All Sciences Proceedings
All Sciences Proceedings
http://as-proceeding.com/

5th International Conference on Applied Engineering and Natural Sciences
July 10-12, 2023 : Konya, Turkey



https://www.icaens.com/

# Evaluation of the Unslotted CSMA_CA in Zigbee Networks

Sadika KHOUNI[1,*], Samia KHESRANI[2]

[1] *Ferhat Abbas University, Faculty of Technology, Department of Electronic, Sétif, Algeria;*
[2] *Ferhat Abbas University, Faculty of Technology, Department of Electronic, Sétif, Algeria;*

*sadika2009@gmail.com

***Abstract*** – A Zigbee network with 12 nodes (end device) and a coordinator is developed to evaluate the performance of the un-slotted CSMA_CA protocol for the two frequency bands 2.4GHz and 900 MHz by varying the BE (Backoff Exponent) parameter . The simulation is effected for BE=1, 2 and 3 to observe the End to End delay which characterizes the response speed of the network. The network implementation and his simulation were effected under Opnet 14.5.

*Keywords – Zigbee, CSMA_CA, IEEE 802.15.4 Standard, Frequency, Beacon, End To End Delay.*

## I. INTRODUCTION

The IEEE 802 15.4 standard is one of the wireless communication standards used for low data rate applications with better reliability. The IEEE802.15.4 standard offers 3 frequency bands: 2.4GHz, 915MHz, 868MHz[1].

Zigbee network uses IEEE 802 .15.4 standard and works only on the two frequency bands 2.45 GHz and 900MHz[2].In this work we have developed a Zigbee application to optimize medium access times by exploiting the un-slotted CSMA_CA (Carrier Sense Multiple Access collision avoidance) protocol[3]. This manuscript is divided into 3 sections: Section II gives a brief definition of the 802.15.4 standard. Definition of the CSMA_CA protocol is given in section iII. The analysis and discussion of the simulation results are illustrated in section VI and we will end with a conclusion in section V.

## II. DEFINITION OF IEEE 802.15.4 STANDARD

The IEEE 802.15.4 standard operates for WPAN (Wireless Personal Area Network) networks. In WPAN networks [3], there are two types of nodes, FFD (Full Functional Device) and RFD (Reduced Functional Device). FFDs can operate as PAN coordinators or routers, while RFDs only operate as a single node. FFDs are able to exchange information with FFDs as well as RFDs, while RFDs cannot communicate information with the rest of RFDs. For this reason RFDs are always placed as end nodes in wireless networks. The different possible topologies to build are: Star, Mesh and Tree topology. In star topology the nodes communicate information with the coordinator only.

The standard operates on 3 frequency bands, 868MHz, 915MHz and 2.4GHz offering a data rate of 20Kbps, 40Kbps and 250Kbps respectively. These 3 bands make it possible to have 27 channels of different frequencies numbered from 0 to 26. Channel 0 operates on 868 MHz band, channels from 1 to 10 on 915 MHz band and channels from 11 to 26 on 2.4 GHz band. Two traffic modes are adapted, beacon mode and beaconless mode.

### A. *Beacon Mode*

The IEEE 802.15.4 standard frame is subdivided into 2 periods, the active period and the inactive period. During the inactive period all the nodes are in the sleep state including the coordinator. The active period is divided into 16 slots, The first slot is occupied by the beacon frame, the rest of the slots are divided into 2 periods, the CAP (Contention Access Period) and the GTS (Guaranteed Time Slots) (often 7 slots)(Fig 1)[1]. The coordinator is active throughout the active period. The rest of the associated nodes are active in the GTS phase only during the allocated slot.

During the CAP period, the nodes that do not have data to send or receive turn off their transmitters and go into the sleep state. The communication protocol used is slotted CSMA_CA, a protocol to avoid collision[1].

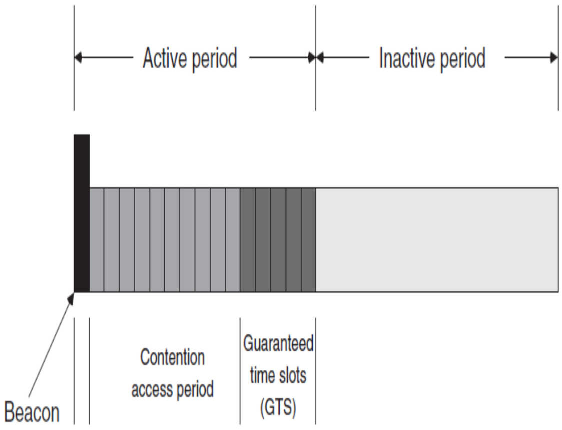


Fig. 1 Superframe structure of the IEEE 802.15.4 standard[1][4]

### B. *Beaconless mode*

In beaconless mode, the coordinator does not send the beacon frame, which induces the non-synchronization of communication between node and coordinator.

