Clustering and Traffic Distribution Approach for Load Balancing in Wireless Sensor Network

Ms. Tejal Irkhede[1] Ms. Shruti Tiwari[2] Ms. Prerna Deshmukh[3] Ms. Vaishali Jadhao[4]
Assistant Professor[1, 2, 3, 4], Priyadarshini College of Engineering, Nagpur, Maharashtra, India

***Abstract* -- One of the major challenges in wireless sensor network (WSN) is to curb down congestion in the network's traffic, without compromising with the energy of the sensor nodes. Congestion affects the continuous flow of data, loss of information, delay in the arrival of data to the destination and unwanted consumption of significant amount of the very limited amount of energy in the nodes. In wireless sensor networks (WSN), unbalanced load allocation results in congestion. Load balancing is of great importance in wireless sensor networks because of the limited resource constraint. Proposed method combines the idea of clustering and traffic allocation protocol to achieve load balancing and network life time. Analysis and simulation shows that the new approach can improve the network performance in terms of network life time, energy, load balancing, end-to-end delay, packet drop ratio.**

***Keywords*- Clustering, disjoint path, load balancing, traffic distribution, wireless sensor network (WSN).**

INTRODUCTION

Wireless sensor network (WSN) is a collection of nodes organized in cooperative network. WSN are characterized by low power sensor node that periodically sensed the data to one of several sink nodes in disjoint path manner. Wireless sensor network can efficiently provide environment monitoring for many civil and military applications [1].

Roughly speaking, the aim of congestion control is to optimally decide on the volume of traffic routed under a fixed set of routes. The aim of load balancing is to optimize these routes, assuming that the traffic requirement of all nodes is predetermined, and not subject to optimization [2]. Many routing protocols have been proposed to reduce load from network. The increases in the WSN life time is result of evenly distributed the load on all discovered path. The node routes data through high energy nodes over nodes with lower energy, which effectively ensures that the low energy nodes remain alive for a longer period of time. Load distribution in a WSN is usually uneven due to factors such as network topology, hop factor, network connectivity and WSN application. Hence we aim to achieve the best possible load balancing in the network subject to such factors.

Energy efficiency is the important key for WSN. To achieve long lifetime in large-scale network, the network is divided into several clusters; each cluster includes its cluster head responsible for every activities which impact to network performance. In sensor networks, the sensor network can be grouped in to small clusters by their physical proximity to achieve better performance, and each cluster may elect cluster-head to coordinate the node in the cluster [3, 4].

In this paper we proposed clustering and traffic distribution protocol for load balancing in WSN. The proposed protocol effectively smooth out the traffic evenly on all discovers routes. Proposed protocol is to combine the ideas of clustering first and then traffic is evenly distributed in network.

This paper is organized as follow; methodology for registration of applications is explained in section II, in which during transmission of data traffic how data is distributed in network and random and explain the process of election of cluster head. Proposed methodology algorithm is given in section III. Simulation result and discussion are given in section IV and last conclusion is given in section V.

i. METHODOLOGY

In this paper, proposed load distribution protocol called clustering and traffic distribution to balance the load in network and increases the network life time. There are three steps in proposed algorithm initialization of network, clustering and traffic allocation. During clustering phase select the cluster head according to value of energy of nodes and adopt the same concept of round with E-LEACH. Cluster head is responsible for data transmission. Traffic allocation method distributes the data packet in split table manner according to capacity of routes. Figure.1 shows the basic idea of working. As shown in figure.1 S is source node and D is destination node. Source node sends the data packets D_{p1}, D_{p2}, D_{p3} towards the destination node D according to the capacity of the route. For example if data packet size is 5mb then capacity of route to carry the data packet is equal to 5mb or greater than 5mb. Sensor nodes collect the data packets coming from source node and forward to the nearest cluster head. One cluster head is sending the data packets to that cluster head which is nearest from destination node.

