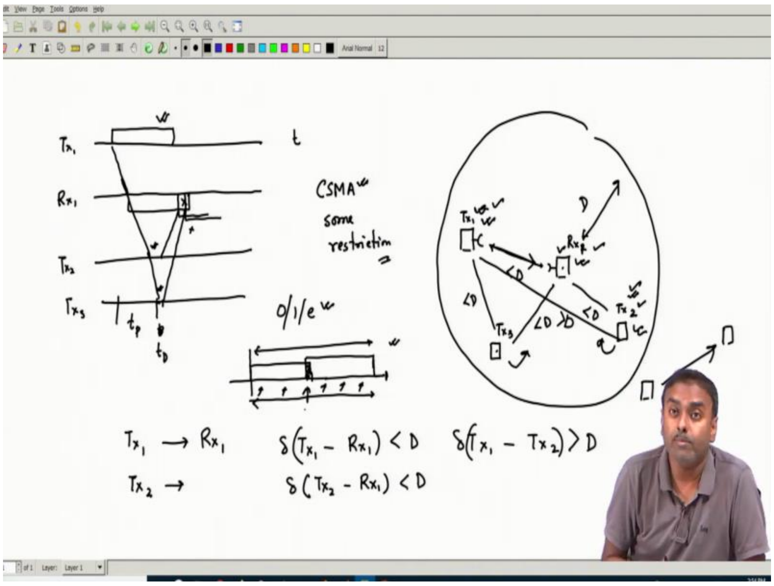
Communication Networks
Prof. Goutam Das
G. S. Sanyal School of Telecommunication
Indian Institute of Technology, Kharagpur

Module - 09
Media Access Control Protocol
Lecture - 47
CSMA/ CA Contd

Ok so, so we have been discussing this Media Access Control Protocol effect because of the media underlying media. So, in that quest actually, we have already discussed wired or means like optical fiber or coaxial cable media. Now, we are actually in the process of discussing wireless media.

So, we have already seen that in wireless media probably one thing that we cannot do is collision detection which is something we have already discussed. There is also one advantage that we have discussed which is spatial multiplexing. Start our discussion from where we have left. So, what we have said is that in wireless what happens is the collision that happens that is at the receiver ok, or the receiver will be the center of focus from where we should check things.

(Refer Slide Time: 01:25)



So, let us say I have a particular transmitter T x it is a wireless transmitter and I have a receiver over here and we have already said if this distance is below some value D up to which the wireless signal can be properly detected. We have taken an assumption that it is in every direction it is a means omnidirectional antenna and it is every direction it has homogeneous propagation properties.

So, if we see that if I transmit up to a distance D basically that transmission can be meaningfully received by the receiver. So, what we can see is that if I draw a disk of radius D around the transmitter within that disk any receiver that is there if they are the intended receiver will be able to get that signal, if they are outside it is not possible. So, if this is within D, it is a valid transmission.

But, now remember the focus goes to receiver. So, the receiver around that with the center around the receiver, and then I draw another circle of let us say radius D. Now, if any transmitter comes inside this other transmitter. So, this is transmitter 1 intended transmitter and intended receiver. So, if any transmitter comes under this radius this might be this one, this might be another one, so transmitter 2, transmitter 3.

So, if they are all having a distance which is less than D they are potential collision creator. So, if they transmit at the same time it does not matter when they start transmitting this particular guy is supposed I take this timeline and transmitter 1 is transmitting in between and this let us say this is receiver 1.

So, with some propagation delay, he is receiving it ok. In between in any time if this guy starts transmitting or this guy starts transmitting. So, if I take that as transmitter 2 and transmitter 3, if they start transmitting anywhere in between and add the propagation delay if that comes within that time there will be a collision.

So, for say this guy also same thing if he starts transmitting over here with some propagation delay if that comes within the transmission, there will be a collision. So, it is very important that these guys are not transmitting ok within this time. Now, these guys will not be transmitted because carrier sensing is still possible. If these guys are within the vicinity of the transmitter they will not be transmitting.

So, if let us say he is within distance D, then if he starts transmitting of course, with the propagation delay he will be able to propagation delay and detection. So, if he starts transmitting that actually gets received by transmitter 2 also ok or transmitter 3 also so, with some propagation delay.

