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Comparative performance analysis of IEEE 802.15.4 in WSN using NS2

Abhijit Paul* and Prodipto Das

Department of Computer Science, Assam University, Silchar, India

*Corresponding author: abhijitpaul84@gmail.com

ABSTRACT

Wireless Sensor Networks (WSNs) are type of network which is mainly deployed to those areas where infrastructure network is unavailable and where people cannot reach easily. To those areas sensors are deployed to collect information about the environment. Since sensors are run by battery power, long time use of sensors to those remote areas, is one of the main challenges for WSN. To deal with long time use of battery power, low power consumption technique is used. IEEE 802.15.4 standardization is used for Low Rate Wireless Personal Area Network (LRWPAN). To get a lesser amount of consumption of power, few parameters of IEEE 802.15.4 are changed in our proposed strategy. At last comparison of proposed strategy and IEEE 802.15.4 is made where proposed strategy performs well for low power consumption.

Keywords: WSN, IEEE 802.15.4, Battery Power and NS2

A WSN is a wireless network consisting of spatially distributed devices with sensors to cooperatively monitor physical or environmental conditions such as temperature, sound, movement of the object etc. at different locations [1] [2]. WSNs consist of hundreds to thousands of low-power multi functioning sensor nodes, operating mostly in an unattended environment with limited computational and sensing capabilities [3]. Each node in WSN is typically equipped with a radio transceiver, a small microcontroller and an energy source, usually a battery. These inexpensive and power-efficient sensor nodes works together to form a network for monitoring the target region. WSN through the co-operation of sensor nodes, collect information about the monitoring environment and then forward these messages to the base station [4] for further processing. After processing the message is sent to the user. The development of WSNs was originally motivated by military applications such as battlefield surveillance, but after that through the advancement of different technologies WSNs are now widely applicable to different new areas such as environmental monitoring, object tracking etc. [5] [6] [7].

The energy source in sensor node is battery which has limited lifetime. Sensor nodes once deployed cannot be maintained since WSNs mainly are deployed in unattended areas. Therefore recharge of battery is not possible for such applications. Considering the issue of long battery life, a lower delay based energy efficient WSN protocol is implemented [8] [9]. For that purpose IEEE 15.4 and Zigbee standardization is used to get energy efficient communications. Other standards such as Wireless LAN, Bluetooth are not used because it can not satisfy the requirement for WSN application. IEEE 802.15.4 is emerging technologies for WSN. The IEEE 802.15.4 standard was specifically developed to meet the demand of low power, low-bit rate connectivity to the smaller devices so that it can increase the lifetime of battery [10].

OVERVIEW OF IEEE 802.15.4

The ZigBee Alliance and the IEEE 802.15.4 committee specify the entire protocol stack and the commercial name of this technology is specified as ZigBee [11]. ZigBee is a standard for reliable, cost-effective, low-power wireless networking. ZigBee provides low cost and low power connectivity for equipment that needs long battery life from several months to several years but does not provide high data transfer rates like other technologies such as Bluetooth. ZigBee specify upper layers of the protocol stack: application, transport and network layer. IEEE 802.15.4 specifies lower two layers of the protocol: MAC layer and Physical (PHY) layer. The IEEE 802.15 working group defined three classes of Wireless Personal Area Network (WPAN) standards: IEEE 802.15.1, IEEE 802.15.3 and IEEE 802.15.4 differentiated by data rate, battery drain and quality of service (QoS). IEEE 802.15.1 known as Bluetooth defines PHY and MAC for medium rate data transfer and it has QoS suitable for voice communications. IEEE 802.15.3 defines PHY and MAC which is suitable for multimedia data transfer with high data rate data and high QoS. IEEE 802.15.4 known as LR-WPAN defines PHY and MAC for low power consumption and low cost with relatively slow data rate and low QoS. The low data rate enables the LR-WPAN to consume low power.

