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Fuzzy Based Improved EDCS Clustering Protocol for Hetrogenous Wireless Sensor Networks

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Abstract: This paper deals with increase of the network lifetime of EDCS protocol of WSN by utilizing the fuzzy waiting nodes. The major aim is to make improvements in the Fuzzy based EDCS for increasing the stable region of EDCS for clustering hierarchy method of WSNs in heterogeneous sensor networks. For finding the optimal cluster heads, the residual energies of the sensor nodes are used. The proposed technique does not necessitate any global information of energy at any time throughout the lifetime of WSNs. Fuzzy waiting nodes technique are used for the nodes which are waiting for a long time to be converted into a cluster head. The node which has the maximum fuzzy waiting node factor will generate maximum probability for becoming the cluster head. If in any case more than one node has the same value of FWV then First Come First Serve (FCFS) would be utilized.

Keywords: WSN, FCFS.

I. INTRODUCTION

Wireless sensor network consists of hundreds or thousands of nodes that communicate with each other through sensing and monitoring the physical world. A wireless sensor network consists of a large no. of small sensor nodes which are used for sensing the physical environment. These sensor nodes are arranged in such a way so that they can sense, monitor the movement in the network. In this, sensor nodes collect the data and send the collected data to sink node which have the maximum energy and then sink node aggregates the data which is sent by the senor nodes. These networks are mobile ad hoc networks and theses networks also not take the burden of sender and receiver. These networks enhance the lifetime of a network. And also balances the load among the whole network. Wireless sensor networks are currently working in a various applications ranging from medical to military, and from home to industry.

[Heinzelman, Chandrakasan et al. (2000)] presented communication procedure which have a major effect on the whole energy dissipation of WSN's. This paper introduced Low energy adaptive clustering Hierarchy protocol that uses randomized rotation of cluster heads to equally distribute the energy so that any single node does not lead to dead stage. Local synchronization is used to permit robustness for dynamic networks and incorporate data aggregation into routing techniques to reduce the amount of information that must be transmitted to base station. In this protocol, the nodes systematize themselves into local clusters. LEACH works in various phases. Communication starts with setup phase in which clusters is arranged and then comes to steady state phase in this data is sent to the base station. This protocol is used to enhance the network lifetime and also minimize the energy restrictions. This is also used to equally distribute energy among nodes at different time. At random time, every node had the responsibility of capturing the data from neighboring nodes and after compression, data is sent to the base station. **[Manjeshwar ,Agrawal 2001]** proposed the classification of WSN's based on their functioning such that Proactive or reactive . This paper introduced TEEN (Threshold sensitive energy efficient sensor network) protocol. TEEN is mostly used for reactive networks. Reactive networks are the network which reacts instantly to changes in parameters. In this technique, nodes sense the environment continuously .This protocol is mainly dependent on hard threshold and soft threshold, hard threshold is the value which was used by node for activation of their transmitter and sent notification to their cluster head. Soft threshold is the small changed value of sensed parameter which used for transmission. **[Heinzelman, Balakrishan 2002]** presented a low-energy adaptive clustering hierarchy(LEACH), a protocol architecture for micro sensor networks that combines the ideas of energy-efficient cluster-based routing and media access together with application-specific data aggregation to achieve good performance in terms of system lifetime, latency, and application-perceived quality. LEACH includes a new, distributed cluster formation technique that enables self-organization of large numbers of nodes, algorithms for adapting clusters and rotating cluster head positions to evenly distribute the energy Load among all the nodes, and techniques to enable distributed signal processing to save communication resources. Our results show that LEACH can improve system lifetime by an order of magnitude compared with general-purpose multihop approaches.

