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# Design Energy Efficient SMAC Protocol for Wireless Sensor Networks using Neighbour Discovery Scheduling Algorithm

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**ABSTRACT**
Wireless sensor networks have recently attracted much attention from research. This project reviews the medium access control (MAC), which is a capable technology in wireless sensor networks called SMAC (Sensor-MAC). MAC protocols control how sensors reach a shared communication channel to communicate with neighbors in small area coverage. SMAC sets the protocol nodes to sleep during the transmission of other nodes. During this large amount of time waste in the data communication process, the neighbor node has to wait till the nodes get started. Also, many packets are lost when all the nodes send the data packet simultaneously to a single node and this leads to data loss or corrupt data. In wireless sensor network the efficient use of energy leads to enhance the network lifetime. Idle listening, collision, control overhead and over hearing are the main reasons of energy waste in SMAC protocols. Thus, to conserve energy and enhance network lifetime we propose a new contention-based Energy Efficient SMAC protocol called EE-SMAC for wireless sensor networks.

***Keywords:*** *Wireless Sensor Network (WSN), Media Access Control (MAC), Sensor-MAC (SMAC), Energy Efficient SMAC (EE-SMAC), Idle Listening, Collision, Overhearing.*

## 1. INTRODUCTION

WSN [6, 10] is related to energy consumption and sensing applications in sensor nodes. Sensor nodes should operate using limited energy sources (batteries) due to their small size. Since the MAC protocol has full control over the wireless radio, so their design can contribute significantly to the overall energy requirements of the sensor node. The MAC [1] protocol in WSN, the nodes do not always need to activate. They allow medium periodic access to the transmission of data and put their radio in low-power sleep mode between periodic transmissions. The amount of device spent in active mode is called duty cycle.

Sensor Medium Access Control (SMAC) is an important technique that enables the successful operation of the network. One fundamental task of SMAC protocol is to avoid collision so that two interfering nodes are not transmitted at the same time. If higher energy efficiency demands are also considered, then it becomes clear that the design of MAC protocol for WSN is a daunting task [2]. The following features are considered for preparing a good SMAC protocol for wireless sensor networks. The first throughput is then the packet is delayed and finally the end is delayed. As the sensor nodes are likely to operate before the battery, and it is often difficult to replace or recharge the batteries for these nodes [10]. In fact, someday it will be expected that some nodes will be so cheap that they will be abandoned rather than recharge.Long-term network lifetime for these nodes is an important issue. Another important feature is scalability and adaptive for network size change, i.e. the number of nodes in the network. Some nodes may die over time; some new nodes may join later; some nodes can go to different places. A good MAC protocol should adjust the changes in this kind of network behavior [4].

## 2. Issues in SMAC Protocol

Three major energy wastage events occurring at a SMAC layer have been identified:

1. Collision results in energy wastage due to retransmissions of collided packets.
2. Overhearing occurs when a node listens to transmissions not intended for it, needlessly wasting power.
3. Idle listening occurs when nodes listen in the hope of receiving any possible data, also wasting energy.

Thus, due to above reasons all the nodes get dead in very less time after being deployed for any applications. And the network is to be again requiring maintaining and upgrading for continuous servicing of the application. Thus, the changes can be made in SMAC protocol itself by reducing the duty cycle so that the energy consumption can be minimized. In case of single hop routing, long time is required for data transmission and the energy gets depleted during this time and the nodes get in active.

To improve this more than one hops can be used to transmit the data to the destination. Thus, the throughput, energy consumption and network lifetime of the WSN can be improved. The objective of this work is to develop an "Energy Efficient SMAC" protocol for WSN in order to reduce the consumption energy by all the nodes in the WSN so that more number of nodes remains alive for long duration in the network which will result in improving the lifetime of the network. Also, this paper investigates the performance of the proposed EE-SMAC protocol by calculating the end-to-end delay, total energy consumed and throughput of the network.

