Control of access to the half.

The links network HE they can split in two categories: the that they use connections spot to spot and those who use broadcast channels.

In any broadcast network the issue is how to determine who can use the channel when there is competition for it. In the literature, Broadcast channels are called multi-access channels or random access channels.

The protocols used to determine who goes next on a multi-access channel belong to a sublayer of the data link layer called the MAC (Medium Access Control *) sublayer* .

The sublayer MAC has special importance on the networks, in special the wireless ones on that the channel wireless is of diffusion by nature. In contrast, the WAN they use links spot to point, except on satellite networks.

Assignment static of the channel.

The manner traditional of assign a only channel, between multiple users competitors, is split its capacity by using one of the multiplexing schemes such as FDM (Frequency Division Multiplexing *)* . If there are N users, the bandwidth is divided into N equal-sized parts and each user is assigned a part.

When only there is a amount fixed and constant of users, each one has a flow stable, the division is a mechanism of assignment simple and efficient. Without embargo, when he number of issuers is large and varies continuously or when traffic is bursty, the FDM presents some problems.

Although the number of users remained, in some way, constant in N , splitting the single available channel into several static subchannels is inefficient. The problem is that when some users are inactive, their bandwidth is wasted.

Assignment dynamic of the channel

All he job made by the protocols of assignment dynamic HE base in 5 assumptions described next .

1. **Traffic independent.** He model consists of in *N* **stations** independents (computers, phones), each with a program or user that generates frames for transmission. The expected number of frames that are generated in a interval of length $\Delta \boldsymbol{t}$ and $\lambda \Delta \boldsymbol{t}$, where λ is a constant (the arrival rate of new frames). Once a frame has been generated, the station blocks and does nothing until the frame has been successfully transmitted.

2. **Single channel.** There is only one channel available for all communications. All stations can transmit on it. Stations are assumed to have equal capacity, although protocols may assign them different roles (priorities).

3. **Collisions observables.** Yeah two plots HE transmit of shape simultaneous, HE overlap in time, and the resulting signal is altered. This event is called **a collision** . All stations can detect a collision. A collided frame must be retransmitted afterward. There are no other errors except those generated by collisions.

4. **Continuous or slotted time.** It can be assumed that time is continuous, in which case the transmission of a frame can begin at any time. On the contrary, time HE can revive either split in intervals discreet (called slots). In this case frame transmissions must start at the beginning of a slot. A slot may contain 0, 1 or more plots, corresponding to an inactive slot, a successful transmission or a collision, respectively.

5. **Carrier sense or non-carrier sense.** With carrier sense, the stations they can know Yeah he channel this in use before of attempt use it. Yeah is detected that he channel this busy, none season would try use it. Yeah No there is Carrier sense means stations cannot detect the channel before attempting to use it. They simply transmit. Only then can they determine whether the transmission was successful.

ALOHA

The basic idea of an ALOHA system is to allow users to transmit when they have data over the air. send. There will be collisions and the plots in collision is damage. The issuers need some way to know if this is the case. In the ALOHA system, after each station sends its frame to the central computer, the central computer rebroadcasts the frame to all stations. Thus, a transmitting station can hear the diffusion of the season earthly teacher (hub) for see Yeah passed his plot or not.

Yeah the plot was destroyed, he transmitter simply wait a time random and the sends of new. The weather of wait has to be random either the same plots they will collide a and other to the time, in synchrony. Systems in which several users share a common channel in such a way that it can lead to conflicts are known as **contention systems** .

An interesting question is, what is the efficiency of an ALOHA channel? In other words, what fraction of all transmitted frames escape collisions under chaotic circumstances?

