ISSN22773061

Performance Analysis of IEEE 802.15.4 Based Wireless Sensor Networks using LAR protocol for CBR and ZIGBEE Traffic Applications

Surender.R and P. Samundiswary*
Department of Electronics Engineering, School of Engineering and Technology,Pondicherry University, Pondicherry, India
ragunathansurender@gmail.com
samundiswary_pdy@yahoo.com*

ABSTRACT

IEEE 802.15.4 standard based wireless sensor networks (WSNs) emerges as the next generation wireless standard for low-rate wireless personal area networks. IEEE 802.15.4 standard offers low power, low data rate and short range networking for wireless battery powered devices. It has also started to demand much attention towards research. The performance of the network can be analysed by using different types of routing protocols. In this paper, the performance analysis of IEEE 802.15.4 based Wireless Sensor Networks is done by using Location Aided Routing (LAR) protocols for the traffic applications such as Constant Bit Rate (CBR) and Zigbee traffic application. The LAR protocol enables the routing of data between the source and destination by using directional flooding technique. The performance metrics such as throughput, delay, jitter and packets dropped of LAR for CBR and Zigbee traffic application is evaluated and analysed. The simulation is modelled by using QualNet.

Keywords

WSN, IEEE 802.15.4, LAR, CBR, ZigBee Application.

Council for Innovative Research
Peer Review Research Publishing System
Journal: INTERNATIONAL JOURNAL OF COMPUTER AND TECHNOLOGY
Vol 10, No. 9
editor@cirworld.com
www.cirworld.com, member.cirworld.com

1. INTRODUCTION

Recently, different applications for Wireless Personal Area Networks(WPANs) have been widely developed for their requirements in terms of data rate, power consumption, and quality of service. IEEE 802.15 working group has defined three classes of WPANs. IEEE 802.15.1 standard (Bluetooth) supports medium data rate networks for cable replacement and consumer devices. High data rate networks for real-time and multimedia applications are supported through IEEE 802.15.3 standard, while the recent standard IEEE 802.15.4 standard is intended to be the key enabler for low complexity, ultra-low power consumption, and low data rate wireless connectivity among inexpensive fixed, portable and moving devices [1]. IEEE802.15.4 based Wireless sensor networks (WSNs) have revolutionized the world of distributed systems and enabled many new applications [2].The successful release of the IEEE 802.15.4 standard has made WSNs to play more and more decisive roles in various aspects such as wide-range environmental surveillance, short-range health monitoring, inventory tracking, military locating etc. The IEEE 802.15.4 standard has evolved to realize the PHYsical (PHY) and Multiple Access Control (MAC) layers of Low Rate Wireless Personal Area Networks (LR-WPANs) [3]. ZigBee standards have been developed to solves interoperability issues from the physical layer to the application layer.

ZigBee supports three kinds of topology namely star, tree, and mesh networks. In star topology , PAN coordinator with end devices communicates directly to each other. ZigBee coordinator and multiple ZigBee routers orginates tree and mesh network. In these topologies, devices communicate with each other in a multihop fashion. In the tree and mesh network the end devices can get communicated by associating with coordinator or router. In a tree network, PAN Coordinator and routers can initialize beacons and assign beacons to all end devices. Beacons enabled network are important for power management which in turn helps in traffic application. Therefore, tree topology is preferred. However, regular beacons are not authorized in a mesh network. IEEE 802.15 WPAN TaskGroup 4 further defines a revision of the IEEE 802.15.4 specification in 2006 [4] to support ZigBee beacon-enabled tree networks.

The work in this paper analyses the performance of IEEE 802.15.4 standard WSN using LAR protocol for CBR and ZigBee traffic application. The rest of this paper is organized as follows. Section 2 gives an overview of IEEE 802.15.4 standard. Section 3 discusses about the LAR protocol and traffic application involved in the paper. Section 4 presents the simulation results. Finally, Section 5 concludes the paper with future scope.

2. OVERVIEW OF IEEE 802.15.4 STANDARDS

The IEEE 802.15.4 standard 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 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 neighbour nodes with the help of router. IEEE 802.15.4 network can operate in beacon-enabled mode or non-beacon enabled mode. A tree topology network considering IEEE 802.15.4 standard can operate in beacon-enabled mode. In beacon-enabled mode, PAN coordinator transmits beacon frame periodically and makes the network consistent for communication [5].