So this is the propagation delay we can call that t P after that some process I mean this t D will be there so, detection delay. So, within that, if the transmission is still going on for the first transmitter they will be known.

But, there is a possibility that some of the distant transmitters who is above D distance, whereas, he is below this D distance from the receiver intended receiver. So, basically, he is away from the transmitter, but he might be close to the receiver for him whatever he is transmitting he will never be able to receive that. So, CSMA also has some restrictions as you can see over here.

So, these restrictions were basically he could still turn a blind eye over his transmission. Whereas, if he starts transmitting he will create a collision with the actual intended receiver basically the transmission that transmitter 1 is making which is intended for receiver 2 will be lost. But, the system says that CSMA is not activated over here so; that means, whatever CSMA we have that has a restricted application.

So, the CSMA has some restrictions. So, whatever we were talking about the spatial multiplexing that the same frequency can be reused. If he was transmitting to let us say if somebody else is transmitting to I can take another transmitter he is transmitting to another receiver they are separated enough.

Then these two transmissions can simultaneously go through without creating any collision because of this particular technique or this particular up-to-D distance only they can meaningfully receive signals beyond D they cannot listen to each other, and they cannot get anything that is above the noise level.

So, because of that there is a spatial multiplexing, but that spatial multiplexing also comes with some disadvantages. The disadvantage is my CSMA get something some restriction over here. So, I am just listing out the characteristics of the channel is now posing some more problems and some advantages also. So, we have to while designing the protocol we keep all these things in mind. So, that is what protocol designing is all about.

So, you have to see that this spatial multiplexing is something that has to be facilitated that is one thing. Second thing is we have observed that because of spatial multiplexing now CSMA has some restriction ok that is another thing.

The third thing is collision detection because whenever you are transmitting you cannot detect your collision because your receiver will be saturated by your own transmission all others' transmission will be just like noise to and you will not be able to detect whether in the presence of you others are also present in the channel.

So, collision detection is ruled out, all these things we have observed now this is characteristics of the channel ok. So, we have to see we have to devise a mechanism that you will see later on so, that all these things are alleviated. It will be good if I can give a simple solution or a very single unidirectional solution that solves all these problems. So, that something we will try to see ok.

So, we have also seen that over here channel feedback is something I had forgotten last time we discussed, channel feedback is restricted. So, in the channel feedback what I can get because collision detection is not possible? So, basically, I can detect if I am transmitting ok. So, I can detect if I am not transmitting or if the channel is idle that I can detect.

But, if I transmit whether it is successful or it is collided I do not know I have no idea. So, that feedback I cannot get. So, I need to get some extraneous feedback. So, again protocol needs to take care of that.

So, these four things we have now identified. Of them, I have given a solution already that every packet should be followed by acknowledgment coming from the receiver. So, that resolves the problem of getting proper feedback from the channel. If I do not give acknowledgement then you assume that ok I have transmitted that has not been probably received properly that the cause might be you then assume that the cause might be due to collision.

So, therefore, I have an erroneous this one or an unsuccessful transmission. So, it is a collision. If I have transmitted the acknowledgment has received successfully then I can say it is a successful transmission. So, again that 0 1 e feedback I can actually restore back. So, for that, I need to add some redundancy and I need to add responsibility towards the receiver.

So, he has to send acknowledgment or no acknowledgment, of course, that means, you do not do anything. So, these things have to be done by the receiver whenever you successfully receive a packet you send an acknowledgement back to that sender. So, the sender knows that everything was successfully transmitted. So, that is one thing one problem has been solved. How do we solve all these other problems? Spatial multiplexing how do we actually put forward?

How do we solve this? Earlier CSMA CD we have seen whenever see we wanted to reduce the time of collision and time of idle period; idle period CSMA helps us. Only detection time or slightly bigger than detection time I can put as idle time. But, for collision some collision detection mechanism has to be there after the collision detection you send a jamming signal and that is the end of collision period.

You can keep this time much smaller than the packet size then successful packet transmission time will be bigger than collision time. So, your wastage will be reduced, but here that something we cannot do, whatever the successful packet transmission time is there.

So, if this is successful packet transmission time I can also add another packet which will be still occupying the channel, but this will waste this much amount of channel time, but still they are collided. So, it is a huge loss, huge waste. So, that is something we have to keep in mind if we allow this collision to happen there will be a huge amount of wastage.

