Communication Networks
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Module - 09
Media Access Control Protocol
Lecture - 41
Binary Back-off Algorithm

Ok. So we have been trying to stabilize the ALOHA slotted ALOHA protocol. In that method, we have already seen a pseudo-Bayesian way of stabilizing ALOHA where we were updating q r by estimating the number of backlogged nodes. And that estimation was done through a channel this one feedback. So, we could get the channel feedback from there we did that.

Now if the channel feedback is not available we will also show later on where channel feedback is available and where channel feedback cannot be available. So, if the channel feedback is not available then what we should do? So, that is exactly what we will be targeting today in today’s class.

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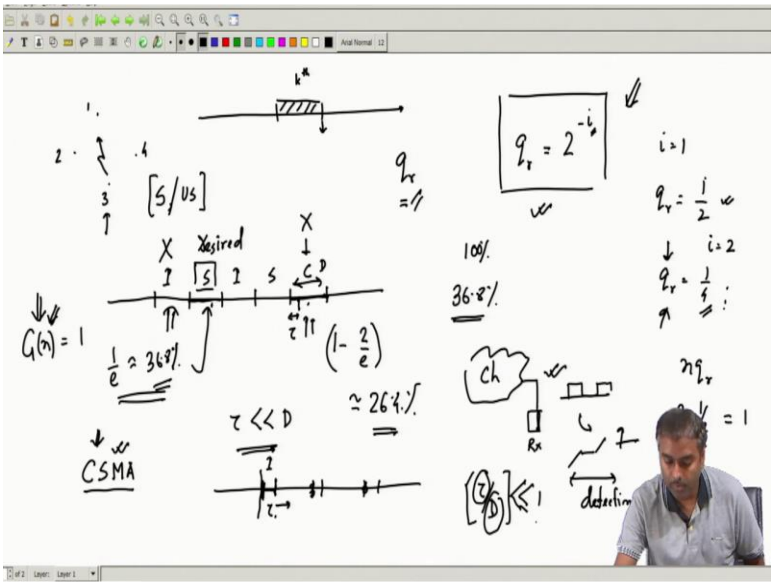

So, let us see channel feedback not available means all the nodes, let us say there are node 1, node 2, node 3, and node 4 who are willing to access a common media ok, media access control is all about that. So, they are willing to access common media. Now, let us try to see if the channel feedback is not available; that means, only he has access to his own feedback; if he has transmitted to somebody in a particular slot. So, let us say this k th slot he has transmitted.

So, he must attempt transmission, so node 3 has attempted transmission. So, for that transmission, he will be getting feedback at the end of this slot, whether he had a successful transmission or unsuccessful transmission. This is the only feedback you will get.

So, whether it was a success; that means, he successfully transmitted the packet or he could not successfully transmit the packet. So, in that case, what do we do? So, the binary backup algorithm says, that you update the q r without actually getting an estimation of how many nodes are there in the system in backlog.

So, that estimation like, we were doing in the previous one, where the channel feedback was available. So, that is impossible now, because now I am not even getting feedback about the channel. Whether means; somebody else has transmitted, whether that was successful or not. So, all this channel feedback I am not getting. I can only see when I am transmitting whether it is successful or not successful this is the only thing I can see.

So, I cannot actually make any assumption about other nodes at least in the previous case through the channel I was linked to other nodes. I was getting a summary probably, but I was able to see if somebody else was transmitting and whether his transmission was true or not with that I could at least end hat that estimation of how many nodes are in backlog.

So, that was possible now this is almost impossible because I do not know anything about all other nodes. I only know when I do, I probe the channel whether I am getting successfully transmitted or my packets are not being successfully transmitted. This is the only feedback I can get, from that feedback can I do something? So, what they did they try to do like this, what is this? So, q r this sorted this is a heuristic kind of up gradation ok or estimation of this direct q r they are trying to put ok.

So, what does that mean, what is this I first of all let us try to see. So, when you are trying to get feedback what you are trying to do is something like this, that is how many times I have attempted and successively I have got a collision. This is the estimation of i, so i is how many times my retransmission has failed in the past. So, that is the only thing you are keeping in mind because you cannot get any other feedback, so this is the only feedback you are keeping inside. What is the purpose of this? So, the purpose of this is like this.

So, because it is 2 to the power something, basically it is every increment of i you are reducing it with a power of 2. So, when fresh you are trying to attempt transmission i is 0. So, no retransmission you have made, so it is 2 to the power 0 1 with a certain probability you will be attempting ok, new nodes immediately come and attempt it next to this one.