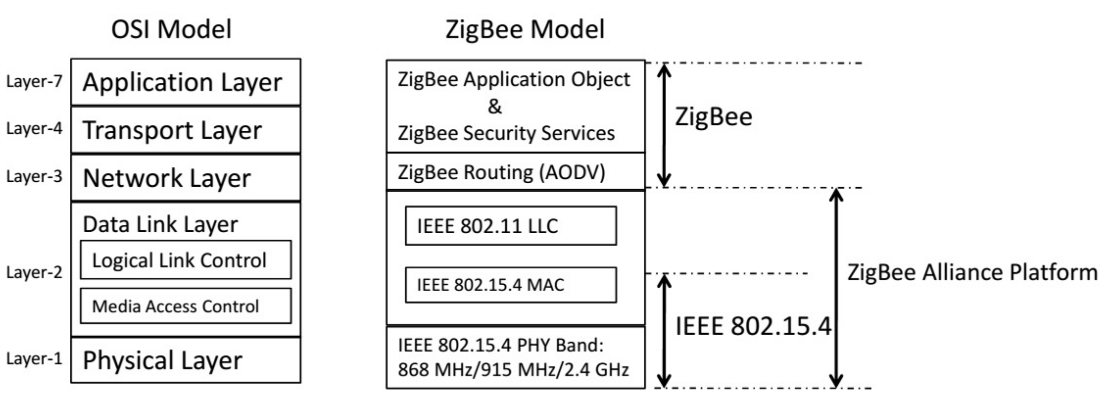


Figure1. Comparison of OSI Model and ZigBee Model

ZigBee application object is basically a device profile which is used to add extra functionality of the devices. When a device is started, all the endpoints registers with the application object and provide descriptions of device profile and their capabilities. ZigBee security service provides specification for key establishment, key transport, frame protection and device authorization. It uses Advanced Encryption Standard (AES) with a 128 bit key length. The AES algorithm is not only used to encrypt the information but to validate the data which is sent. AES algorithm use symmetric key which is shared by both originator and recipient of a protected transaction. Key is acquired through pre-installation, agreement or transport. IEEE 802.11 logical link control (LLC) uses the same IEEE 802.2 LLC and 48-bit addressing as other 802 LANs. IEEE 802.2 LLC provides three types of services: connectionless service without an acknowledgement of delivery, connectionless service with an acknowledgement of delivery and connection oriented service with an acknowledgement of delivery. IEEE 802.15.4 MAC uses CSMA/CA based protocol which listens to the channel before transmitting to reduce the probability of collisions with other ongoing transmissions. IEEE 802.15.4 MAC defines two different operational modes: beacon-enabled and the non beacon-enabled. In the non beacon-enabled mode, each node delays any activities for a random number of back-off periods. After this delay, if the channel is free the node immediately starts the transmission; but if the channel is busy the node enters again in the back-off state. In the beacon-enabled mode, the access to the channel is managed through a superframe, starting with a packet, called beacon, transmitted by WPAN coordinator. The superframe contains active and inactive part. Inactive part allows nodes to go in sleep mode and the active part is divided into two parts: the Contention Access Period (CAP) and the Contention Free Period (CFP), composed of Guaranteed Time Slots (GTSs), allocated to specific nodes. The use of GTSs is optional.

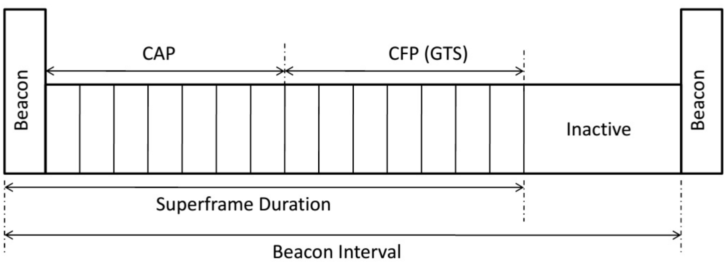


Figure 2. IEEE 802.15.4 MAC Superframe structure

IEEE 802.15.4 PHY is designed to operate in unlicensed radio frequency bands. The unlicensed RF bands are not the same in all territories of the world. The three bands are centered on the following frequencies: 868, 915 and 2400 MHz.

