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Energy Control In Non Beacon Enabled Mode Of Ieee 802.15.4

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ABSTRACT : *There are many problems in the wireless sensor network but energy trouble lasts always the most critical problem in this domain. Many approaches were proposed to reduce the energy consumed such as the IEEE 802.15.4 which is included in the Low Rate Wireless Personal Area Networks (LRWPANs). The IEEE 802.15.4 includes two modes which are the beaconenabled mode and the non beacon-enabled mode. The present paper is interested in the non beacon-enabled mode which is based on unslotted mode of the Collision Avoidance Carrier Sense Multiple Access CSMA/CA. Our work consists mainly on computing the energy consumed by the node using unslotted algorithm of CSMA/CA. Then the coordinator detects the node which suffers from energy faults after comparing its residual energy to a set threshold which leads to a quick intervention by reducing its duty cycle in order postpone its death..*

KEYWORDS *-Duty cycle,Energy, IEEE 802.15.4, Non beacon enabled mode,WSN.*

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I. INTRODUCTION

In this recent years, the Wireless Sensor Network (WSN) succeed to attract the attention in both the research and industrial domains. WSN is formed by a hundreds nodes. WSN is remarkable by its muli-functions of its devices which sense an event, and send it to the a sink node. WSN has divers application domains such as the health [1], [2], [3] industrial process [4], [5], [6], [7], military automation [8], [9] and environment [10], [11] and [12].

It suffer from so much problems but could be classified on three groups which are time-division multiple access (TDMA) based protocols, preamble sampling protocols and protocols with common active periods. The 802.15.4 standard present the physical and medium access control (MAC) layers of the ZigBee technology. It is worth highlighting that the standard

IEEE 802.15.4 presents the major technology used in the Internet of Thing networks [13]. Indeed, it displays the most appropriate choice fit for interaction with the IoT system's relating physical and MAC layers. Actually, this technology was initially proposed for solving many challenges facing the WSN, specially, the low-rate, the huge area [14]. The IEEE 802. 15. 4 standard has the ability to use two different communication modes which are the beacon enabled mode and the non beacon enabled mode. The last mode is enabling the unslotted mode of the Collision Avoidance Carrier Sense Multiple Access CSMA/CA. The energy efficiency, the robustness and the flexibility of this standard specially the MAC layer present a good advantages for the standard IEEE 802.15.4 to be chosen in the WSN. Two kinds of nodes are enabled in this technology: Reduced Function Devices (RFDs) and Full Function Devices (FFDs) [13]. The first kind has the ability to act as a PAN coordinator, a router or as an end devise. So it is possible to communicate with an RFD node or an FFD node. Although an FFD node has an only chance which is to behave as an end devise node. The standard of the IEEE 802.15.4 is able to enable three different topologies: mesh, peer-to-peer and and star topology. In the Beacon enabled mode, the CAMA/CA slotted is enabled. So a beacon data is sent every period from the PAN coordiantor to all network members in order to synchronise all of them with the same parameters such as the duty cycle so all nodes are active in the same period. The data frame is composed by three parts which are the beacon data, the Contention Access Pariod CAP part and the Contention Free Period(CFP). In the CFP period the Time Division Multiple Access (TDMA) algorithm is enabled. Although the CAP is engaged by the CSMA/CA unslotted mode [15]. With the unslotted version of the CSMA/CA protocol, the absence of the beacon data causes the absence of the synchronization between all network members. As presented below in figure 1, the unslotted CSMA/CA is not a complicate approach. The first step is dealing with initializing some parameters such as the NB to 0 and the BE to the macMinBE. After that a rondombackoff is generated which would be included in (0 and 2ˆ(BE-1) in order to initialize the timer. The next step consist on exploring the availability of the canal of transmission using the Clear Channel Assessment (CCA) parameter. In the case that it is available the data could sent to its destination but in the the case of its inaccebility the data will be concerved and the state will be updated as mentioned below so the NB = NB+1 and BE = min(BE + 1,macMaxBE) until the backoff value reach the macMaxCSMABackoffs [16]. After that the data will lost. Moreover an othermacanism is enabled by the IEEE 802.15.4 in its non beacon enabled mode which is based on theretransmission mechanism. This mechanism depends specially from the reception of acknowledgment data and the timeouts that is why the reception node must send an acknowledgment message to it message sender. In the case of the absence of the acknowledgment or its reception after the considered time, the data will be considered as not received and it will retransmitted many time until the macMaxFrameRetries will be reached. The number of retransmission attempts is a present a parameter at the MAC layer [17]. Some research paper have already demonstrate that disabling the ACKs leads a bad results on the delay and packet delivery ratio (PDR) such as in [17].