## 3. Related Work

Author [2] recognizes necessary changes in traditional MAC protocols so that WSN may be suitable review some MAC protocols that expand the energy efficiency and their properties and defects. Common sources Energy waste, control packet overhead, idle listening, overhearing and over emitting. Communication patterns such as broadcast, cast convergence, local gossip and multicast are reviewed and their Applications are discussed in different types of scenarios.

MAC [16] protocols like SMAC, T-MAC, Wise MAC, TRAMA, SIFT, D-MAC and DSMAC are reviewed with their respective work, advantages and disadvantages. In the end the underlying technologies like TDMA, FDMA and CDMA are briefly explained in the context of the MAC layer in WSN. There are several MAC layer protocols [17] proposed for the sensor network, there is no protocol accepted as standard. After going through the background work, it is found that there are several existing MAC protocols for the WSN including the SMAC. SMAC [8] is the most popularly used MAC protocol for WSN.

## 4. Proposed Approaches

SMAC is a contention-based random-access protocol with a fixed listen/sleep cycle. It uses a coordinated sleeping mechanism, similar to the power saving mechanism of IEEE 802.11. SMAC [5] design is to reduce energy consumption from all the sources that we have identified to cause energy waste (collision, overhearing, idle listening, and control overhead) while supporting good scalability and collision avoidance. To achieve the design goal, we use the SMAC that consists of three major components: periodic listen and sleep, collision and overhearing avoidance, and message passing. This project proposes an EE-SMAC protocol with:

- A new threshold value for all the nodes i.e. the time for which the node will remain active will be minimum.
- Load balancing (energy consumption by all the nodes should be equal) with duty cycle.
- Collision in the packet transfer is to be minimized by using RTS, CTS packets.
- Data is forwarded to the nodes which are in its nearest neighbour so that less power will be consumed in data transmission process.

This protocol uses low-powered Sink Node to synchronize the nodes and to schedule their transmissions and receptions in the network. Sink node is mainly the Access Point which will gather topology information and announces the transmission schedule to the other nodes. Considerably SMAC operates on duty cycle and Energy Efficient SMAC operates on load balancing by minimizing minimum duty cycle using a node to node transmission so that the intermediate node distance will be less or the number of intermediate nodes is less. So, energy usage is less and efficient. The "Neighbour Discovery Scheduling Algorithm" will minimize the delay in transferring the packet from source node to the Sink Node.

**Algorithm:**

1. Define the Initial node Si and Destination Node Di
2. Find the Min Distance and Min Distance Path between Si and Di
3. Find All N Neighbour Nodes of Si called
4. Neighbour i<Distance Vector for I=1 to N
5. Find Min Distance, Min Energy, and Node for all the Neighbours nodes
6. If (Energy (Neighbour)) =Min Energy&&
7. Node (Neighbour) <=Threshold && Distance (Neighbour) =Min Distance
8. Set Neighbour node as Next node
9. Else if Distance (Neighbour) =Min Distance
10. Set Neighbour node as Next node
11. Else (Energy (Neighbour)) =Min Energy
12. Set Neighbour node as Next node
13. Else if (Energy (Neighbour)) =Min Energy and Distance (Neighbour) =Min Distance
14. Set Neighbour node as Next node
15. If Node (Neighbour) has data to send
16. Set Node as Active
17. If Node is Active and Receiver wants to send
18. Send RTS to receiver
19. Send CTS by receiver
20. Data transmission begins
21. No packet Collision
22. Else If Node is Active and Receiver is not ready to receive
23. Data loss
24. Else If Node is Active and Receiver do not wants to send
25. Energy Loss
26. Else
27. Collision occurred, retransmit and reschedule
28. Else
29. Set Node as Sleep
30. No energy loss

**5. Simulation Methodology**

This section illustrates, the work which has been performed using NS-2 simulator and compare the result of EE-SMAC protocol with SMAC protocol with respect to different parameters like residual energy consumption, throughput, packet delay ratio and end-to-end packet delay by varying the inter arrival time of data packets or message.

