Performance Evaluation of Zigbee Protocol Using Opnet Modeler for Mine Safety

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Abstract

ZigBee, also known as IEEE 802.15.4 standard, is becoming a popular way to create wireless personal area network due to its power consumption and scalability. Zigbee ad-hoc mesh networks are designed to support a large number of nodes (>64,000) with dynamic routing in case of a node failure. This paper will simulate and explore the performance of ZibBee WPAN's under various conditions using OPNET. According to the simulation results concluded that ZigBee protocol gives less end to end delay. Traffic dropped in route while traveling to destination is also very less. It can be seen that steady stream of traffic is sent without disruption. Due to this ZigBee is widely used in wireless sensor networks applications such as patient monitoring, automatic meter reading system, and mine security application.

Keywords: *End-End delay, Throughput, OPNET, Zigbee, QoS*

1. Introduction

Use of wireless personal area networks has grown in recent years.This is due to convenience of using wireless Signals in areas such as office space,campus or home rather than having to lay out wires.Removing the length constraints and troublesome of physical limitation of wires,wireless solutions provide much more diversity and potentially relevant cost[5].

Zigbee is wireless protocol in the IEEE 802 family, along with well known protocols such as Wi-Fi, Bluetooth which uses 2.4 GHz ISM radio band. Zigbee also utilizes 868MHz and 915 MHz bands in different parts of the world.Zigbee was developed for low rate which feature long battery life by having low data rate[4]. ZigBee has three layers. The top layer is called the application layer (APL). This layer gives the device its functionality. Basically, this layer converts the input into digital data, and/or converts digital data into output. A single device may run multiple applications to perform different tasks (i.e. reading temperature and humidity). The application layer is on top of another layer called the network layer (NWK). The network layer provides ZigBee functionality and acts as a buffer between application layer and data link layer (DLL).The network layer is responsible for network structure, routing, and security such as encryption, key management, and authentication. The data link layer is provided by IEEE 802.15.4 standard. This layer consists of two sub-layers – medium access control layer (MAC) and the physical layer (PHY)[4].
This paper will cover the use of OPNET Simulation tool as well as study the low data rate protocol Zigbee. OPNET Simulate several Zigbee WPAN Networks while altering certain parameters.

2. OPNET

To provide further clarity on software simulation investigation of OPNET Modeler for ZigBee WSN topology and to ascertain its general capabilities for these situations. The effect of the number of nodes on the MAC throughput and end-to-end delay is inclusively evaluated [6]. Further, the effect of handshaking on the end-to-end delay between the nodes is also investigated.In order to provide a general performance evaluation of OPNET 14 Modeler for ZigBee WSNs, the performance criteria presented in this paper will include end-to-end delay, number of employed hops, throughput, data dropped and simulation time. In general these parameters give a clear prospective of the QoS parameters in WSNs [6].

2.1 Evaluation Scenario

Figure 1 represents scenario which includes coordinator and four end devices connected in star configuration. Then set parameters such as transmission band,network parameters,transmission power, packet interarrival time,packet size,destination,data rate,enable or disable ACK mechanism ,setting CSMA-CA parameters of coordinator and end devices using edit attributes menu.Star,Tree,Mesh Configuration is available in drop down menu of attributes.