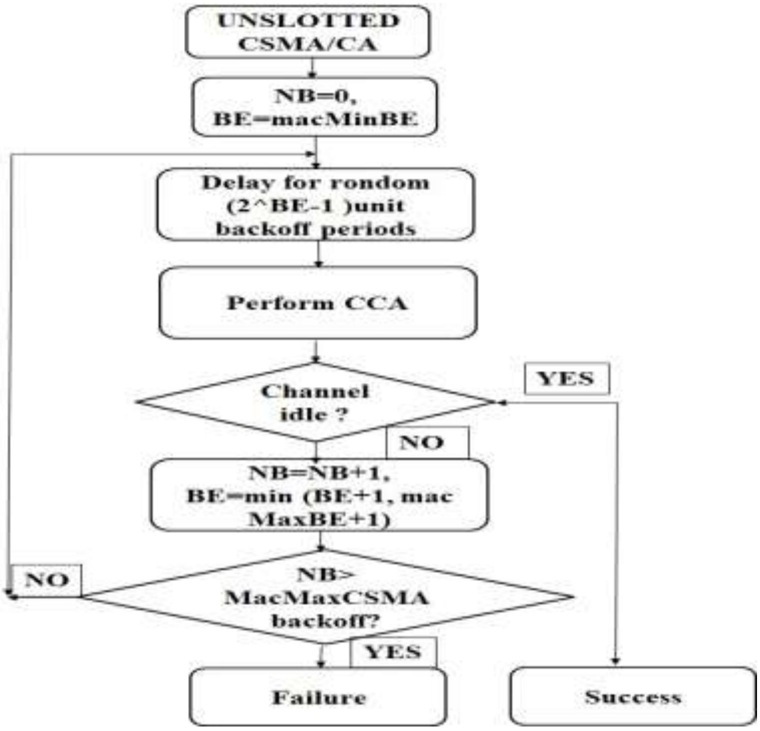

Fig. 1. CSMA/CA unslotted version

The beacon enabled mode of the IEEE 802.15.4 was well studied in many works. It is based on the unslotted CSMA/CA protocol which is described below by figure [?]. So the first step star by initializing all the protocols parameters, specifically, Backoff Exponent (BE) and the Congestion Window (CW) as well as the number of successive backoffs (NB).

The next step consist on setting two successive Clear Channel Assessment CCA in order to discover the transmission canal performance [16]. If the canal is not free, the CCA parameter will be then be reduced 1 the same procedure is repeated until it turns out to be 0. In case that the canal appears to be busy, the NB and BE parameters would be then decreased to 0, and CW set to 2. However, all the other parameters will be then updated, and the node would will try to transmit its pertaining information, as described in figure 2, below..

