ISSN: 2278 – 909X
International Journal of Advanced Research in Electronics and Communication Engineering (IJARECE)
Volume 5, Issue 6, June 2016

Analysis of how average energy consumption of nodes in ZigBee technology very with Beacon Order With different Superframe Order.

Ganesh V. Awati, Ram Sharma, Vinay Sangolli

***Abstract*— In this paper we analyze the average energy consumption of nodes in ZigBee technology with variation of Beacon Order with Different Superframe Order. Superframe order value and beacon order value on IEEE 802.15.4 protocol determines the number of data packets that can be transmitted in each Superframe and also the length of the inactive period in each Superframe. This study uses NS2 simulation to analyze the average energy consumption of nodes in star wireless sensor network with seven nodes. The analysis result shows that on increasing the Beacon Order, average energy consumption of nodes decreases and on increasing the Superframe Order, average energy consumption of nodes increases.**

***Index Terms*— Superframe order, Beacon order, NS2, Beacon-enabled IEEE 802.15.4**

I. INTRODUCTION

The IEEE 802.15.4 standard [1] is originally designed for low rate wireless personal area networks. Its application in the fields of wireless sensor networks expand and diversify to include several application features. In fact, IEEE 802.15.4 defines the characteristics of the physical and data link layers for Low Rate Wireless Personal Area Network (LR-WPAN). The standard allows the interconnection of wireless devices with low autonomy (battery powered) and does not require high bit rate. Two different device types can participate in IEEE 802.15.4 networks: full-function device (FFD) and reduced-function device (RFD). A personal area network (PAN) coordinator can be operated as FFD. Communication is established between the central PAN coordinator and the neighbor nodes with the help of a router [9]. IEEE 802.15.4 network can operate in beacon-enabled mode or non-beacon enabled [2] mode.

In beacon-enabled mode, Superframe is use for transmission of data packets on IEEE 802.15.4 standard [11]. Superframe is period of time between two consecutive beacons. Beacon is a sign being sent from a wireless node to another wireless node that is within its radio transmission range. Use of beacon signal is to synchronize the device, identify the Personal Area Network (PAN) and describe the Superframe structure. Superframe is divided into active period and inactive period. In inactive period node does not do anything. In active period it performs the process of connecting with other nodes and data transmission. The width of the active period depends on the Superframe order. The greater the Superframe order on the same beacon interval it will increase the width of the active period and vice versa. The effect of the value of Beacon order and Superframe order on the average energy consumption of nodes in star network will be examined in this study using NS2 simulator.

II. THE SUPERFRAME STRUCTURE

The structure of Superframe is determined by the PAN coordinator [8]. The coordinator can also switch off the use of a Superframe by not transmitting the beacons. The Superframe duration is divided into 16 concurrent slots. The beacon is transmitted in the first slot. The remaining part of the Superframe duration can be described by the terms, CAP, CFP and Inactive. The Superframe is used to provide vital statistics like synchronization, identifying the PAN and the Superframe structure, to the devices connected in a Wireless PAN. This information is critical for the operation of the PAN in a Beacon enabled network [5-6] [12].

Contention Access Period (CAP) is the time duration in symbols during which the devices can compete with each other to access the channel using CSMA-CA [13] and transmit the data. Contention Free Period/Guaranteed Time Slots (GTS) is the time duration for which certain low-latency application devices are given exclusive rights over the channel and the devices can directly start transmitting the data.

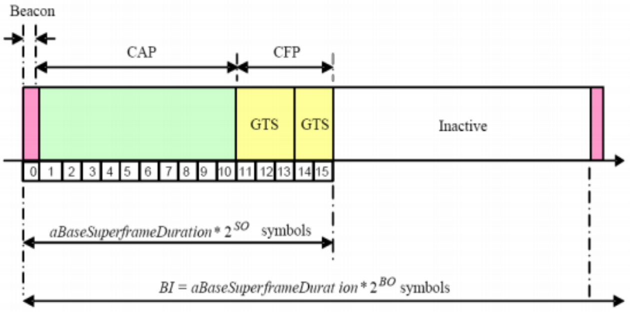

Fig 1. Superframe structure

There can as many as 7 slots assigned for GTS transmissions. These transmissions start immediately after the contention

Manuscript received June,2016.
1.***Ganesh V Awati,*** *Department of Electronics and communication, Jain College of Engineering,Belagavi,India,7204366529.*
2.***Ram Sharma****, Department of Electronics and Communication, Jain College of Engineering ,Belagavi,India,7397863993.*
3.***Vinay Sangolli****, Department of Electronics and Communication, Jain College of Engineering ,Belagavi,India,8904316912.*

access period. Inactive Period is the time period during which the coordinator goes to a power save mode and it would not interact with the PAN. Therefore, during this time, there will be no beacon transmissions. This implies that the devices also go to sleep mode for this duration. Superframe Duration is the total time duration of the CAP, CFP (GTS) and a Beacon. The Superframe duration doesn't include the inactive period [1] [4].