POWER CONSUMPTION IN WSN

Power consumption in WSN takes place due to main three reasons. These are power consumption in communication, power consumption in data processing and power consumption in sensing.

Power consumption in data processing

A sensor node in WSN spends maximum energy in data communication both for transmission and reception. To achieve minimum energy in data communication, short range communication with low radiating power is used. Modern low power short range transceivers consume power between 15 to 300 mW when sending and receiving data. Also to maintain minimum energy in data communication, short data packets are used for communication. When data packet size is reduced, start-up power can be controlled.

$$P_c = P_{te} + P_{re} + P_o \tag{1}$$

Where P_c is the power consumption for data communication. $P_{(te/re)}$ is the power consumed in the transmitter or receiver electronics including the start-up power. P_o is the output transmit power.

Power consumption in data processing

Power consumption in data processing is much less than the power consumption in data communication. To reduce power consumption in data processing small size data packet is considered. Since local data processing is crucial in minimizing power consumption in a multi-hop network, data processing takes place at local level i.e. at sensor node. Since the sensor nodes are smaller in sizes and limited to simpler calculation, only simple calculations of data takes place which minimize power consumption.

Power consumption in sensing

Power consumption in sensing depends on the type of application, nature of sensing, detection complexity and noise levels. For application, energy consumption depends on area coverage, smoothness of the area, clarity of the area etc. [12]. For nature of sensing, it depends on whether sensing will takes place randomly or constantly. For random sensing power requirement is less compare to constant sensing. But in case of random sensing complexity increases.

NETWORK SIMULATOR-2 (NS-2)

NS-2 is an open source object oriented discrete event network simulator developed at Lawrence Berkeley Laboratory at the University of California, Berkeley. NS-2 is a virtual inter-network testbed used for simulating routing algorithms, multicast and TCP/IP protocols. NS-2 later extended with support for node mobility. NS-2 support different protocols for wired networks, wireless networks, wireless mobile networks, wireless ad-hoc networks, WSNs etc. NS-2 supported protocols are: FTP, TELNET, CBR, HTTP for application layer; UDP, TCP, SCTP for transport layer; DSR, DSDV, AODV [13] for network layer.

PROPOSED STRATEGY

Communication in WSN is another challenge. In the absence of infrastructure network, communication is made possible by implementing base station with the wireless nodes. Base station works as a bridge between the wired and wireless network. To get communication for long time, the wireless nodes should live for long time. By implementing low power consumption policy, the wireless nodes are kept available for communication. To implement low power consumption policy, IEEE 802.15.4 standardization is used. This strategy implements power shutdown to nodes. In our proposed strategy, a new strategy has been established which states that the idle or inactive nodes shutdown its power. Therefore only the active nodes will participate in communication process.

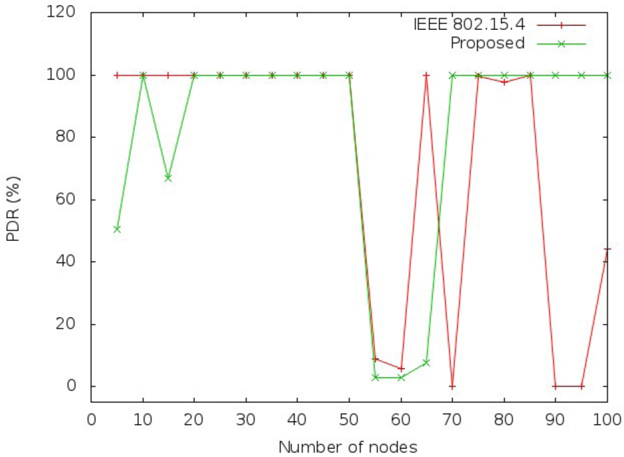
PERFORMANCE COMPARISON OF PROPOSED STRATEGY WITH IEEE 802.15.4

Performance of proposed strategy in terms of packet delivery ratio (PDR), average end to end delay, throughput, routing overhead and average energy consumption is compared with IEEE 802.15.4. Among different network performance, energy consumption has given atmost priority as energy efficient design of WSN is the primary objective [14].