Table shows the important simulation parameters used in the simulation process. The simulation is done in a 5 x 5 flat grid star topology having 25 nodes one node is the Sink node also can be called as Access Point. It is the node which acts as the destination node for all other 24 nodes in the network. Sink Node is marked as SINK_NODE on start of simulation. The Sink node acts as the network coordinator and performs the entire task such as scheduling synchronizing of the nodes etc. if any node wants to transmit the packet it first becomes active and sends RTS signal to receiver nodes. The receiver nodes in turn send the CTS signal and the data transmission begins between the two nodes.

During this data transmission if any other node wants to transmit the data to the node that is already in process of communication, it will send the request to the Sink Node and goes to sleep state. The Sink Node will perform scheduling after the first communication of receiver nodes gets complete and the requested node will then wake up. Thus, the time for which the node remains active gets minimized since the duty cycle is reduced.

For transmitting the data to the sink node from the node that is too far, the neighbour node is calculated by finding the minimum distance between the two using the GPS system and the nearest node is chosen for forwarding the data packet. Thus, all the nodes get active for short interval of time and the energy of all the nodes remain almost equal which results in load balancing. The rest of all the nodes are sensor nodes with no any marking so as to present clarity in the animation. The energy of the entire node is set as EM variable using Energy Model.

Finally, the Perl script is used to plot the graph of the proposed algorithm (i.e. EE-SMAC). And these graphs are compared with the SMAC protocol on various parameters given below. It has been found that the network lifetime and throughput of the WSN is better when we use the proposed algorithm than that of using SMAC protocol. Also, more nodes are alive in case of using proposed algorithm for data transmission. The different simulation parameters that have been set up are given below:

**TABLE: Parameters used for simulation**

| DESCRIPTION | PARAMETER |
|---|---|
| Traffic type | CBR |
| Channel type | Wireless/Phy |
| MAC layer | Sensor MAC |
| No. of nodes | 25 |
| Propagation model | Two rayground |
| Queue length | 50 |
| Interface type | Drop Tail/PriQueue |
| Antenna type | Omni Antenna |

## 6. Parameters for Comparison

**a. End-to-end delay**

Average End-to-End delay is a metrics used to measure the performance with time taken by a packet to travel across a network from a source node to the destination node. The average end to end delay of a data packet is calculated by subtracting time at which first packet was transmitted by source from time at which first data packet arrived to destination.

End-to-End Delay=Σ (arrive time – send time) / Number of connections

**b. Remaining Energy/Residual Energy Consumption**

Residual Energy = Total Energy Consumed – (Total no. of packets sent + Total no. of packets received+ Total time spend by the devices in sleep mode)

**c. Throughput**

Throughput of a network can be defined as the number of successfully delivered packet.

**d. Packet Deliver Ratio**

The packet delivery ratio is the ratio of number of packet received to the number of packets sent in network.

## 7. Results& Discussion

In this paper we compared SMAC and EE-SMAC under varying traffic load. The snapshots below show the NAM output of 25 nodes. Fig.1 shows when energy model is configured for the nodes the color of the node automatically sets to green