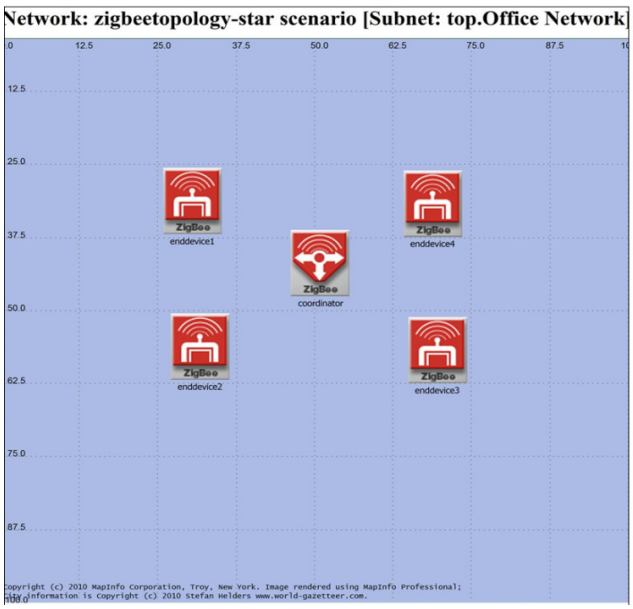

Fig 1 Zigbee Scenario

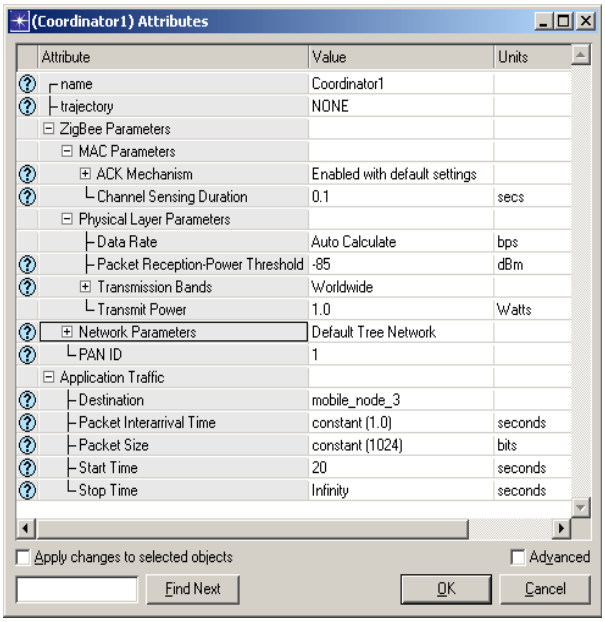

Fig .2 Edit Attributes Menu

3. Performance Evaluation

Quality of service includes different statistics such as Delay,Throughput,Packetsdropped,Simulation time,Traffic sent(packets/sec) , Traffic received(packets/sec),simulation time.By setting such statistics for IEEE 802.15.4 MAC Layer,Zigbee Network Layer,Application layer simulation can be done.

3.1 Global statistics For MAC Layer

802.15.4 Data traffic received (bits/sec):-Represents the total traffic successfully received by the MAC from the physical layer in bits/sec. This includes retransmissions [6].

802.15.4 Data traffic sent (bits/sec):- Traffic transmitted by all the 802.15.4 MACs in the network in bits/sec. While computing the size of the transmitted packets for this statistic, the physical layer and MAC headers of the packet are also included.This statistics include all the traffic that is sent by the MAC via CSMA CA. It does not include any of the management or the control traffic, nor does it include ACKs.

Fig 3 represents traffic sent and received by 802.15.4 layer.

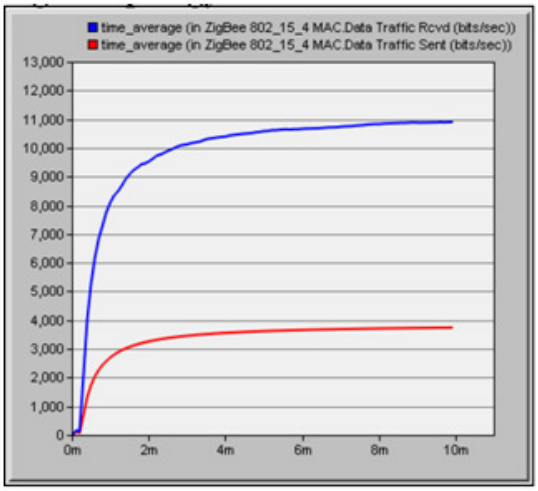

Fig .3 802.15.4 Traffic sent & Received in bits/sec

Delay (sec):-Represents the end to end delay of all the packets received by the 802.15.4 MACs of all WPAN nodes in the network and forwarded to the higher layer.