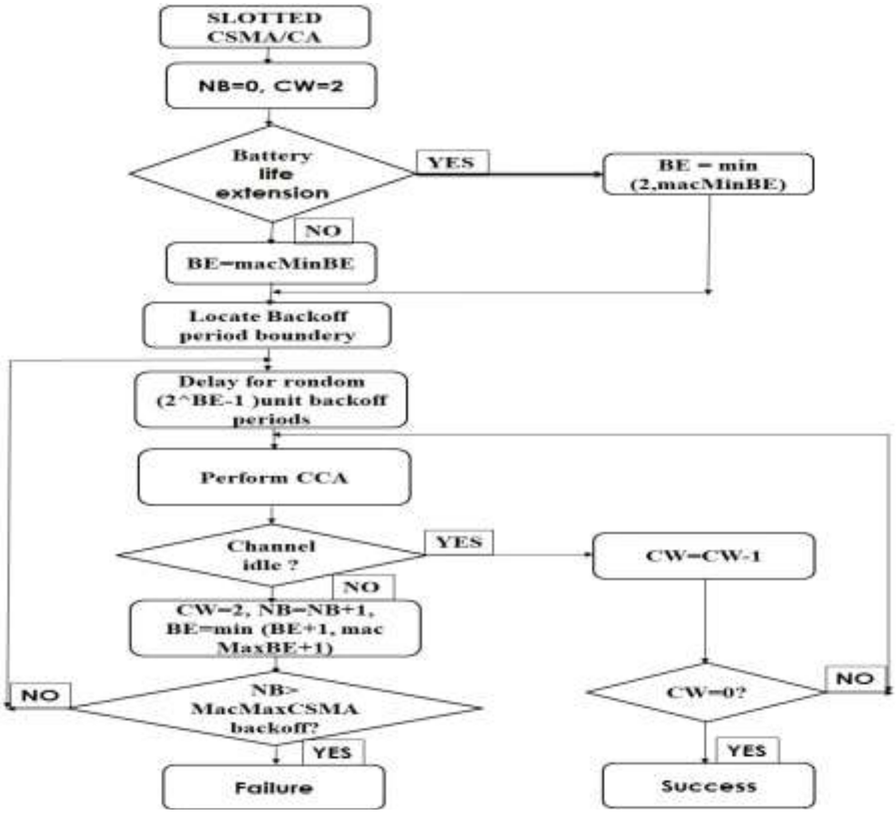

Fig. 2. CSMA/CA unslotted version

II. RELATED WORK

There are many algorithms developed in the literature which interest to resolve the problems of the wsn such as the fault detection [18] and the energy trouble [19], [20], and [21]. Numerous solutions are based on the duty-cycle adjustement such as in [22]. The author choice is base on the value of the energy consumed in bit to make the best decision about the most efficient direction used in order to minimize its consumed energy which contribute to increase its lifetime. Despite, these approaches suffer from divers limits such as its neglect to some parameters like the random access to the transmission canal, the collision of the data as well as the period needed by node to change its state. In addition to that its decision depends from the last level of the energy in the battery.

The authors describe two different approach in [23]. It is about adapting the duty cycle of the node. The first approach deal with a dynamic duty cycle which depends specially from the period of time wasted in waiting the packet. Although the second method depends from the energy consumed. Somecharacteristics are the same for the two algorithm such as the inter-arrival period that the node need to send its data.

The B-MAC is an asynchronous approach [24]. B-MACis interested in the duty cycle (sleep/active period) without mind to the scheduling of this operation. Therefore the node is waking up every period in bit to test the availability of the transmission canal. The B-MAC protocol set 8 periods each one presents one of the 8 listening modes which its time of reception is bigger than the check duration. 8 different preambles are presented.

In [25], the writers define two different duty cycle algorithms named dynamic duty-cycle control (DDCC) and asymmetric additive duty-cycle control (AADCC). The AADCC is dealing with a linear variation (increase or decrease) of the duty-cycle with reference to the number of packets which are really received. If five consecutive packets are successfully received, so the sleep duration will be minimized by 0.1s. Despite in the DDCC the authors try to adapt the energy consumed with the reliability. Then a decision is made and the duty cycle was updated.

The X-MAC presents is an advance version of the BMAC approach [26]. Therefore it is about an asynchronous algorithm. It is special by its less energy consumption and its preamble length. When the node receives its data it send an acknowledge ACK. This approach contributes to minimize the time wasted in transmitting the preamble which is based on the overheard of the canal of transmission. The X-MAC protocol depends from using a short preamble length which lead to take in consideration the simplicity, the low power listening and lead to disjoint the sleep period of the receiver and the transmission.

In [27], the authors are concentrated in the energy problem of the network. So the most suitable duty cycle value present the most critical challenge in bit to develop the lifetime of the network.

