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Maximizing Lifetime of WSN through Energy Efficient Parameters

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ABSTRACT

Energy efficient clustering is done within wireless sensor networks provided PAN-coordinator has less node density and contains smaller distance from end node. This paper gives analysis of node density and node's distance at different duty cycle (50% and 100%) to inquire about the impact of energy consumption within WSN. Parameters including throughput, end to end delay, collision status and BER are investigated to analyze, as which of these one cause high energy consumption. . Node density and distance of end nodes from its PAN are directly proportional to Energy consumption. This research has concluded that it is futile to prefer sleep mode (50% duty cycle) in very small node density area. Minimizing node density and end node distance from its PAN at 50% duty cycle can be resultant in less energy consumption, low BER, less collision status and thus prolong WSN lifetime.
KEYWORDS: Sensor node, WSN, Network lifetime, sleep mode, E2E.

1. INTRODUCTION

WSN is most imperative field now days. WSN is a collection of thousands of sensor nodes that are deployed at different monitoring areas to sense data from sensing environment. A sensor node within sensing environment has capability to sense, processing and communicating which helps to transfer sensing data to base station and base station responsible to perceive and respond according to the sensing condition in specific environment (Gilbert., et al 2012).Energy efficient sensor node is important issue now days. Cluster scheme is consider best approach for energy efficient WSN. In Clustering approach, sensor nodes are gathered to form cluster. Each cluster has at least one Cluster Head (CH) which controls the group of sensor node. Cluster Head receives the data from its neighboring sensor nodes and aggregates the sensed data and transfer it to the Base station (BS) through multihop (CH to CH and CH to BS) or single hop (CH to BS direct way) path. Cluster divides the large area into small area to reduce the distance between CH and base station; it can also reduce energy consumption (Jadidoleslamy, 2013). Many other advantages of clustering scheme are discussed in (Gupta & Dave., 2010). Wireless sensor node is followed IEEE 802.15.4 standard which has short range, low cost and low processing capability.

IPP Hurray Group (Petr Jurcik 2007) describes the structure and function of sensor node with battery module. Sensor node work in two ways: beacon enabled mode and Non- beacon enabled node. GTS node follow beacon enabled mode with super frame structure whose active period is divided in to Contention Access Period (CAP) and Contention Free Period (CFP). During CAP all nodes access channel through CSMA/CA, CAP is optional which is followed by CFP and CFP is responsible to guaranteed time slot. The distance between two beacons is called Beacon Interval (BI) which follow active and inactive period.. In this paper we take consideration on Energy efficient parameters by using GTS and Non-GTS node. Here, we take distance and node density parameters under consideration to check its impact on energy consumption.

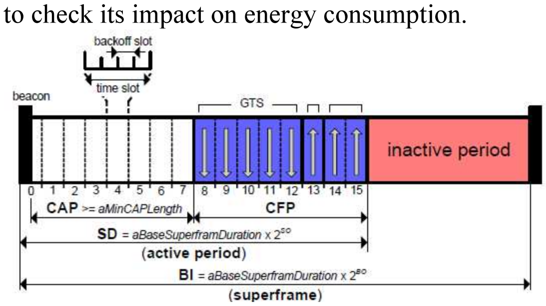

Figure 1. IEEE 802.15.4 Superframe structure [4]

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Rest of the paper consist of: Section 2 covers literature review, section 3 gives the detail of simulation tool and its error, section 4 describes performance analysis and section 5 show conclusion of this paper.

2. RELATED WORK.

WSN and its energy is cynosure for the researchers due to its sensing capability in surveillance area and other areas, where human access is inaccessible. So, many researchers have done their work in WSN field to conserve its energy through reduce distance and prolong the lifetime of sensor node. These researchers works are as follow:

(Shin and Chung 2011) proposed algorithm in which each node calculates the probability of itself to become the cluster Head (CH) on the basis of node density and it also makes redundant nodes to sleep. Cluster head randomly selects sleep nodes and informs all its members by sending TDMA schedule. If the density of node is very small then node is not turned into sleep mode.

Researchers also presented an efficient fault tolerant data aggregation approach for large scale WSN, to maximize the lifetime of networks by dividing the heterogeneous network into multiple small zones at different level (Karim et al., 2010). Researchers proposed multilevel clustering algorithm to prolong the lifetime of WSN, Which have the ability to make enable distant nodes to communicate with base station with less consumption of energy (Soni and Chand 2010). Performance Improvements in IEEE 802.15.4 standard are made through traffic detection in such way to save extra energy consumption (Mir et al., 2007). Analysis result of beacon enabled and non-beacon enabled mode by applying GTS and CSMA\CA respectively. Result reveals that GTS allocation is supported only 7 end nodes for single cluster, which is not suitable for high node density (Hassan et al., 2014).

(Jin et al., 2011) presents analytical analysis of energy consumption model of re-clustering which reduces the control overhead and transmission of sensory data to prolong lifetime of network.

