ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(An ISO 3297: 2007 Certified Organization)

Website: www.ijareeie.com

Vol. 6, Issue 6, June 2017

Performance Analysis of ZigBee based Wireless Sensor Network for Grain Storage Monitoring

D. S. Shelar[1], D. C. Gharpure[2], A. D.Shaligram[3]

Assistant Professor, Dept. of Electronic Science, New Arts, Commerce & Science College, Ahmednagar, Maharashtra, India[1]

Professor, Dept. of Electronic Science, Savitribai Phule Pune University, Pune, Maharashtra, India[2]

Head & Professor, Dept. of Electronic Science, Savitribai Phule Pune University, Pune, Maharashtra, India[3]

ABSTRACT: Maintenance and monitoring of grain storage warehouses, is a difficult task which has to be carried out meticulously to ensure safe grain storage over long time periods. Wireless sensor networks can be effectively used for automating the process. This paper reports work done to evaluate the performance of a wireless sensor network for monitoring of food grain storages. Indoor environment of foodgrain storages is different as compared to other applications of WSN which affects the performance of the sensor network. Deployment of sensor nodes inside foodgrain storages is an important issue, which decides coverage and connectivity of the sensor network. In this paper, we used WSN planer Tool software for arrangement of sensors nodes in the network andNS2 simulator with IEEE 802.15.4 standard tostudy performance characteristics of the Wireless Sensor Network. We have conducted experiments for finding the best position of coordinator and to study the effect of varying packet size and number of connections with two-ray ground and shadowing propagation models using NS2.

KEYWORDS: Wireless Sensor Network, 802.15.4, ZigBee, packet delivery ratio, throughput,NS2, AODV,WSN Planner Tool.

I. INTRODUCTION

Grain production has been steadily increasing due to recent development in production technology, but improper storage results in higher losses in grains. Large amounts of the world's food grain are wasted because of inadequate handling and storage at various stages between production and consumption. If grain is stored in unsuitable and primitive ways, the storage losses (caused by germination, microbes, rodents, birds and insects) can be as much as 20 to 40% while at the same time the quality of the rest, may be badly impaired. Preservation of the wholesomeness or the quality characters of a food grain commodity is the basic aim of safe storage [1]. The storage of food grains is a complex function of ecological systems comprising of physical, chemical and biological variables. Monitoring of temperature, humidity and CO_2 is important for avoiding foodgrain losses during storage. Grain temperature and moisture content are the primary factors that affect the grain storage. As temperature and moisture content increases, the grainsdeteriorate faster.Without having an automated data acquisition and monitoring process, variation in aforementioned parameters could lead to damage of the grain, defeating the purpose of storage. Wireless sensor network [1,2] is regarded as a viable technology for data collection and monitoring large structure as well as structures located in remote locations [3].

Wireless Sensor Network consist of number sensor nodes, which cooperatively monitor certain environmental conditions. WSNs are collections of compact-sized, relatively inexpensive computational nodes that measure local environmental conditions or other parameters and forward such information to a central point for appropriate processing. Sensor nodes have sensing, processing and communication unit’s working on battery [3]. WSNs nodes (WNs) can sense the environment, can communicate with neighbouring nodes, and can, in many cases, perform basic computations on the data being collected. WSNs support a wide range of useful applications[4]. A wireless sensor node

ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(An ISO 3297: 2007 Certified Organization)

Website: www.ijareeie.com

Vol. 6, Issue 6, June 2017

equipped with temperature, humidity and CO_2 sensor can be placed in each stack of foodgrain bags for monitoring inside foodgrain storages. For such applications, sensor deployment is a critical issue because it affects the cost, detection capability and quality of service (QoS) of a wireless sensor network. A good sensor deployment considers both coverage and connectivity issues [2]. The coverage is defined as the probability that any target point in the area of interest is within the sensing range of any nearby sensors. In other words, it reflects how well the sensed field is monitored or tracked by the sensors. The network connectivity is defined as the probability that a packet broadcast from any sensor can reach all the other sensors in the network[5].

The WSN Planner tool is a simulation software developed using MATLAB at department of Electronic Science, Savitribai Phule Pune Universityfor planning of wireless sensor network.The WSN Planner tool provides facility to find the best arrangement of nodes with minimum number of nodes to cover the maximum area. This application simulates the connectivity pattern between these wireless nodes for given parameters such as range and arrangement [10].