It might be even bigger the collision period might be even bigger than the actual successful period because every time I will see how a packet gets collided like this just at the end still it is corrupted and I keep on sensing the channel every node sees that it is busy so only after this transmission can happen this entire time is wasted just because of the collision which is bigger than even the successful period. So, that is a huge waste I do not want to do that. How do I solve this problem? That is the first problem.

If I can solve this problem this collision period if I can somehow reduce it by some means we will see that. How do I solve the other problem? That just now we have talked about that the CSMA sometimes is not working like I have given that example, that if I again list that scenario of that example. So, transmission transmitter 1 is transmitting to receiver let us call this receiver 1 ok.

So, this is happening and then somewhere this transmitter 2 wants to also transmit to somebody no matter where he wants to transmit ok? So, if he wants to transmit then what happens as you can see both transmitter 1 so, condition is both transmitter 1 is the distance between let us say transmitter 1 to receiver 1 that distance delta is less than D. So, this is there and again delta between transmitter 2 and receiver 1; transmitter 2 and receiver 1 that is also less than delta.

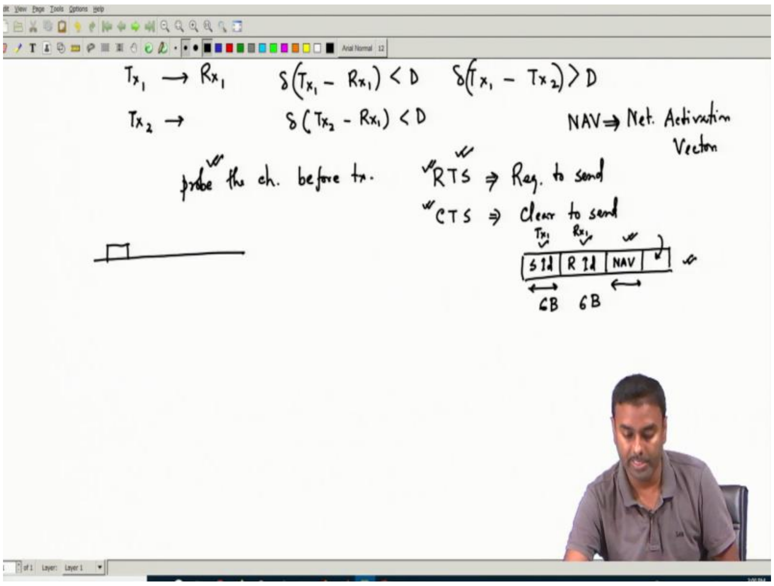
So, they have potential means if both of them transmit at the receiver there will be a collision because transmitter 1 is the intended receiver; receiver 1 there will be a collision if he transmits anything because they use the same frequency band. But, I have an additional condition that the transmitter 1 to the transmitter 2 distance is greater than the delta.

This is possible we can see already by these three things that are possible. Then what will happen? Whenever transmitter 1 is transmitting the CSMA facility for transmitter 2 is not capable of detecting transmitter 1's transmission.

So, therefore, the entire period is vulnerable, during the entire period of transmission he cannot hear transmitter 2 and cannot hear what transmitter 1 is doing. So, any time he can initiate transmission. So, these kinds of possibilities are there. So, this is something we have to block. There will be collision possibilities that we have to block and we have to also see if the same method can we do, can we facilitate this spatial multiplexing.

So, the two can initiate transmission without worrying about the receiver there will be a collision. So, that they should somehow resolve this spatially, any transmitter and receiver pair should be able to even though they are distributed they should have some coordination among themselves. So, that this can be resolved. Now, the fantastic proposal that came which is very simple you will see all three things will be resolved by this one particular trick.

(Refer Slide Time: 15:09)



What is the trick? This trick is called probe the channel before transmission. So, there is a typical two control message which has been designed for this one is called RTS or it is called request to send and one is called CTS it is called clear to send ok.

So, these two messages have been created these are very short control messages, the only thing that is there is inside. So, the control message, of course, has to be defined it is a control message that does not contain any data. So, it must have the source ID who is trying to transmit, and the destination ID that will be receiving it. So, there will be unique MAC IDs for all these stations we will discuss that later on.