But if you see that the first time you have collided then you will update to 1, because 1 retransmission attempt already I have transmitted and I have collided, I did not get success. So, the next time when I will be doing that is my second retransmission attempt. So, at that time q r immediately comes down to 1 by 2. If there also I am unsuccessful then I get updated to 2 and q r becomes 1 by 4 and so on.

So, because it is decremented with a binary factor of 2, that is why it is called binary backup or because it is as you can see, as I am in a collision I am actually making these things probability lower and lower in exponential fashion. I am decreasing it with 2 to the power ok of minus i. So, therefore, I am decrementing it in an exponential fashion. So, it is also called exponential backup.

So, this particular thing is the intuition behind this, so let us try to understand this. The first thing we can see if there are collisions multiple collisions are happening. Of course, I must decrease this qr because I know that see first time I collide my general assumption means a very intuitive assumption if I give. It is like this at least other than me one more is there ok, so I have reduced it to half.

So, half means what? With half probability, I will be attempting next. So, similarly, the other node also will be doing the same thing if he has collided with me he will be also making it half, only we 2 if we are there. So, with half probability I will be attempting next, there is a good amount of this that my collision will be resolved. If more than two nodes have collided then we know that more than two nodes are in means backlogged.

Then I know that with this half also we would not be able to resolve it, because it should be even less than half right. If two stations are there q r half makes sense because then n into q r this is 2, this is half immediately it gets 1, so that is my targeted G n.

But if it is more than 2 I should reduce it, so my feedback to myself is if I collide more than twice sorry, more than one time then probably there are more nodes. And then why do i increase it exponentially? Because the deeper into back off I go; that means, the more times I actually have to retransmit.

I reduce my q r, what is the consequence of reducing q r? My attempt will be later, so less and less time I will be attempting ok. As I reduce q r in the next slot I will be attempting that is 1 by that ok or sorry that is probability q r. If q r is reduced then with a very slight chance that I will be transmitting in the next slot or next to the next slot. So, I will take a huge amount of time to actually attempt the next retransmission.

So, basically, then I am getting less and less feedback from the channel. So, therefore, it is safer for me to reduce my QR even less because I will be getting less feedback. So, even there also if I collide then there is a chance that even more nodes are there, more nodes are attempting. So, therefore, I must reduce it with these particular things in mind.

So, basically with every feedback if I keep on colliding I will increase this exponentially this q r. Knowing that maybe it is deep into collision too many nodes are back backlogged, so I must reduce this.

Reducing this collision is only possible if I reduce my q r, so that is exactly what is being done. So, this is a very intuitive solution people have also shown we will also do an analysis of this when we will be doing the analysis of our Wi-Fi. So, we will see what is the particular analysis of this, binary back off or exponential back off algorithm.

But what you can see now with very limited feedback when the channel feedback is also not available, you do not know how many stations are there, who has been doing it, and whether their transmissions are successful or not.

Even without that feedback also you can make some sense out of this, so that is this particular thing. Where you just keep counting how many times you have collided and then with that count only you update your q r to make it stabilize. Of course, this will be not as good as your means of centralized stabilization method with centralized feedback or even with channel feedback.

So, those two are much better this will not be that good, but this still will work. We will see that in practical situations most of the time this is the one that is required those things where you need to get channel feedback or centralized feedback will most probably not be available. You can only get feedback from your actions. So, whatever you have done so far from there you have to make some sense out of it and then take this upgradation of q r to keep stabilization intact.

So, this is the best that you will be able to do and we will see that this also gives quite a good performance at least for Wi-Fi analysis you will be able to see that this might even get your throughput quite high. So, that is something we will do later on. Right now, that is the end of our discussion of this particular part, which is probably the collision avoidance part or collision resolving part as you can see. We have devised multiple algorithms, so to stabilize ALOHA.

So, ALOHA what it was trying to do was, it was trying to avoid collision by this value of q r. So, whenever there is a collision you actually have a probability that I will be attempting transmission, and with that you are avoiding a collision. And then we could see that this q r can be further nicely adjusted so that I can actually avoid collision in a much better fashion and we can achieve the best throughput that we can get, in slotted ALOHA ok; we were not talking about anything else.

So, this is a practical mechanism that has been devised by this backlog estimation getting channel feedback or individual node feedback, by doing either exponential backup or this Bayesian estimation and then updating q r. We could see that we can do something we can do some mechanism to go at least towards whatever has been predicted as the best throughput of slotted ALOHA.