III. ENERGY EFFICIENT

Eem defines the emission energy which is the quantity of energy wasted by node in bit to send its information to other nodes of the network. This special procedure is described through the equation (1), presented below.

$$Eem = nbsend*Eb \qquad (1)$$

(Eb) defines the binary energy. Although (nbsend) present the number of bit of all the frames transmit by node. Even in receiving data the node lost some quantity of energy named (Erc) which is presented by equation (2).

$$Erc = nbreceived*Eb \qquad (2)$$

With (nbreceived) defines the number of all bits received by node. The energy consumed in overhearing and overmitting phase, is presented by formula (3).

$$Eo = nbrtr*dtra*Eb* PER \quad (3)$$

nbrtr presents the number of bits transmitted by node. (dtra) defines the size of frame (bit). Although PER is the error rate which is reached as the average of packet transmitted without being well received.
Concerning the energy consumed in collision state (Ecol), it is presented by expression(4).

$$Ecol = Nbrck*Zpck*Eb \qquad (4)$$

(Nbrck) presents the number of collision. Zpck define the size of the packet transmitted in the network.
In the non beacon mode of the IEEE 802.15.4, the csma/ca unslotted algorithm is enabled. Thecoordinator node is considered al time active and ready ti receive any data from the nodes of the networks. Although all other node of the network have two different period which: active and sleep in which the node is not abe to communicate with other network members. This mechanism helps in conserving the energy in the battery of the node. (ESLP) presents the sleep energy, it is described by the expression below (5).

$$ESLP = U * I * PS \qquad (5)$$

U presents the voltage value, I is the current value as well as the PS describes the sleep period. The energy lost in idle state is given by equation (5).

$$Eidle = Db * U * I \qquad (6)$$

Db defines all the duration of backoff state. Our goal is to well manage the quantity of energy available in the battery of nodes in bit to postpone its disparation which contributes to increase the lifetime of all the network.
Therefore, when the lasted energy reach the threshold value, The coordinator intervene quickly by changing the duty cycle of the node which suffers from the energy fault.
The first step consists mainly on computing the energy consumed by the node (Ec) which is presented by formula (7). After that, the energy remaining (ER) will be get as giving by expression (8). The next step is about adapting the duty cycle of nodes.

$$Ec = Eem + Ecol + Eo + ESLP + Erc + Eidle \qquad (7)$$

$$ER = Eini - Ec \quad (8)$$

IV. IMPLEMENTATION AND SIMULATION RESULTS

Our work is implemented through the OMNET++/INETMANET simulator.OMNET++/INETMANET presents many advantages such as it is an open-source network simulator. Moreover, it is well knowen by its graphical tools and its hierarchical models. It presents also a very developed environment which presents all the layer of the nodes. It is an oriented object modular with discrete event network simulation used for both the wired and wireless networks. INETMANET framework is also an open-source model [28].

Table 2 presents the simulation parameters. As described, the first step deals with computing the energy consumed of all nodes of the network. After that the coordinator node make a simple comparaison with a threshold already chosen. In our case the node number 10 presents a fault energy. So the PAN coordinator intervene by reducing the duty cycle from 50 percent to 25 percent in bit to suspend its death. In this state, only the node with energy fault will receive the intervention by changing its duty cycle will be changed. Our simulation parameters are mentioned in table I. Our network is composedby 35 nodes.

TABLE I SIMULATION

Parameters	Values
Simulation time (s)	3h
Coverage area	(600,400)
E initial (J)	18720
Nodesnumber	35

PAN number	1
Channel frequency	2.4 GHz
MAC layer	CSMA/CA
Topology	Tree
dispersion	random

There are all controlled by the coordinator node. The topology enabled by our approach is the tree topology. As known, the coordinator node is always supposed an active node. Beside the other nodes have two different states: active and sleep state which due to the duty cycle which is equal to 50 percent. After reaching the energy's value of 200j, an autoadaptation is initiated. Therefore, the duty cycle of the node which suffers from the energy is updated to 25 percent. All the simulation results are described below for all the state that the node: sleep energy, the reception energy, the overhearing and overmitting energy, the emission energy and the idle energy.

The figures 3, 4 and 5 present that simulation results of the energy of reception mode, sleep mode and emission mode which are decreasing by the same manner.