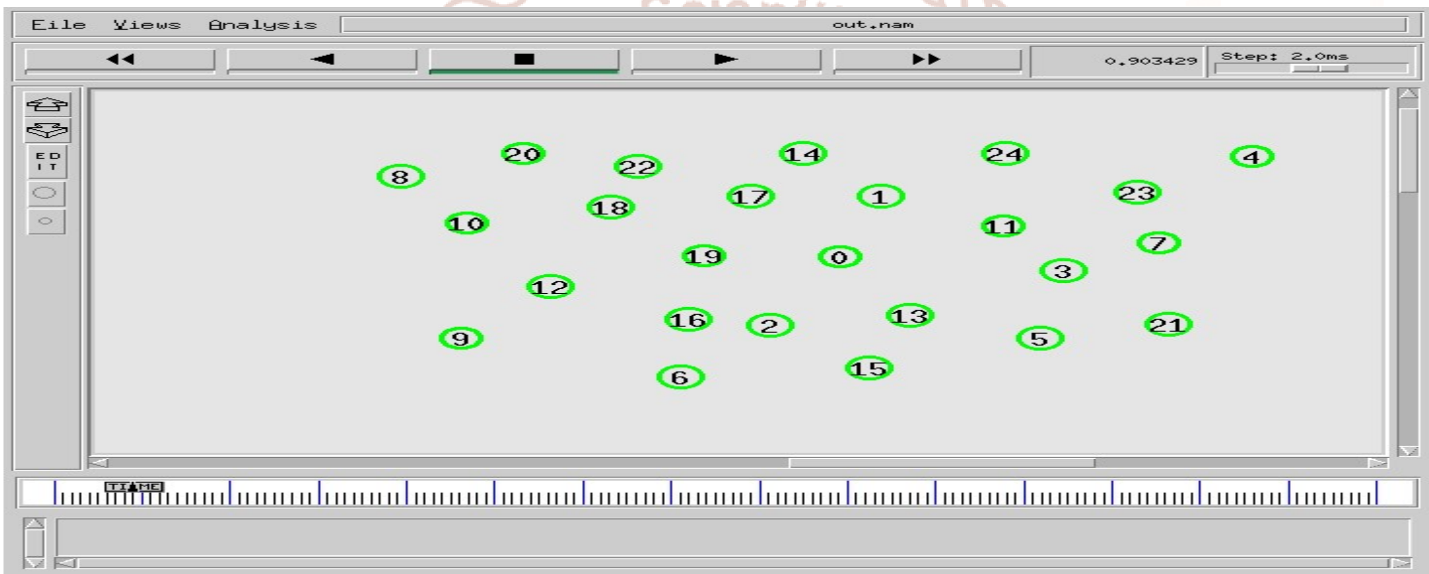


**Fig.1 WSN Scenario with 25 nodes at time t = 1s**

Fig.2 shows the data transmission between the nodes. When the node's energy gets depleted its color automatically changes to yellow.