(Khan et al., 2011) proposed an adapted cluster formed model by introducing Server node which help not only to reduce the energy consumption but also reduce the distance of CH to base station through server node access and K-mean algorithm. In (Khan et al., 2012), researchers presented K-Mean algorithm which precedes different parameters (RSSI, Latency, node’s energy, distance) to form clusters with uniform distribution of nodes. Energy-efficient cluster head election scheme for surveillance area, this scheme divides the network into two regions to minimize the distance of intra-cluster communication to achieve longevity of the network (Pal et al., 2012). Suitable selection of battery module for sensor node minimizes node’s energy consumption; TelosB battery is considered appropriate choice after detail analysis between Micaz and TelosB mote (F.Zafar & Maryam 2014).

Many other algorithms are designed to reduce the energy consumption by minimize distance and node density are consulted (Jerusha et al., 2012; khan et al., 2012; Wang et al., 2007; Zheng et al., 2010; Sasikumar and Khara 2012).

3. SIMULATION TOOL.

OPNET (Optimization Network Evaluation Tool) simulation is selected due to its convenient analysis and technique of presentation task that is not provided by other Network simulation tool. Validity of the OPNET simulation results and the tools is highly reliable and efficient. OPNET modeler facilitates its user with full GUI support. Opnet Modeler version 14.5 is used in this work to design network and its execution.

3.1 WPAN Error Removing Procedure During Adding it in OPNET 14.5.OPNET Modeler 14.5 also provides support to Wireless sensor node, it has supported built in Zigbee model but built in Zigbee model does not give support to battery module. Here, throughout this thesis work we have used WPAN node. OPNET Modeler 14.5 does not give built in support of WPAN node. We have added IEEE 802.15.4 WPAN model into OPNET Modeler 14.5 by following these steps:

1. From Opnet Modeler: Go To **File > Manage Model Files> Add Model Directory**, this path is used to add WPAN model directory in the Opnet Model. We have added IEEE 802.15.4 model V2.0 which is designed by IPP HURRAY.IEEE802.15.4 provide support to Battery Module which is basic requirement for this paper.
2. After Adding this model, this model does not run directly, it show error Repository missing process model (WPAN_sink_Processes_v2.0).

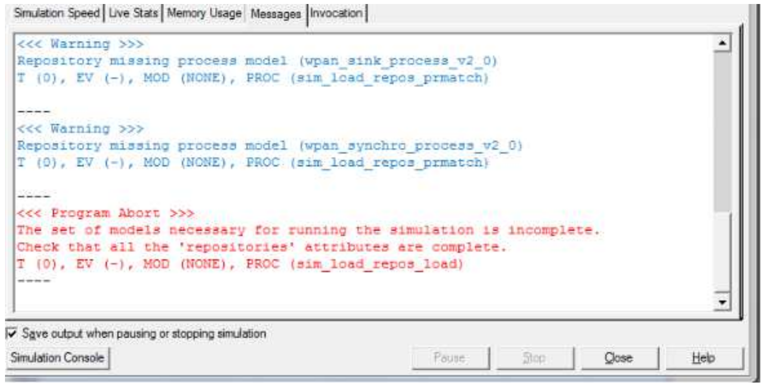


Figure 2. Repository missing Error

3. Removing this error by making some changes in the WPAN model code by adding FIN (function name); after initialization of variables of each function if variable is present otherwise at the start of each function of WPAN modules and FOUT; at the end of each function.

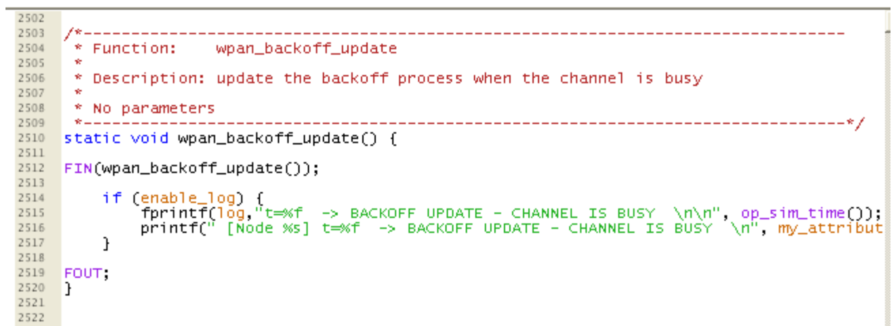


Figure 3. Adding FIN and FOUT to remove Repository missing Error

4. If the data type of function is void, use FOUT at the end of function. Otherwise, each function is ended with FRET.

Figure 4. Adding FRET at the end of function, whose data type other than Void

5. FIN, FOUT and FRET macros are used within the function to debug the ODB. After changing in this model, compile the source code and after successful compilation WPAN model V2.0 ready to run.