[Bandyopadhyay, Coyle 2003] presented a technique so that energy is reduced which is used in communication between cluster heads and base station. This paper focused on the designing of such procedure which arranges nodes into a hierarchy. This technique is based on single hop sensor network in which any node can communication with any other node and also with base station. This paper also proposed the three level hierarchal networks in this one level node communicate with their closest node on the second level. This procedure reduces the communication cost between nodes. Communication proceed in levels of hierarchy was error free and this procedure was particularly used for minimizing energy and cost of communication. **[Ye, Chen et al.(2005)]** presented an energy efficient clustering technique for wireless sensor network. In this, node selected as a cluster head mainly depends upon the residual energy. This scheme is same as that of LEACH. In this communication between nodes and base station was single hoped. It was fully distributed and in this cluster heads selection was depend only on residual energy. All the nodes compete with each other for becoming a cluster head and with maximum energy node declared as a cluster head and then other nodes join their respective cluster head so that minimum overhead occur among the network. It enhanced the network lifetime and minimizes communication overhead. **[Chen, Yu 2007]** proposed a uniformly distributed adaptive clustering hierarchy routing protocol. This routing technique is distributed and the selection of cluster head was only depends on energy distribution among the nodes in the network. Working of this protocol was divided into three main phases. First phase is cluster construction, in this cluster heads were selected and non-cluster head nodes join their respective cluster according to distance and then proceed to second phase which was the construction of cluster head tree. Tree constructed on the basis of weight. Cluster head with the maximum weight become the parent node of the tree. At last, cluster send their data to their cluster head on their allocated time slot and then cluster head aggregates data and send data to Base station directly. This protocol overcomes the drawback of LEACH and LEACH-C protocol. **[Chamam, Pierre 2009]** evaluated distributed energy efficient cluster formation protocol for WSN's. This protocol chooses the cluster head by using three way message exchanges. This protocol increases the lifetime of network. It also considered the residual energy for cluster head selection process. Three main messages exchanged between nodes were: Score Advertisement Broadcast (SAB) indicated the capacity of a particular node to act as a cluster head., Relative Cluster Head Rank Advertisement (RCRA) showed the particular status of selected cluster head ., Election Message used to declare finally cluster head which communicated with Base Station.

[Elbhiri, Rachid et al. (2010)] proposed Developed Distributed Energy- Efficient Clustering technique for heterogeneous wireless sensor networks. This focused on energetic and proficient technique of cluster head selection. This technique enhanced the lifetime of network and also balanced the cluster head selection on the basis of respective residual energy and initial energy. It also estimated ideal value of network which used for computation of energy which had expended. In this each and every node elects itself as a cluster head on the basis of initial and residual energy at every selection round. This technique was used for dynamic balancing of energy equally among the nodes in the network. **[Le, Mbogho et al.(2010)]** proposed the various clustering schemes for wireless sensor network's. In clustering scheme, each and every cluster send the data to their belonging cluster head and cluster head compress data and then that compressed data is sent from cluster head to base station. These schemes were used to minimize the energy which was used in transmission and also used to enhance the lifetime of network. These techniques also minimized the overhead between nodes. LEACH, EECS, HEED, EEUC, EEHC are the various techniques which were used for clustering procedure.

[Ren,Chen et al.(2012)]introduced an efficient ring based multihop clustering routing protocol for WSN's. This protocol was not only focused on the residual energy but also consider the cluster head number for the selection of cluster head. This protocol includes multi-round clustering. In this every node select itself as a cluster head on the basis of distance factor. After cluster head selection, cluster head send notification to all other nodes to tell them that in this particular ring that become the cluster head .The other nodes join the cluster head on the basis of distance. Distance factor was introduced to save the energy. In this, nodes are allocated their specific time slots .In this technique, it was not compulsory that at every round cluster head changed. This protocol overcomes the drawback of ring based multihop clustering.

[Hong,Zhang 2013] presented an efficient and dynamic clustering scheme protocol for heterogeneous multilevel WSN's . This protocol focused only on the cluster head selection process. In this, cluster heads are selected on the basis of energy which they have a particular round and also depends upon the energy which is consumed by nodes in each round. In this all nodes are assigned their slot time at this time particular node communicates with cluster head and according to assigned slots communication proceeds and then cluster head compress all the data which was received by nodes and then after compressing cluster head communicates with the base station directly .This protocol is used to remove the Shortcomings of LEACH, SEP, DEEC protocols.