Now the question is there something that can be done in an even better fashion because our throughput target must be 100 percent ok? Whereas we have achieved through slotted ALOHA only 36.8 percent, that too we had to do device so much mechanism of collision avoidance and up gradation of q r ok. With that we could achieve at most 36.8 percent, I am not satisfied with that and at that time whoever was designing protocols, was thinking this was also not satisfactory.

Almost one-third of the bandwidth I am utilizing for transmission, the rest of the things are either wasted by the ideal period or collision period ok. So, now let us try to see what was happening in the channel. So, if I have all these slots out of those slots some slots were idle, some slots were having successful transmission and some slots were having collision ok. Among them, we could see, that if I could keep my G n close to 1 then I could see that this 1 by e percentage of time which is actually approximately 36.8 percent of time ok.

I could keep my slots idle or 36.8 percent of the time I could keep my slots successfully transmitted. Collision was we have also estimated that 1 minus 2 by e ok. So, that much is approximately 36.4 percent of the time it was remaining in a collision. So, at least if I can achieve this which was the part of achievement by updating q r properly by stabilizing ALOHA, we could see that this is happening this is the scenario on an average, and that is pretty clear we have already calculated them.

Now, the problem is what is the wastage over here, successful transmission is the only desired thing. Sorry, this is the only desired thing both this collision and idle are not desired I do not want them ok? So, I wish to take them out of this idle and collision, my next target will be collision improvement will be concentrating on these two things. Can I devise some mechanism to take out either this idle slot or this collision slot or reduce them?

If I cannot take them out I can reduce them. So, what is the mechanism of doing it, let us first target this ideal slot. Because that is the highest amount, that is 36.8, whereas collision is just 26.4 percent. Also, we will target this later on, but probably the most important thing is this idle which is unnecessarily wasting 36.8 percent of the time I am remaining idle I am doing nothing.

So, that is something that is deliberately happening because I have been updating my q r in such a fashion that sometimes it is not attempting to keep my G n intact. Can I now take this out, let us try to see how we can do that. What is the idle period? So, I have a slot where no transmission is happening I keep that entire slot idle, but probably this might not be required.

So, now I can devise a mechanism which is called very famously CSMA or carrier sense multiple access. So, this carrier sensing or sometimes also called channel sensing. So, this carrier sense is nothing but this particular mechanism of reducing the idle period, what is this mechanism, what is this device? Basically whatever channel we are transmitting.

Suppose I am not transmitting anything, at that time what I can do I can immediately start sensing the channel. So that means, receiving things that there in the channel. So, right now I am not transmitting, I just make my receiver active I sense whatever is happening in the channel. Some transmissions for others may be not intended for me or may be intended for me if some transmission is going on in the channel. It is a common channel so somebody is utilizing the channel.

I can always detect that, so what I can do I can tap the power ok? So, basically, whatever they're, suppose this is my channel and this is my receiver. So, I can tap the power and put it through an integrator, so that will be accumulating the signal. Integrator means it is let us say, if the channel is just some sequence of binary 1 0 1 0 are going if it is modulated signal I will first demodulate it, again I get baseband signal of sequence 1 0 1 0 something like that.

And then I actually put it through an integrator what will happen? Whenever there is one it will ramp up 0, it is like this again once it will ramp up like this it will keep on going ok. So, if there is something going on if it is noise then noise will be canceling each other because noise has 0 power right 0 means we talked about. So, if it is noise it will always cancel.

So, overall time if I integrate I will get 0. Whereas, if it is a signal which is a baseband signal let us say, then it will integrate and gather some amount of power. So, after some amount of time which we call detection time, if I now try to compare it with a threshold, for noise it will be below the threshold. If it is something is being transmitted by some other station it does not matter. I will be above that threshold and then I can declare the channel is busy.

That means, somebody is doing a transmission it might not be me I am not doing that, but when I am trying to receive it or I am trying to sense the channel; I could see that somebody else is transmitting. So, immediately I can declare the channel is busy ok? So, if a successful transmission or a collision is going on, then after some amount of detection time let us call that a tau amount of time. So, after that detection time, and of course, I will design it in such a manner that tau is much less than this slot duration D I will design it that way.

That is you will see the purpose of that and that is generally the fact ok. So, if this is happening then after a certain amount of time I will be able to detect that the channel is busy, this is something I can do. What is the advantage of that? The advantage is that if a slot is busy ok I was earlier also what I was doing.

Anything that comes over here I was skipping that slot and I was only going in the next slot and transmitting. So, when it is busy either successful transmission or collision I do, not have any advantage, but when it is idle now I have an advantage.