## III. THE UN-SLOTTED CSMA_CA PROTOCOL

The Un-slotted CSMA_CA technique is suitable for the mode Beaconless[3]. As already said, in the beaconless mode the coordinator does not send the beacon frame which causes the coordinator-nodes to be out of synchronization. The node is defined by 2 variables: NB (Backoff Number) and BE(Backoff Exponent) that represents the current backoff.

The Un-slotted CSMA_CA algorithm is as bellow (Fig 2):

1. NB=0, BE=macMinBE.

2. The node waits until the end of the current backoff then designates a random number r from the interval [0.$2^{BE}$-1].

3. The node must wait r backoff periods and then execute CCA (Clear Channel Assessment) operation:

If the channel is Idle, it must wait for the end of the next backoff then test the channel.

If it is still Idle, the node starts sending data packets, otherwise it assumes the channel is busy and drops the data frame announcing a failure.

For a CSMA_CA protocol, the node is either Idle, active, in a scan state or failure (Fig 3).

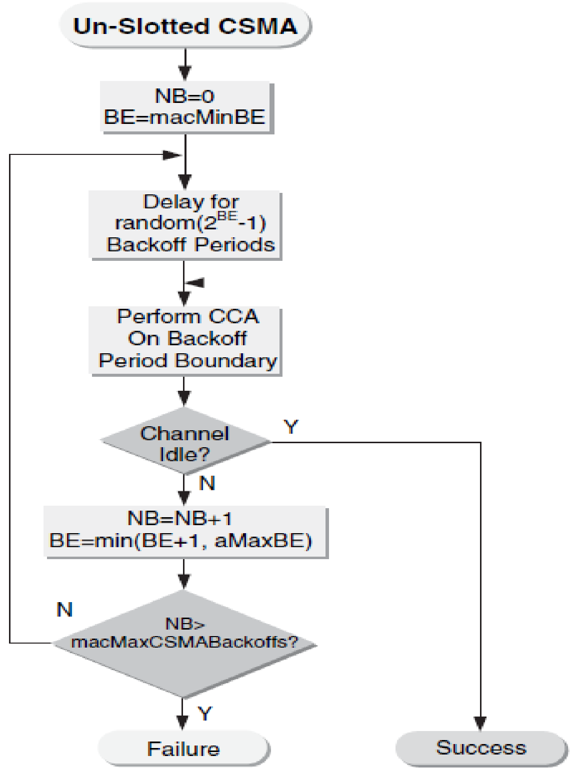


Fig. 2 UN-Slotted CSMA_CA flowchart[3]

## IV. DISCUSSION

An application to the Zigbee network (star topology) with 12 nodes (end devices) and a coordinator is developed (Fig 4). To evaluate the performance of the un-slotted CSMA_CA protocol for the two frequency bands 2.4GHz and 900 MHz, the attributes as given in Fig 5 is affected to the coordinator in Opnet modeler 14.5.