Network Simulator (Version 2), widely known as NS2, is simply an event driven simulation tool that has proved useful in studying the dynamic nature of communication networks. Simulation of wired as well as wireless network functions and protocols (e.g., routing algorithms, TCP, UDP) can be done using NS2. In general, NS2 provides users with a way of specifying such network protocols, and simulating their corresponding behaviours. NS2 consists of two key languages: C++ and Object-oriented Tool Command Language (OTcl). While the C++ defines the internal mechanism (i.e., a backend) of the simulation objects, the OTcl sets up simulation by assembling and configuring the objects as well as scheduling discrete events (i.e., a frontend) [14].

II.LITERATURE SURVEY

Large foodgrain warehouses need support of modern technology to save a large amount of grain presently wasted due to various reasons. Temperature, humidity and CO_2 levels are of prime importance in order to maintain the grain quality and quantity [10]. Paper [17] provides an insight into the issue of storage of food grains in the country, the losses which are occurring due to non-availability of proper covered storage and the scientific storage, due to which millions of tonnes of food grains are wasted. Intelligent Food Management System, structured modular design concept was adopted and the system was designed with Renesas microcontroller, temperature sensor, humidity sensor, smoke sensor, LDR and Bluetooth module. Android cell phone and database created using the MySQL software was used for monitoring [16].

The IEEE 802.15.4 was implemented by J.Zheng and M.J.Lee on the NS2 simulator, to carryout a comprehensive study of the standard. Results show that 802.15.4 is an energy-efficient standard favouring low data rate and low power consumption applications [12]. In paper [13] routing protocol AODV, AOMDV, DSR and DSDV are analysed by comparing the different performance metrics such as packet delivery ratio (PDR), loss packet ratio (LPR), and average end to end delay of wireless sensor network with varying pause time and number of nodes underTCP & CBR connection using network simulator NS2.35.Authors of Paper [9] attempt to extend existing efforts but focuses on evaluating the performance of peer-to-peer networks on a small scale basis using the NS2 simulator, they analyse the performance based on commonly known metrics such as throughput, packet delivery ratio, and average delay. In [3], practical architecture of WSN which is suitable for the application of monitoring grain storage is proposed and experiments are conducted in a house-mode granary Paper [4] elaborates a performance study of IEEE 802.15.4 protocol for wireless sensor networks via several sets of simulation, including impact of the traffic loads and data payload size.A performance comparison with the IEEE 802.11 protocol is also conducted.With the increase in the reporting rate, the throughput of the network increases considerably. But after a threshold value, the value of the throughput decreases. This is because of the congestion or delay into the network [18].

These papers are related to simulation study of IEEE 802.15.4 standard for low data rate and low power consumption applications and performance analysis of different routing protocols with varying pause time, number of nodes, traffic load,reporting rate and data payload size.These simulations are not application specific or not for analysis of network for indoor environments.

In this paper, we address the issue of deployment strategy and performance analysis of wireless sensor network with the specifications of XBee Pro S2B module inside a large foodgrain storage.The XBee/XBee-PRO RF modules are designed to operate

ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(An ISO 3297: 2007 Certified Organization)

Website: www.ijareeie.com

Vol. 6, Issue 6, June 2017

within the ZigBee protocol and support the unique needs of low-cost, low power wireless sensor networks. ZigBee is built on top of the IEEE 802.15.4 standard. The foodgrain warehouse application is in indoor environments, therefore the physical conditions are different than other applications. The foodgrain bags stacked inside storage or warehouse can lead to shadowing effects, hence we have used both two-ray ground and shadowing models for the simulation study.

III.BRIEF OVERVIEW OF IEEE 802.15.4

The 802.15.4 standard defines physical (PHY) and medium access control (MAC) layer protocols for supporting relatively simple sensor devices that consume minimal power and operate in an area of 10m or less. The point of service (POS) may be extended beyond 10m but this requires additional energy to operate. It also allows two types of topologies such as a simple one hop star or a self-configuring peer-to-peer network to be established. There are two categories of devices in 802.15.4. One of them is called full-function device (FFD) while the other is reduced-function device (RFD). RFD is crude device supporting simple application such as a switch or sensor. It is usually controlled by FFD device. RFDs can be used to communicate among themselves and with FFDs [12].

IV.EXPERIMENTAL SETUPAND PERFORMANCE METRICS

A. Experimental Setup

In Food corporation India (FCI) storages, foodgrain bags are arranged in stacks. In each stack the grain bags are stacked one over other up to 22 layers. The actual arrangement of foodgrain bags stack inside a foodgrain warehouse is shown in figure1 (right).A typical arrangement of wireless sensor network for foodgrain warehouse monitoring systems is shown in. figure 1 (left), where 12 sensor nodes are deployed in foodgrain warehouse. One sensor node is placed in each stack shown by circle. The coordinator is shown by rectangle at the center.