To avoid transmission of all the nodes at the same time, IEEE 802.15.4 standard uses two techniques.The most common is the Carrier Sense Multiple Access-Collision Avoidance (CSMA-CA). Each node listen to the medium prior to transmission. Further, node waits for a random time until the detected energy level is higher than the specific level of the node (including in an interval). The time slot can be calculated by using the parameter named macMinBE. This parameter sets the back-off exponent to be used for retransmission. The second one is Guaranteed Time Slots (GTS). In this scheme,this system uses a centralized node (PAN coordinator) which allocates time slot for each node so that all end devices in the network decide when to communicate with the PAN coordinator or with other end devices. There are 16 possible slots of time. As a first step, a node must send a GTS request message to the PAN coordinator. The co-coordinator will send a beacon message as response containing the time slot allocated and number of slots assigned. One of the functionalities implemented in 802.15.4 is the channel energy scan. This strategy implies the amount of energy (activity/noise/interferences) present in all nodes (or several channels) prior to utilizing it. By using this strategy, it can choose the free channel by saving the energy, before initialising the network for transmission.

3. ROUTING PROTOCOLS AND TRAFFIC APPLICATIONS

Routing protocols of wireless sensor network are classified into two types: reactive and proactive. The protocols which depend on routing tables are called proactive routing protocols. It maintains the routing table for each node in which routing informations are stored and periodically updated as the information in the node changes over time. Proactive protocols are not applicable for large networks, since they need to maintain node entries for every node. This can be detrimental for dense nodal networks, due to increase in energy consumption [6]. Reactive protocols do not maintain routing information for all nodes. When source needs to transmit a data packet to the destination they perform route discovery. To reduce the overhead by maintaining information for active routes only reactive routing protocols are designed.

Figure 1 illustrates the routing in LAR protocol. If A source node S needs to find a route to destination node D, node S must broadcasts a route request to all its neighbors. X receives a route request from the Intermediate node and compares the destination with its own identity. If it does not match, then node X broadcast the request to its neighbors (sequence numbers used to detect duplicate and eliminate/avoid redundant transmissions). Node D responds by route reply messages to sender which traverse the path in reverse of the path received by D (route request packet contains path of all

nodes traversed starting S). If any transmission error or node D is unreachable, timeout scheme is used to re-initiate route request with new sequence number. However, proactive protocols depend on routing table which is constructed with respect to source and also reactive protocol establishes the route based on the demand of source node. Hence control packets overhead is high in the proactive due to the routing tables and and no of route discovery procedure is more reactive routing protocols. But in LAR protocol routing is done with respect to position of destination node to reduce the overhead and route discovery procedure.

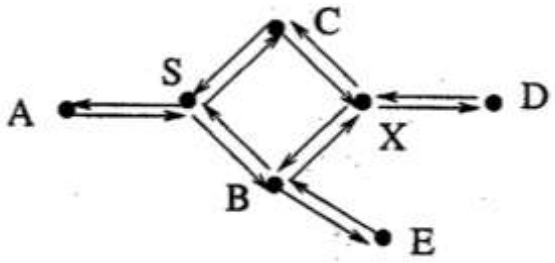

Figure 1 Illustration of Flooding

Two different schemes are proposed in LAR [7]. The first scheme uses a request which defines a boundary where the route request packets can travel to reach the required destination. The second method identifies the coordinates of the destination in the route request packets. These packets can only travels in the direction where the relative distance to the destination becomes smaller as they travel from one hop to another. Both methods limit the control overhead transmitted through the network and hence it conserves the bandwidth. It also determines the shortest path (in most cases) to the destination, since the route request packets travel away from the source and towards the destination. The main disadvantage of this protocol [8] is that each node carries GPS information. And the other disadvantage is that the LAR protocol leads to more congestion for more dynamic type of networks.