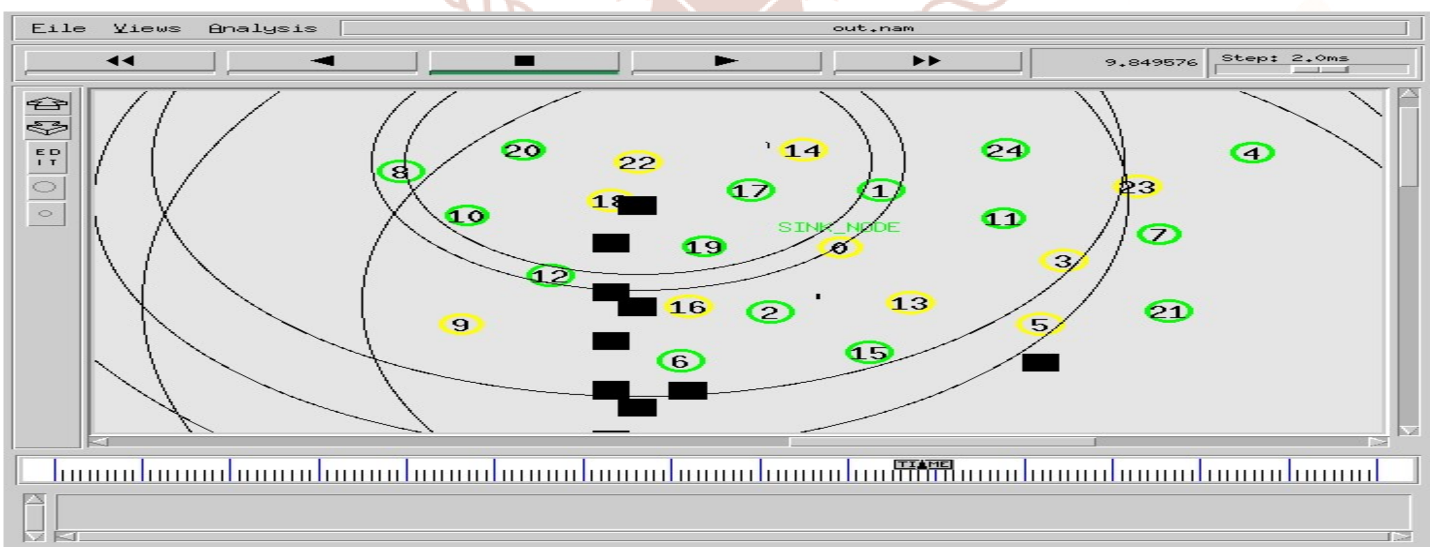


**Fig. 2. WSN nodes depicting its energy levels at time t-=10s**

Fig.3 shows the energy level of nodes at time t = 14s. When the energy of the nodes becomes very less or zero as the time increases then the node's color automatically changes to red.

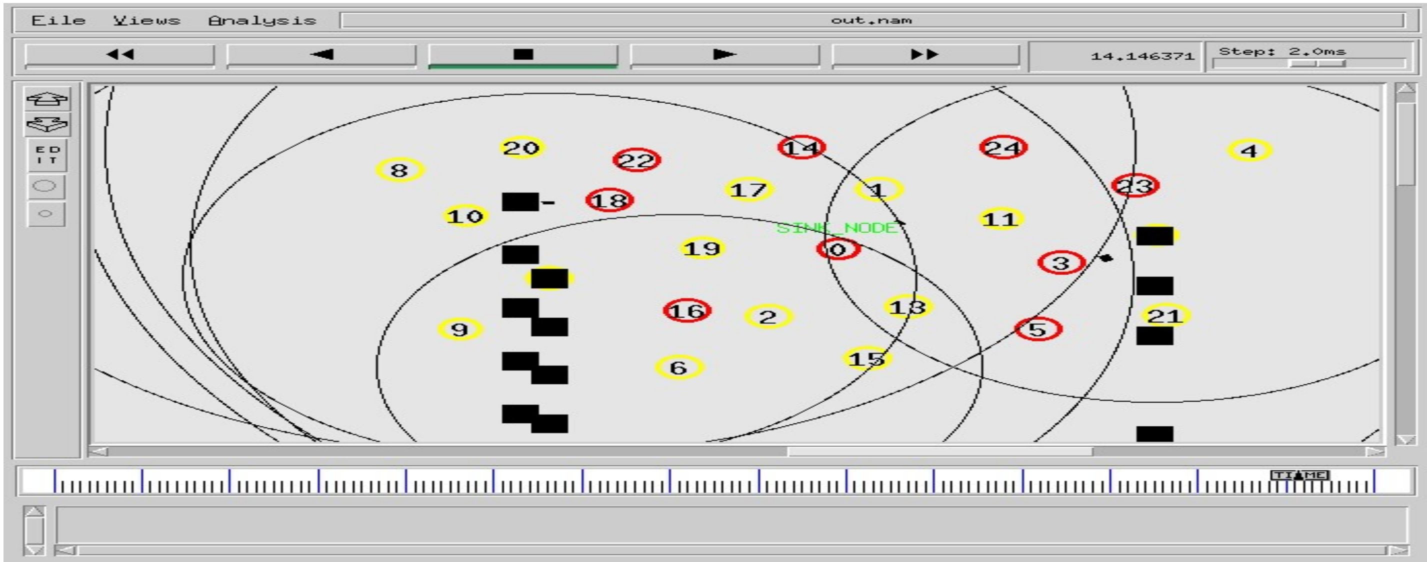


**Fig. 3 WSN nodes depicting its energy levels at time t-=14s**

The average residual energy consumption under various packet interval times for EE-SMAC and SMAC is plotted in Fig.4. Variation of energy consumption in EE-SMAC under high density traffic is less than that of SMAC. From fig.4, it can be concluded that EE-SMAC better perform than SMAC both under low and high traffic densities.