Throughput (bits/sec):-Represents the total number of bits (in bits/sec) forwarded from 802.15.4 MAC to higher layers in all WPAN nodes of the network.

Fig.4 represents Delay and Throughput performance in 802.15.4 MAC Layer.

3.2 Global statistics For Application Layer

End-end delay:- Total delay between creation and reception of an applicaton packet.This statistic is dimensioned by ZigBee Network (PAN ID) for values of PANID ranging from 1 to 255.All other PANIDs(including auto-assigned PAN IDs) will be combined into the '0' statistic.

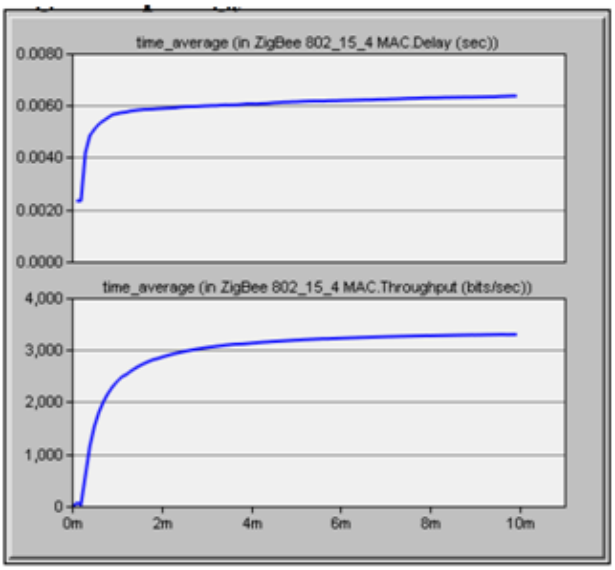

Fig. 4 802.15.Delay(sec) & Throughput(bits/sec)

Traffic received (packets/sec):-Application traffic received by the layer in packets/sec.this statistic is dimensioned by ZigBee Network (PAN ID) for values of PAN ID ranging from 1 to 255. All other PAN IDs (including auto-assigned PAN IDs) will be combined into the '0' statistic.

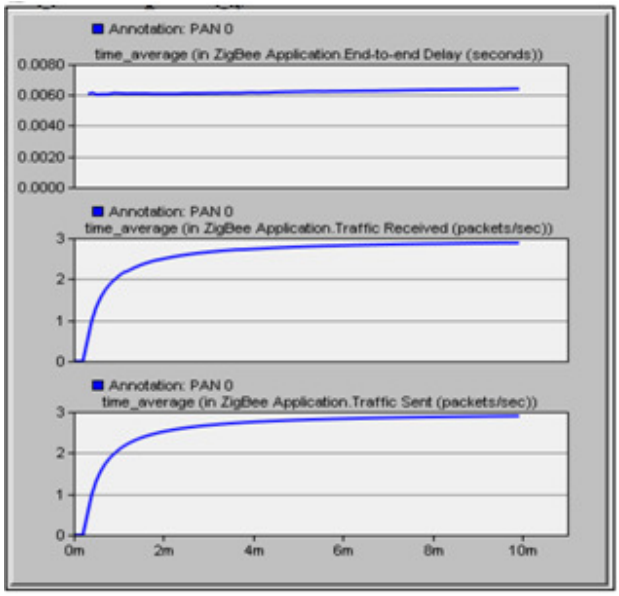

Fig. 5 Application End-end DeLay, Traffic Sent &Received (packets/sec)

Traffic sent (packets/sec):-Application traffic sent by the layer in packets/sec.This statistic is dimensioned by ZigBee Network (PAN ID) for values of PAN ID ranging from 1 to 255. All other PAN IDs (including auto-assigned PAN IDs) will be combined into the '0' statistic [6]. Fig 5 shows performance of application layer.

3.3 Global statistics For Network Layer

Number of hops:-Average number of hops traveled by application traffic in the PAN.as shown in scenario number of hops for each end device for sending data to coordinator is one.Fig 5 shows Number of hops required in Network Layer.