So, they will have those IDs you have to put those IDs because you can identify another user only by their ID like we do with their name. So, every machine has to understand the other machine if they are sending somebody they have to encode that right packet switching is all about that you have to tell whom you are sending the packet.

So, therefore, that ID has to be given. So, that unique ID will be there for every station. So, transmitter 1 if is transmitting to receiver 1 then transmitter 1 will have its own ID let us call that 1, and receiver 1 will have its own ID let us call that 2. So, 1 will be transmitting 1 is the transmitter ID and 2 is the recipient ID. So, this has to be given in both wherever RTS, and CTS this control messages are being sent.

So, control messages at least must have these things, one is the sender ID, and receiver ID and you will see later on that there will be some field which is called NAV; what is this I will talk about that later ok Network Activation Vector. So, this NAV is actually a Network Activation Vector. Why this is required I will also talk about that; that is the whole philosophy actually. So, Network Activation Vector.

So, there will be a NAV specified over there and there can be some error check so, that the packet can be checked for error, if everything is erroneous everything, all this control information will be erroneous. So, that is why there should be errors error-checking facility, CTS also will have same thing similar structure.

So, what this control message does? This is a very small control message as you can see no data has been used this ID is MAC ID generally 6 bytes long this is 6 bytes long, NAV will have some amount of bytes, and all those things ok. So, it is generally not a very long packet it is a very short packet and it has a fixed size it will not vary because there is no data there is no variable over here ok?

So, what is the purpose of that? Let us try to see this transmission. So, what was happening? This entire period was vulnerable right we have seen that already because of CSMA there is a restriction somebody might become a potential collider without the knowledge without being capable of doing carrier sensing so, that we have already seen.

This spatial multiplexing we cannot do properly because we do not know who is where they do not know the location, they do not have location service activated that is our assumption and of course, that will be very difficult to do.

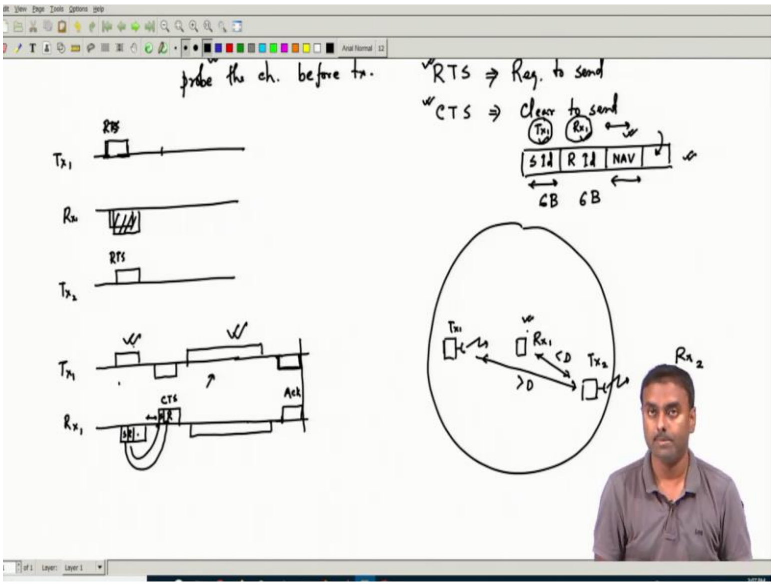
So, that is something, and collision avoidance, of course, is not possible. So, let us try to see what we can do instead of colliding in the whole packet can I probe the network? So, that is why it is called probe the channel. So, probing the channel means the collision if it happens should happen in a smaller packet and there will be not much wastage. So, what do they do? Suppose I have something to transmit I do not immediately transmit that thing rather I transmit this request to send.

So, a request to send is telling the network that this is something I have a request to send to the same recipient. And of course, in the RTS it will be definitely specified whom I am transmitting. So, whoever I am who is transmitting my ID will be given the source ID and whom I intend to transmit later on.

Still, the data is not being put it is just probing the channel by a control packet. So, there I will put the receiver ID. So, if transmitter 1 wants to transmit to receiver 1 in our example. So, here the transmitter 1 MAC ID will come, and here the receiver 1 MAC ID will come.

This NAV will tell this is actually amount of time if I get the chance to hold the channel and transmit my data how much amount of time I will be occupying the channel. This NAV vector will tell everybody ok. So, now, let us try to see this scenario in this particular picture.