IEEE 802.15.4 standards mainly use CBR and ZigBee traffic application. The CBR service is used for connections that transports traffic at a constant bit rate. It has an inherent dependence on time synchronisation between the traffic. CBR is tailored for any type of data for which the end-systems require predictable response time and a static amount of bandwidth is continuously available for the life-time of the connection. The ZigBee Application generates traffic at a constant rate by transmitting packets (also called “items”) of a fixed size at a fixed rate. It is generally used to provide background traffic in a sensor network where devices use the GTS mechanism for data transmission. The ZigBee Application can be used to simulate applications for which the end-systems require predictable response time and static amount of bandwidth is continuously available for life-time connection. It is specially developed in QualNet for ZigBee to analyse the application based on IEEE 8012.15.4 standard.

4. SIMULATION RESULTS

Table 1: Simulation Parameters

Parameters	Values
ZigBee frequency band	2.4GHz
Data rate	240Kbps
Modulation	O-QPSK
Battery model	Simple Linear , 20mAhr
Protocol	Location aided routing protocol
Terrain Area	100x100 m^2
No. of nodes	50
MAC layer	IEEE 802.15.4
Packet size	70 bytes
Traffic Application	CBR and ZigBee
Simulation time	300 sec

Performance metrics like throughput, delay, jitter and packets dropped of IEEE 802.15.4 based wireless sensor networks are compared between CBR and Zigbee application using the LARrouting protocols. Table 1 shows the simulation parameters used in the simulation.

4.1 Throughput of LAR protocol

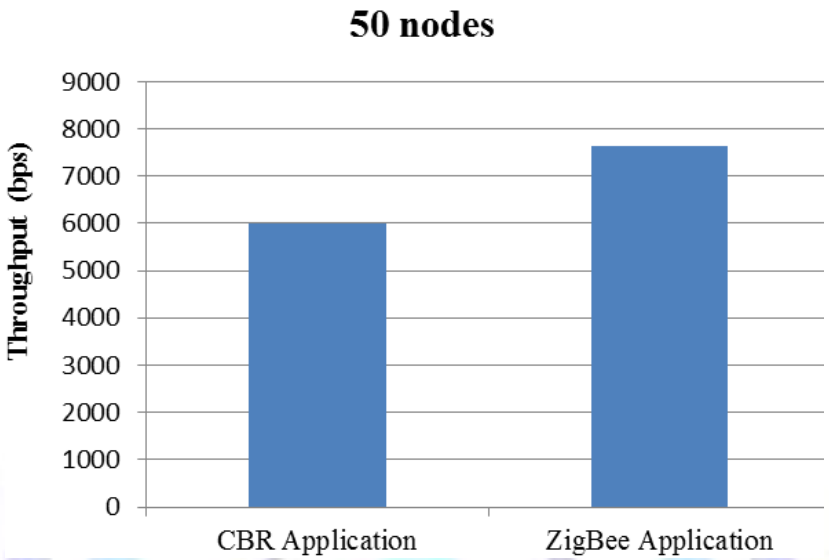

Figure 2 Performance comparison of throughput using traffic application

Figure 2 shows the throughput comparison of the Zigbee networks using location aided routing protocol. Throughput is defined as the average successful rate of message delivery in a network. High throughput is always desirable in a communication system. The throughput of ZigBee application outperforms CBR traffic application due to less packet loss obtained by ZigBee application compared to that of CBR traffic.

4.2 Delay of LAR protocol

Delay refers to the time taken for a packet to be transmitted across a network from source to destination. Figure 3 portrays the performance comparison of delay using traffic application. ZigBee Application uses Guarantee Time Slots for routing in the network and time slot is also fixed. So number of hops required to transmit the packet from source to destination is less which in turn reduces the delay. Hence delay of ZigBee application is lesser than CBR which do not use GTS.