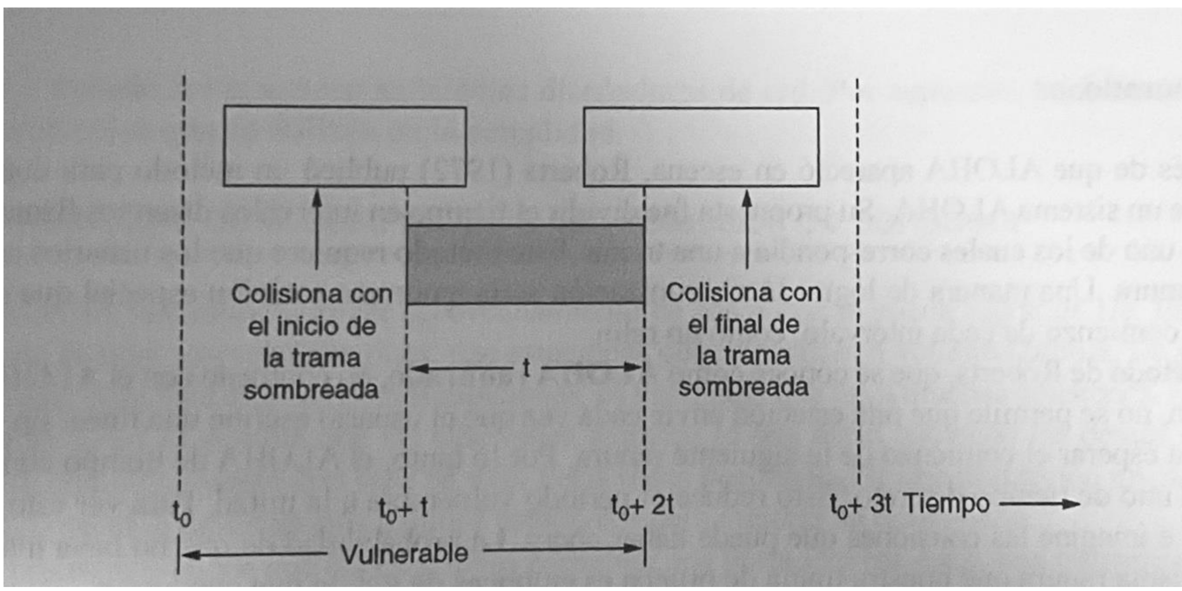
To answer this question, consider an infinite number of users typing at their stations. A user is always in one of two states: typing or waiting. Initially, all the users are in he state of writing. Upon completion a line, the user leaves of write, in wait of a answer. After, the season transmits a plot (that contains the line) to through the channel shared until the computer central and check he channel for know Yeah arrive with success or not. Of be So, he user go the answer and continues writing. Yeah No, he user continues waiting while the station transmits the frame over and over again until it is successfully sent.

The "plot time" denotes the time required to transmit the standard plot in length fixed (i.e., the frame length divided by the bit rate). Suppose that new frames generated by the stations are good modeled according to a distribution of Poisson with a average of N plots by time of plot (the assumption of population infinite is necessary for ensure that N does not decrease as users are blocked). If $N > 1$, it means that users are generating frames at a rate greater than the channel can handle, and almost every frame will collide. For a reasonable transmission rate, one would expect that $0 < N < 1$.

In addition to new frames, stations also generate retransmissions of frames that previously suffered collisions. Suppose the new and old combined frames are well modeled according to a distribution of Fish, with a average of G plots by time of plot.

Certainly $G >= N$. With low load (i.e. $N \approx 0$) there will be few collisions and therefore few retransmissions, by it that $G \approx N$. With loads high there will be many collisions, by it so much, $G > N$. With all loads, the actual transmission rate S is just the offered load, G , multiplied by the probability P_0 of that a transmission have success (is say, $S = GP_0$, where P_0 is the probability that a frame will not suffer a collision).

A plot No will suffer a collision Yeah No HE they send others plots during a time of plot from your shipment as shown in the following figure.



Period vulnerable for the plot shaded . In Tanenbaum, TO. and Wetherall, D. Networks Computer Science (p. 227). Pearson, 2012

Let t *be* the time required to send a plot. If any another user generated a frame between time 0 and $t_0 + t$, the end of that frame will collide with the beginning of the shaded frame. Likewise, any other frame that starts between $t_0 + t$ and $t_0 + 2t$ will collide with the end of the shaded frame.

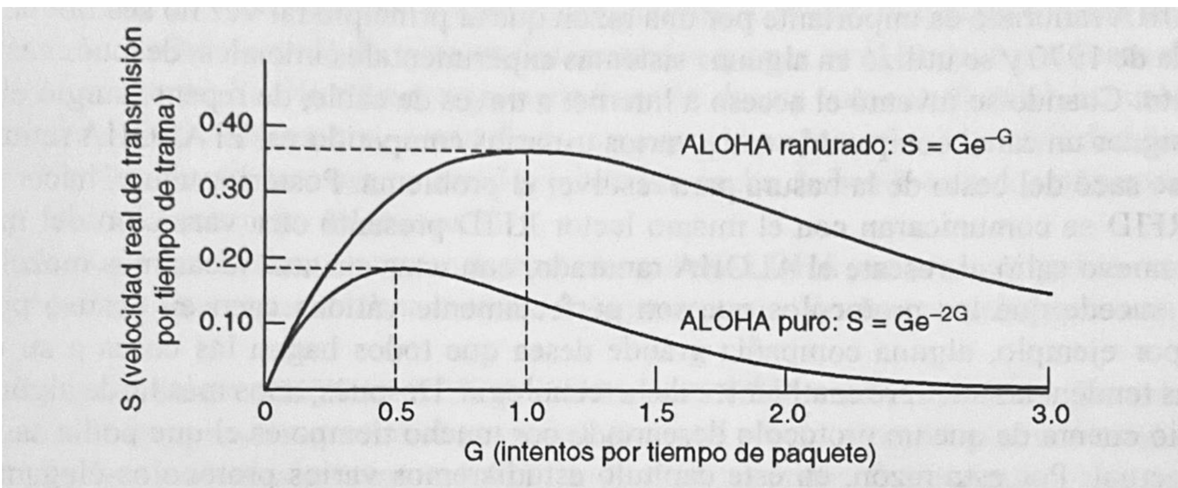
The probability of that HE generate k plots during a time of plot certain, in where G *frames* are expected , it is given by the Poisson distribution:

$$\mathrm{P_r}[k] = \frac{G^k e^{-G}}{k!}$$

Thus, the probability of 0 frames is simply e^{-G}. Over an interval of length two frame times, the average number of frames is $2G$. The probability that no frames are initiated during the entire vulnerable period is then given by $P_0 = e^{-2G}$. If $S = GP_0$, we obtain:

$$S = Ge^{-2G}$$

The following figure shows the relationship between offered traffic and actual transmission speed. The maximum real speed of transmission occurs when $G = 0.5$, with $S = \frac{1}{\text{2nd}}$, that is around of 0.184. In others words, it further that HE can wait is a use of the channel of the 18%. With all seasons transmitting to the random, hardly HE could wait a rate of 100% success.



Speed real of transmission against traffic offered in the systems ALOHA . In Tanenbaum, TO. and Wetherall, D. Computer Networks (p. 227). Pearson, 2012

ALOHA Slotted

Shortly after ALOHA appeared, a method was published to double the capacity of an ALOHA system. The proposal was to divide the time into discrete intervals called **slots** , each of the which corresponded to a plot. This method requires that the users agree limits of slot. A manner of achieve the synchronization I would be have a season special that issued a signal at the beginning of each interval, like a clock.

Slotted ALOHA, in contrast to ALOHA, does not allow a station to send every time the user writes a line. In change, HE you obliges to wait he beginning of the following slot. This reduces the vulnerable period by half.

The best what can be expected using ALOHA slotted is 37% from empty slots, 37% success rate and 26% of collisions. Yeah HE opera with values older people of G HE reduces he number of slots empty, but the number of collisions increases exponentially.

With slotted ALOHA, the best channel utilization is 1/e. This low result is not surprising, since with stations transmitting at will, without paying attention to what other stations are doing, many collisions are inevitable. However, in LANs, stations can detect what other stations are doing and adapt their behavior accordingly.

The protocols in the that the stations listen a carrier (is say, a transmission) and act accordingly and are called carrier detection protocols.

CSMA persistent and No persistent.

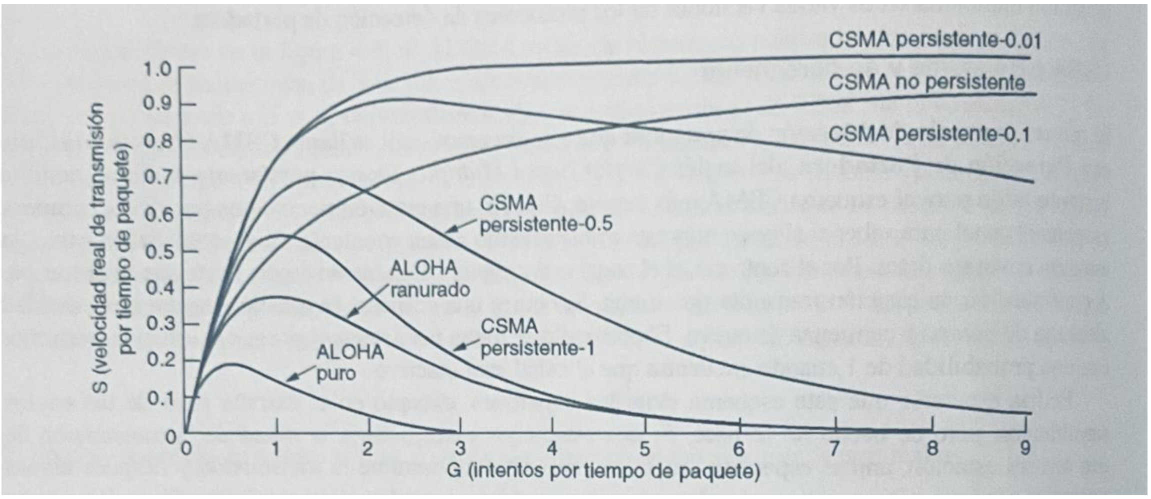
He first protocol is called CSMA (Access Multiple with Detection of Carrier, of the Carrier Sense *Multiple Access*). When a station has data to send, it first listens to the channel to find out if someone more is transmitting in that moment. Yeah he channel this idle, the season sends its data. If the channel is busy, the station waits until it becomes free. The station then transmits a frame. If a collision occurs, the station waits a random amount of time and starts over. The protocol is called persistent-1 because the station transmits with probability 1 when it finds the channel idle.

