Media Access Control protocols

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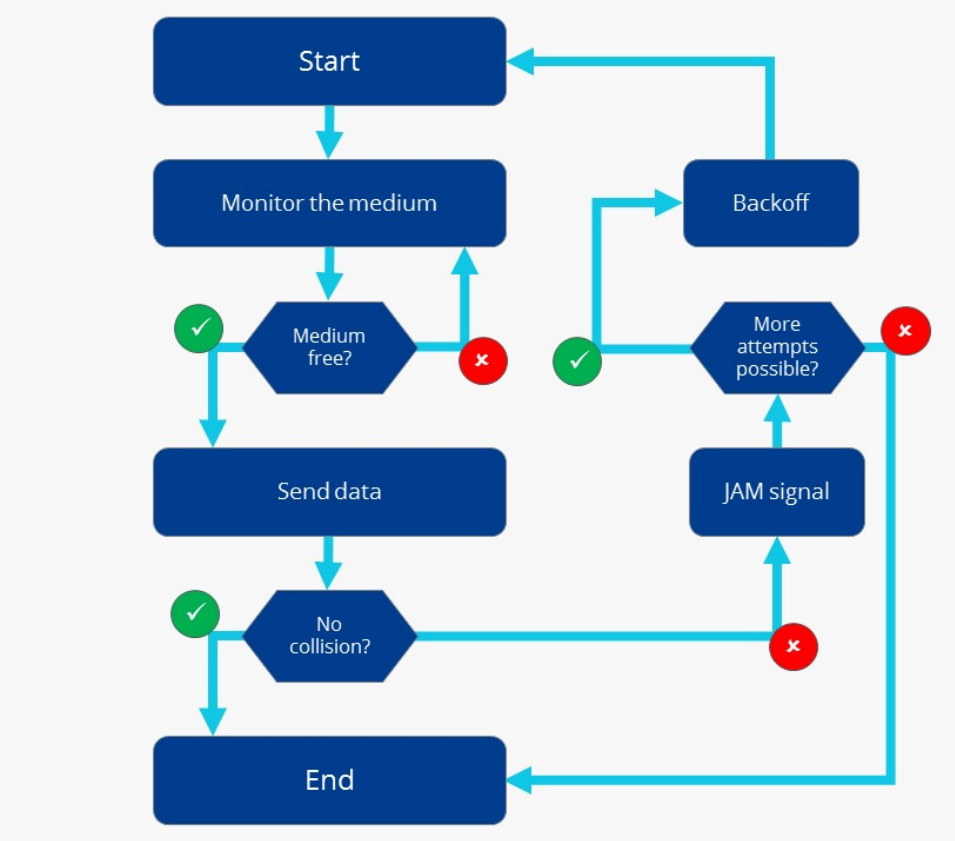
In this report I will go further on some protocols used by MAC layers. The protocols I'm going to talk about are all Multiple Access protocol when multiples nodes to interact through a shared medium. Those protocols determine how to share this medium (that can be a physical link or just air for radio frequencies).

CSMA (Carrier-Sense Multiple Access)

Before initiating a transmission, a node listens to know if another node is emitting. If there is one the node waits for it to finish before initiating his own transmission.

Two variations of the protocol exist in order to improve performance in case of packet collision.

- CSMA/CA (with Collision-Avoidance)
  If the medium is busy the node waits for a random time t before transmission. Each time the medium is sensed busy value t reduce for each need at a random rate. The chance that two nodes waiting will re-emit at the same time gets very low.
  Used by Wi-Fi.
- CSMA/CD (with Collision-Detection)
  When a collision is detected the transmission is determined. The node can then retry faster to communicate.
  Used by Ethernet.



Other variations of CSMA depends on the algorithm that to determine the moment to initiate transmission and its aggressivity to “take” the medium. A guard interval is putted at the end of each time slot, when the transmission moves into this interval the system adjust the slot timing.

TDMA (Time-Division Multiple Access)

Allocate to each node a time slot to transmit. Each node transmits in rapid succession using its own slot.

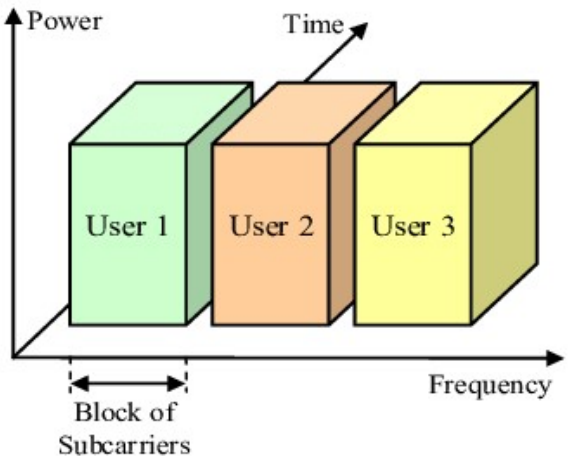
This protocol is used with 2G communications.