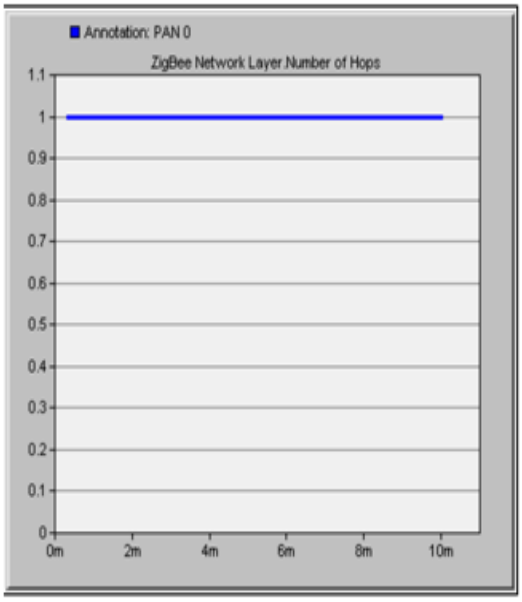

Fig 6.Number of Hops

Global statistics provide information that relates to the overall system. Many separate objects may contribute to one global statistic during a simulation. For example, every node in a network model may use the same global statistic to record the end-to-end delay experienced by the packets it receives. The result is one statistic for the network's end-to-end delay performance[7].

3.4 Node Statistics

Node statistics provide information about individual node such as coordinator or end device.it will gives idea about individual delay of each node, packets dropped by separate nodes, amount of time required by each node to reach to destination, traffic sent and received by each node.

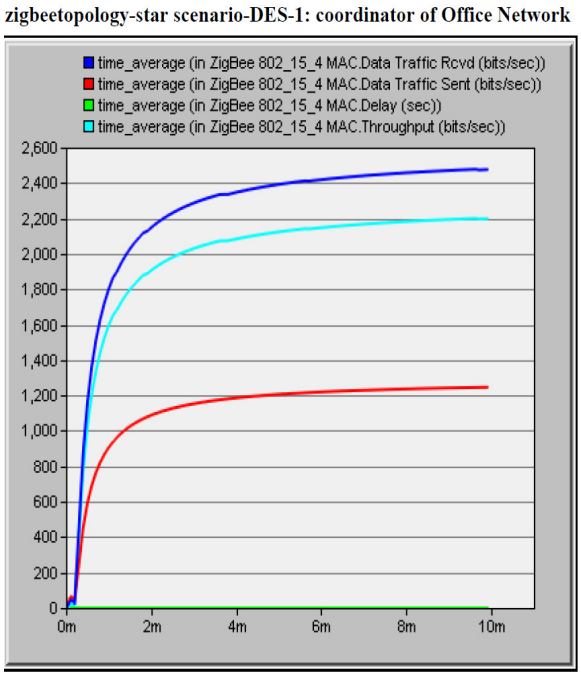

Fig. 7 802.15.4 Node statistics of coordinator

Fig 7 shows 802.15.4 node statistics of coordinator. It can be seen that steady stream of traffic is sent without disruption. Small spikes in at the beginning of the simulation are indications of management and control traffic sent and received to determine the presence of devices as well as the optimal route.

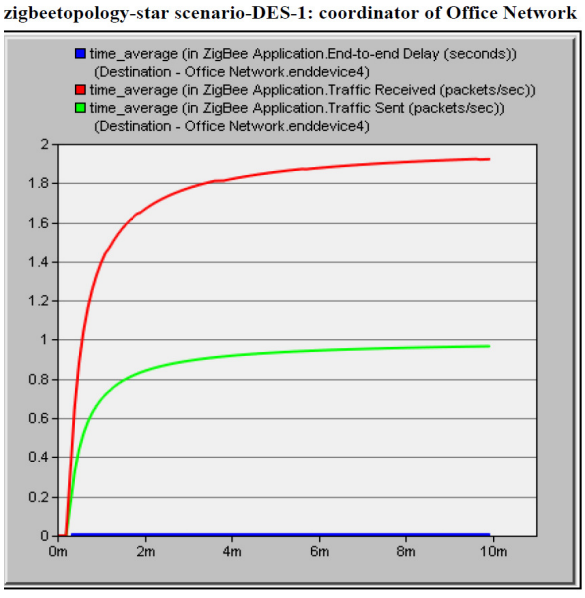

Fig 8. Application Node statistics of coordinator

Fig 8 represents Application End-end Delay, traffic sent and received (packets/sec) statistics of coordinator.