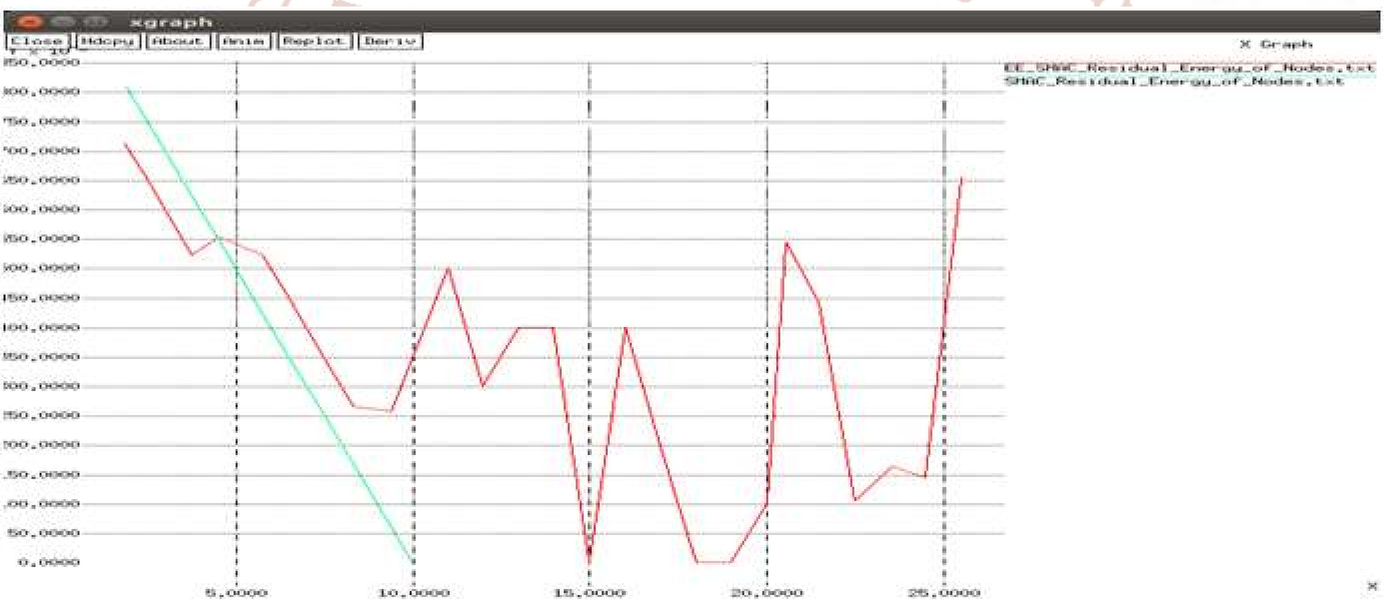


**Fig. 4 Residual Energy of Nodes**

Fig. 5 and Fig. 6 shows the End-to-End Delay and Packet Delivery Ratio respectively, with different traffic density for SMAC and EE-SMAC protocols. For SMAC packet delivery ratio is increases in low density traffic, whereas for high density traffic delivery ratio decreases. In EE-SMAC the variation of average end-to-end packet delay and delivery ratio is better perform as compare to SMAC through load balancing technique.

