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Research on Performance Evaluation of Zigbee Wireless Sensor Networks using Various Parameters

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Abstract **: Zigbee (IEEE 802.15.4) is a wireless technology which is usually used in devices that require low power and long battery life . This paper aims at finding the impact of different traffic management mechanisms such as CSMA/CA and acknowledgement on the two different zigbee networks having different densities using discrete event simulator OPNET . all the networks are configured by using various configuration parameters with optimized values taken from literature.**

Keywords-Sensor Networks , Zigbee (ieee 802.15.4)

1. INTRODUCTION

Wireless technology is being used to a great extent now a days. All types of applications are able to communicate without the need of any wires. The purpose of wireless communication is to collect information or to perform certain specific tasks in the environment. A typical sensor node contain the basic three C's and they are communication units, computation and collection. Computation unit contains microcontrollers and memory. The collection unit has series of sensors and then finally communication unit contains transceiver to transmit and receive data. The reason for which zigbee wireless technology is in great trend is not one but there are many like –it is very reliable technology and it is easy to deploy. We can't neglect the advantage of its low cost with long battery life which can run for several years. It supports large number of nodes and it can be used globally and many more.

2. OPNET Simulator - OPNET is extensive and powerful simulation software with wide varieties of possibilities. It enables the possibility to simulate the entire heterogeneous networks with various protocols. The development work was started in 1986 by MIL3 ,Inc , while nowadays the company is called opnet technologies , Inc.. originally the software was developed for the needs of military, but it has grown to be world leading network simulation tool. OPNET is high level event based network level simulation tool. The simulation operates at packet level. Nowadays the possibility of wireless simulation network is very wide. The basic simulations are done as a function of simulation time. It has accurate network behaviour and the level of event accuracy can be extended to be as detailed as needed. simulation results as a function of time are typically as such not suitable as scientific results, since statistical accuracy is needed.OPNET tutorials is very good starting point for beginners. Wide product documentation is available to help the users through all the issues considering OPNET.

3. Network Design and Implementation

3.1 Network Design

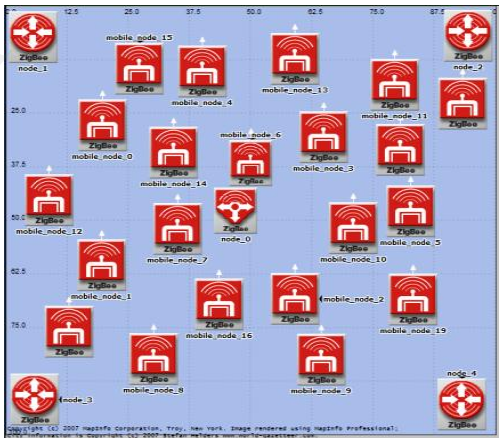


Figure 3.1(a Sample 20 Nodes Network)

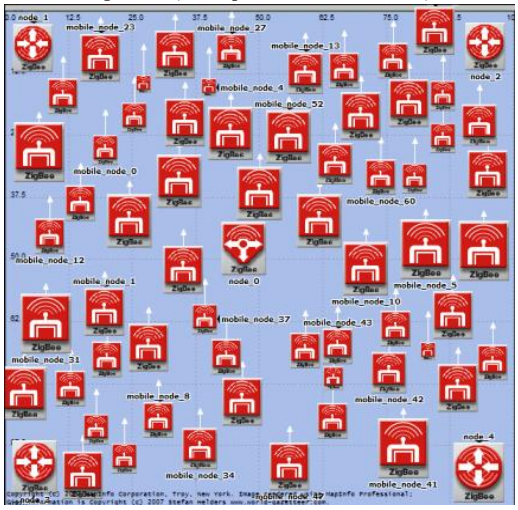


Figure 3.1(b) Sample 60 Nodes Network

Figure 3.1(a) and 3.2(b) have shown two sample zigbee based 20 nodes and 60 nodes network respectively. To gather and evaluate the results of zigbee protocol under two traffic management mechanism such that acknowledgement and carrier sensing multiple access/collision avoidance to improve the quality of services (QoS) of the networks, various zigbee based networks have designed with two different node densities such that 20 nodes and 60 nodes. Each network consists of 4 routers and 1 coordinator. All the nodes such as end-devices, routers and coordinators are placed in the networks according to the tree topology and configured according to the parameters given in the table 4.1. The packet interval time such that the duration between the transmission of two consecutive data packets has kept to 1 second and the size of each packet is 1024 bits. To define mobility for the end devices, default mobility model (trajectory) of OPNET simulator called Vector has used, which is the simulation of the movements of any mobile device in a real life situation such that a mobile device can move in any direction randomly without any predefined movement pattern. All the networks are simulated for 3600 seconds.