3.2 Simulation Flow. Step by step methods are used to make the simulation flow perfect and easy. Apply configuration statistics on whole model of WSN separately and with respect to each individual scenario. Simulation is performed several times to get precise results that are defined in each scenario. Results are gathered from each scenario in the form of graphs and stored in .jpg files that are further use in the thesis report. Some graphs were plotted one over another and with different parameter selections**.**

Network Models are designed on OPNET Modeler 14.5 by simple selecting WPan model through Object palette. After selecting, design a topology and select configuration Parameters that are necessary to select the appropriate results. In OPNET Modeler, there are two kinds of statistics i.e. Global statistics and Object Statistics. Object statistics can be defined as the statistic that can be collected from individual node and Global statistics are collected from the entire network. First select the desired statistic and then run the simulation to see these collected results and analyzed by simple click on DES icon and go to Results .Subsequent model for simulation flow are as follow:

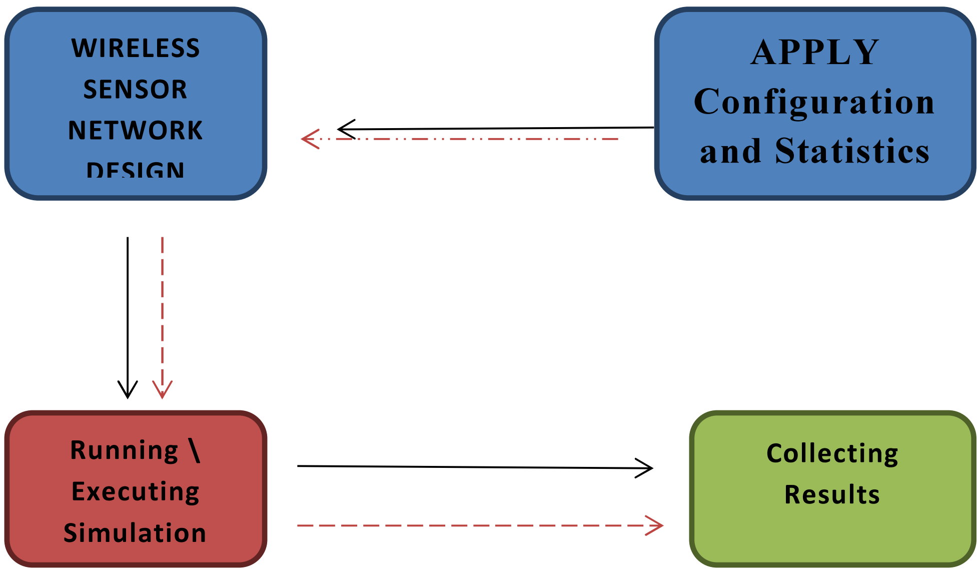


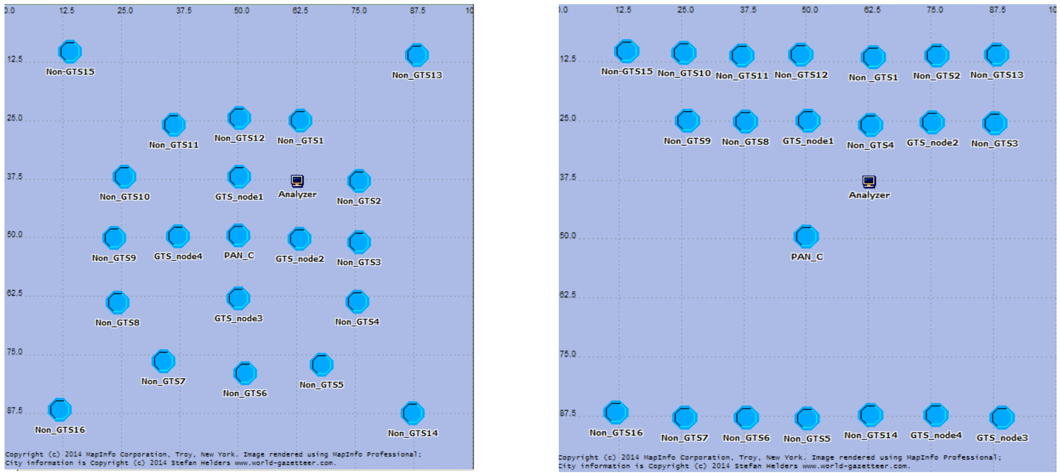
Figure5: Simulation Flow

4. **Performance Evaluation.** We perform simulation on OPNET Modeler 14.5; we have implemented GTS and Non_GTS nodes with single PAN node, sensor node follow IEEE 802.15.4 standard. Here, PAN node acts as highly dense node which is deployed in 100*100meter area. The default parameters values of this scenario are as follow.