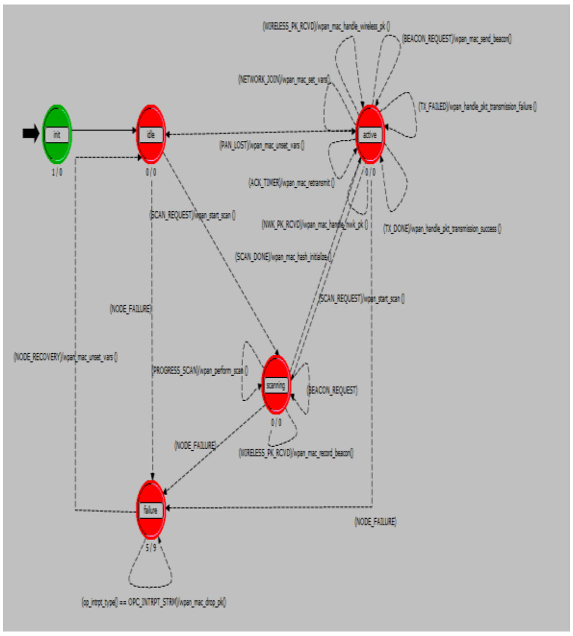

Fig. 3  The process model of the CSMA_CA protocol

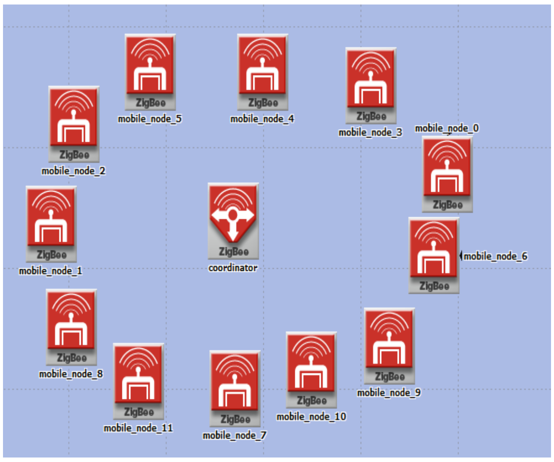


Fig. 4  The process model of the CSMA_CA protocol

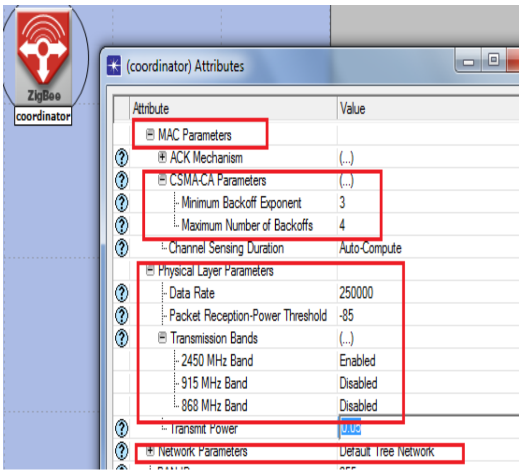


Fig. 5 .The process model of the CSMA_CA protocol

We have simulate the model for the 2.4 GHz frequency band with a data rate of 250 Kbps (Scenario 1 (Fig 6)) and for the 900 MHz frequency band with a data rate of 40 Kbps the delay(Scenario 2 (Fig 7)).

We can see that the End to End delay is more reduced for 2.4 GHz frequency.

For a given frequency band, the End to End delay variation is a function of the Backoff Exponent (BE) parameter, The values of the Backoff Exponent BE are 1, 2 and 3.

We can see that the End to End delay is more reduced for 2.4 GHz frequency(Fig 6 and Fig 7).

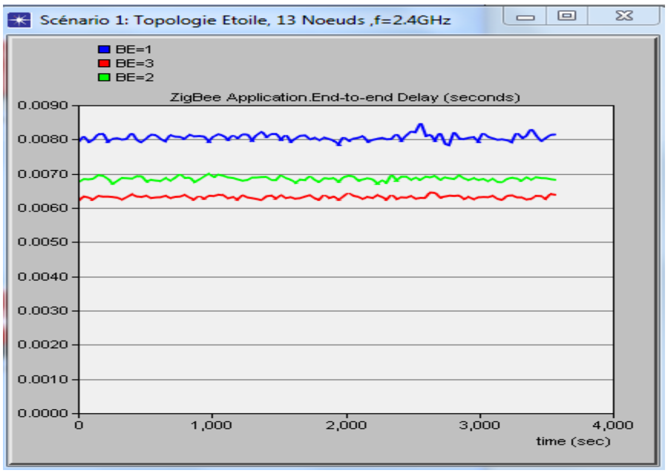


Fig. 6 . End to End delay function of BE for f=2.4 GHz

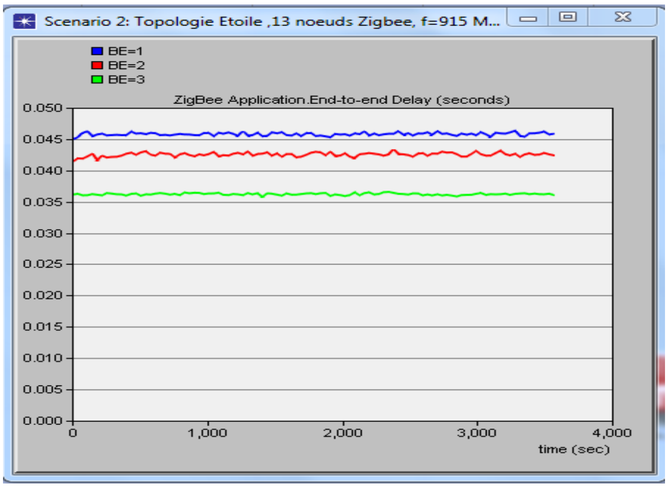


Fig. 7 . End to End delay function of BE for f=900 MHz

## V. CONCLUSION

We have exploited the Unsloted CSMA_CA protocol of the 802.15.4 standard in order to be able to analyze the influence of frequencies as well as the BE parameter on the variation of End to End delay in Zigbee networks. The simulation under

Opnet modeler shows that the End to End delay is better for high frequencies and for high data rates.

## REFERENCES


[1] Anis K., Mario A, Eduardo T., "GTS allocation analysis in IEEE 802.15.4 for real-time wireless sensor networks", In the Proceedings of the 20th IEEE International Parallel Distributed Processing Symposium, 8, 2006, DOI: 10.1109/IPDPS.2006.1639415.

[2] Baker N., "ZigBee and Bluetooth strengths and weaknesses for industrial applications", Computing Control Engineering Journal, 16, 2, 20-25. 4/2005, DOI: 10.1049/cce:20050204.

[3] XIANGYANG L., "Wireless Ad Hoc and Sensor Networks Theory and Applications'', Cambridge University Press, 2008.

[4] De D., Giuseppe A., Seghitti A., Anastasi G., "From IEEE 802.15. 4 to IEEE 802.15. 4e: A step towards the internet of things", In Advances onto the Internet of Things. Springer International Publishing, 260, 135-152, 2014, DOI: 10.1007/978-3-319-03992-3_10.