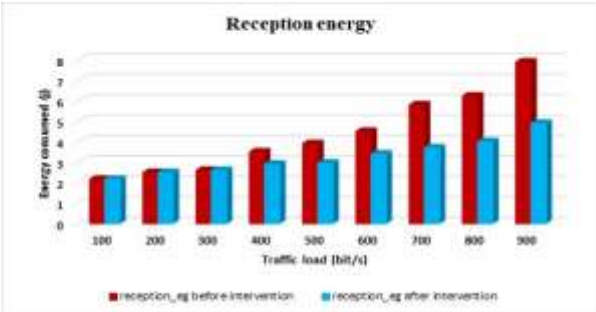

Fig. 3. Reception energy in unslotted CSMA/CA

The collision energy (figure 6) and the energy in idle state (figure 7) as well as the energy of overhearing and overmitting (figure 8) are all decreasing with the decline of the traffic load which define the best proof of theefficiency of our interventionin this moment. The auto-adaptation describe a very interesting solution for the energy problem in wireless communication network.

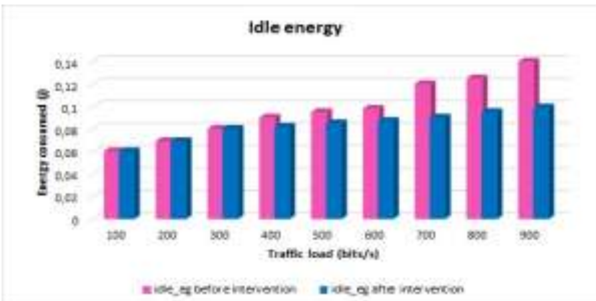

Fig. 4. Idle energy consumed in CSMA/CA unslotted version

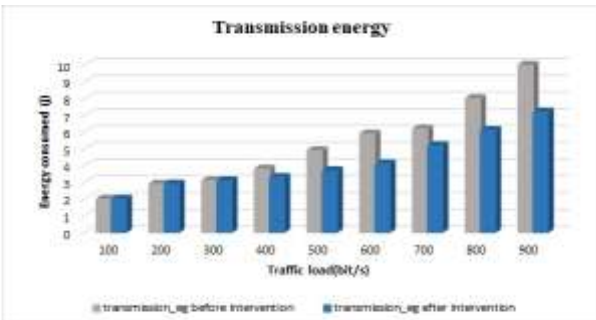

Fig. 5. Emission energy in unslotted CSMA/CAin this moment.