See if a channel is idle let us say the idle period has started over here, so this is the idle period nobody is transferring. So, this has started over here from there after a amount of time every station will sense that the channel is idle. Now do I have to extend this idle period for a longer duration? No, all the channels have sensed that it is idle. So, I can reduce my idle time and then readjust my slot. So, now, this will no longer be my slot this one. So, this will happen to be my slot duration.

And because this is synchronous to everybody because everybody will be sensing the channel once one slot is over. That means, if one transmission is over immediately I can sense the channel and I can sense it within tau duration, if the tau I make it fixed for every station. So, every station after tau only will declare that the channel is idle, and then every station will accordingly take a decision.

So, what has eventually happened by doing this carrier sensing is I have actually reduced my idle time by a factor which is this tau by D. The Smaller this tau is compared to D lesser amount of time I will be wasting by this idle period, that is a very good advantage that will be getting now; that was my target earlier. When I started this discussion what we told that I knew that there are two culprits one is the idle period the other one is the collision period.

Success is good I want to maximize this success and I want to reduce this idle and collision period. So, immediately I can see that this is a very good device. If I now just make this circuitry where I will have a receiver the receiver will bring it to baseband, if there is a modulation. If it is baseband data that is being transmitted that is also fine I will take that data and then I will just have an integrator and a threshold detector ok?

So, a comparator probably. So, integrator followed by a comparator I can immediately detect whether there is something in the channel or not something in the channel ok. I will design my tau accordingly, and I will also design my D accordingly so that this ratio remains quite low, this remains much much less than 1. So, that is something we would like to do now.

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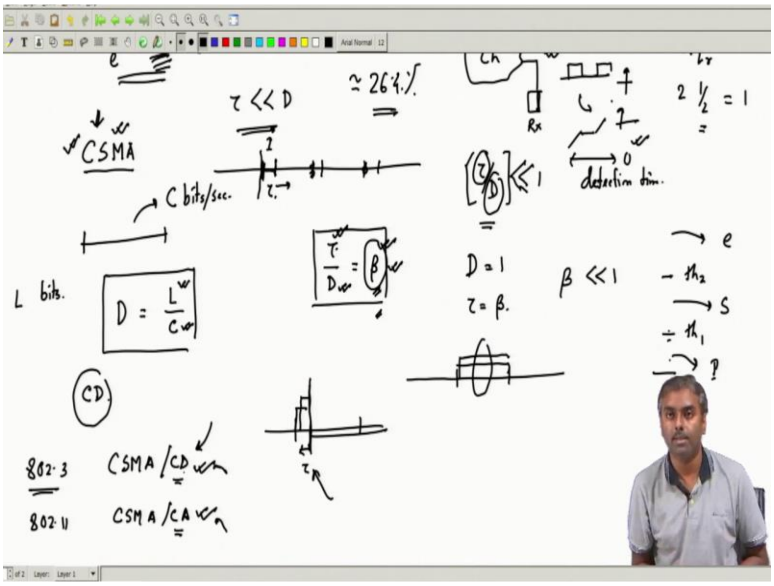

So, what will try to do now? First, let us try to characterize these things in this ratio. So, basically this tau by D we call as a factor beta ok. So, if my D is equal to 1 then this tau is equal to beta-like earlier ok. Of course, beta will be much much less than 1 we have to design it that way. So, basically what we will try to do? If the tau detection time is a little bigger then we will also make this D a little bigger, that is where the restriction of D comes into the picture, what does that mean?

What is D actually? D is the duration over which a packet is being transmitted. So, suppose the packet length is L bytes or L bits, and the channel that transmission channel that is being used can transmit C bits per second. So, that is the transmission rate, so then what is D? D equals L divided by C ok? So, generally, this C will be constant if it is Ethernet, let us say 1 gigabit per second Ethernet. So, it is always C is 1 gigabit per second ok. So, that is not going to be changed, but this L packet size I can change.

Bigger I make the packet size what will be the advantage? The advantage will be that my beta will remain smaller and smaller. Because the higher I make my D compared to tau this beta will become lesser and lesser, and the lesser it becomes I have the better advantage. So, this is one design aspect that comes into the picture whenever you are designing media access control protocol, if you implement this CSMA. You will see that not everywhere you will be able to implement CSMA because the channel might be in such a manner we will talk about that channel also.

Channel might be in such a manner, that you cannot means listen to the channel.

That means what others are doing you would not be able to listen we will show you physically this kind of channel exists ok? That is a very important medium to transmit it is also a common media that is shared, but not everybody will be able to sense each other channels that might happen. So, their CSMA will not be employed if you can employ CSMA then you want to make this beta as close to 0 means as much less than 1 as possible.