Synchronization is key for better throughput in the network. Every device in the network when ready to transmit data should compete for the channel. But to compete for the channel, they should know when the contention access periods start. And this is what the Superframe structure or truly, the beacon transmission does. This information is embedded into the beacon, and the device receiving the beacon can extract this information and get ready to compete for the channel. Similarly is the case when a device wants to exclusively transmit in the GTS mode. It is the coordinator that would assign a device access to the GTS.

The structure of the Superframe is determined by two parameters [5]. The Superframe Order (SO) and the Beacon Order (BO). The Superframe order is the variable which is used to determine the length of the Superframe duration. Similarly the Beacon Interval is determined by the variable BO.

$$1 \leq SO \leq 15$$
$$1 \leq BO \leq 15$$

For BO=15 shall indicate that there are no beacon transmissions [1]. Also for SO = BO, the beacon interval is same as the Superframe duration indicating there is no inactive portion. Similarly, when BO is greater than SO, indicates there is an inactive portion present in the Superframe.The beacon interval and the Superframe duration given by following formulae. BO and SO are also use to define Duty cycle [7].

$$BI = aBaseSuperFrameDuration \times 2^{BO}$$
$$SD = aBaseSuperframeDuration \times 2^{SO}$$
$$\text{Duty cycle} = 2^{SO-BO}$$

Inactive part of Superframe =

$$aBaseSuperFrameDuration \times (2^{BO} - 2^{SO})$$

III. SIMULATION SETUP

Many researchers analyzed IEEE 802.15.4 using different simulator. In this paper IEEE 802.15.4 is analyzed using NS2 in which we configure a star topology which consist of seven nodes including coordinator in ZigBee network as shown.

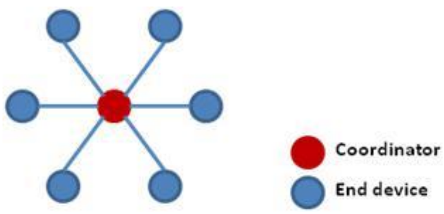

Fig 2 Star topology

There is one PAN coordinator and remaining FFDs are appointed as coordinator. The devices are deployed in a way such that there are no hidden devices in the network. There are six nodes and a PAN coordinator in the network. Transmission is point to point. The parameters which varied are BO and SO. The simulation setup description is shown in Table1.

TABLE 1

Parameter	Value
Network topology	Star
Number of nodes	7
Distance between nodes and coordinator	15m
Beacon order(BO)	6- 10(Beacon enabled)
Superframe order(SO)	0-2 (Beacon enabled)
Initial energy	1 joule
Transmit power	0.3 watt
Receive power	0.3 watt
Simulation time	100 second

IV. RESULTS AND DISCUSSION

At the beginning of the simulation the node has initial energy. Energy is consumed when the node receives or transmits a packet. When the energy level at the node goes down to zero, no more packets can be received or transmitted by the node. We have set the parameters of the star topology as show in the above table. We have fixed the initial energy as 1 joule and we got the final energy of nodes after the simulation through trace file. The energy consumption of each node can be calculated after subtracting the initial energy from the final energy and the average energy consumption of each node is calculated.

We have repeated the process by varying Beacon order with different Superframe order. With the calculated values we got the following result.

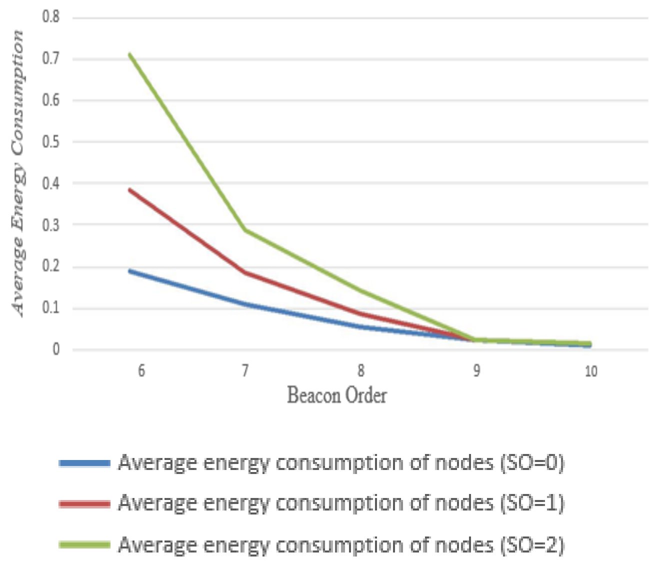

Fig 3 Average Energy Consumption against BO

The above figure show that on increasing the Beacon order, average energy consumption of nodes decreases and on increasing the Superframe order, average energy consumption of nodes increases.