Fig. 1 Arrangement of foodgrain stacks inside foodgrain storage

The simulation software WSN Planner tool is used for planning the wireless sensor network inside the large foodgrain warehouse. In input widow of WSN Planner tool area, position of base station, number of nodes, communication range and sensing range are entered. Output section shows result of arrangements and experiments in the form of number of nodes connected, area covered and sensed area.We have performed experiment using random arrangement and Cartesian arrangement using 12 sensor nodes and one coordinator. Figure 2 shows Cartesian (left) and random (right) deployment of 12 sensor nodes and 1 coordinator with coverage area marked.

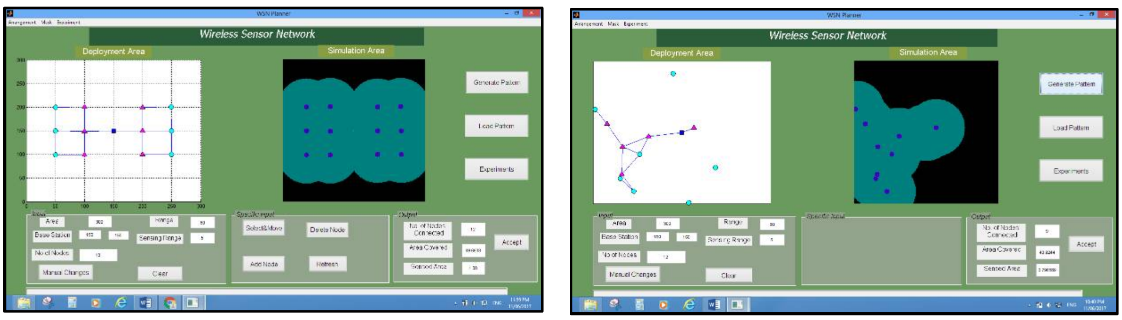


Fig.2 Cartesian and Random arrangement of Sensor nodes using WSN planner tool.

Cartesian arrangement is chosen for experiments and simulations were performed using Network Simulator 2 (NS2) software (NS-2.35).Themulti-hop wireless network is formed withmesh topology consist of 12 nodes and 1

ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(An ISO 3297: 2007 Certified Organization)

Website: www.ijareeie.com

Vol. 6, Issue 6, June 2017

coordinator. The simulation is performed with the following parameters mentioned in Table 1. The trace file is post processed usingPerl scriptinglanguage and throughput,packet delivery ratio and throughput are measured.

Parameter	Details
Channel type	Channel/Wireless Channel
Simulation Tool	NS-2.35
Radio-propagation model	TwoRayGround and Shadowing
MAC Protocol	IEEE 802.15.4
Interface queue type	Queue/Drop Tail/PriQueue
Max packet in ifq	50
Routing Protocols	AODV
Frequency/Bandwidth	2.4 GHz/250kbps
Number of nodes	12
Transmission Range	60 m
Traffic Type	Constant Bit Rate (CBR)
Packet Size (bytes)	80 bytes
Transmission Rate	100 bps
Simulation Area	300X200
Simulation Time (Sec)	1000

Table 1 Simulation Parameters

B. Performance Metrics

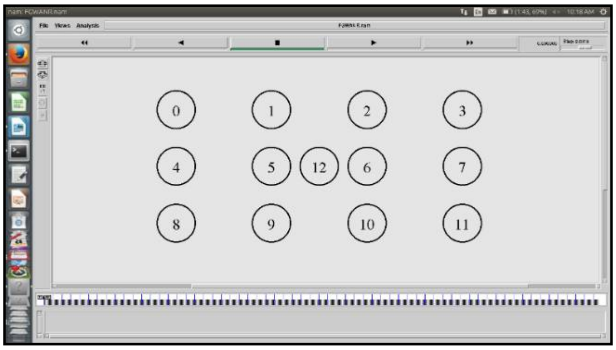
In order to evaluate the performance of the wireless sensor network, the following metrics are considered:

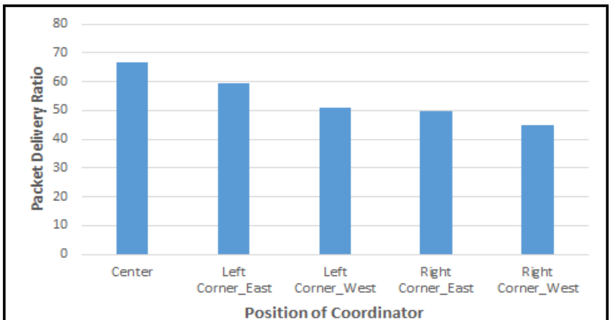
- *Packet Delivery Ratio*: The ratio of the number of data packets successfully delivered to all destination nodes and the number of data packets generated by all source nodes.
- *Throughput:* The throughput metric measures how well the network can constantly provide data to the sink. Throughput is the number of packet arriving at the sink per second.
- *Average End-to-End Delay:* The average time interval consumed between the generation of a packet in a source node and the successfully delivery of the packet at the destination node.