Table 1. OPNET Scenario Parameters

Simulation Parameters	value
Physical and MAC model	IEEE802.15.4
Area	100*100 meter
Simulation time	2200secods
Energy Model	TelosB
Payload size	50 bytes
BO and SO values	(4,4) and (4,3)

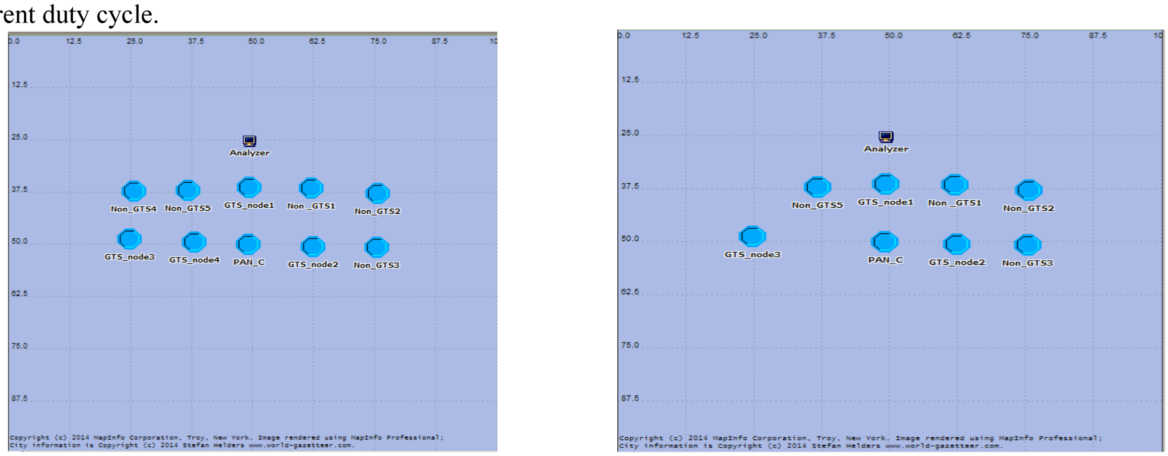
3.3 Node Density and distance. WPAN Node density is the number of End nodes associated with one PAN Coordinator follows star topology and node distance mean distance of end node from its PAN coordinator. If Number of End nodes want to transmit its GTS traffic and PAN node in receive mode, it can receive all traffic of End nodes but if the number of End nodes are increased, all end nodes want to transmit its traffic to PAN Coordinator some of these nodes have to wait for it turn or collision of traffic occur and only few nodes can transfer its GTS traffic to the PAN Coordinator. GTS or Non GTS node request is sent by End devices to PAN Coordinator, in response PAN node allocate beacon signal to end devices. But Non_GTS node is self-organizing node, each node communicate through CSMA\CA mechanism. To check the effect of node density and distance by increasing the number of end devices for following Parameters: **Consumed energy, E2E delay, Throughput, collision status and BER.**



(a) Scenario1 (b) Scenario 2

Figure 6. End nodes with small and large distance from PAN node

(Fig 6.) consists of 4 GTS and 16 Non GTS nodes, this scenario run for 100% and 50% duty cycle to check the impact of duty cycle on node distance from PAN node. We also analyze how much energy will be consumed with different duty cycle.



(c) Scenario 3 (d) scenario 4

Fig 7: High and low dense areas of nodes

(Fig 7) scenarios are designed to check the impact of energy consumption on node density. Fi g4c consists of 5 Non GTS nodes and 4 GTS nodes and fig 4d show3 non GTS and 4 GTS nodes to check how much energy will be consumed with 100% and 50% duty cycle by removing two nodes.

4. RESULTS AND DISCUSSION

In this section, we evaluate the performance of node density and distance of end nodes from PAN node on the basis of energy consumption with 50% and 100% duty cycle. Here, our aim to get energy efficient sensor nodes and prolong the life time of sensor nodes.

4.1 Consumed Energy:

(Fig 6a) is highly dense nodes area and all end nodes are close to PAN node except 4 end nodes, first we run this scenario to check the impact of duty cycle. Results reveal that 50% duty cycle show more energy efficient result than 100% duty cycle. Fig 4a scenario consists of 4 GTS nodes, only GTS nodes go to sleep mode, Non GTS node follow non beacon enable mode. Each node is self-organized; Node is operated in non_beacon enabled mode by using CSMA/CA during CAP. By increase or decrease 1 in BO or SO value, then node has a chance to go to sleep mode for half of the Beacon Interval period. Here, in case of 50% duty cycle all GTS node go to sleep mode which make less node density that's why result is more efficient than 100%. In 100% duty cycle all end nodes send request to PAN node continuously and there is no sleep mode, which cause collision of traffic. Fig 6b scenario show that all end nodes are far away from its PAN node , this scenario is run to check the impact of large distance on energy consumption with 50% and 100% duty cycle. At the end, we have made comparison of GTS node 2 in both scenarios 1 and 2. Results reveal that GTS node2 at scenario 1 close to PAN node consume less energy to transmit it data as compare to GTS end node 2 in scenario 2 that is far away from the PAN node, both at 50% duty cycle. Scenario 4 results concluded that it is useless to offer sleep mode in less node density because result almost same at 100% and 50% duty cycle, 50% duty cycle show minimum high energy consumption than 100% , further analysis require to check this impact. We will check it for E2E delay and collision status.