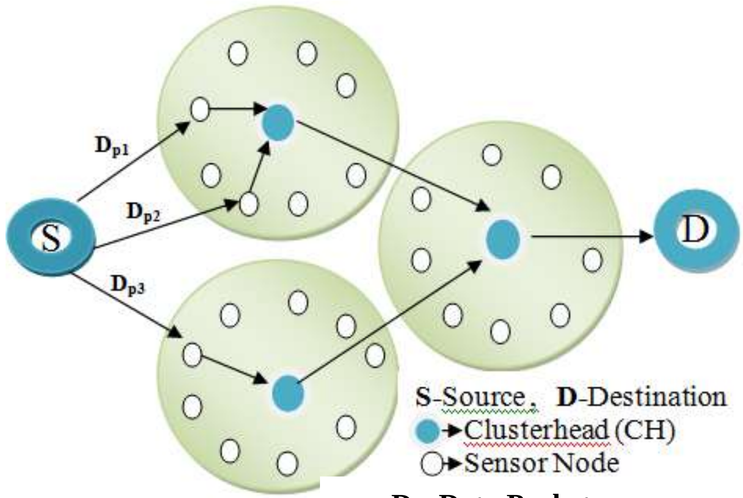

Fig.1.Basic Working Idea

A. Initialization of Network:

In this paper it is assumed that there are N sensor nodes distributed in square area. The assumptions are as follows.

i. Base station (BS) is fixed and located far away from the square area.
ii. Cluster size is random
iii. Energy level of each node sends to the BS

B. Selection of Cluster Head

Although clustering protocol like LEACH, LEACH-V, and ELEACH prolongs the network lifetime in contrast to plane multi-hop routing and static routing, it still has problem of overload energy consumption. Cluster heads (CH) are selected without considering the energy at node. The nodes with low energy have same priority to be a cluster head; thereby the consumption of system energy is increases.

To ensure that energy is distributed throughout the network, the additional parameter ε_j including the average energy and the consumed energy for transmitting data are applied to optimize the process of cluster head selection. All Sensor nodes calculate value of ε_j according to the information of remaining energy once selected as cluster head and then send it to the BS. The node whose value of ε_j is high selected as CH of the network and broadcast the information to the member node. For CH election of any node in next round depend on decision made by the node by choosing random number (N) between 0 and 1. If number is less than threshold T(n) the node become cluster head for next round [5]. The threshold T(n) is set as:

$$T(n) = \begin{cases} \frac{P}{1-P^*(r mod \frac{1}{P})} * \varepsilon_j & , n \in G \\ 0 & , Other \end{cases} \quad (1)$$

Where, εj is average energy of node.

$$\varepsilon_j = \frac{E_{initial} - E_{Current}}{E_{Initial}} \quad (2)$$

$E_{initial}$ is initial energy of node and $E_{current}$ is current energy of node at the r round, P is probability of node being cluster head, G is set of nodes that are not cluster head in last 1/P rounds.