This scheme might be expected to avoid collisions except in the rare case of simultaneous dispatches, but of made No it does. Yeah two stations are lists to the half of the transmission from a third station, both will wait until the transmission ends and then both will start transmitting at exactly the same time, which will cause a collision.

Even so, this protocol has a better performance that ALOHA. Since both stations have the descent of leave of interfere with the plot of the third season. It same HE applies in he ALOHA slotted.

A second carrier-sensing protocol is **non-persistent CSMA** . This protocol makes a conscious attempt to be less selfish than the previous one. As before, a station listens to the channel when it wants to send a frame, and if no one else is transmitting, it begins doing so. If the channel is already in use, the station will not listen continuously in order to seize it immediately upon detecting the end of the previous transmission, but will wait a random period. and will repeat he algorithm. In consequence, this algorithm drives to a better use of the channel, but produces higher delays than persistent CSMA-1.

The last protocol is **CSMA persistent-p** which is applied to slotted channels and works as explained to continuation. When a season this list for send, listen he channel. Yeah HE If the station is found to be idle, it transmits with probability p . With probability $q = 1 - p$, it defers to the next slot. If that slot is also idle, the station either transmits or defers once more, with probability p and q . This process HE repeat until that HE transmits the plot either until that another station begins transmitting. In the second case, the unfortunate station acts as if it had occurred a collision (is say, wait a time random and starts of new). Yeah to the principle the station detects that the channel is busy, wait until the next slot and applies the previous algorithm.



Comparison of utilization of the channel against the burden for several protocols of access random . In Tanenbaum, A. and Wetherall, D. Computer Networks (p. 230). Pearson, 2012

CSMA with detection of collisions

The protocols CSMA persistent present a improvement regard to the protocols ALOHA, due They ensure that no station will begin transmitting while the channel is busy. But if two stations detect that the channel is inactive and begin transmitting at the same time, their signals will collide.

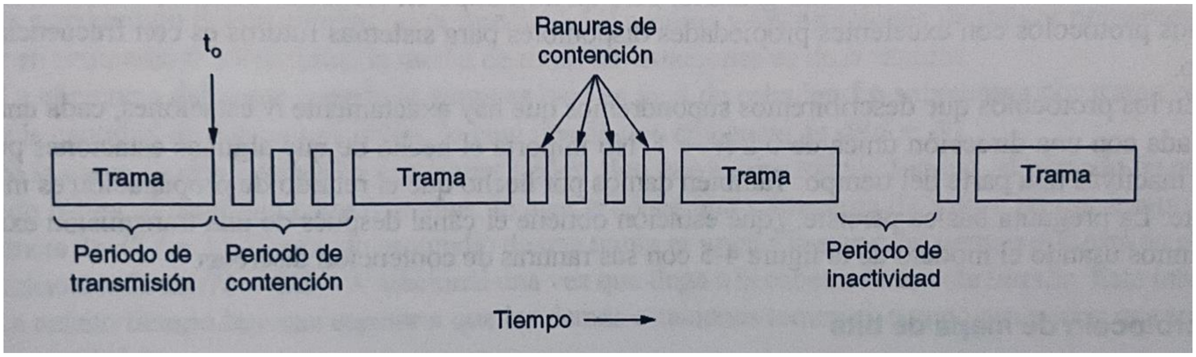
Having stations quickly detect the collision and stop transmitting immediately is a strategy for save time and broad of band. He protocol acquaintance as CSMA/CD (CSMA with Collision Detection, from English *CSMA with Collision Detection*), is the basis of the Ethernet LAN.

Collision detection is an analog process. The station's hardware must listen to the channel while transmitting. If the signal it receives is different from the one it's sending, it knows a collision is occurring.