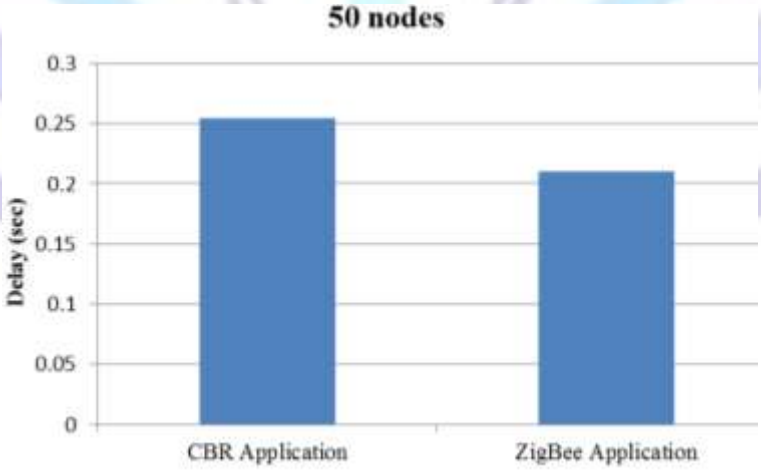

Figure 3 Performance comparison of delay using traffic application

4.3 Jitter of LAR protocol

Figure 4 depicts the performance comparison of Jitter using traffic application.Jitter refers to variation of delay in received packets even if they are transmitted at same time. Jitter in the network may be due to congestion, improper queuing, or configuration errors. Delay and jitter corresponds to each other;if delay increases, jitter also increases and vice versa. But the metric value of jitter will be less than delay. In location aided routing,

zigbee application delay is less than CBR traffic application which in turn corresponds to the lowered jitter level.

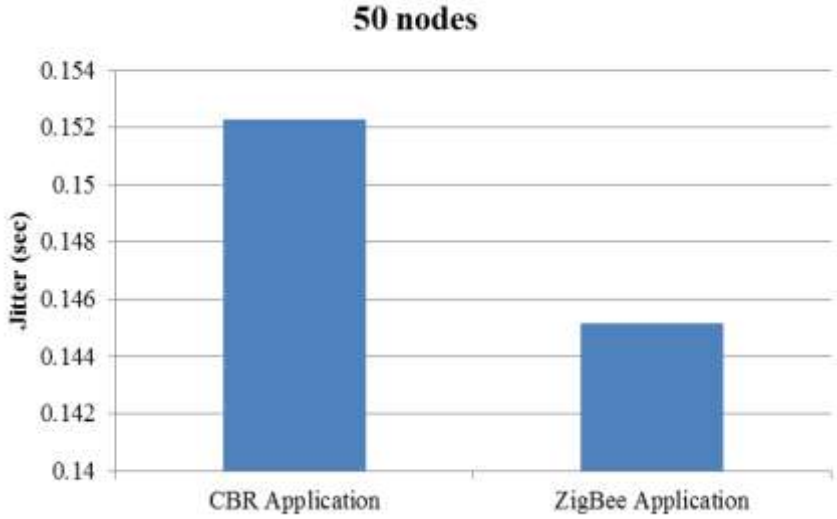

Figure 4 Performance comparison of jitter using traffic application

4.4 Packets dropped in LAR protocol

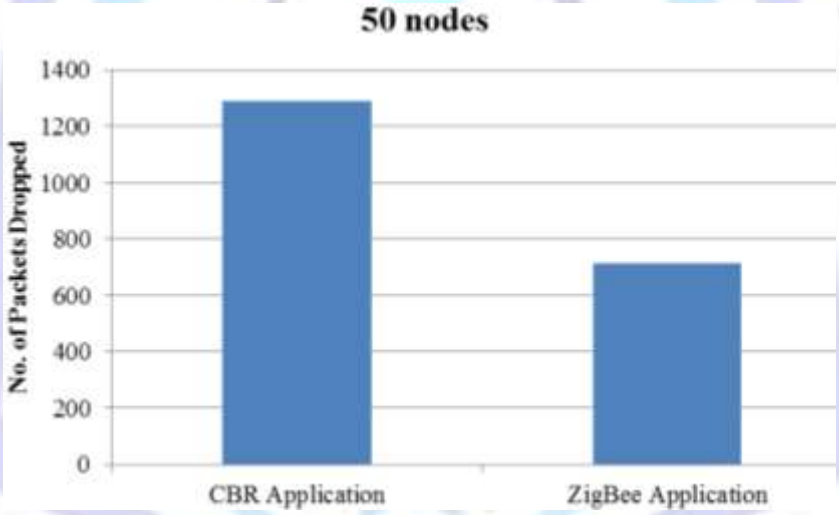

Figure 5 Performance comparison of packets dropped using traffic application

Figure 5 illustrates the packet dropped in the MAC layer for CBR and Zigbee traffic application. In LAR protocol, route discovery is reliable and also each packet makes route discovery with the help of GPS which rduce the packet drop . Further GTS mechanism involved inZigbee application is an added advantage to reduce the packet drop. Hence,the packets dropped of the network using LAR protocol for the ZigBee application is less compared to that of CBR traffic.