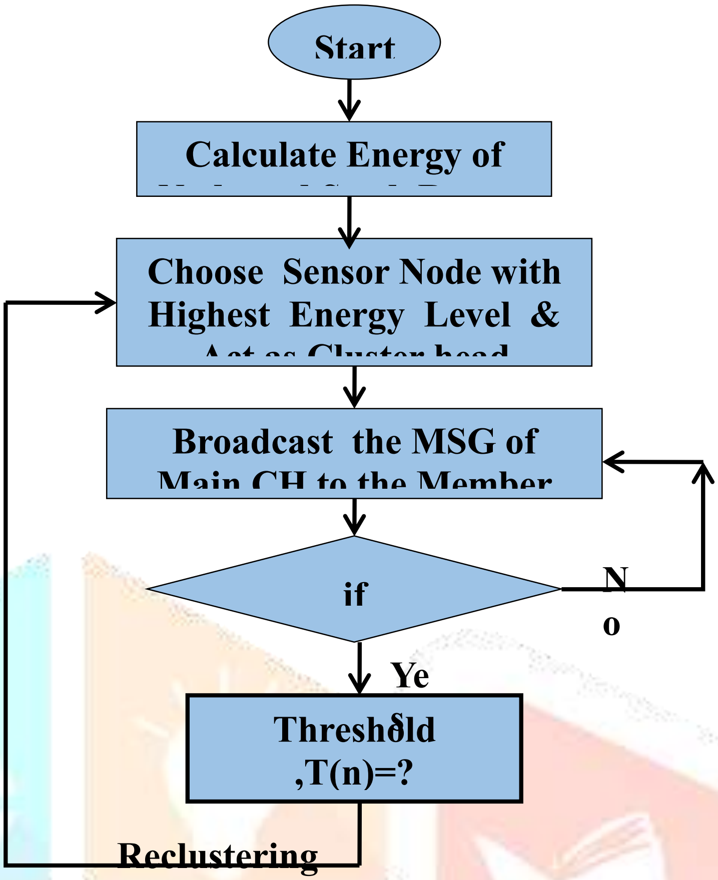

Fig.2.Flowchart for Cluster head Selection

C. Traffic Allocation

Traffic allocation strategy used to deal with how the data is distributed among the all discovered path. Traffic allocation start from source node till the data transmitted up to the destination. Traffic allocation start after finding the multipath routes using on demand routing strategies. Path selected which have the highly available back up node on that path i.e. reinforced path. Traffic allocation consist of two part first is route weight assignment method and second is distribute the load evenly among the all discovered path.

i. Route Weight Assignment :

The proposed method calculates the weight for each route and assigns weight to each route. The weight reflects the route capacity to deliver the data packet from source to destination.

Calculation of weight of each route according to formula used in [6]:

$$\mathrm{Path_j} = \frac{\varepsilon_j}{\lambda_j * (h_j)^{\beta}} \quad (3)$$

Where, $Path_j$ is weight of route j,

ε_j is remaining energy at node calculate in equation (2),

λ_j is load for the route j,

h_j is the number of hop for route j calculate in equation (7),

β is the network hop factor, it is define the impact of route number of hops on the weight for route j.

For calculating the weight of route we have to calculate the network factor which is considered for weight route calculation. The wireless sensor network factor formula is proposed in [TSP].

The network factors are:

a. Network Size factor:

It is the average number of hopes from all nodes to destination [TSP].

$$S_f = \frac{\sum_{i=1}^{i=L}(i * L_i)}{N} \quad (4)$$

Where,

S_f is the network size factor

L is lowest layer order

L_i is number of nodes in network layer i
N is number of node in network

b. Network routing factor:
Network routing factor calculate the average number of route discovered by node[TSP].

$$r_f = \frac{T}{N} \quad (5)$$

$$r_f = \frac{\sum_{i=1}^{i=N} t_i}{N}$$

Where,
γ_f is the routing factor
T is total number of routes discovered by all nodes
N is the total number of node in network
t_i is total number of routes discovered by node i

c. Network connectivity Factor:
Network connectivity factor calculate average number of node connected to any node [TSP].

$$c_f = \frac{\sum_{i=1}^{i=N} c_i}{N} \quad (6)$$

where,
C_f is the network connectivity factor
c_i is number of node connected to node i

d. Network Hop Factor (β) :
β define impact of number of hope on the weight assigned to route. As β is get smaller, the weight assigned to route is bigger that means it select the longer route. β is get bigger, the weight assigned to route is smaller.

$$\beta = \frac{1}{3}\left[\frac{s_f}{(s_f+1)} + \frac{r_f}{(r_f+1)} + \frac{c_f}{(c_f+1)}\right] \quad (0< \beta >1) \quad (7)$$

ii. Traffic distribution :
Traffic distribution starts after route assignment method. The traffic is distributed among all discovered route according to weight of route. For example if weight of route j is 5mb then j route allow for transmission only 5mb or less than 5mb data packets. For total network we calculate the actual work load by using formula

$$W_j(k_i) = \tilde{n}_j * k_i \quad (8)$$

Where ,
$Wj(k_i)$ is the expected work load i.e. theoretical work load calculated on the basis of network factor.
$\tilde{n}_j$ is the normalize route for the route j
k_i is the number of messages forwarded by the node i

The goal of traffic allocation method objective is

- To minimize the workload on all routes
- Minimize the energy consumption and increases the network life time
- To minimize the end to end delay
- To achieve the maximum packet delivery ratio.

Figure 3 shows the complete flowchart of traffic allocation.