4. EXPERIMENTAL SETUP

S.No.	Attributes	Values
1.	Topology Type	Tree
2.	Number of Nodes	20, 60
3.	Number of Coordinators	1
4.	Number of Routers	4
5.	Packet Interval Time	Constant (1.0)
6.	Packet Size (bits)	Constant (1024)
7.	Simulation Duration (sec)	3600
8.	Trajectory	Vector

Table 4.1 General Configuration Parameters

A) Acknowledge Mechanism Configuration

The Acknowledge mechanism has configured according to the parameters given in table 5.2. ACK wait duration is the duration for which the MAC will wait to receive ACK for a given transmission. If the ACK is not received during the given duration the MAC will retransmit. For all the networks, the MAC duration has kept to .05 seconds. The number of retransmission is the number of times a packet is retransmitted before it is marked as failed. The value for number of retransmissions has set to 5

S.No.	Attribute	Values
1	Status	Enabled
2	ACK Wait Duration (sec)	.05
3	Number of retransmissions	5

Table 4.2configuration parameters for acknowledgement mechanism

Table 4.2 Configuration Parameters for Acknowledgement Mechanism

B) Carrier Sensing Mechanism Configuration

CSMA/CA (Carrier Sense Multiple Access/Collision Avoidance) is a protocol for carrier transmission, which acts to prevent collisions before they happen. In CSMA/CA, as soon as a node receives a packet that is to be sent, it checks to be sure the channel is clear (no other node is transmitting at the time). If the channel is clear, then the packet is sent. If the channel is not clear, the node waits for a randomly chosen period of time, and then checks again to see if the channel is clear. This period of time is called the back off factor, and is counted down by a back off counter. If the channel is clear when the back off counter reaches zero, the node transmits the packet. If the channel is not clear when the back off counter reaches zero, the back off factor is set again, and the process is repeated.

Table 4.3 shows the configuration parameters used to configure the CSMA/CA mechanism. Minimum back off factor gives the minimum value of the back off exponent in the CSMA/CA algorithm. If the value is set to 0, collision avoidance is disabled during the first iteration of the algorithm but in the work done, value has set to 3. Maximum Number of Back offs has set to 0, such that no wait will be done to get the channel clear and channel access failure will be declared directly.

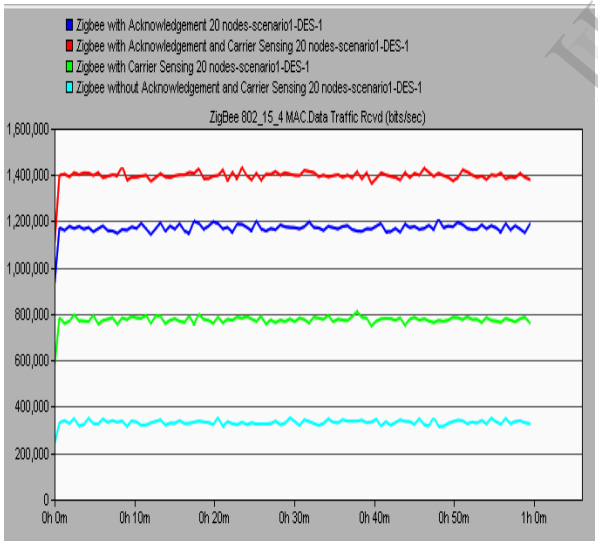
Table S.No.	Attributes	Values
1.	Mechanism	Collision Avoidance (CA)
2.	Minimum Backoff Exponent	3
3.	Maximum Number of Backoffs	4

Table 4.3 Configuration Parameters for CSMA/CA

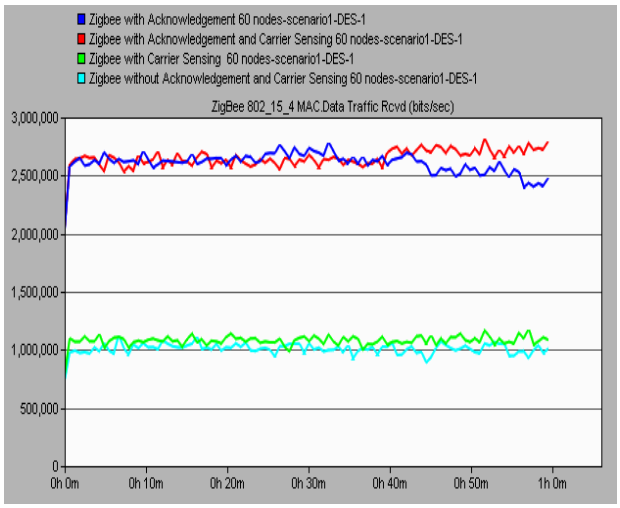
5. RESULT

1.Data Traffic received (bits/sec):

