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Study of the MAC Layer for Wireless Sensor Network

5 ISS Report

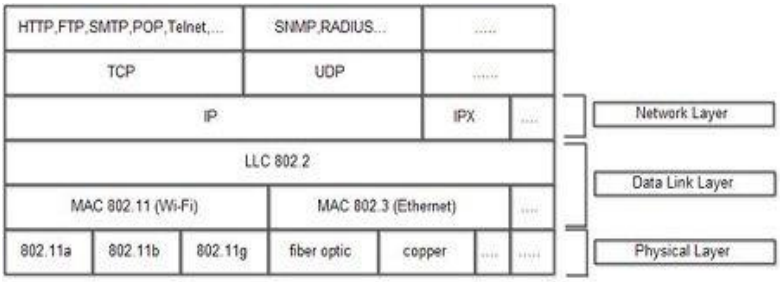
ALBERTI Johan

Group : A2

The sub-layer MAC

Within the OSI model, the MAC (Medium Access Control) sublayer of the Data Link layer provides two main functionalities:

- Medium Access Control (to overcome collision problems).
- The control of the integrity of the transmission (error detection).



Network layers.

It should also be noted that a sensor network differs from a "standard" wireless network:

- High importance given to energy consumption.
- Nodes deployed randomly.
- Wide variety of software for the different sensors.
- Sensor density can result in extremely high data traffic.

As a result, traditional MAC protocols are not suitable for setting up a sensor network.

To manage access to the medium, MAC protocols use various access techniques to avoid data collisions: CSMA/CA, FDMA, TDMA and CDMA …

CSMA/CA : Carrier Sense Multiple Access with Collision Avoidance

With the CSMA each node listens to the medium before transmitting its data. If the medium is busy the node must delay its access and try again the same procedure until the medium is free. This access method is the basis of the IEEE 802.11 (Wifi) standards.
From an energy point of view, the fact that nodes are constantly listening increases their energy consumption. Moreover, this consumption tends to increase according to the density of the network.

Example :

The S-MAC protocol

S-MAC seeks to reduce energy losses due to collisions and idle listening. The idea is to minimize CSMA/CA idle-listening by periodically putting the nodes to sleep ("listen"/"sleep" sequence).
Principle: The nodes synchronize their listen/sleep cycle ("duty cycle") with their neighbors ("cluster") by sending SYNC packets in broadcast. RTS/CTS flow control is associated with CSMA/CA access to limit collisions and power consumption.
Advantages & Disadvantages: S-MAC is adaptable to changes in network topologies, easy to implement and consumes medium power. It is suitable for the transmission of large data volumes.

The T-MAC protocol

A variant of S-MAC, TMAC makes the duty-cycle dependent on traffic volume, unlike the fixed cycle of an S-MAC protocol.
Principle: Like S-MAC, also uses RTS/CTS control. However, the protocol keeps track of the traffic: if the traffic is low the listen period is shorter to save energy otherwise the periods are longer.
Advantage & Disadvantages: Suitable for smaller data volumes or variable traffic. However, nodes tend to go into "sleep" mode too early and it is possible to lose data during large transmissions.

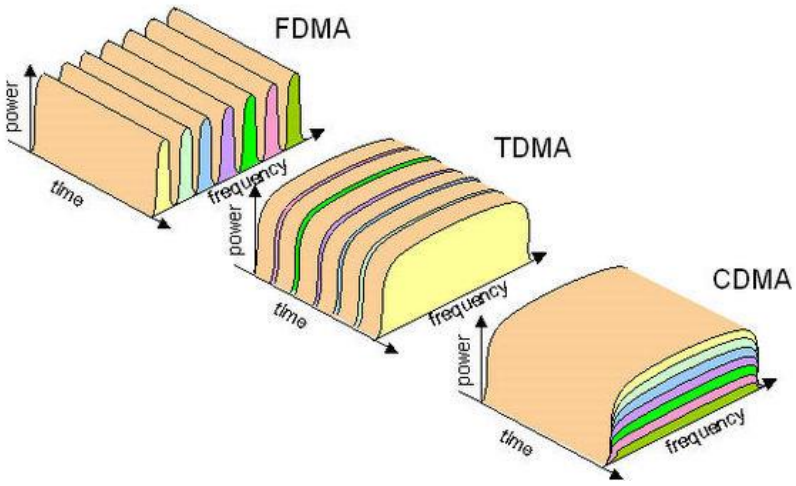
FDMA: Frequency Division Multiple Access

The Frequency Division Multiple Access (FDMA) is based on the same principle than the TDMA protocol. Each device which uses the FDMA protocol has an allocated frequency to communicate using a medium. Consequently, several nodes can communicate in the same medium at the same time, only if they use different frequencies. Each node can have one or several frequency bands allocated to communicate using FDMA. This protocol is widely used in mobile telecommunications

TDMA: Time division multiple access

TDMA is based on time division multiplexing: users use the same frequency while occupying different time slots. Each node uses all the bandwidth allocated to the transmission system during this slot. This was partly the technique used by the GSM (Global System for Mobile communications) telephony standard.

Since each node knows in advance the time slot it will occupy, it goes into a "sleep" state during idle times, which avoids consuming energy by being "idle". However, with TDMA it is necessary to periodically transmit synchronization packets to update the clock in order to synchronize the network, which consumes a large amount of energy.



CDMA : Code Division Multiple Access

Developed in the 1980s for satellite communications, CDMA consists of "spreading the spectrum" through a code allocated to each communication. The receiver uses this same code to demodulate the signal it receives and extract useful information. The code itself does not carry any information.
CDMA consumes a lot of power but compensates with its long range.

Conclusion

We focused on the study of methods of access to the medium CSMA, FDMA, TDMA and CDMA even if others exist.
These access methods allow the implementation of protocols such as S MAC or T MAC and can be classified according to 3 important criteria for IoT: mobility, energy consumption and quality of data transfer (avoid collisions...).

Sources

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