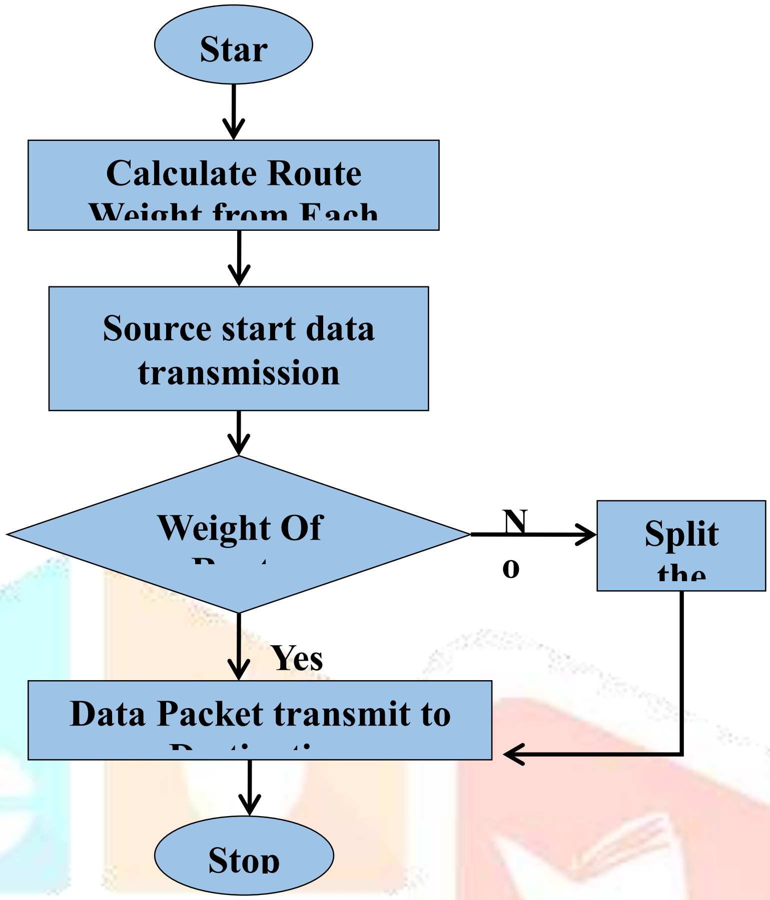

Fig.3.Flowchart for Cluster head Selection

ALGORITHM OF PROPOSED METHOD

Step 1: Initialize the network
Step2: Calculate the energy factor of each node ε_j

$$\varepsilon_j = \frac{E_{initial} - E_{Current}}{E_{Initial}}$$

Step3: The node having highest energy factor considered as cluster head (CH) at initially
3.1 select the number (N) between 0 nad1,
if (N< T(n))
then , node become CH
Step4: Start packet data transmission from source to destination
Step5: Select the node which has highest no of routing factor to transfer the packet data
Step6: Calculate the weight of routes $\boldsymbol{Path_j}$,

$$\mathrm{Path_j} = \frac{\varepsilon_j}{\tau_j * (h_j)^{\beta}}$$

6.1 if weight of route is less than the packet data go to the **step 8**
else
go to step 8
Step7: Spilt packet data according to route capacity
Step8: Transfer the data packet to destination (Repeat step3to 8 till transmission completed.)

SIMULATION RESULT

This paper presents a detailed implementation of the WSN simulation module using Microsoft Visual Studio .NET 2008. Visual Basic is a programming language based on the original DOS language called BASIC (Beginners' All-purpose Symbolic Instruction Code).

The instructions can be used to define the topology structure of the WSN and the motion mode of the nodes, to configure the service source and the receiver, to create the statistical data track file and so on. To verify the proposed algorithm we will compare the result with earlier protocol E-LEACH and TSP.

D. Simulation Setup

A fifty sensor nodes are arrange in the field of 200sqm x 200sqm. As shown in figure 4 one source node and one destination node along with base station. The continue bit rate (CBR) traffic are used. All nodes are no longer mobile as long as they are place. Our simulation setting and parameters are summarizing in table 1.