V. CONCLUSION

This paper presents the average energy consumption of nodes in ZigBee network. We found that as the Superframe order increases average energy consumption of nodes increases as higher the SO, longer the active period which results contention for the channel. A device trying to transmit data senses the channel repeatedly and waits for a significant amount of time. This delay increases the average energy consumption of nodes, when Superframe order is high.

VI. REFERENCE

[1] IEEE Std 802.15.4™-2006, (Revision of IEEE Std 802.15.4- 2003), part 15.4: Wireless medium access control (MAC) and physical layer (PHY) specifications for low-rate wireless personal area networks (WPANs), IEEE 3 Park Avenue New York, NY 10016-5997, USA 8 September 2006

[2] C. Buratti and R. Verdone, "A mathematical model for performance analysis of IEEE 802.15.4 non-beacon enabled mode," in *Proceedings of the 14th EuropeanWireless Conference (EW '08)*, pp. 1–7, June 2008.

[3] D. Rohm, M. Goyal, H. Hosseini, A. Divjak, and Y. Bashir, "A simulation based analysis of the impact of IEEE 802.15.4MAC parameters on the performance under different traffic loads," *Mobile Information Systems*, vol. 5, no. 1, pp. 81–99, 2009.

[4] N. Salles, N. Krommenacker, and V. Lecuire, "Performance study of IEEE 802.15.4 for industrial maintenance applications," in *Proceedings of the IEEE International Conference on Industrial Technology (ICIT '08)*, pp. 1–6, Chengdu, China, April 2008.

[5] Gaurav Sharma, Rajeev Paulus, A K Jaiswal, Vaishali Sahu " Impact of BO and SO on Beacon enabled IEEE802.15.4",*International Journal of Computer Application* (0975-8887), volume 66-No.18,March 2013

[6] Jos´e A. Gutierrez, Marco Naeve, Ed Callaway, Monique Bourgeois, Vinay Mitter,Bob Heile, "IEEE 802. 15.4: A developing standard for low-power low-cost wireless personal area networks", IEEE Network, vol. 15, no. 5, September/October 2001 pp. 12-19

[7] F. Xia , A. Vinel, R Gao, L. Wang and T. Qiu, " Evaluating IEEE 802.15.4 for Cyber Physical System," *EURASIP Journal on Wireless Communications and Networking, 2011*

[8] Rudiyanto and Riri Fitri Sari "Analysis of The Effect of Beacon Order and Superframe Order value to the Performance of Multihop Wireless Networks on IEEE 802.15.4",*ICACSIS* 2012

[9] N. Golmie, D. Cypher, and O. Rebala, "Performance Evaluation of Low Rate WPANs for Sensors and Medical Applications", Proceedings of Military Communications Conference (MILCOM 2004), Oct. 31 - Nov. 3, 2004

[10] D. Rohm, M. Goyal, H. Hosseini, A. Divjak, and Y. Bashir, "Configuring beaconless IEEE 802.15.4 networks under different traffic loads," in *Proceedings of the IEEE 23rd International Conference on Advanced Information Networking and Applications (AINA '09)*, pp. 921–928, University of Bradford, Bradford, UK, May 2009.

[11] Jianliang Zheng and Myung J. Lee, "A Comprehensive Performance Study of IEEE 802.15.4", Volume: 4, Publisher: IEEE, Pages: 1-14, ISBN: 0780392833, DOI: 10.1109/ICICS.2005.1689245

[12] C. Buratti, "Performance analysis of IEEE 802.15.4 beacon enabled mode," *IEEE Transactions on Vehicular Technology*, vol. 59, no. 4, pp. 2031–2045, 2010.

[13] C. Y. Jung, H. Y. Hwang, D. K. Sung, and G. U. Hwang, "Enhanced Markov chain model and throughput analysis of the slotted CSMA/CA for IEEE 802.15.4 under unsaturated traffic conditions," *IEEE Transactions on Vehicular Technology*, vol. 58, no. 1, pp. 473–478, 2009.

Ganesh V Awati M.Tech in Communication Engineering from National Institute of Technology Karnataka,Surathkal.

Ram Sharma M.Tech in Communication Engineering from National Institute of Technology Karnataka,Surathkal.

Vinay Sangolli M.Tech in Digital Communication and Networking from Gogate Institute of Technology Belagavi, Karnataka.