II. VARIOUS ENERGY EFFICIENCY PROTOCOLS

2.1 DEEC

DEEC is designed to cope with nodes of heterogeneous WSNs. For CH selection, DEEC uses initial and residual vitality of nodes. Let ni denote how many rounds to be a CH for node si. PoptN is the optimum quantity of CHs in our network during each round. CH selection criteria in DEEC are based on vitality of nodes. As in homogenous network, when nodes have same amount of energy during each epoch then choosing pi = popt assures that poptNCHs during each round. In WSNs, nodes with high energy are more probable to become CH than nodes with low energy but the net value of CHs during each round is add up to poptN. Pi is the probability for every node si to become CH, so, node with high energy has larger value of pi as set alongside the popt) denote saverage energy of network during round r which may be given as in [10]:

$$E(r) = \frac{1}{N}\sum_{i=1}^{N} E_i(r) \tag{1}$$

Probability for CH selection in DEEC is given as in [10]:

$$p_i = p_{opt}\left[1 - \frac{\bar{E}(r) - E_i(r)}{\bar{E}(r)}\right] = p_{opt}\frac{E_i(r)}{\bar{E}(r)} \tag{2}$$

In DEEC the average total number of CH during each round is given as in [10]:

$$\sum_{i=1}^{N} p_i = \sum_{i=1}^{N} p_{opt}\frac{E_i(r)}{\bar{E}(r)} = p_{opt}\sum_{i=1}^{N}\frac{E_i(r)}{\bar{E}(r)} = Np_{opt} \tag{3}$$

p is probability of each node to become CH in a round. Where G is the set of nodes eligible to become CH at round r. If node becomes CH in recent rounds then it belongs to G. During each round each node chooses a random number between 0 and 1. If number is less than threshold as in [10], it is eligible to become a CH else not.

$$T(s_i) = \begin{cases} \dfrac{p_i}{1 - p_i(r \bmod \frac{1}{p_i})} & if\ s_i \in G \\ 0 & otherwise \end{cases} \tag{4}$$

As popt is reference value of average probability pi. In homogenous networks, all nodes have same initial energy so they use popt to be the reference energy for probability pi. However in heterogeneous networks, the value of popt is different according to the initial energy of the node. In two level heterogenous network the value of poptis given by as in[10]:

$$p_{adv} = \frac{p_{opt}}{1+am}, p_{nrm} = \frac{p_{opt}(1+am)}{(1+am)} \quad (5)$$

Then use the above padvand pnrminstead of popt in equation 10 for two level heterogeneous networks as suppose din [10]:

$$p_i = \begin{cases} \frac{p_{opt}E_i(r)}{(1+am)\bar{E}(r)} & if\ s_i\ is\ the\ normal\ node \\ \frac{p_{opt}(1+a)E_i(r)}{(1+am)\bar{E}(r)} & if\ s_i\ is\ the\ advanced\ node \end{cases} \quad (6)$$

Above model can also be extended to multi level heterogeneous network given below as in [10]:

$$p_{multi} = \frac{p_{opt}N(1+a_i)}{(N+\sum_{i=1}^{N} a_i)} \quad (7)$$

Above pmultiin equation 10 instead of popt to get pi for heterogeneous node. Pi for the multilevel heterogeneous network is given by as in [10]:

$$p_{multi} = \frac{p_{opt}N(1+a_i)}{(N+\sum_{i=1}^{N} a_i)} \quad (8)$$

In DEEC we estimate average energy E(r) of the network for any round r as in [10]:

$$\bar{E}(r) = \frac{1}{N}E_{total}(1-\frac{r}{R}) \quad (9)$$

R denotes total rounds of network lifetime and is estimated as follows:

$$R = \frac{E_{total}}{E_{round}} \quad (10)$$

Etotal is total energy of the network where Eround is energy expenditure during each round.