5. CONCLUSION AND FUTURE SCOPE

In this paper, performance analysis of IEEE 802.15.4 based wireless sensor networks using LAR protocol for CBR and Zigbee traffic applications has been investigated using QualNet. Then the performance metrics of the network are examined and compared for the above mentioned traffic applications. The simulation results show that ZigBee traffic application outperforms the CBR traffic application in terms of throughput, delay, jitter and packets dropped. Future work is focused on the performance enhancement off IEEE 802.15.4 based wireless sensor networks by considering the mobile scenario , security algorithms and energy efficient algorithms in the network.

REFERENCES

[1] Jelena Misic, ShairminaShafi and Vojislav B. Misic,"The impact of MAC parameters on the performance of 802.15.4 PAN", Ad Hoc Networks,Volume 3, Issue 5, pp. 509–528, September 2009.

[2] JelenaMisic, ShairminaShafiand Vojislav B. Misic, "Performance limitations of the MAC layer in 802.15.4 low rate WPAN", Journal of Computer Communications, Volume 29, Issue 13-14, pp. 2534-2541, August 2006.

[3] 2005Jianping Zhu, Zhengsu Tao andChunfengLv,. "Performance evaluation for a beacon enabled IEEE 802.15.4 scheme with heterogeneous unsaturated conditions", International Journal of Electronics andCommunications, Volume 66, Issue 2, pp.93–106 ,February 2012

[4] Meng-Shiuan Pan, Yu-Chee Tseng, "Quick convergecast in ZigBee beacon-enabled tree-based wireless sensor networks", Computer Communications, Volume 31, Issue 5, pp.999–1011, March 2008.

[5] Taejoon Kim, Young Kim, Won Ryu and Jong-Tae Lim, "Performance Enhancement in IEEE 802.15.4 Wireless Sensor Networks by Link-Quality Based Node Grouping", Proceedings of 15th International Conference on Advanced Communication Technology (ICACT), pp:645 – 648, , January 2013.

[6] Adam Dahlstrom and Ramesh Rajagopalan, " Performance Analysis of Routing Protocols in Zigbee Non- Beacon Enabled WSN" ,Proceedings of IEEE Conference on Consumer Communications and Networking, Las Vegas, Nevada, pp.932-937, January 2013.

[7] Mehran Abolhasan, Tadeusz Wysocki, ErykDutkiewicz, "A review of routing protocols for mobile ad hoc networks" , Ad Hoc Networks, Volume 2, Issue 1, pp.1–22, January 2004.

[8] Y.B. Ko, N.H. Vaidya, Location-aided routing (LAR) in mobile Ad hoc networks, Proceedings of the Fourth Annual ACM/IEEE International Conference on MobileComputing and Networking, , Dallas, Texas , Volume 6, Issue 4, pp. 307-321, July 2000

Biography

R. Surender received his B.Tech Degree from Rajiv Gandhi College of Engineering and Technology affiliated to Pondicherry University, Pondicherry in 2006. He has obtained his M.Tech. Degree from Pondicherry Engineering College affiliated to Pondicherry University, Pondicherry in 2008. He is currently working as Project Fellow in Department of Electronics Engineering of School of Engineering and Technology, Pondicherry University, Pondicherry, India. His areas of interests include Wireless communication, Sensor networks and Computer communication.

P. Samundiswary received the B.Tech. degree (1997), M.Tech. degree (2003) and Ph.D. (2011) in the Department of Electronics and Communication Engineering from Pondicherry Engineering College affiliated to Pondicherry University, India. She has nearly 15 years of teaching experience. She is currently working as Assistant Professor in the Dept. of Electronics Engineering, School of Engineering and Technology, Pondicherry University, Pondicherry, India. Her research interests include Wireless Communication and Wireless Networks