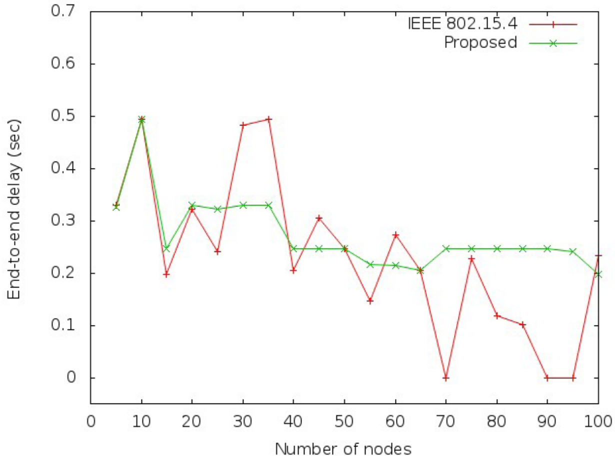
$$\text{PDR} = \frac{\text{Total number of data packet received}}{\text{Total number of data packet sent}} \times 100\% \quad (2)$$

$$\text{Average end to end delay} = \frac{\text{Receive time} - \text{Send time}}{\text{Total number of data packet sent}} \text{ (in sec)} \quad (3)$$

$$\text{Average energy consumption} = \frac{\text{Total energy consumption}}{\text{Number of nodes} \times \text{Initial energy}} \text{ (in joule)} \quad (4)$$



(a)



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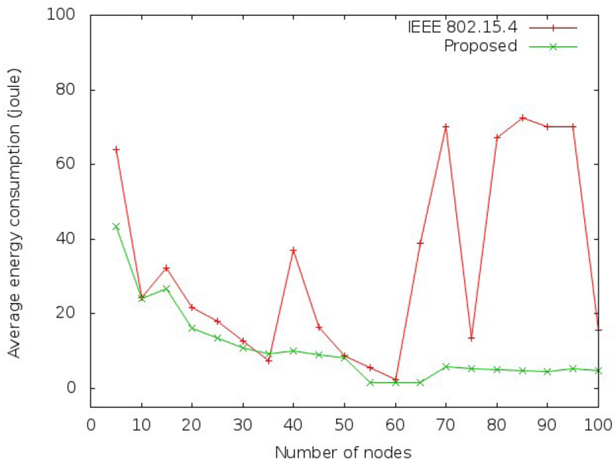

(c)

Figure3. (a-c) Comparison of IEEE 802.15.4 with proposed strategy for PDR, end-to-end delay and average energy consumption

Comparison of IEEE ZigBee standard with proposed strategy by considering mobility of three nodes: node-0, node-2 and node-3 takes place. Simulation result shows that our proposed strategy reduces 39.18% average energy consumption compare to IEEE 802.15.4 standard (shown in figure-3). For PDR, proposed strategy increases it by 4.35%. For end-to-end delay there is 6.88% reduction using proposed strategy. PDR, End-to-end delay and average energy consumption is measured and compared for both of the proposed strategies and IEEE 802.15.4.

EXPERIMENTAL SETUP

In order to conduct comparison studies with IEEE 802.15.4, we select AODV [15] as routing algorithms. The goal of our simulation experiments is to assess the impact of different aspects of realistic mobility scenarios on the ability of the WSN routing protocols to successfully deliver data packets. Simulations were conducted using NS2. We adopt a simulation environment where out of 25 mobile nodes 3 nodes are movable about in an area of 500m x 500m. Each node in the simulation has a radio transmission range of 150m. We report packet delivery ratios for pause times of 0, 10, 20, 30, 40, 50, 60, 70, 80, 90, 100 seconds. The data traffic characteristics are based on constant bit rate (CBR).