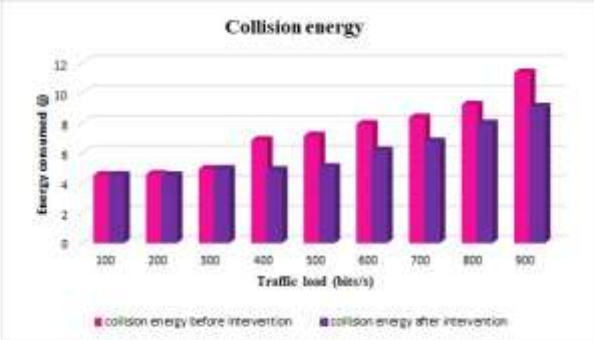

Fig. 6. Collision energy in unslotted CSMA/CA

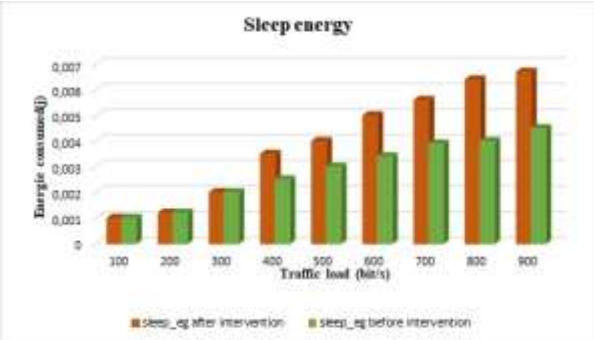

Fig. 7. Sleep energy in unslotted CSMA/CA

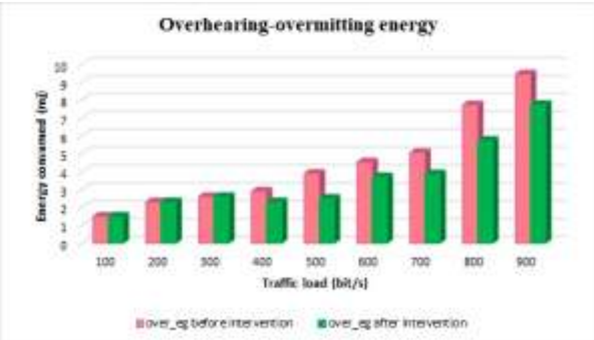

Fig. 8. Overhearing and overmitting energy in unslotted CSMA/CA

V. CONCLUSION

The present work describes the consumed energy in the technology of IEEE 802.15.4 specially the non beacon mode. Our method is based on a mathematical model which presents every case of node which are transmission, reception, idle, sleep, collision, as well as overhearing and overmitting. Our major goal consists on detecting the node with energy fault when its consumed energy reaches the threshold set. Afterthat the duty cycle of this node is changed in order to protect its last quantity of power in its battery. Our main success is our ability to change just the duty cycle of the node with energyfault without affecting the duty cycle of the other node of the network which lead to use two different duty cycle in the same network. The simulation results proves the efficiency of our methods which contributes to reduce the energy consumed of the node after the intervention of its PAN coordinator. As perspective an experimental validation will be a good challenge to discover.

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REFERENCES

[1]. Minaie, A., Sanati-Mehrizy, A., Sanati-Mehrizy, P., &Sanati-Mehrizy, R. (2013). Application of wireless sensor networks in health care system. 23(1).

[2]. Chen, Y., Shen, W., Huo, H., & Xu, Y. (2010, July). A smart gateway for health care system using wireless sensor network. Fourth International Conference on Sensor Technologies and Applications (SENSORCOMM),(pp. 545-550). IEEE.

[3]. Liu, X., Cao, J., Lai, S., Yang, C., Wu, H., & Xu, Y. L. (2011, April). Energy efficient clustering for WSN-based structural health monitoring. In INFOCOM, 2011 Proceedings IEEE (pp. 2768-2776). IEEE.

[4]. Silva, F. A. (2014). Industrial Wireless Sensor Networks: Applications, Protocols, and Standards [Book News]. IEEE Industrial Electronics Magazine, 8(4), 67-68.

[5]. Lin, S., Liu, J., & Fang, Y. (2007, August). ZigBee based wireless sensor networks and its applications in industrial. In Automation and Logistics, 2007 IEEE International Conference on (pp. 1979-1983). IEEE.

[6]. Gungor, V. C., & Hancke, G. P. (2009). Industrial wireless sensor networks: Challenges, design principles, and technical approaches. IEEE Transactions on industrial electronics, 56(10), 4258-4265.

[7]. Chi, Q., Yan, H., Zhang, C., Pang, Z., & Da Xu, L. (2014). A reconfigurable smart sensor interface for industrial WSN in IoT environment. IEEE transactions on industrial informatics, 10(2), 1417-1425.

[8]. urii, M. P., Tafa, Z., Dimi, G., &Milutinovi, V. (2012, June). A survey of military applications of wireless sensor networks. Mediterranean Conference on Embedded Computing (MECO), (pp. 196-199). IEEE.

[9]. Winkler, M., Street, M., Tuchs, K. D., & Wrona, K. (2012). Wireless sensor networks for military purposes. In Autonomous Sensor Networks (pp. 365-394). Springer Berlin Heidelberg.

[10]. Kassim, M. R. M., & Harun, A. N. (2016, October). Applications of WSN in agricultural environment monitoring systems. 2016 International Conference on Information and Communication Technology Convergence (ICTC), (pp. 344-349). IEEE

[11]. Yoo, S. E., Kim, J. E., Kim, T., Ahn, S., Sung, J., & Kim, D. (2007, June). A 2 S: automated agriculture system based on WSN. In Consumer Electronics, 2007. ISCE 2007. IEEE International Symposium on (pp. 1-5). IEEE.