V. RESULT AND DISCUSSION

Experimental result of WSN Planner tool shows Cartesian arrangement gives better connectivity and coverage as compared to random arrangement.

The first experiment performed using NS2 simulator is for checking the best position of the coordinator. We used 12 sensor nodes and 1 coordinator.





Experiments are performed by placing coordinator

Fig.3 Arrangement of sensor nodes in NAM windowFig.4Packet Delivery Ratio vs. position of Coordinator

ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(An ISO 3297: 2007 Certified Organization)

Website: www.ijareeie.com

Vol. 6, Issue 6, June 2017

at centre, all corners and at the side of foodgrain storage namely at center, Left corner_East,Left corner_West, Right corner_East a Right corner_West. The arrangement of sensor nodes (n0-n11) and coordinator (n12) is shown in figure 3.

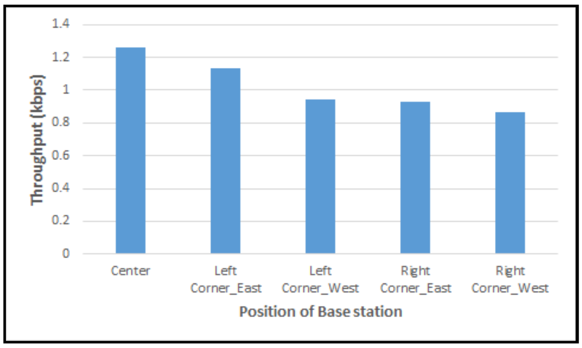


Fig.5 Throughput vs. Position of Coordinator

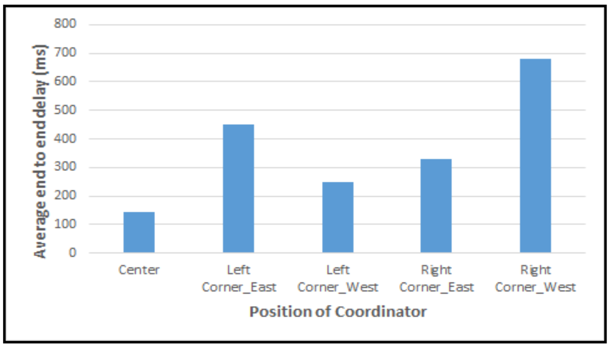


Fig.6 Avg. end to end delay vs. Position of Coordinator

It is well known that position of coordinator is very important for good performance characteristics. Figure 4 and 5 shows the coordinator position at the center gives good packet delivery ratio and throughput compared to other positions. End to end delay is less for base station at the center is shown in figure 6. Therefore, the coordinator at center gives good values of packet delivery ratio and throughput and less delay.

Thus for further experiments the Coordinator was paced at center to analyse packet delivery ratio, throughput and end to end delay.We have performed three experiments, in first experiment we have varied packet size, in second experiment we have varied number of connections and in third experiment we have studied the effect of Path loss exponent and Shadowing Deviation.

A. Effect of Varying Packet size

In this experiment, the network consists of 12 nodes (n0-n11) and 1 coordinator (n12) and, all nodes send a constant bit rate (CBR) traffic data toward coordinator. The packet size is varied from 10 to 100 and packet delivery ratio, throughput and average end to end delay are measured. The experiment is performed using Two-ray ground and shadowing propagation models.