CONCLUSION

The overall goal of this paper is to measure the simulations of WSN using IEEE 802.15.4 technology. Using these measurements we calibrate the NS-2 simulator in order to be able to produce more real simulation environment and evaluate the IEEE 802.15.4 MAC in a reliable way. Proposed strategy has been implemented by modifying few parameters in IEEE 802.15.4 and compared with it. Our results clearly show that the simulated PDR, end to end delay and energy consumption is better for proposed strategy compare to IEEE 802.15.4.

REFERENCES

[1] Akyildiz, I. F., Su, W., Sankarasubramaniam, Y., and Cayirci, E. 2002. A Survey on Sensor Networks. *IEEE Communications Magazine* **40**(8): 102-114.

[2] Yick, J., Mukherjee, B. and Ghosal, D. 2008. Wireless sensor network survey. *Computer Networks* **52**: 2292-2330.

[3] Akkaya, K. and Younis M. 2005. A survey on routing protocols for wireless sensor networks. *Ad Hoc Networks* **3**: 325-349.

[4] Han, J. K., Park, B. S., Choi, Y. S., and Park, H. K. 2001. Genetic approach with a new representation for base station placement in mobile communications. *Vehicular Technology Conference.* **4**: 2703-2707. Atlantic City, NJ: IEEE.

[5] Hughes, D., Ueyama, J., Mendiondo, E., Matthys, N., Horre, W., Michiels, S., et al. 2011. A middleware platform to support river monitoring using wireless sensor networks. *Journal of the Brazilian Computer Society* **17**(2): 85-102.

[6] Hwang, J., Shin, C., and Yoe, H. 2010. Study on an Agricultural Environment Monitoring Server System using Wireless Sensor Networks. *Sensors* **10***:* 11189-11211.

[7] Ingelrest, F., Barrenetxea, G., Schaefer, G., Vetterli, M., Couach, O., and Parlange, M. 2010. SensorScope: Application-Specific Sensor Network for Environmental Monitoring. *ACM Transactions on Sensor Networks* **6**(2): **17**:1-17:32.

[8] Juang, P., Oki, H., Wang, Y., Martonosi, M., Peh, L. S., and Rubenstein, D. 2002. Energy-efficient computing for wildlife tracking: design tradeoffs and early experiences with ZebraNet. *Proceedings of the 10th international conference on Architectural support for programming languages and operating systems* 96-107. New York, NY, USA: ACM.

[9] Zhou, J., and Roure, D. D. 2007. FloodNet: Coupling Adaptive Sampling with Energy Aware Routing in a Flood Warning System. *Journal of Computer Science and Technology* **22**(1): 121-130.

[10] Callaway, E., Gorday, P., and Hester, L. 2002. Home Networking with IEEE 802.15.4: A Developing Standard for Low-Rate Wireless Personal Area Networks. *IEEE Communications Magazine* 70-77.

[11] Baronti, P., Pillai, P., Chook, V. W., Chessa, S., Gotta, A., and Hu, Y. F. 2007. Wireless sensor networks: A survey on the state of the art and the 802.15.4 and ZigBee standards. *Computer Communications* **30**: 1655–1695.

[12] Rajendran, V., Obraczka, K., and Garcia-Luna-Aceves, J. J. 2006. Energy-efficient, collision-free medium access control for wireless sensor networks. *Wireless Networks* **12**(1): 63-78.

[13] Jambli, M. N., Zen, K., Lenando, H., and Tully, A. 2011. Performance evaluation of AODV routing protocol for mobile wireless sensor network. *7th International Conference on Information Technology in Asia (CITA 11)* 1-6. Kuching, Sarawak: IEEE.

[14] Polastre, J., Hill, J. and Culler D. 2004. Versatile low power media access for wireless sensor networks. *Proceedings of the 2nd international conference on Embedded networked sensor systems* (pp. 95-107). Baltimore, Maryland, USA: ACM New York, NY, USA.

[15] Perkins, C. E., and Royer, E. M. 1999. Ad-hoc on-demand distance vector routing. *Proceedings of Second IEEE Workshop on Mobile Computing Systems and Applications* 90-100. New Orleans, LA: IEEE.