Application traffic received by the layer in bits/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. Figure 6.1 and 6.2 shows the data traffic received by the nodes in a ZigBee based network with network density of 20 nodes and 60 nodes, respectively. For network having 20 nodes, it has seen that the network using acknowledgement method to increase the reliability of the network performs better than the network using the carrier sensing to ensure the reliability of the network in terms of data traffic received. But when the data traffic received achieves it maximum when both the methods, such that acknowledgement and combined, CSMA/CA are such that the data received in the network has increased by 15.62 % than the data received by the nodes in the network using only acknowledgement technique. But CSMA/CA performs better by 57.52 % from the network not using any of the mechanisms. But when the network density i.e. number of nodes in the network has increased (60 nodes) acknowledgement technique performed almost equal to the combination of both acknowledgement and CSMA/CA, such that the gap remains only of 2.07 %. CSMA/CA has got outperformed, when used alone in high density network such that difference between the data traffic received by the nodes of the network not using any mechanism and network using CSMA/CA has remained only 5.28%.



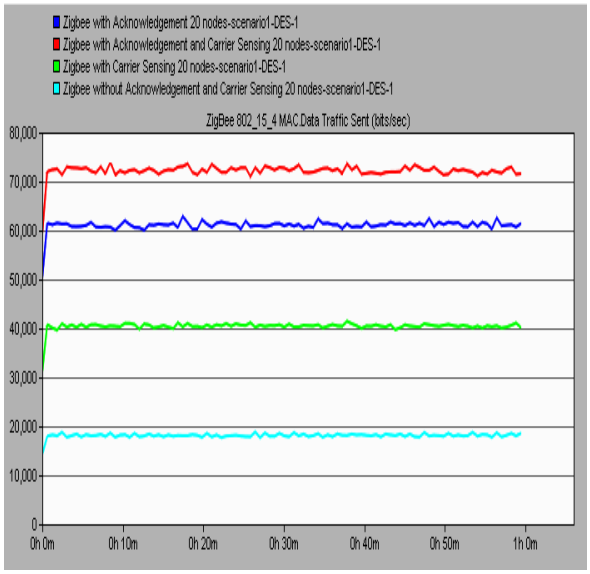
Data traffic received for 20 nodes



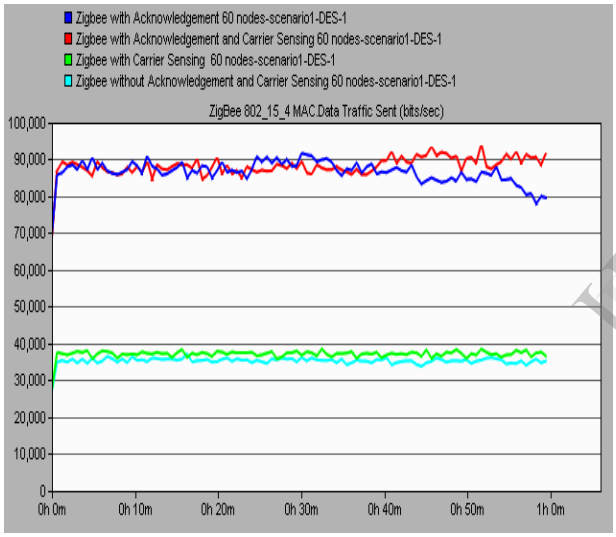
Data traffic received for 60 nodes

2.Data Traffic sent (bits/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. The data traffic sent by the nodes of the ZigBee network consisting of 20 nodes and 60 nodes are represented by figure 6.3 and figure 6.4 respectively. As seen the results for data traffic received by the nodes in the networks of both densities, Acknowledgement technique dominates the CSMA/CA. For the network consisting of 20 nodes, though the combination of both techniques outperforms the acknowledgement alone by 15.04 % but it performs better than the CSMA/CA carrier sensing technique by 34.17 %. In the case of the networks having 60 nodes, both acknowledgement and the combination of acknowledgement and CSMA/CA performs almost same from the perspective of data traffic sent by nodes in the network, such that the performance in both cases differ by only 1.45 % but in the case of CSMA/CA alone and without any of the data reliability technique, the difference in the data sent in the network is only of 4.75% such that the CSMA/CA is not suitable to the high density networks.