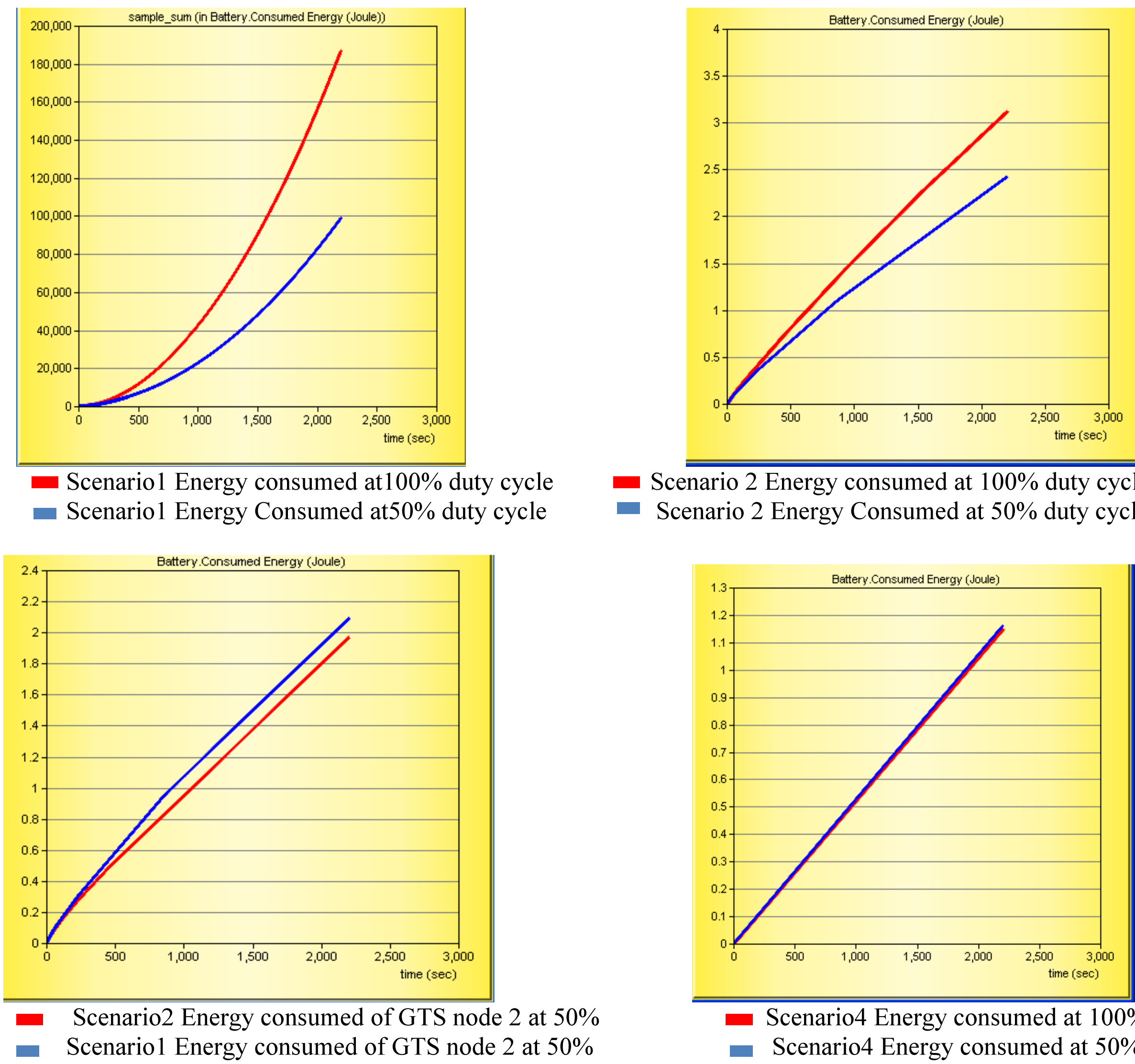
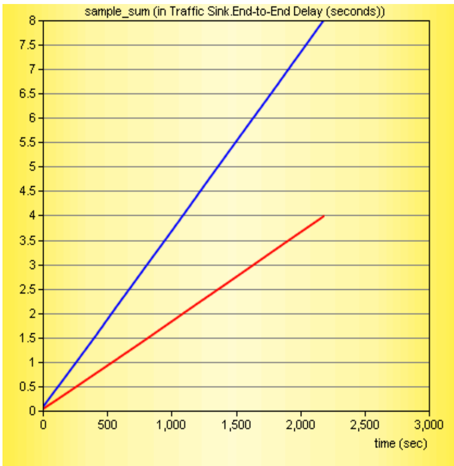
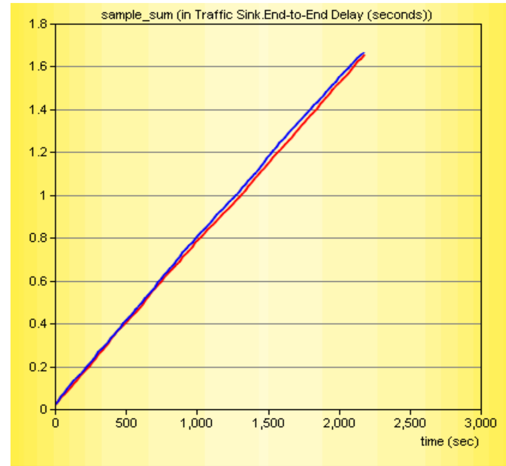