2.2 TEEN

TEEN is the very first reactive protocol. In this scheme, closer nodes form clusters with a CH to transmit the collected data to 1 upper layer. This really is identical to LEACH protocol however, at every cluster change time, the CH broadcasts two threshold values i.e hard and ST. HT could be the absolute value of an attribute to trigger on its transmitter and report to its respective CH. HT allows nodes to transmit data, if the information occurs in the product range of interest. Therefore, an important reduced total of the transmission delay occurs. Moreover, ST is the little change in the value of the sensed attribute. Next transmission occurs when there is a small change in the sensed attribute once it reaches the HT. So, it further reduces how many transmissions. In this scheme, at every cluster change time, along with the attributes, the cluster-head broadcasts to its members, *Hard Threshold* is just a threshold value for the sensed attribute. It's the absolute value of the attribute beyond which, the node sensing this value must switch on its transmitter and report to its cluster head. *Soft Threshold* is just a small change in the value of the sensed attribute which triggers the node to change on its transmitter and transmit. The nodes sense their environment continuously. Initially a parameter from the attribute set reaches its hard threshold value, the node switches on its transmitter and sends the sensed data. The sensed value is stored in an interior variable in the node, called the *sensed value (SV)*.The nodes will next transmit data in the present cluster period, only if *both* these conditions are true:

1. The present value of the sensed attribute is greater compared to hard threshold.

2. The present value of the sensed attribute differs from *SV* by an amount equal to or greater compared to soft threshold.

Each time a node transmits data, *SV* is set equal to the existing value of the sensed attribute. Thus, the hard threshold tries to lessen how many transmissions by allowing the nodes to transmit only once the sensed attribute is in the product range of interest. The soft threshold further reduces how many transmissions by eliminating most of the transmissions which can have otherwise occurred when there is little if any change in the sensed attribute once the hard threshold. The main drawback of this scheme is that, if the thresholds are not reached, the nodes won't ever communicate, the consumer will not get any data from the network at all and will not come to understand even though most of the nodes die. Thus, this scheme isn't well suited for applications where the consumer needs to have data on a typical basis. Another possible problem with this scheme is that a practical implementation will have to ensure that there are no collisions in the cluster. TDMA scheduling of the nodes can be utilized to prevent this problem. This may however introduce a delay in the reporting of the time-critical data. CDMA is another possible solution to the problem.

2.3 EDCS

The energy factor is the principal problem that every communication protocol must face. Estimating the typical energy of the network about another round is beneficial to pick the cluster accurately. Let's assume the perfect scenario where all sensor nodes are uniformly distributed and will die at the same time frame as a result of load balancing. Let denote the typical residual energy at round *r* of the network in such an ideal situation, which can be obtained by

$$E_{ideal}(r) = \frac{1}{N}E_{total}(1-\frac{r}{R} \tag{11}$$

where *R* is the total rounds of the network lifetime. Every node consumes the same amount of energy in each round, i.e., all sensor nodes may die at the same time so as to prolong the network lifetime.

To compute $E_{ideal}(r)$ by (11), the total rounds of the network lifetime *R* is very important. Usually, it is difficult to accurately predict the real network lifetime. Thus, *R* can be approximated in the ideal state as follows

$$R = \frac{E_{total}}{E_{round}} \tag{12}$$

where E_{round} denotes the sum energy consumed by the network in each round. According to the energy consumption model, the energies dissipated in the cluster head and non-cluster head node during a round when sending *l* bits message are respectively given by

$$E_{CH} = \left(\frac{N}{k}-1\right)lE_{elec} + \frac{N}{k}lE_{DA} + lE_{elec} + l\delta_{fs}d_{toBS}^2 \tag{13}$$

$$E_{nonCH} = lE_{elec} + l\delta_{fs}d_{toCH}^2 \tag{14}$$

where E_{elec} is the energy dissipated per bit to run the transmitter or the receiver, δ_{fs} is a transmittal and amplifying parameter, k is the number of clusters, E_{DA} is the data aggregation cost spent in the cluster head, d_{toBS}^2 is the average distance between the cluster head and the base station, and d_{toCH}^2 is the average distance between a cluster member and its cluster head. If the *N* nodes are uniformly distributed in the $M \times M$ square area, then d_{toBS}^2 and d_{toCH}^2 can be shown respectively

$$d_{toBS} = \int_{M^2}^{0}\sqrt{x^2+y^2}\,\frac{1}{M^2}dM^2 = 0.3825M \tag{15}$$

$$d_{toCH} = \sqrt{\iint (x^2 + y^2)p(x,y)dxdy} = \frac{M}{\sqrt{2\pi k}} \quad (16)$$