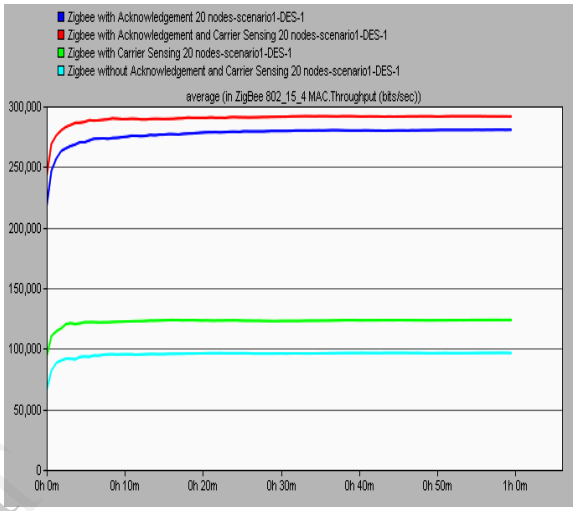
Data traffic sent for 20 nodes



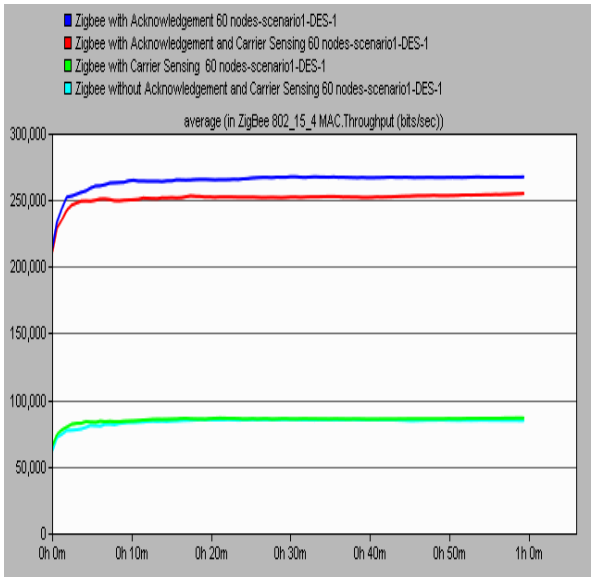
Data traffic sent for 60 nodes

3.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. From the literature it has seen that throughput has considered as the main performance evaluation metrics to evaluate the performance of a network. Figure 6.9 and 6.10 shows the throughput for the ZigBee networks with 20 nodes and 60 nodes, respectively. The rendered graphs depicts that whenever both the data or data packets reliability mechanisms such that CSMA/CA and acknowledgement mechanisms are combined, the network possess maximum throughput in the case of low density networks such that 20 nodes but whenever the number of nodes in a network increased such that 60 nodes, acknowledgement mechanism outperforms throughput of the network using the combination both CSMA/CA and acknowledgement by 4.7 %. In the case of 20 node network, CSMA/CA network possessing high throughput than the network without using any reliability method by 1.81% but the acknowledgement method outperforms the CSMA/CA by 55.86 % in terms of throughput. But in the case of 60 nodes network, very minute change in throughput has seen in the network using CSMA/CA mechanism and network not using any of the reliability mechanism. But, the acknowledgement mechanism still outperforms CSMA/CA by 67.88%.



Throughput for 20 node network



Throughput for 60 node network

6. CONCLUSION

Performance evaluation of zigbee based network with two network densities such that 20 nodes and 60 nodes are done under two different traffic management mechanisms such as CSMA/CA and Acknowledgement that are used to ensure the reliability of the data in the networks. All the networks are configured by using various configuration parameters with optimized values taken from the literature. All the networks are simulated by using a Discrete Event Simulator (DES) called OPNET. After the intensive simulation it has been concluded that for the low density networks such that the network consisting of 20 nodes, acknowledgment mechanism dominates the CSMA/CA but the acknowledgement mechanism has outperformed by the combination of both mechanisms. When the network density has increased (60 nodes), CSMA/CA has no impact over the improvement of the performance of the network such that network without any mechanism performs equally well as the network using CSMA/CA but acknowledgement mechanism has proved its iron in the high density network as well. So it can be said that when the number of the nodes in the network are below 40, the combination of both mechanisms can be used but for the networks having nodes more than 40 only acknowledgement mechanisms need to be used to reduce the extra processing required by CSMA/CA.

7. FUTURE SCOPE

A lot of work could be done or need to be done to improve the concluded results in this study. More optimized values could be considered to configure the configuration parameter and various other performance evaluation metrics need to be considered to make the concluded results more justified. The evaluation of other data traffic mechanism designed to ensure the reliability of the flow of data in the network need to be done.

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