Figure 8. Energy consumption analysis of node density and end node distance from PAN node

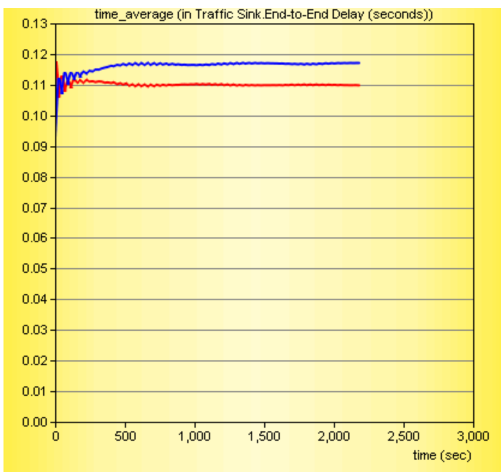
4.2. E2Edelay. E2E delay is the time at which packets are generated by the source and receive at the destination. So, this is a time at which packet go across the network. This time is expressed in Sec. Here, we will check the impact of node density on E2E delay with different duty cycle. In these scenarios 1 and 2 nodes are synchronized with PAN_C and other 16 nodes are non-beacon enable node for the purpose of communication. Results reveal that 50% duty cycle show high E2E delay as compare to 100% duty cycle in case of high and low node density or distance, which is not suitable. But at individual node analysis reveals that E2E delay is high at GTS node 2 in scenario 2 due to its large distance from PAN.



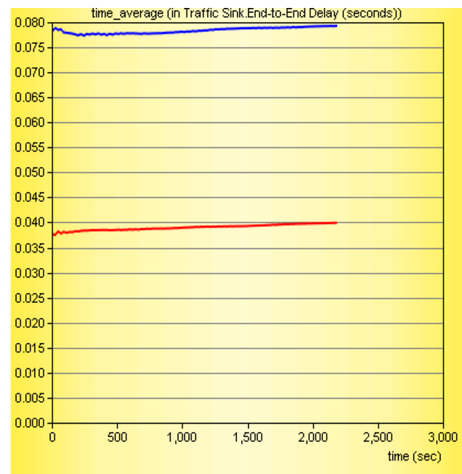
Scenario 1 E2E delay 50% duty cycle
Scenario 1 E2E delay at 100% duty cycle



Scenario 1 E2E delay of GTS node2 at 100%
Scenario 2 E2E delay of GTS node 2 at100%



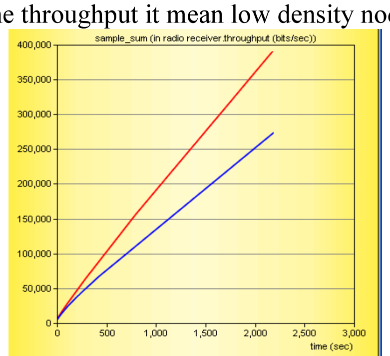
Scenario 4 E2E delay at 100%
Scenario 4 E2E delay at 50%



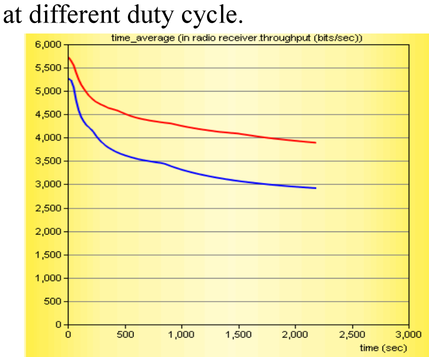
Scenario 2 E2E delay at 100%
scenario 2 E2E delay at 50%

