Wireless Technology and Standards : CSMACA

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Now it's time to tackle our third topic in the session. It's call Carrier Sense Multiple Access/ Collision Avoidance. You have to say a few times before you actually manage to memorize it. But what's important to understand about it is that it's a mechanism that controls the way communication is being done over these magnetic waves that are modulated in order to insert information, digital information, in them, inside LANs.

If you want to make an overview just before we dive into this, we looked at why is wireless important; we look at what are electromagnetic waves and their basic properties; why is frequency very important; and how we managed to raise the data rate of the bandwidth without necessarily raising the frequency by using different modulation techniques,
which control the quantity of data, that you can insert inside a frequency band.

So let's look at the transmissions. We've already talk a bit or scraped this topic - why it's hard to access the medium and transmit into the wireless environment. Wireless is always going to be half duplex - you cannot send and receive at the same time because of the way that the electromagnets waves work inside your stratosphere. This is very similar to the 10Base5 and 10Base2 of coaxial implementations on wire, if you know the older wired standards that existed at the beginning of computer networks. If two stations transmit at the same time in the same frequency band, a collision will occur.

Now, if I have a very smart modulation that is working on that frequency band, then I can sustain some of the information in that frequency band, in that wave. But still, I'm going to lose a lot of it, so collision will occur. Now this is detectable by unsteady frequencies and incorrect modulation. So, you can tell it, you can see it somehow in the air. How you can see it? Easy, because these waves they create a new wave that is basically flapping around that specific frequency, and when you see it at the receiving side it just don't looks like something you generated using the standard rules of the 802.11 standard.

It looks like noise and that's the biggest problem really. You can have a smart processor to really get out the data from that noise, but if the noise is very high, it's going to be very hard to tell if that is a collision or just something else that was transmitting in the 2.4GHz or 5GHz ISM band in which a lot of the devices can transmit.

What is the conclusion? Conclusion is we need a control method of transmitting these waves. We cannot just let everybody transmit all the time. If you know anything about Ethernet, you know that in Ethernet we use - under wired environment - a Carrier Sense Multiple Access / Collision Detection, so we detect collisions in Ethernet. Once we detect them, then we can train everybody in the network to do a retransmission of the specific data that collision.

In wireless, however, it's harder. First, because it's harder to detect collisions in the air. Second, sometimes you don't even see that specific collision. It's not like everybody's connected to the same wire like you are in a wired infrastructure.

Look at this example. Let's assume that collision is happening between Host1 and the Access Point. As you can see in Host1 area of view, only a small part of it is the part that Host2 also sees. The Access Point is privileged, it gets to see from both worlds. But Host2 doesn't see a portion of the spectrum that Host1 sees. So if the collision is going to happen in that specific spectrum, then Host2 is never going to be able to see that collision even happening.

You can clearly not try to detect the collisions because the spectrum of electromagnetic wave doesn't work like that. Sometimes we cannot even see those collisions happening in the air like we have in this example.

So what do you do? First of all, you got to implement an access control. You can do this with acknowledgement message. For each frame sent, you expect an acknowledgement to be received. If no acknowledgement is received, you immediately do a re-transmission.

Let’s think of a specific case here. Host2 wants to send the message to Host1. Host2 sends it to the AP, and that works perfectly. But when the AP sends it to Host1, Host1 doesn't get it because of a collision with something else in that medium. Host2 never sees it because it just can't see that far. You're looking at the circle that encompasses Host2. Immediately if it doesn't get an acknowledgement from Host1 that the frame was received, that needs to re-transmit the frame.

You can imagine that although this mechanism is necessary and it happens in wireless transmissions, it also takes a lot of the bandwidth. That means when somebody tells you the theoretical data rate of a certain transmission is - let's say, 10Mbps you're immediately going to be skeptical about that, and understand that is just a theoretical number. Since you're also sending them acknowledgement frame for each and every frame of data, even though the acknowledgement frame is empty and doesn't contain actual data, it still takes a lot of the environment time and takes a lot of the channel time of transmission. If the theoretical bandwidth is going be 10Mbps, you're going to be almost cut in half the actual data rate because you're using acknowledgements. This is reality, and this is something very important to understand.

Another method of access control that can be implemented is with something called the Request-to-Send, Clear-to-Send mechanism. What we saw in the previous example is that the Access Point was privileged by the fact that it could see both left and right. It could see both spectrum of H1and spectrum of H2. Taking advantage of that fact that the Access Point is in the middle, we can implement a system where one station that want to send at a specific moment in time, send the Access Point a message called RTS -- a request-to-send; and basically talks to the Access Point and tells it, “you know, I don't see any kind of signal in the air right now but I don't see all the signals that could happen in this LAN. But you as the Access Point as the one that is in the middle can see everything. So tell me, am I request-to-send, and can I send right now, can I send my message right now?”