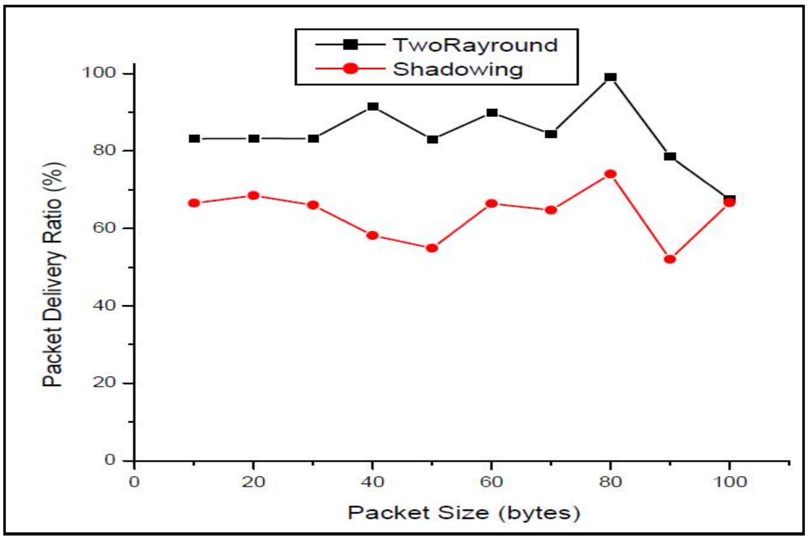


Fig. 7 Packet delivery ratio vs. Packet size

ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(An ISO 3297: 2007 Certified Organization)

Website: www.ijareeie.com

Vol. 6, Issue 6, June 2017

The performance of packet delivery ratio vs. varying packet size is shown in figure 7. It is observed that packet delivery ratio for two-ray ground model is more compared to Shadowing model. For packet size 80, the packet delivery ratio (PDR) for both propagation models has the highest value.

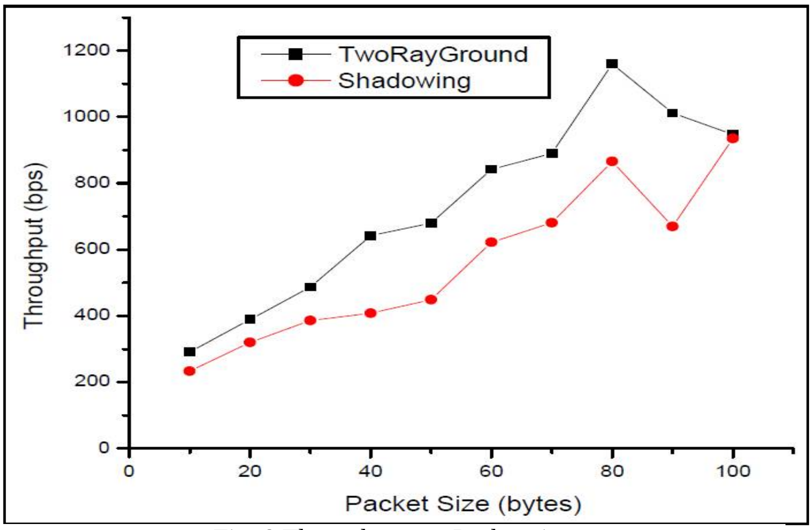


Fig. 8 Throughput vs. Packet size

Throughput increases with increase in packet size is shown in figure 8. For packet size 80, maximum throughput is observed for both propagation models.

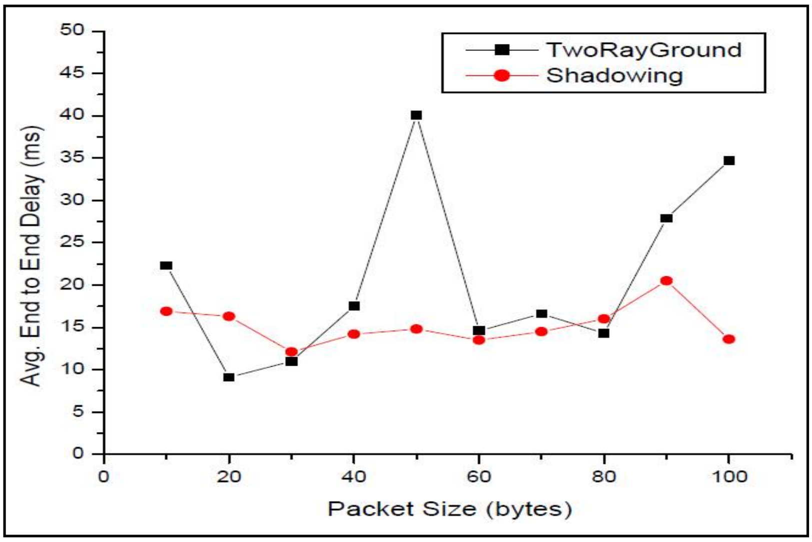


Fig. 9 Avg. End to end delay vs. Packet size

Figure 9 shows, average end to end delay shows non-linearity for Two-ray ground model. End to end delay for shadowing model varies between10 to 20ms. For packet size of 80 it is nearly the same approximately 15ms.

ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(An ISO 3297: 2007 Certified Organization)

Website: www.ijareeie.com

Vol. 6, Issue 6, June 2017

B. Effect of varying number of Connections

In this experiment coordinator is placed at the center,packet size is kept at optimum value of 80 bytes and the number of connections are varied starting from 1 and incremented on a scale of 1 up to 12 and performance is analysed for Two-ray ground and shadowing propagation models.

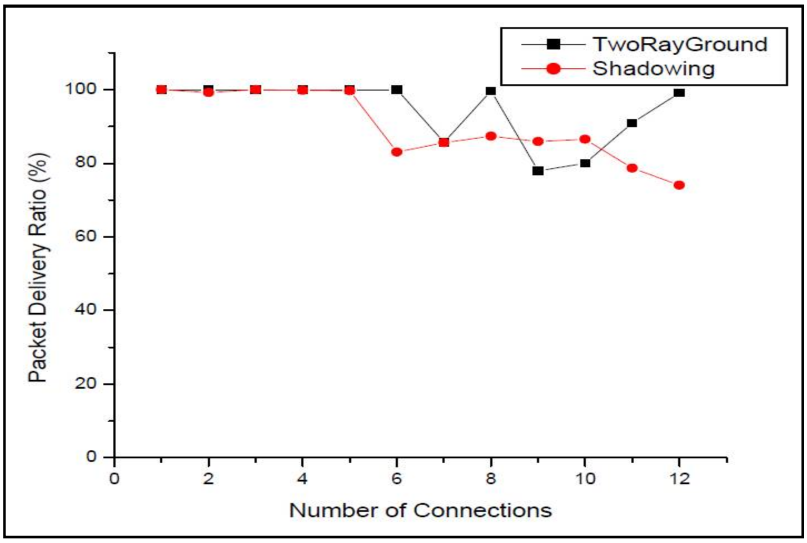


Fig. 10 Packet delivery ratio vs. Number of connections

The figure 10 shows the graph of the packet delivery ratio vs. varying number of connections. The packet delivery ratio is nearly 100% up to 5 connections for both propagation models.

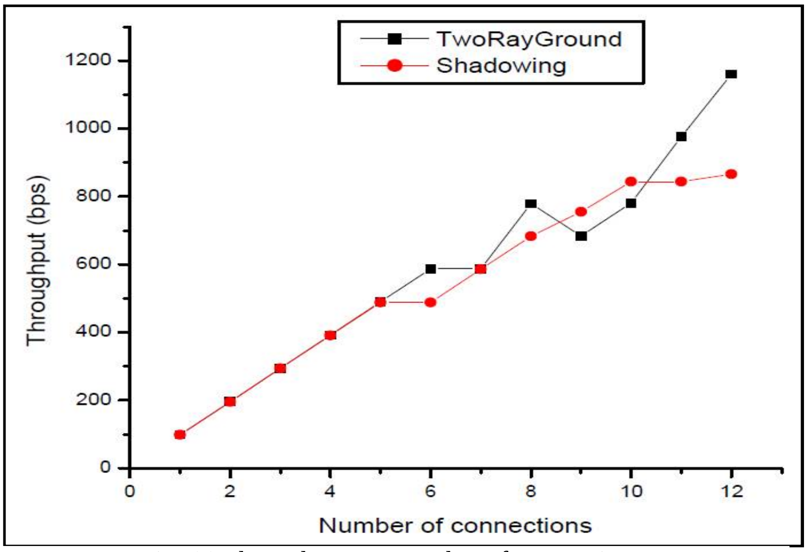


Fig. 11 Throughput vs. Number of connections

The graph of throughput vs. varying number of connections is shown in figure 11. The throughput is increased linearly up to 5 connections for both propagation models. Two-ray ground models shows the maximum throughput than shadowing model at a number of connections are 11 and 12.

ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(An ISO 3297: 2007 Certified Organization)