X-Axis Residual Energy in Joules

Y-Axis Times in Second

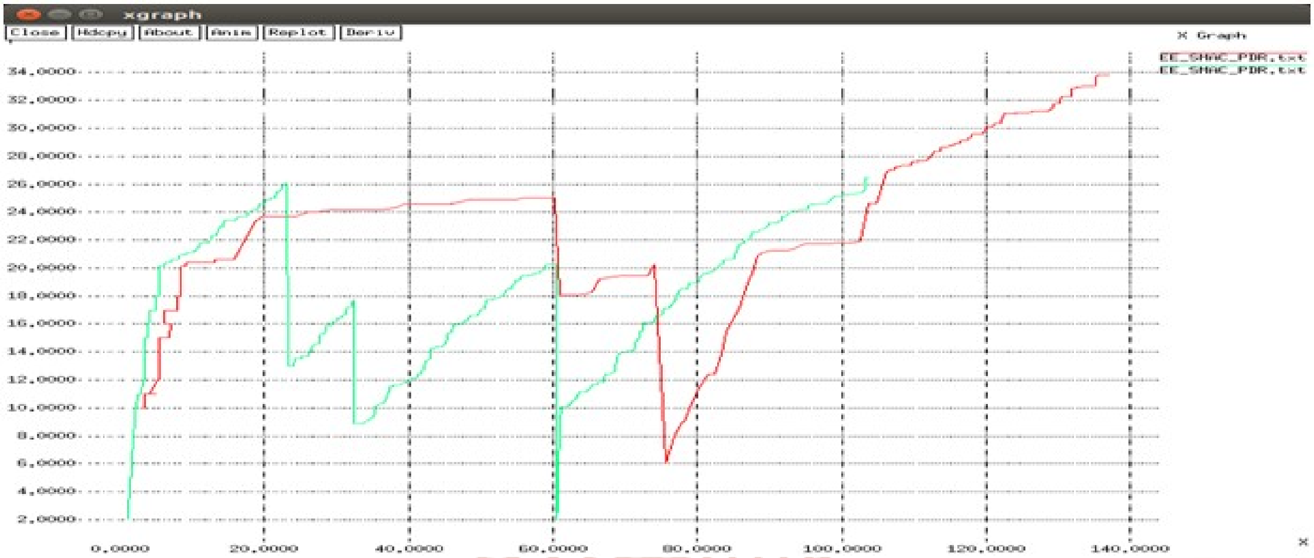


**Fig. 5 Packet Delivery Ratio**

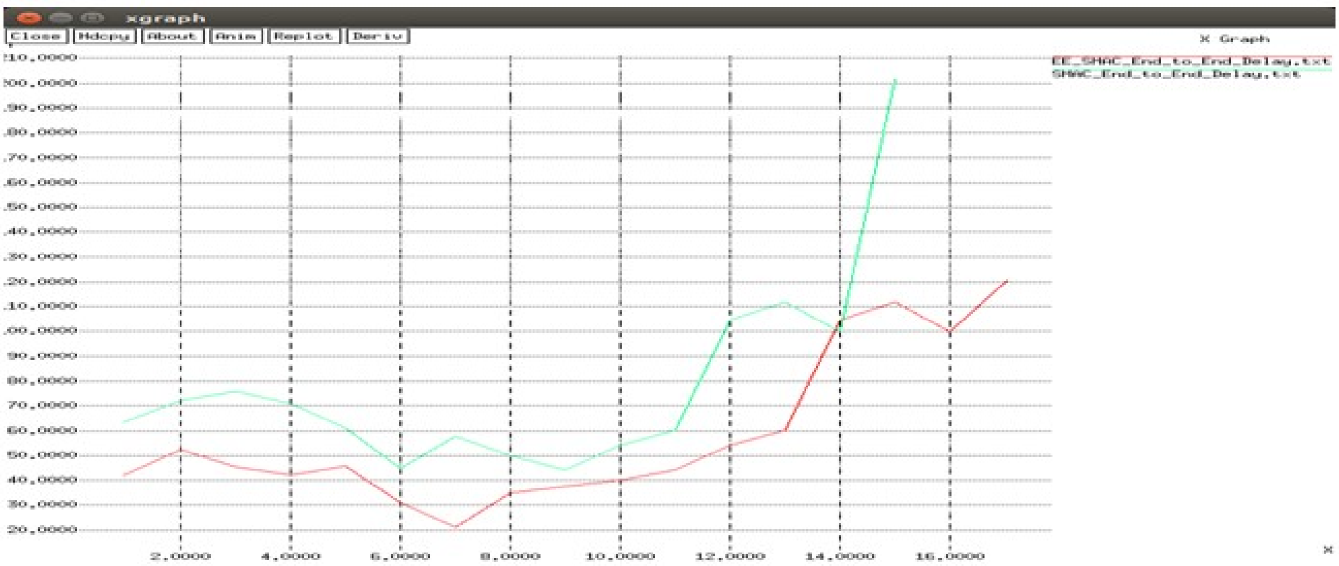


**Fig.6. End-to-End Delay**

Fig. 7 shows the variation of average throughput with different traffic density for SMAC and EE-SMAC protocols in graph. EE-SMAC performs better than SMAC protocol under the variation of low traffic density to high traffic density.