The Access Point looks at the environment. In a favorable case, it can see that nobody else is transmitting right then and gets back to the station with the CTS message (Clear-to-Send), and tells the station, “okay I've look at the environment, nobody is sending right now, go ahead and send your data.” The beauty of this Clear-to-Send message - is that the Clear-to-Send message is broadcasted at Layer 2. So all the stations in the LAN see the Clear-to-Send, which inside the data structure contains the ID - the Mac address of the station that is about to send. So the way this works is, if you're the station just requested to send and you receive a Clear-to-Send and you see your Mac address inside a Clear-to-Send message, it means you're lucky. It means you got the floor; you can speak. But if you're another station and if you receive a Clear-to-Send and your Mac address is not embedded inside it, it means you have to remain silent and shut up for the next standard interval of transmission.

In that way you manage the transmission from the Access Point of view. Still you have the acknowledgements because you have to use them, you have to be sure the data was there. But in this way, you have a clear access control in your Wireless LAN.

We saw how we are able to manage these communications and transmissions, but still, we are at a level where we can easily say that wireless is half-duplex. And even though we manage different time frames of sending the signal, we still cannot understand if we can make it possible to send and receive at the same time in an ISM band. The answer to that specific query is 'yes'. We can send and receive in the same ISM band at the same time using something called communication channels.

Now, it is clearly not possible from the physics point of view to transmit in the exact same frequency without collisions. However, you remembered that the ISM band was not just one single frequency; it was different intervals in the 2.4 and the 5Ghz band? The 5 GHz was 5.4 and 5.7 and we're different ranges that were reserved in those frequency spaces.

Now, you can ask yourself how many hertz I need, for example, to transmit 54Mbps, which is the theoretical speed in one of the wireless LAN standard called the 802.11g.

Please don't focus on the 802.11g right now, just consider - this question, “how many hertz will you need to transmit this amount of date? And the answer using the QAM 64 modulation is 22 MHz. People that are smarter than you and me have figured this out. So, if you need just 22 MHz to transmit the whole data from that wireless LAN, then as a proposed solution, you can take the ISM band -- which is way bigger then 22 MHz. You can split it into different channels, and you can map each transmission, so each VLAN, each wireless LAN on a single channel, thus having multiple networks in the same band.

So, that means that I can bring together two Access Points and have one Access Point occupy one channel of 22MHz from the ISM band, another Access Point occupy a different 22MHz channel in the same ISM band; and they're never going to collide together, because they're effectively using different frequencies in the same Industrial, Scientific and Medical band. Because QAM 64 modulation is so smart, it can put that entire quantity of 54 theoretical megabits into just 22 MHz bands.

This is actually a visual representation on how these channels look. As you can see from this picture, we have 11 channels in the standard in the ISM band that are split between 22MHz, so each channel has a 22MHz width, and it's space between the other channels is about 5Hz.

What does that means? It means Channel 1 has 22 MHz, Channel 2 has 22 MHz, and the spacing between the beginning of the first channel and the beginning of the second channel is 5 Mhz. That means that you have 18 MHz of overlap between the first channel and the second channel. If you would use two Access Points like in my previous example - and set one Access Point in Channel 1 and another Access Point in Channel 2, you'd get 18 megahertz of possible collisions, which is not that cool. However, if using Channel 6, Channel 1 and Channel 11 that you see are bolded up -- these channels don't have any kind of overlap between them. There is actually space between them with 3 MHz.

That takes you to a very fast conclusion - that you have three channels, three WLANs that can coexist in the same space. And that is actually one of the standard algorithm problems, algorithmic problems that has been solved over time, called the honeycomb problem, which says- how many channels, how many different honeycombs would you need of different colors to be able to color an entire honeycomb, and never have the same color adjacent. The answer is 'three', that is very relevant for a problem that we have in WLANs of how can we cover an infirment amount of space with different channels without ever having collisions or overlaps? The answer to that is "three". If you organize like you see in this graphic, if you organize three channels-- just three channels, you can never have the same channel being adjacent to itself. So, you can never have a collision, and you can easily see that these channels in terms of, let's say, not geographical but spatial placement, they're overlapping in terms of electromagnetic waves.

That's okay, because they're working on different frequencies, that even more than okay; that's actually a functionally call 'Roaming'. For example, if I'm in a cell on Channel 6, and I'm moving into another cell that is on Channel 1, the technology of roaming is built into the driver - it's built into the 802.11 standard, so that I don't lose my signal at all. It's completely transparent to the end user. I get a world without collision, infinite possibility of covering the surface with the three channels, and being able to roam from one to another with zero collisions; and without losing my signal. 'Channels' solved the problem of making the wireless communications – half duplex communication by splitting them between different channels.