Figure 9: Analysis of End to End Delay

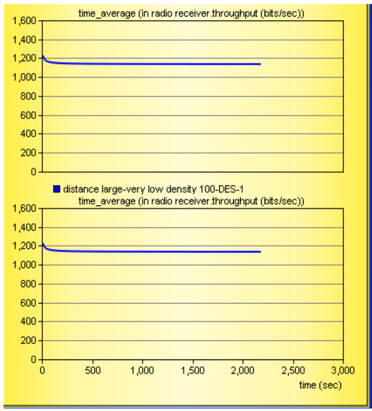
4.3 Throughput. Results reveal that throughput is maximum at 100% duty cycle as compare to 50%. So, we have compared individual GTS node 2 for both scenarios 1 and 2 at 100% to check radio receiver throughput, it is clear that a node in scenario 2 that is far away from PAN node show high throughput as compared to GTS node 2 in scenario 1 Which is close to PAN node. At the end, comparison of scenario 4 at 50 and 100% duty cycle show same throughput it mean low density nodes show same result at different duty cycle.



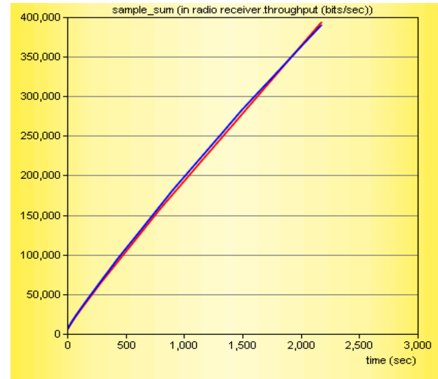
Scenario 1 throughput at PAN with 100%
Scenario 1 throughput at PAN with 50%



scenario 4 throughput at PAN with 100%
scenario 4 throughput at PAN with 50%



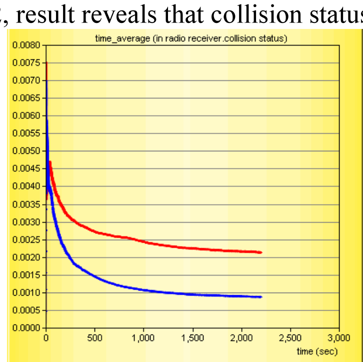
Scenario 4 throughput at PAN with 50% and 100%



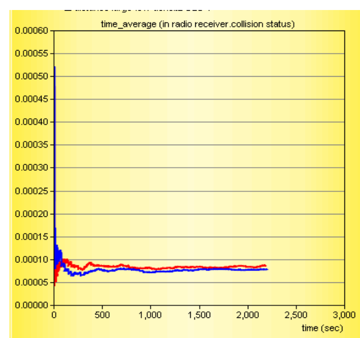
scenario 2 throughput of GTS node 2 at 100%
Scenario 1 throughput of GTS node 2 at 100%

Figure 10. Analysis of throughput at different duty cycle

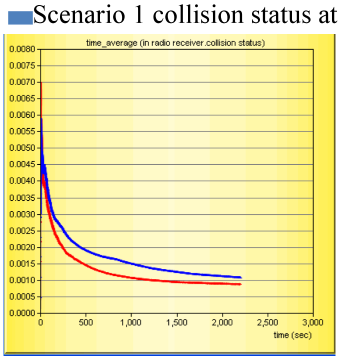
4.4 Collision status. Number of packets collides with each other at receiver channel. In our analysis, result show that at sleep mode or 50% duty cycle collision status is low as compare to 100% duty cycle. In sleep mode some of GTS node goes to sleep, node density become small and less energy will consume. Scenario 4 show low node density and high collision status at both duty cycles. At GTS node 2 in scenario 1 close to PAN as compare to scenario2, result reveals that collision status low at Scenario 1 due to small distance.



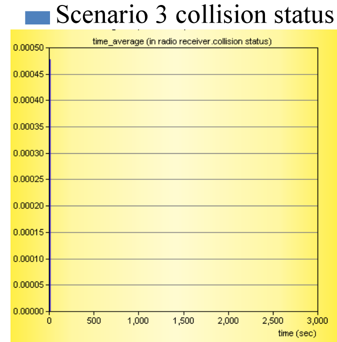
Scenario 1 collision status at 100% duty cycle
Scenario 1 collision status at 50% duty cycle



scenario 3collision status at 50%
Scenario 3 collision status at 100%



Scenario 1 GTS node2 collision status at 50%
Scenario2 GTS node 2 collision status at 50%



scenario 4 collision status at 100%
Scenario 4 collision status at 50%

Figure 11: Analysis of collision status

4.5 Bit Error Rate. This parameter represents BER among the bit of the packet which is completing arrival at the receiver channel .Scenario 1 is highly dense node scenario which reveals high BER at 100% duty cycle. As we compare Scenario 1 PAN node with scenario 4 PAN which is very low dense node area , results reveal that high density area has high BER while very low dense area's PAN show no BER at 50% duty cycle. Now, we compare scenario 1 and 2 PAN node for radio receiver BER at 50% duty cycle. End nodes of scenario 1 are close to PAN node as compare to scenario 2 node, Scenario 1 results show low BER due to small distance. Last comparison between scenarios 4 for both duty cycles, there is no BER in case of very low density area.