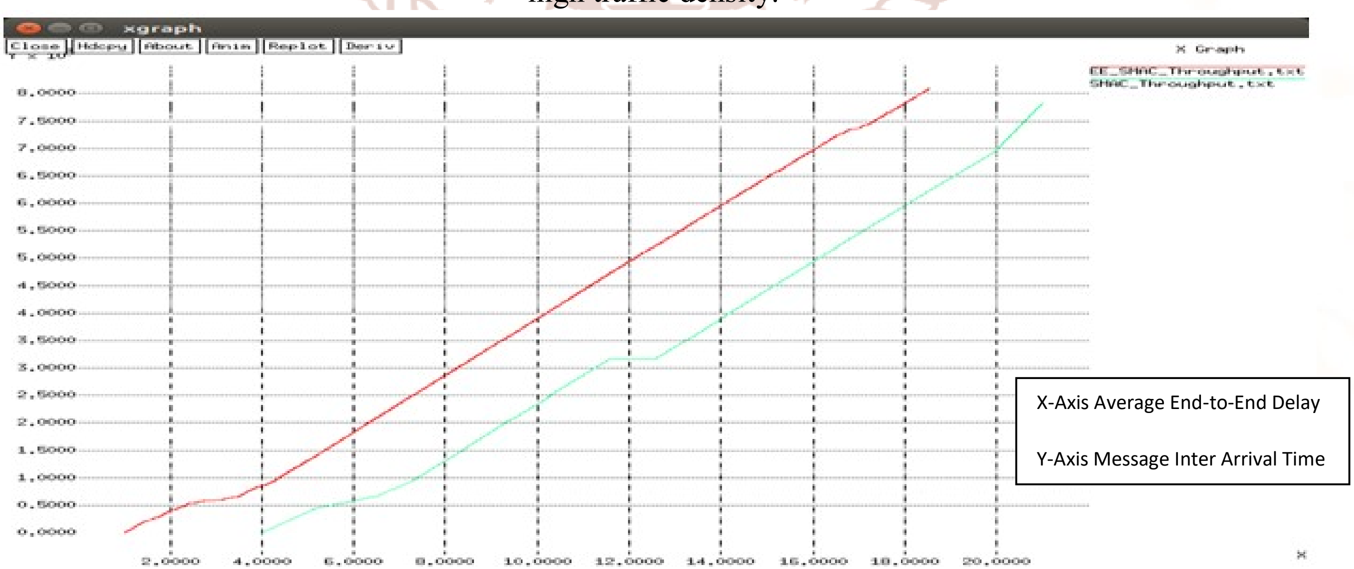


**Fig.7. Throughput**

**7. Conclusion and Future Scope**

Several MAC layer protocols have been developed for WSN. One of them is SMAC in which there are some issues. This project proposes the EE-SMMC protocol for the WSN and examines it with SMAC protocol for WSN in relation to various performance metrics such as delays, residual energy and throughput and packet distribution ratio at the end of the NS2. The proposed algorithm shows significantly better results by reducing the duty cycle of nodes, more and more nodes are active for long periods of time period when neighboring nodes are used for long periods of data transmission. Thus, the use of EE-SMAC protocol throughput of the network increases. Delay in transmitting packets is also minimal and using a pre-SMAC protocol, a large number of packets are distributed, indicating that the minimum packet is collision. Duty cycle adjustment and variations in other network parameters can be done in future in so as to improve the network performance. Also, effect of varying duration of duty cycle and node synchronization can be addressed as a partfuture work.

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