(Refer Slide Time: 20:40)



So, let us say again I have the same scenario, I have the receiver at the center R x 1 I have a transmitter T x 1 ok? Let me for more convenience let me draw T x of course, it has to be within the radius let me draw it over here. So, that is my T x it is within distance D so definitely.

So, what happens is he sends an RTS actually he broadcasts an RTS on the air which is a very small amount of duration packet he broadcasts. So, whenever he broadcasts it will specify the transmitter 1 wants to transmit to the receiver 1 whoever that is in the network I do not know but the receiver will identify that.

For this amount of time, I want to hold the channel for transmitting some data I have in my buffer this is what he will be telling me. So, this is the RTS. Now, what might happen if another transmitter let us say this like we were telling T x 2 is there he also wants to transmit to somebody let us say some other receiver; receiver 2. So, he wants to transmit. So, he will also he might also broadcast at the same time ok?

So, whenever he broadcasts if the broadcast happens at the same time or within overlapping time ok. So, transmitter 1 and transmitter 2 in the channel broadcast these two things at the same time. Then what might happen at the receiver? They will collide, but this collision is of shorter duration because the packet size is short.

If there is a collision then what will happen? This is followed by as we have talked about this acknowledgment, is followed by an acknowledgment which is CTS. So, if the receiver, basically what is happening? If I just redraw these things in a little bit cleaner fashion. So, if you see RTS is being sent by transmitter 1. Let us say the propagation delay is very small and negligible we take that ok.

So, it will be almost immediately received by receiver 1. Now, on the other side, another transmitter 2 is also let us say sending RTS at this point. He can send RTS because he cannot even if he senses the channel he cannot sense the presence of the RTS because he is more than D distance away, so, he cannot sense the channel. So, because he cannot sense the channel, he will be transmitting RTS and that RTS will be received by him also because he is within D that distance is within D. So, they will collide.

Now, what has been told is that the receiver if he receives RTS successfully is not the case over here. If he receives RTS successfully he will be transmitting after some amount of time a CTS which is clear to send. He will just reverse the source ID and destination ID. So, now, the receiver will become the source, and the transmitter who has requested this RTS will pick that from the packet and put it at as destination.

So, he will just reverse that and he will send it, but if there is a collision you cannot do that this is impossible ok because he has not received it. So, no CTS will be transmitted. So, therefore, immediately user 1 will understand that there has been a collision, but the good part is this collision has occurred over a shorter packet duration.

So, the amount of collision time that is being wasted will be much shorter this was our target. So, this has been resolved. What we will try to see even though this has resolved the means amount of wastage due to collision has that resolved the CSMA problem, has resolved the spatial multiplexing problem is something we will try to enquire about in the next class in more detail.

But, over here let me also show when successful transmission happens what happens, what are the sequences that will happen? So, transmitter 1, receiver 1, so transmitter 1 transmits this, receiver 1 receives this he is the only one who is transmitting at this point because successful.

So, RTS is successful he receives it after some amount of time what is that constant we will talk about that later. So, some constant amount of time will be specified by the protocol and that is also very important we will see the importance of those things.

So, he will transmit a clear to send CTS. What he will do? Whatever the source is there he will put it in the receiver and his ID which is R he will put as source ok, NAV vector he will keep intact and he will transmit this; this CTS will be received by him. He will know that ok things are smoothly gone; that means, nobody will be colliding with me.

We will also see that is what will be happening if this goes through successfully nobody will collide. He defines the collision domain very nicely and nobody in his vicinity will be colliding with him that is something also we will try to appreciate by seeing the exact region where the transmitter receiver will listen to these things.

Once this is done after again some constant amount of time he can transmit his data because now the collision has been resolved. So, nobody else will disturb it they already have identified that there are some RTS and CTS. So, others will not be disturbed we will also see talk about that later on which will go to the intended receiver again.

Then followed by some amount of time after some amount of time he will send an acknowledgement which is also a control packet this will be successfully received by him and that is the end of transmission. So, the data packet goes successfully. So, a bigger data packet goes successfully if I can resolve the collision at a smaller control packet.

So, this is a probing of the channel. So, we will see how these things resolves other problems or other advantages that it can give to the media that something we will talk about, but this RTS, CTS resolves most of the issues you will see that.

Thank you.