[12]. Awati, J. S., Patil, V. S., &Awati, S. B. (2012). Application of Wireless Sensor Networks for Agriculture Parameters. International Journal of Agriculture Sciences, 4(3), 213.

[13]. De Guglielmo, D., Restuccia, F., Anastasi, G., Conti, M., & Das, S. K. (2016). Accurate and efficient modeling of 802.15. 4 unslotted CSMA/CA through event chains computation. IEEE Transactions on Mobile Computing, 15(12), 2954-2968.

[14]. C. Buratti, R. Verdone, Performance Analysis of IEEE 802.15.4 Non Beacon-Enabled Mode, IEEE Transactions on Vehicular Technology, Vol. 58, No.7, pp. 3480-3493, 2009.

[15]. Gutierrez, J. A., Callaway, E. H., & Barrett, R. L. Low-rate wireless personal area networks: enabling wireless sensors with IEEE 802.15. 4. IEEE Standards Association, 2006.

[16]. M. Gribaudo, D. Manini, A. Nordio, C.F. Chiasserini, Transient Analysis of IEEE 802.15.4 Sensor Networks, IEEE Transactions on Wireless Communications, Vol. 10, No. 4, 2011.

[17]. Govindan, K., Azad, A. P., Bynam, K., Patil, S., & Kim, T. (2015, January). Modeling and analysis of non beacon mode for low-rate WPAN. In Consumer Communications and Networking Conference (CCNC), 2015 12th Annual IEEE (pp. 549-555). IEEE.

[18]. Ayadi, H., Zouinkhi, A., Boussaid, B., &Abdelkrim, M. N. (2015, December). A machine learning methods: Outlier detection in wsn. 2015 16th International Conference on Sciences and Techniques of Automatic Control and Computer Engineering (STA), (pp. 722-727). IEEE.

[19]. Ayadi, H., Zouinkhi, A., Val, T., Boussaid, B., &Abdelkrim, M. N. (2017). Multi operating mode for energy adaptability in Wireless Sensor Network. 25th Mediterranean Conference on in Control and Automation (MED), 3-6 July, Valletta, Malta, pp. 974-979.

[20]. Hayfa Ayadi, Ahmed Zouinkhi, BoumedyenBoussaid, M NaceurAbdelkrim, Thierry Val, Energy efficiency in WSN: IEEE 802.15. 4, 17th International Conference on Sciences and Techniques of Automatic Control and Computer Engineering (STA), 2016.

[21]. Ayadi, H., Zouinkhi, A., Boussaid, B., Abdelkrim, M. N., Val, T., &Khssibi, S. (2017, February). An effective approach for energy aware in wireless sensor network. 2017 International Conference In Smart, Monitored and Controlled Cities (SM2C), pp. 128-133.

[22]. Hua, C., & Yum, T. S. P. Asynchronous random sleeping for sensor networks. ACM Transactions on Sensor Networks (TOSN), 3(3), 15, 2007.

[23]. Ning, X., & Cassandras, C. G. Dynamic sleep time control in wireless sensor networks. ACM Transactions on Sensor Networks (TOSN), 6(3), 21, 2010.

[24]. Polastre, J., Hill, J., & Culler, D, Versatile low power media access for wireless sensor networks. In Proceedings of the 2nd international conference on Embedded networked sensor systems, 95-107, 2004.

[25]. Merlin, C. J., &Heinzelman, W. B. Duty cycle control for low-powerlistening MAC protocols. IEEE Transactions on Mobile Computing, 9(11), 1508-1521, 2010.

[26]. Buettner, M., Yee, G. V., Anderson, E., & Han, R. X-MAC: a short preamble MAC protocol for duty-cycled wireless sensor networks. In Proceedings of the 4th international conference on Embedded networked sensor systems, 307-320, 2006.

[27]. Cohen, R., &Kapchits, B. An optimal wake-up scheduling algorithm for minimizing energy consumption while limiting maximum delay in a mesh sensor network. IEEE/ACM Transactions on Networking (TON), 17(2), 570-581, 2009.

[28]. Varga, A. (2010). OMNeT++. Modeling and Tools for Network Simulation, 35-59.

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