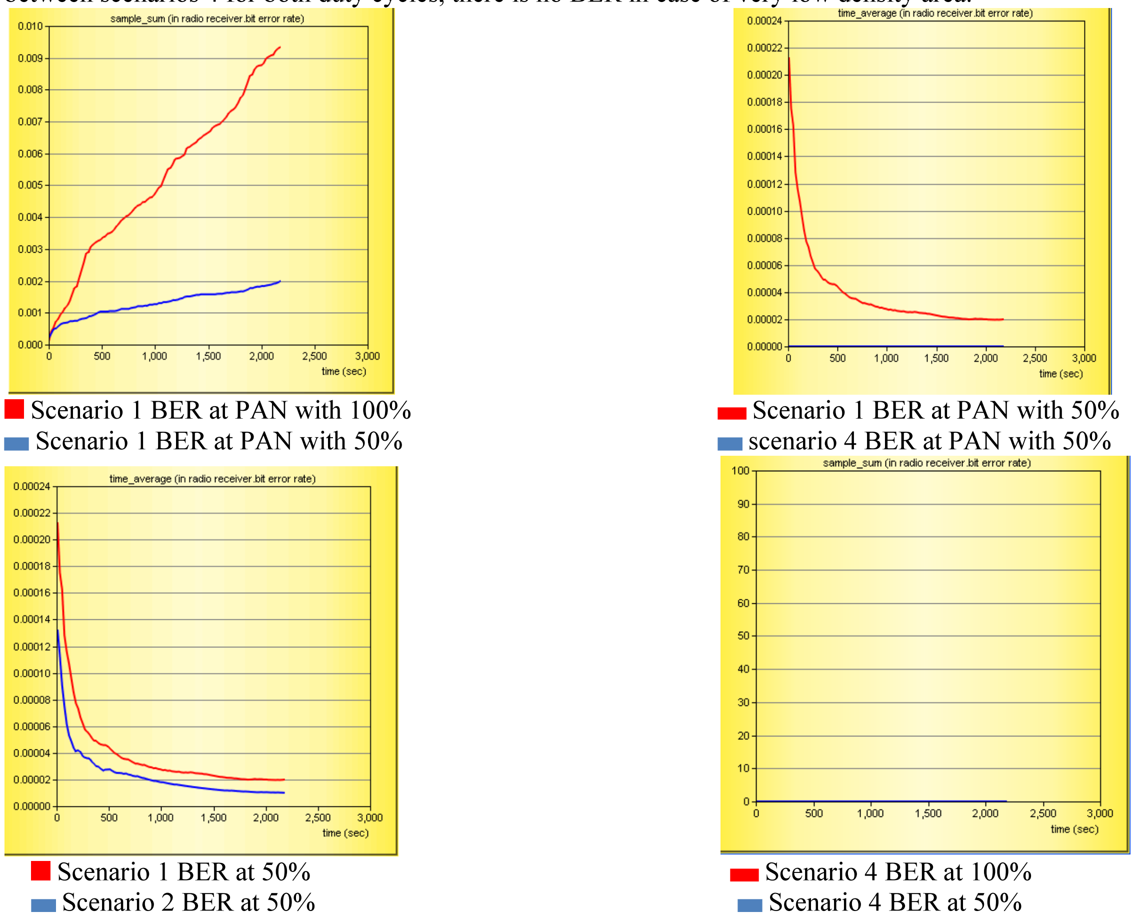


Figure 12. Analysis of Bit Error Rate for node density and distance

5. CONCLUSION

In this paper, we have analyzed wireless sensor nodes in term of distance and node density at different duty cycles. Our aim is to prolong the lifetime of sensor nodes in wireless environment. Results have revealed that energy consumption is directly proportional to distance and node density. We have analyzed energy consumption for throughput, E2E delay, collision status and BER parameters at 100% and 50% duty cycle. It is noticed that it is useless to offer sleep mode at very low node density. The results which suggested that at very low node density, higher energy consumption was obtained at 50% duty cycle, which is due to high E2E delay and collision status.

If we place end node at a larger distance from its PAN node, it has shown high E2E delay. If we compare same scenario for 50% and 100% duty cycle, it demonstrates that 100% duty cycle has less E2E delay as compare to 50%.

Collision status and BER is found low at 50% duty cycle. As we concern with less consumption of energy, 50% duty cycle is preferable at PAN node with small distance and accurate node density due to low BER and collision status. Derived results narrate that very small node density has caused high collision of traffic and shown same result at both duty cycles, thus it is futile to offer sleep mode at very small node density.

Future work is required to improve the performance of IEEE 802.15.4 in terms of duty cycle, at 50% duty cycle, E2E should be minimum and throughput should be high but we conclude that it does not show best results.

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