Therefore, we can obtain energy dissipated in every cluster during a round, and then the total energy of the k clusters dissipated during a round is equal to

$$E_{round} = k.E_{cluster} = E_{CH} + \left(\frac{N}{k} - 1\right) E_{nonCH} \approx l(2NE_{elec} + NE_{DA} + k\delta_{mp} d^4_{toBS} + N\delta_{fs} d^4_{toCH} \quad (17)$$

Substitute obtain lifetime R in the ideal state. In addition, letting k_{opt} be the number of optimal clusters head and p_{opt} be the occupation ratio of optimal cluster head, we have

$$k_{opt} = N.p_{opt} \quad (18)$$

How to get the number of optimal cluster heads is a typical NP-hard problem[3]. We can obtain k_{opt} from (18), and substitute it as k into (18) for further calculating. Furthermore, p_{opt}t is always set by the priori knowledge.

Actually, the average residual energy of network and the lifetime R are both estimated values in such ideal environment, i.e., the results are unreliable and can not fit the real heterogeneous WSNs. We consider the average residual energy and dissipated energy of the network after clustering in the last round. So the average residual energy of the network in the next round can be more accurately predicted as follows

$$E(r) = \alpha E_{ideal}(r) + (1-\alpha) * (E(r-1) - \frac{1}{N}\sum_{i=1}^{N} E_i(r-1) \quad (19)$$

From (19), we are able to obtain the predicted value of average residual energy in the r-th round, where and $Ei(r-1)$ are the average residual energy of network and the vitality dissipated at node si in the $(r-1)$th round respectively, and i=1 $Ei(r-1)$ is the sum energy dissipated of every node in the last round. Note that each and every node si doesn't have to know the remainder energy of others. It puts its residual energy in to the message packet and sends to the beds base station or the sink node before the end of every round. Without energy restraint, the beds base station or the sink node will compute and send results as the shape of packet to each node step-by-step. Moreover, α from (19) is the weighted coefficient and $\alpha \in (0, 1)$; the smaller the α, the greater the proportion of the historical reference energy consumed in the present round in predicting of average residual energy, and vice versa. On the other hand, (19) shows that the ultimate predicted result reduces the estimated error at the previously ideal state, making the estimated value of average residual energy in the r-th round more closed to the particular value.

III. Proposed Algorithm

Step 1: First of all initialization of the sensor network will be done by setting up the various constants and variables of the network. Like diameter of sensor network, distance of base station from the network, no of nodes, probability of a node to become a cluster head, energy supplied to each node, transmitter energy per node, receiver energy per node, amplification energy, distance between cluster head and base station etc. However as this research work focuses on the Fuzzy Waiting Values.

Step 2: For every sensor node i, find the various probabilities of nodes to define them as advance node, normal nodes and intermediate node.

Step 3: Probabilities of normal (eq.20), advance (eq.21), super nodes (eq.22) for CH selection in are showing below.

$$\frac{P_{opt}E_i(r)*FWN}{(1+m(a+m_ob))\bar{E}(r)} \text{ for normal nodes if } E_i(r) > T_{absolute} \quad (20) \text{ otherwise}$$

$\frac{P_{opt}(1+a)E_i(r)*FWN}{(1+m(a+m_o b))\bar{E}(r)}$ for advance node if $E_i(r)>T_{absolute}$ (21) otherwise

$\frac{P_{opt}(1+b)(r)*FWN}{(1+m(a+m_o b))\bar{E}(r)}$ for super nodes if $E_i(r) > T_{absolute}$ (22) otherwise

$\frac{P_{opt}(r)*FWN}{(1+m(a+m_o b))\bar{E}(r)}$ for all nodes

Here FWN: Fuzzy Waiting Nodes

$$FWN_i = (WR_i * p) + 1$$

Where WR is number of waiting rounds of a given node i.

P is the optimal probability of cluster head selection.

Step 4: According to the probabilities of the various nodes we elect the cluster head which have the maximum probability of becoming a cluster head and then moves to next steps.

Step 5: Communication will be started after the selection of cluster head.