Table 1
Simulation Parameters

No. of Nodes	50 or 100
Area Size	200 * 200sq.m
Queue Type	Drop Tail
Queue Size	100
Mac	802.11
Routing protocol	AODV
Transmission Range	15m
Simulation Time	50s
Traffic Type	CBR
Data Rate	100kbps
Initial Energy	5 J

E. Simulation and Analysis

There are a lot of parameters to evaluate the clustering and load balancing shames. In this work network load, network lifetime, amount of data messages received by base station are chosen to compare the performance of improved protocol with traffic splitting and E-LEACH. If nodes energy is equal to zero, we define the node is dead node.

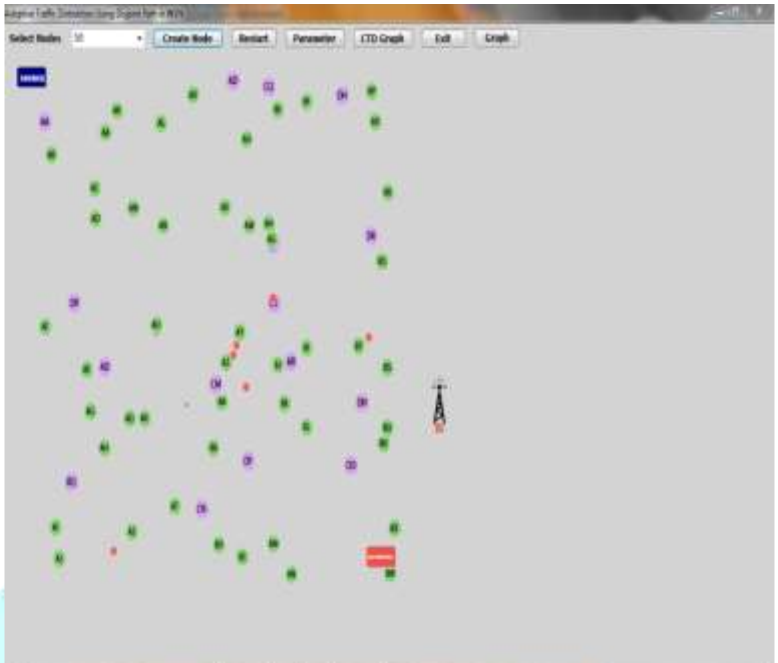

Fig.4.The distribution of WSN nodes

In Fig.5, x-coordinate represents the number of rounds and y-coordinate stands for the number of dead nodes per round. The number of dead nodes reflect the balanced of energy consumption in WSN. If percentage of dead nodes is less, increase the network life time. Fig 5 is the simulation result of network life time for proposed protocol and ELEACH protocol. The system life time increase by 30% of proposed protocol than ELEACH.