Website: www.ijareeie.com

Vol. 6, Issue 6, June 2017

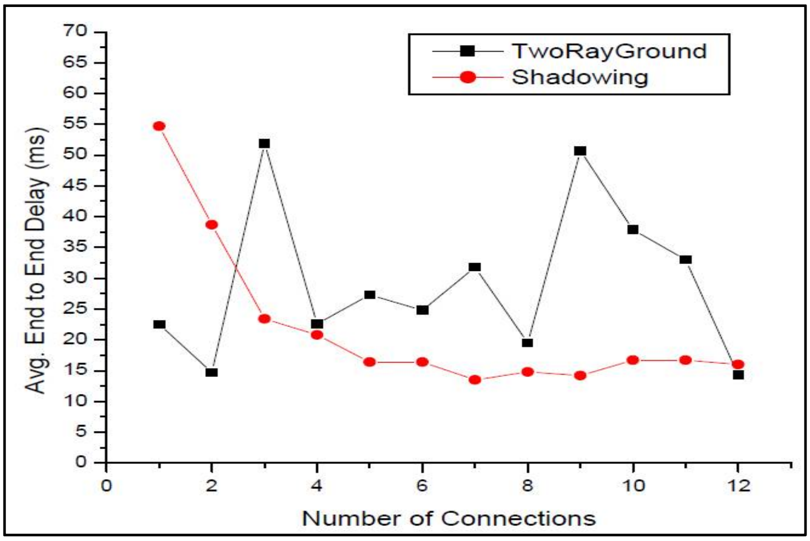


Fig. 12 Avg. End to end delay vs. Number of Connections

Figure 12 shows an average end to end delay vs. number of connections. Initially average end to delay is more for two-ray ground model, but after 3 connections it remains in between 10 to 25 ms, but for shadowing model its value decreases till 3 connections and then slowly stabilises to 15 ms.

C. Effect of Path loss exponent and Shadowing Deviation

Indoor environment inside foodgrain storages is not stable and loading and unloading of grain bags can cause problems of connectivity, which affects the performance of wireless sensor network. The path loss can also vary due to this process and due to the random movement of people inside storages. To study the effect of loading and unloading of grain bags on the performance of wireless sensor network inside a foodgrain storage effect of path loss was studied.The two experiments are performed by changing values of path loss exponent βandshadowing deviationσ_{dB}. For first experiment source nodes and coordinatorare consideredin a line of sight,β = 2.0 and σ_{dB}= 4.0. To study effect of grain bags placedbetween source nodes and coordinator, the values are increased to β = 2.2 and σdB = 5.0 dB.

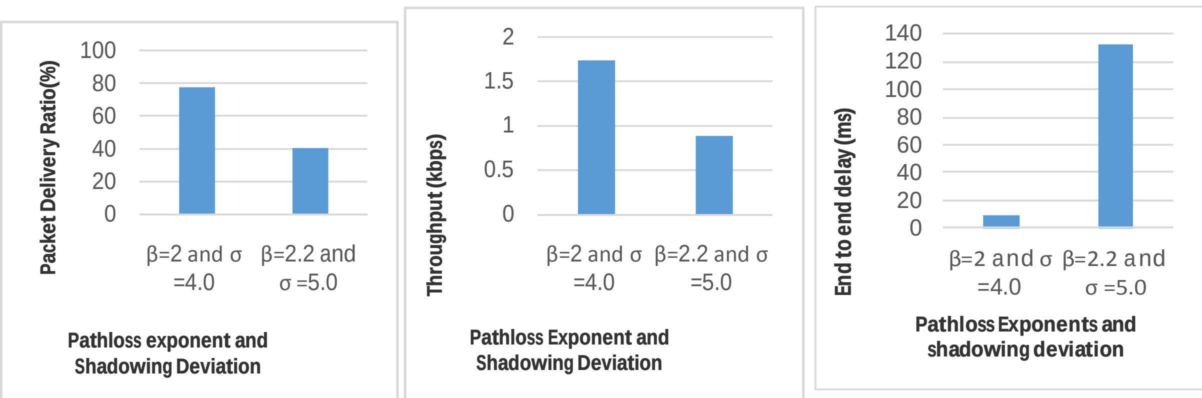


Fig. 13 Packet Delivery Ratio, Throughput and Avg. end to end delay for different values of path loss exponent and shadowing deviation

Figure 13 shows when we increase values of path loss exponent and shadowing deviation, packet delivery ratio and throughput decreases and average end to end delay increases asexpected.

ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(An ISO 3297: 2007 Certified Organization)

Website: www.ijareeie.com

Vol. 6, Issue 6, June 2017

VI.CONCLUSION

In this paper, we have studied the performance of the ZigBee based wireless sensor network for monitoring of large foodgrain storages. The performance of the wireless sensor network depends on different parameter such as the number of sensor nodes, communication range of transceiver, deployment strategy, size of the data etc. Using WSN Planner tool Cartesian arrangement is selected for sensor nodes deployment. NS2.35 simulator tool is used for selection of best position of coordinator and simulations to study the effect of variation in packet size and number of connections on network performance. From the obtained results it is observed that for multi-hop transmission with 12 nodes, coordinator at center is the best position. The simulations show that packet delivery ratio and throughput is more for two-ray ground model than shadowing propagation model. Throughput increases with increase in packet size and also with increasing number of connections. Shadowing models shows less packet delivery ratio and throughput and more average end to end delay. For simulation study of loading and unloading of bagswas carried out by increasing the path loss exponent and shadowing deviation. It was observed that the packet delivery ration and throughput decreases and average end to end delay increases with increase in path loss and shadow deviation as expected.Further work on optimization of the network for quality of service is being carried out.