Similarly for Each end device node statistics will be observed.Fig 9 shows 802.15.4 Traffic sent and received, Delay and Throughput performance of end device.

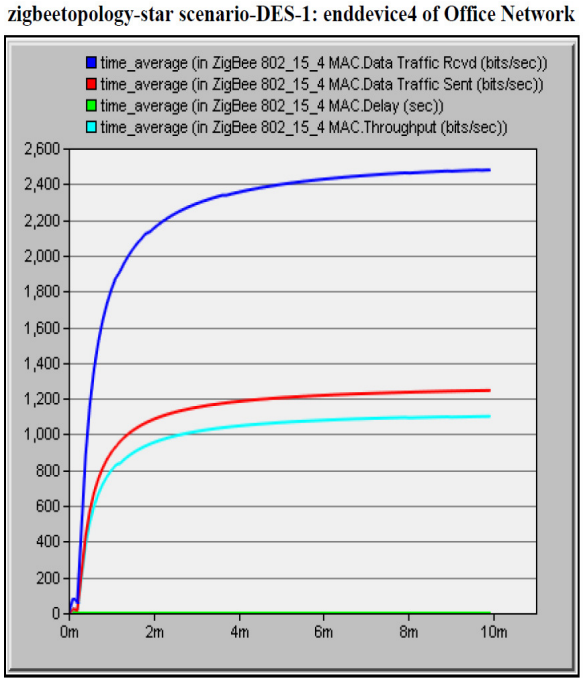

Fig.9 802.15.4 Node statistics of End device

Fig 10 represents End-end delay, Traffic dropped in route and Number of hops parameters of end device.

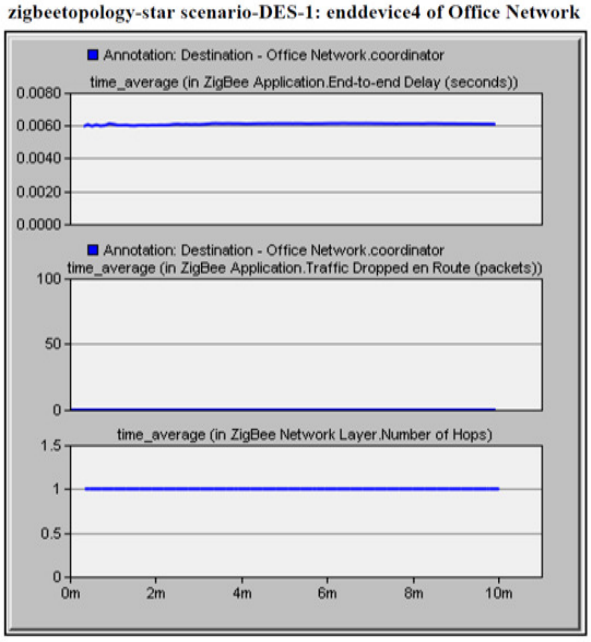

Fig 10.Application Layer Node Statistics of end device

4. Conclusion

The purpose of this paper was to investigate the Performance of OPNET Modeler in simulating ZigBee WSNs. According to simulation results concluded that Zigbee protocol gives less end to end delay. Traffic dropped in route while travelling to destination is also very less. It can be seen that steady stream of traffic is sent without disruption. Due to this Zigbee is widely used in wireless sensor networks applications such as patient monitoring, automatic meter reading system, mine security applications[5].

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