Step 6: If the distance is less than the minimum distance form cluster head to base station the move equation 5 else move to equation 6

$d_{toCH} = \frac{M}{\sqrt{2\pi k}}$, $d_{toBS} = 0.765\frac{M}{2}$

$$E_{Tx}(l,d) = E_{elec} + \varepsilon_{mp} d^4 , \quad d \geq d_0 \qquad (23)$$

$$E_{Tx}(l,d) = E_{elec} + \varepsilon_{fs} d^2 , \quad d < d_0 \qquad (24)$$

Step 7: Now Tx and Rx operations will come into action for sending and receiving the packets between cluster head to base station using mutihop approach.

Step 8: Evaluate energy dissipated and update the remaining energy of each node (i) and move to step 2 again

IV. Results And Discussions

In this section, we simulate different clustering protocols in heterogeneous WSN using MATLAB and for simulations we use 100 nodes randomly put into a subject of dimension100m×100m. For ease, we suppose all nodes are either fixed or micro-mobile and avoid energy loss due to signal collision and interference between signals of different nodes that are due to dynamic random channel conditions.

Table 1: WSNs Set-up

Parameter	Value
Area(x,y)	100,100
x	0.3
Base station(x,y)	50,50 or 50,150
Base station.x	100
Base station.y	100
Nodes(n)	100

Probability(p)	0.1
Initial Energy	0.25
transmiter_energy	$50 * 10^{-9}$
receiver_energy	$50 * 10^{-9}$
Free space(amplifier)	$10 * 10^{-13}$
Multipath(amplifier)	$0.0013 * 10^{-13}$
Effective Data aggregation	$5 * 10^{-9}$
Maximum lifetime	2500
Data packet Size	4000
m (fraction of advanced nodes)	0.3
a (energy factor between normal and advanced nodes)	3
b	1.5
$m_o$fraction of super nodes	0.3

In this scenario, we are considering that, BS is placed at center of the network field. We simulate DEEC, TEEN and EDCS for three-level and multi-level heterogeneous WSNs. Scenarios describe values for number of nodes dead in first, tenth and last rounds as well as values for the packets sent to BS by CH and values for packets sent to CH by nodes at different values of parameters m, mo, a and b. These values are observed for DEEC, TEEN and EDCS. In heterogeneous WSN, we use radio parameters mentioned in Table 1 for different protocols deployed in WSN and calculate approximately the performance for three level heterogeneous WSNs. Parameter m refers to fraction of advanced nodes having additional amount of energy ain network whereas, mois a factor that refers to fraction of super nodes having additional amount of energy b in the network. Below are the graphs shown for dead nodes, alive nodes, packets sent to base station and packets sent to cluster head.