So, what is the trick? Your detection time will probably always be fixed with respect to the circuit design, but what you can do is a packet length that you can enhance. You can increase the packet length and accordingly, you can start thinking about how to reduce my beta ok. So, suppose you have reduced beta and then we will try to see whether we get some advantage out of this.

So, that is one of the mechanisms, we will, of course, do again analysis the drift analysis that we have discussed. From there we will be able to give you some insight about what will be the throughput, if for a certain amount of beta, and then how beta affects the throughput. You will see that immediately the throughput will be jumped, throughput will be increased.

So, compared to that upper bar of 36.8, now you can actually operate at a very high throughput. You can you can, because this particular time mostly you will be utilizing, so that is the advantage. So, that is one thing that will be a means of gaining we will also try to devise a mechanism where we can reduce the collision time. Now let us just in a very brief let us try to discuss that part also.

What happens in a collision? Suppose, in a particular slot there is a collision. So, invariably at least more than one station is transmitting ok. Now if suppose I want to sense this can I implement a device like this again to do these things? This will be possible. How? Because if noise is there I will not get any signal almost it is a 0 mean. So, if I integrate I do not get anything if only one signal is there I will be getting some value.

But if two signals are there then double power I should get. So, I will I can put another threshold and if it goes beyond that threshold also I can say if more than one node is there, that is the mechanism to get feedback about the channel. So, now, you can see this I put threshold 1, and threshold 2 in my comparator. So, if it is below the threshold, so this is 0 below this first threshold I can say idle.

If it is between threshold 1 and threshold 2, I can say success. Whatever is being transmitted whether node 1 or node 2 or my own data I will be able to say success if it goes beyond this is where I can say it is erroneous because there will be colliding. So, this is called collision detection or CD, you might remember from your means you might have heard this term CSMACD.

So, these two things together can detect whether the channel is busy or not. So, you can do carrier sensing and you can also detect a collision, again the collision detection time will be the same as tau. Because with tau only you will be able to again compare with the threshold, now we will be comparing with two thresholds. So, if it goes beyond threshold 2 you will be able to tell that ok, it is not only that there is something going on in the channel, but it is also in the collision domain.

More than one station is attempting transmission, so you will be able to do this collision detection. Now if we can do collision detection immediately what I can do? Suppose I have a transmission going on I have transmitted, I can now also detect that somebody else is also transmitting and within some detection time I will be able to see that there is a collision.

After this collision do I really wish to transmit no point, because I am transmitting garbage; why should I transmit? So, I can immediately abort transmission and start a fresh slot. And everybody because it is again synchronized, everybody whenever there are two collisions going on both the stations who are involved in the collision or three stations who are involved in a collision will be able to detect this collision.

So, they will be aborting transmission. So, everybody aborts the transmission and the next slot starts then again everybody can sense the channel and try to transmit. So, this reduces the collision slot as well. Now, you can see we have devised two mechanisms to reduce whatever we had achieved in slotted ALOHA, maximum throughput.

We can now really enhance the throughput heavily by doing these two mechanisms of carrier sensing which reduces the idle time and the collision detection, which reduces the collision time. So, if we can reduce the slot size of these things we still know that with almost similar probability these collisions will be happening or idle time will be happening. So, the probability remains the same, but now the success time has been increased whereas, collision and idle time has been reduced.

So, overall time aspects if I see most of the time I will be seeing success. So, the success probability can be enhanced up to almost 80 percent which is something you will be seeing. So, this is how the protocol has been slowly developed towards the best-known protocol CSMACD we know for our Ethernet transmission or corresponding CSMACA with binary backup that we know for our wireless access.

So, now what we will do? We will try to in the next class we will try to see what is the effect of this beta ok, so just CSMA what is the effect of that? Later on, we will try to also analyze if I have a collision detection, then what is the overall throughput of a CSMACD protocol, that is something we will be trying to see. And then will also see this will be 8 naught 2 dot 3 or Ethernet protocol and then we will see the Wi-Fi protocol.

802.11, which is called CSMACA where collision detection we will also see appreciate, why this goes from coaxial cable to means wireless media and why in wireless media collision detection is not possible. Then we make a device with another mechanism called collision avoidance where the binary backup will be one of the integrated factors and then we will also do an analysis of both of them.

We will see that almost 80 percent throughput can be achieved in both of these media. This will be the highlight of our means final analysis of this particular media access control. So, we will try to do those things next ok.

Thank you.