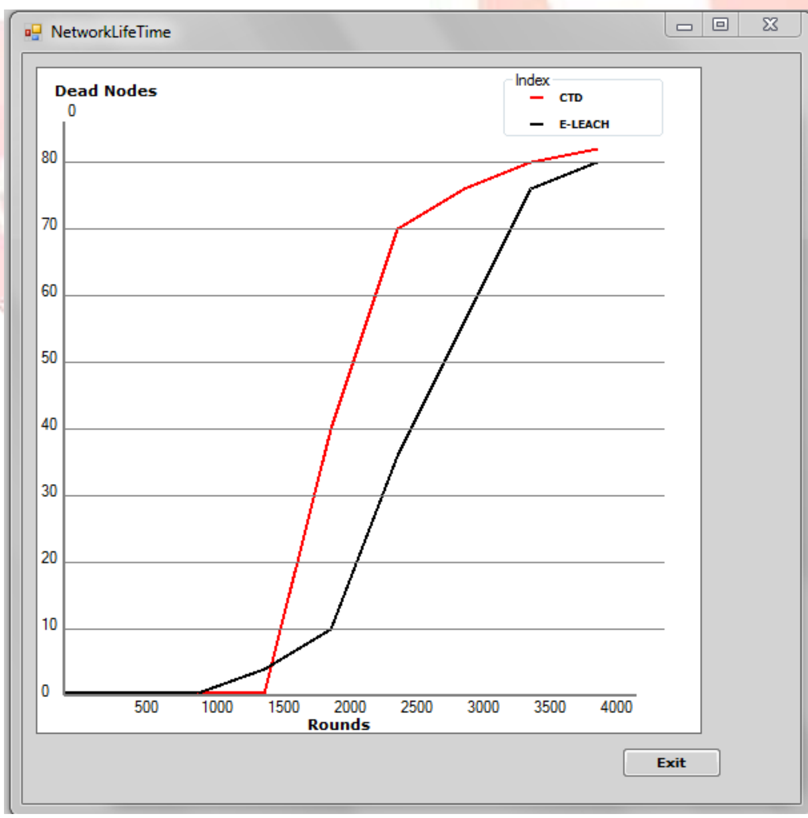

Fig.5.The comparison of life time between E-LEACH and CTD

In fig.6. x-coordinate represent the number of node alive and y-coordinate stand for the messages received at BS. Proposed method delivered 2 times more messages than ELEACH.

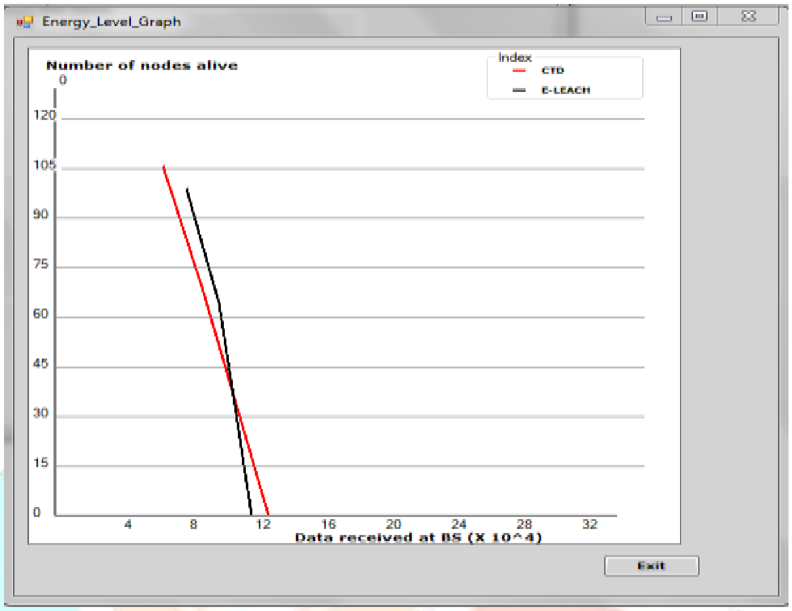

Fig.6. The amount of data message received by the BS with number of nodes alive.

Fig.7.shows the work load comparison between traffic splitting protocol and proposed method. On x- coordinate represent the frequency i.e. frequency of data packets and y-coordinate represent normalize residual work load (messages). Normalize residual work load is difference between actual work load and expected work load. Figure 7 shows that load decreases by 20% of proposed method than improved traffic splitting protocol.