If a station detects a collision, it aborts transmission, waits a random amount of time, and tries again (assuming no station has started transmitting during that time).

This implies that the signs received No must be minors small in comparison with the transmitted signals, which is difficult in wireless networks because received signals can be 1,000,000 times weaker than transmitted signals.

CSMA/CD uses he model conceptual of the following figure.



CSMA/CD can be in state of containment, of transmission either idle . In Tanenbaum, TO. and Wetherall, D. Computer Networks (p. 231). Pearson, 2012

Suppose two stations start transmitting at time t_0. How long will it take for them to realize that that ha occurred a collision? The answer to this ask is important for determine the length of the contention period, the delay and the actual transmission rate.

The minimum time to detect a collision is the time it takes for the signal to spread from one station to other. With base in this time HE can consider that, a season that No ha detected a collision for a period of time equal to the cable propagation time after starting its transmission has taken the cable, therefore, other stations know it is transmitting and do not interfere. However, this is incorrect.

Sea τ the time it takes for a signal to propagate between the two furthest stations. In t_0, a station starts to convey. In $t_0 + \tau - \varepsilon$, a instant before of that the sign I arrived to the station more distant, that station also starts to transmit. The second station detects the collision immediately and stops, but the small burst of noise caused by the collision does not return to the original station until time $2\tau - \varepsilon$. This means that, in the worst case case, a station does not can be sure that it has seized the channel until it has transmitted for 2τ without detecting a collision.

HE can think in containment of CSMA/CD as a system ALOHA slotted with a broad of slot of 2τ. In a 1km long coaxial cable, $\tau = 5\ \mu seg$. The difference for CSMA/CD compared to slotted ALOHA is that slots in which only one station transmits (e.g., the that took he channel) they go followed of the rest of a plot. This difference improvement in considerable form he performance if the time of the slot of the plot it's a lot elderly that he propagation time .

CSMA/CA

CSMA/CA (CSMA with Collision Avoidance) is a medium access protocol used in wireless local area networks, such as Wi-Fi. CSMA/CA is used to prevent data collisions on the network and ensure more reliable data transmission.

He protocol CSMA/CA works of the following manner:

1. Detection of carrier: The devices that wish convey data first listen he means for verify Yeah this busy (detection of carrier). Yeah he half this busy, they wait until that is free to avoid collisions.

2. Power Sense: In addition to carrier sensing, CSMA/CA uses power sensing. for verify the quality of the sign in he half. This aid to reduce the collisions caused by weak signals or interference.

3. Avoidance of collisions: A time that HE determines that he half this free, he device that you want to transmit sends a little package of data called RTS (Request to Send) to the device receiver. The receiver responds with a CTS (Clear) packet to Send) to confirm that it is ready to receive data.

4. Transmission of data: After of receive the confirmation CTS, he device transmitter sends the data. Other devices on the network will wait their turn to transmit when the medium is free.

In summary, CSMA/CA is a protocol used in networks wireless for minimize the collisions and ensure more efficient and reliable data transmission by allowing devices to coordinate their access to the medium in a more orderly manner. This is important in environments where several devices compete for access still shared communication channel, such as in Wi-Fi networks.

The differences regard to CSMA/CD HE group in 3 categories.

1. Detection and management of collisions:

    a. CSMA/CD: When two devices transmit data to the same time and HE If a collision occurs, both devices detect the collision and stop transmission immediately. Then, retry the transmission after of a period of random wait. CSMA/CD HE uses mostly in networks Ethernet with wire, where the detection of collisions It is more practice due to the transmission in it same shared medium .

    b. CSMA/CA: Collision is actively avoided before transmission by requesting and confirming medium access (RTS/CTS). If a collision is detected during transmission, it is taken as a signal that the channel is busy, and a collision is performed. a new application after of a period of wait random. CSMA/CA It is used in wireless networks, such as Wi-Fi, where collision detection is more difficult due to wireless transmission characteristics.

2. Media transmission :

    a. CSMA/CD HE uses mostly in networks wired, where he access to the half It is shared through a physical cable.

b. CSMA/CA is used in wireless networks, where devices communicate via radio signals rather than a shared cable medium.

3. Efficiency

   a. CSMA/CD is more efficient in terms of bandwidth usage and latency on wired networks, as it enables rapid collision detection and resolution.

   b. CSMA/CA introduces additional overhead due to the need to send request and acknowledgement packets before actual transmission, which can impact efficiency and increase latency in wireless networks.

References

Tanenbaum, TO. and Wetherall, D. (2012). *Networks of Computers* . (5th ed). Pearson.