The slots can be allocated dynamically as transmitters move in and out of the emitter range. GSM is a famous cellular system that use TDMA with Frequency Hopping (changing the carrier frequency to avoid interference and eavesdropping).

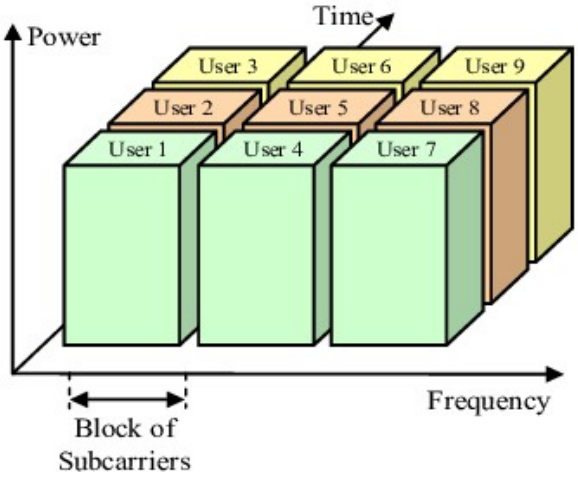
In a system such as GSM each phone needs to synchronize with the rest of the system to get its time of emission and the length of its time slot.

Dynamic TDMA (Adjust time slots according to traffic) is used in Bluetooth protocols. ZigBee use a kind of TDMA (contention-free).

As TDMA allocate time FDMA allocate frequency slot to different user, the two methods are often used together.



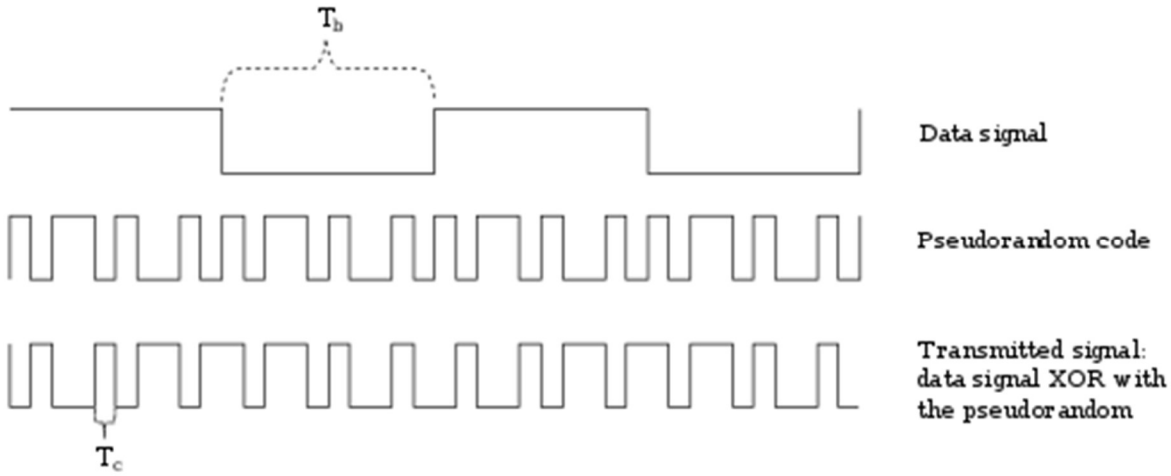
FDMA



FDMA & TDMA

CDMA (Code-Division Multiple Access)

CDMA is a protocol used by 3G and 4G. CDMA sharee a band of frequencies between users without interferences by employing a spread spectrum technology (augment the bandwidth of a signal) and a special coding scheme (where a code is assigned to each node)



Each node us a different code to modulate their signals. The choice of those codes is primordial to separate the signals of the different user. To get the wanted signal we correlate the received signal with the locally generated code of the desired user. If the correlation is high, then that means we can extract the wanted signal.

Two mains categories of CDMA exist: synchronous with orthogonal codes and asynchronous with pseudorandom codes.

Conclusion

I would say that each of the protocol we saw have its advantages. CSMA is easy to implement and understand but doesn't offer the utmost performances in term of use of the medium. TDMA is a nice protocol in term of use of the medium and doesn't separate well the user's transmissions but the allocation of time slot necessity a lot of computing for the emitter. Finally, CDMA is a more complex protocol but procure a good repartition on the medium but it requires a bit of computing on each node.

Figure 1 from Ionos

Figure 2 from ReasearchGate

Figure 3 from Wikipedia