REFERENCES

[1] Neha Deshpande, A. D. Shaligram, B. A. Botre, Satish Bindal and S.S. Sadistap “Embedded E-nose Application to Sense the Food Grain Storage Condition”, International Conference on Computational Intelligence and Communication Networks, pp. 608-611, Nov. 2010.

[2] You-Chiun Wang and Yu-Chee Tseng, “Efficient Placement and Dispatch of sensors in a Wireless Sensor Network”, IEEE transactions on mobile computing, Vol. 7, pp 262-274, Feb. 2008.

[3] JianguangJia, JingmingKuang,Zunwen He and Yuhang Mu, “Design of Monitor System for Grain Depots Based on Wireless Sensor Network”, Proceedings ofthe 2009 IEEE International Conference on Mechatronics and Automation, Changchun, China, pp. 2318-2323, Aug.2009.

[4] Muhamad S. Iqbaland Hamed S. Al-Raweshidy, “Performance Evaluation of IEEE 802.15.4 Standard for Low Data Rate Ad Hoc Wireless Sensor Networks”, ICCAIS, pp. 300-304, 2013.

[5] J. J. Lee, B. Krishanmmachari, and C. C. J. Kuo, “Impact of heterogeneous deployment on lifetime sensing coverage in sensor networks”, First Annual IEEE Communications Society Conference on sensor and ad-hoc communications and networks(SEACON), pp 367-376, Oct 2004.

[6] Data Sheet for XBEE PRO S2B IEEE 802.15.4 2.4 GHz Zigbee RF Transceiver, availableonline at https://www.digi.com/resources/documentation/digidocs/PDFs/90000976.pdf.

[7] Junguo Zhang, Wenbin Li, Dongxu Cui, Xueliang Zhao, and Zhongxing Yin, “The NS2-based simulation and research on wireless sensor network route protocol”, Proceedings of the 5th International Conference on Wireless communications, networking and mobile computing (WiCOM'09), pp.3146-3149, 2009.

[8] Zhao A Qun and Wang Jun, “Application of NS2 in Education of Computer Networks,” 2008 International Conference on Advanced Computer Theory and Engineering,International Conference onAdvanced Computer Theory and Engineering, pp. 368–372, 2008.

[9] Ganesh R. Pathak,Suhas H. Patil, Amar D. Rana, and Yogendra N. Suralkar, “Mathematical Model for Routing Protocol Performance in NS2: Comparing DSR, AODV and DSDV as Example”,IEEE Global Conference on Wireless Computing and Networking (GCWCN), pp. 184-188, 2014.

[10] Neha R. Deshpande, “Development and optimization of Ad-hoc Wireless Sensor Network system for Large Food Grain Storages”. Ph.D thesis, Savtribai Phule Pune University, Sept. 2013.

[11] Wilson T.H. Woon and T.C. Wan, “Performance Evaluation of IEEE 802.15.4 Ad Hoc Wireless Sensor Networks: Simulation Approach,” IEEE International Conference on Systems, pp. 1444–1448, Oct. 2006.

[12] Jianliang Zheng and Myung J. Lee, “A Comprehensive Performance Study of IEEE 802.15.4” pp 1-14.

[13] Bijan Paul et al., “Analysis of AOMDV, AODV, DSR and DSDV Routing Protocols for Wireless Sensor Network”, Sixth International Conference on Computational Intelligence and Communication Networks, pp. 364–369, 2011.

[14] NS2 online manual, http://www.isi.edu/nsnam/ns.

[15] A. V. Patil and A. Y. Kazi, “Performance analysis of IEEE 802.15.4 sensor networks”,Fourth International Conference on Computing, Communications and Networking Technologies (ICCCNT), 2013.

[16] A report on, “Intelligent Food Management System: Maintenance of Agro and Non-Agro Foods in Cold Storage Warehouse”.

[17] Bhartendu Kr. Chaturvedi and Anil Raj TA, “Agricultural Storage Infrastructure in India: An Overview”, IOSR Journal of Business and Management, Vol. 17, Issue 5, pp 37-43, May 2015.

[18] Nikhil Kothawade et al., “Performance Analysis of Wireless Sensor Network by Varying Reporting Rate”, Indian Journal of Science and Technology, Vol. 9(26), pp. 1- 6, July 2016.