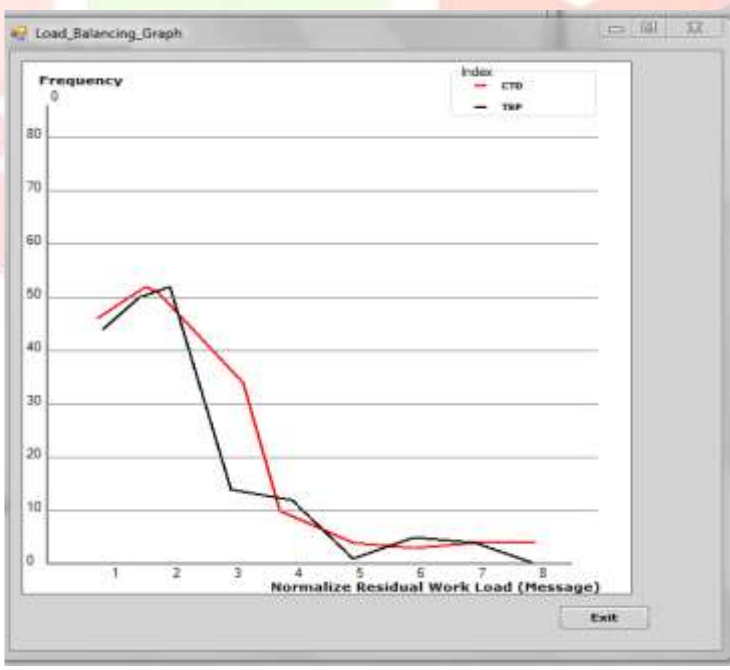

Fig.7.Work Load Comparison between TSP and CTD

The ratio of the data packet delivered to the destination to those generated by the CBR source is known as packet delivery ratio. Packet delivery ratio is calculated by dividing the number of packet received by destination through the number of packets received by the destination through the number of packets generated by source. It specifies the data packet loss rate or packet drop ratio, which limits the maximum throughput of the WSN. Fig 8 shows that data packets sent by source on x-axis and delivered fraction on y-axis. Its result of only proposed protocol.

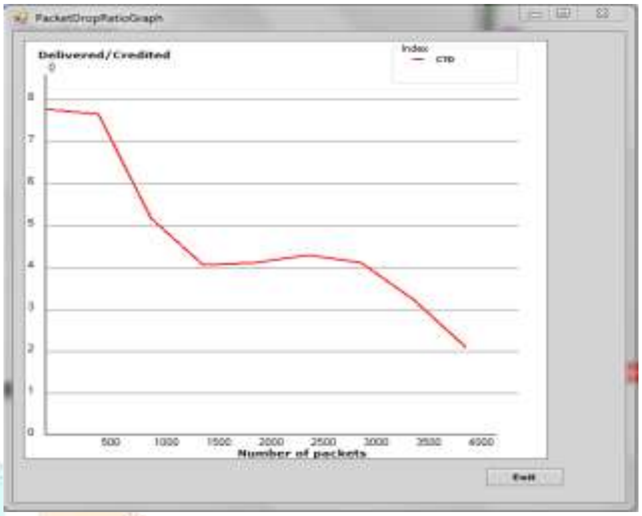

Fig.8.Packet Drop Ratio

Average end to end delay is the average time it takes a data packet to reach to destination in milliseconds. It is calculated by subtracting "time at which first packet was transmitted by source" from time at which first data packet arrived to destination. Fig.9. highlight the relative performance of proposed method.

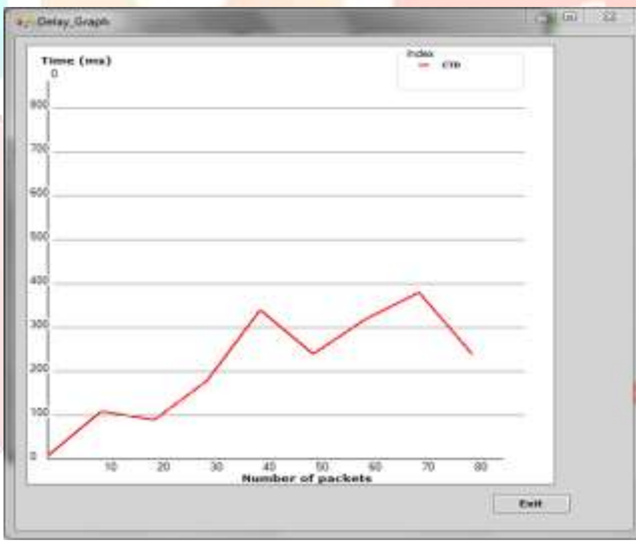

Fig.9. End to End Delay

CONCLUSION

Common WSN experience shows that link congestion, node failure frequently occur. This would cause the load balancing. Hence to avoid this problem the proposed protocol allows a sensor node to elect itself as a cluster-head based on its residual energy and distribute the data traffic evenly among the network by using multiple path. This proposed work is efficient for using the network resources, provide reliable data transmission and reduces the network overhead.

The simulation result shows that the proposed protocol outperforms both the ELEACH and TSP protocol in term of increases network life time, decrease energy consumption and decreases load balancing respectively. Energy consumption is 20% less as compare to E-LEACH and increases the life time of WSN. We tested the two additional parameters of proposed work first is packet drop ratio and second is end to end delay. The experimental results demonstrated that the congestion affected node consumes the free available buffer length of neighbor nodes to decrease the Average End to End Delay and to achieve high performance in terms of Packet Drop ratio.

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