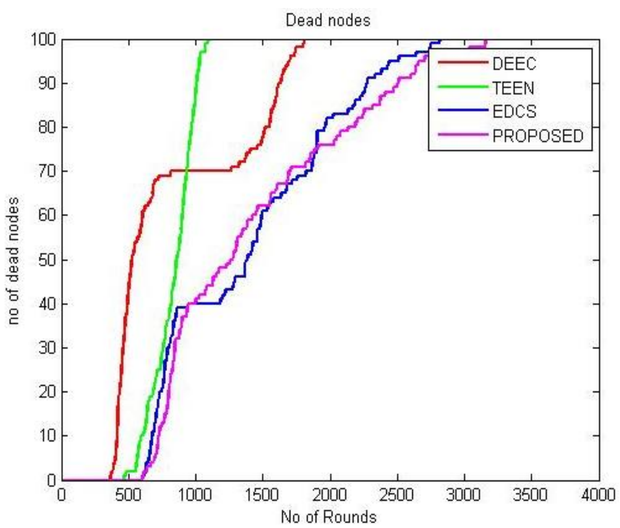

Fig. 2 Nodes dead during rounds

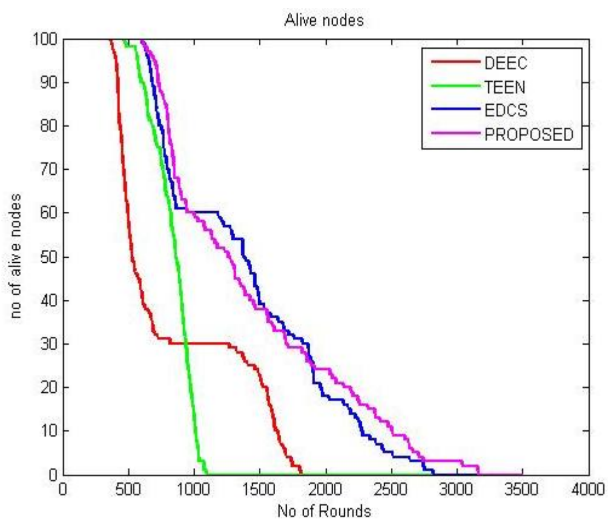

Fig. 3 Nodes alive during rounds

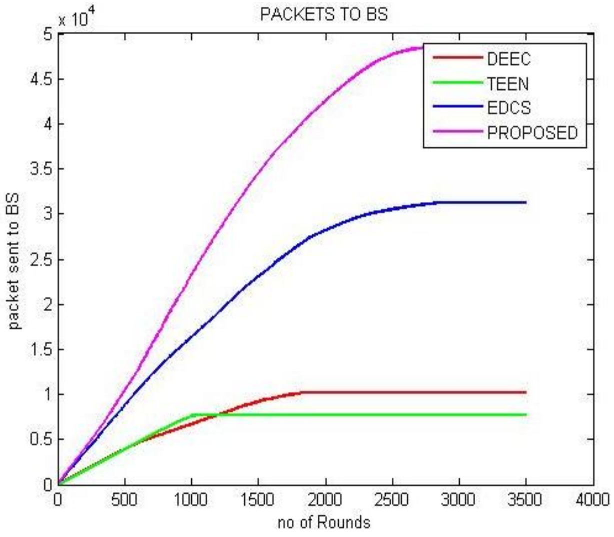

Fig. 4 Packets to BS

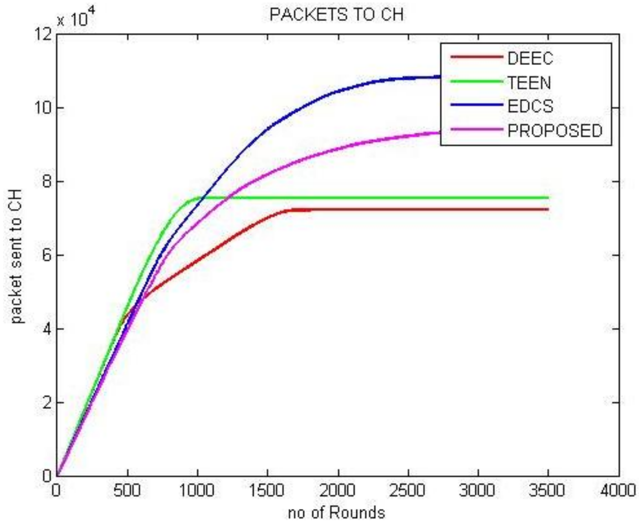

Fig 5. Packets to CH

Table 2 shows the results of various protocols for first node dead, tenth node dead and the all dead nodes.

Table 2: Results

PROTOCOLS	FIRST NODE DEAD	TENTH NODE DEAD	ALL NODE DEAD
DEEC	364	416	1808
TEEN	466	590	1092
EDCS	601	674	2820
PROPOSED	603	721	3158

V. Conclusion And Future Scope

This paper has improved the network lifetime of EDCS protocol with the usage of fuzzy waiting nodes. The motivation behind is to enhance the EDCS protocol to increase the stable region of clustering hierarchy procedure of WSNs for heterogeneous sensor networks. The residual energies of the sensor nodes have been utilized to discover the optimal cluster heads. The proposed technique has not necessitated any global information of energy at any time all through the lifetime of WSNs. Fuzzy waiting nodes procedure has been utilized for the nodes which are waiting for a longer time to turn out to be a cluster head. The node which has the maximum fuzzy waiting node factor would have the maximum probability for becoming the cluster head. If in any case more than one node has the same value of FWV then FCFS would be used. This work has not considered any inter cluster data aggregation technique to enhance the EDCS protocol. So in near future the enhancement will be done by utilizing the Ant colony optimization based inter cluster routing method.

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