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# Performance Evaluation of the DEEC, Teen & EDCS Protocols for Heterogeneous WSNS

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***Abstract: Wireless Sensor Networks (WSNs) have many sensor nodes having restricted battery, which transmit sensed data to the Base Station that requires high energy consumption. Numerous routing protocols have now been proposed in this regard getting energy efficiency in heterogeneous situations. Though, each protocol is inappropriate for heterogeneous WSNs. Efficiency of WSNs declines as varying the heterogeneity of sensor nodes. This paper has evaluated the performance of varied Distributed Energy- Efficient Clustering based protocols like DEEC, TEEN and EDCS under numerous scenarios; comprising various amount of heterogeneity. MATLAB tool is used for experimental purpose. The comparison has shown that the EDCS has very effective results over other DEEC and TEEN variants because special feature of T-absolute i.e. it treats all heterogeneous sensor nodes with same election probability when each node has lesser energy than T-absolute.*** *The comparative analysis has shown that the EDCS* ***outperforms over the available protocols.***

***Keywords: WSN, DEEC, TEEN, EDCS***

## I. INTRODUCTION

Wireless sensor networks are composed of small sensor nodes, computation, and wireless communication capabilities. Many routing protocols have now been specifically made for WSNs where energy responsiveness is a significant strategy concern. In figure 1 the configuration of the WSNs is described, where a sensor network is shown in a cloud that contained the many sensor nodes. These nodes transmit the data to the beds base station or sink node. Sink node aggregates the data from sensor nodes and transmit to the internet. The consumer receives data through internet from sink node. The cluster formation method hints to a two-level hierarchy where in fact the CH nodes form the higher level and the cluster-member nodes form the reduced level. The sensor nodes intermittently send their data to the corresponding CH nodes. CH nodes aggregate the data (thus decreasing the sum total quantity of relayed packets) and transmit them to the beds base station (BS) either directly or through the intermediate communication with other CH nodes. However, because the CH nodes send constantly data to raised distances compared to common (member) nodes, they naturally spend energy at higher rates. A typical solution so as balance the vitality consumption among all the network nodes is always to periodically re-elect new CHs (thus rotating the CH role among all the nodes over time) in each cluster.

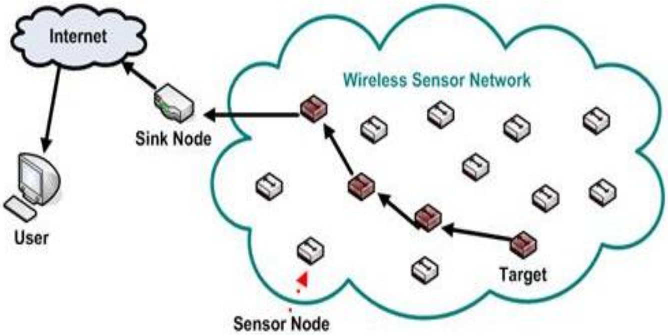

Fig. 1: Configuration of Wireless Sensor Network [17]

## 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]:

$$E(r) = \frac{1}{N}\sum_{i=1}^{N} E_i\,(r)\text{……..}(1)$$

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

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

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

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

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.

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

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]:

$$p_{adv} = \frac{p_{opt}}{1+am},\ p_{nrm} = \frac{p_{op\,t}(1+am)}{(1+am)}\text{…………….}(5)$$

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

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

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

$$p_{multi} = \frac{p_{opt}\,N(1+a_i)}{(N+\sum_{i=1}^{N} a_i)}\text{…………..}(7)$$

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]:

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

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

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

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

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

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

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

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

$$R = \frac{E_{to\,tal}}{E_{round}} \ldots\ldots\ldots\ldots(12)$$

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

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

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

where $E_{elec}$ is the energy dissipated per bit to run the transmitter or the receiver, $\delta_{fs}$ 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* × *M* square area, then $d_{toBS}^2$ and $d_{toCH}^2$ can be shown respectively

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

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

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

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

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

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

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

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

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, $\alpha$ from (19) is the weighted coefficient and $\alpha \in (0, 1)$; the smaller the $\alpha$, 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. LITERUTRE SURVEY

**T**he reactive networks [1] are those that instantly react to the any alterations in the parameters like power availability, position (in case of sensor nodes are mobile), reach ability, type of task. TEEN [1] has found to be much more ideal for realtime applications as it has provided immediate response. TEEN [1] protocol is not suitable for applications where data required frequently. SEP (Stable Election Protocol) [2], a heterogeneous protocol to increase the time interval ahead of the death of the initial node (referred as *stability period*), which can be crucial for all applications where in actuality the feedback from the sensor network must be reliable. SEP is based on weighted election probabilities of every node to become cluster head according to the remaining energy in each node. In this work two forms of sensor nodes are thought normal nodes and advanced nodes. Normal nodes have less energy than advanced nodes. In DEEC [3], the election of cluster-heads is performed by way of a probability based on the ratio between residual energy of every node and the average energy of the network. The epochs to be cluster-heads for nodes are different according with their initial and residual energy. The nodes with maximum initial and residual energy can have greater chances to be the cluster-heads compared to nodes with minimum energy. To avoid that each and every node needs to know the global familiarity with the networks, DEEC estimates the ideal value of network life-time, which can be used to compute the reference energy that each and every node should expend during a round. To maximise the DEEC protocol performances, the DDEEC [4] implemented a balanced and dynamic solution to distribute the spent energy more equitably between nodes. These alterations introduced enlarge better the performances of DDEEC protocol compared to others. DDEEC takes some advantage than DEEC in terms of first node dies and prolong of the stable time. It's as a result of fusion between DEEC techniques and the balanced way in term of cluster head election introduced by the DDEEC. E-DEEC (Enhanced Distributed Energy Efficient Clustering) scheme [5] is based on DEEC with addition of super nodes. Cluster head selection algorithm is broken into rounds. At each round node decides whether to become cluster head centred on threshold calculated by the suggested percentage of cluster heads for the network and how many times the node is a cluster-head so far. This decision is made by the nodes by choosing the random number between 0 and 1. If the number is less than a threshold T(s) the node becomes a cluster head for the existing round. The back-up node [6] is the node that takes the responsibility of cluster head in case of any failure. This technique will even help to make the wireless sensor network more energy efficient. Enhanced Reliable Distributed Energy Efficient Protocol (ERDEEP) provides more energy efficient network and reliability. The protocol solves the problem of the reliability by selecting a Back-up Node for each and every cluster head. The Back-up Node will stay static in the sleep mode and if cluster head gets down; a sign is send to back-up node alongside data and responsibilities by cluster visit back-up node and it (Back-up node) starts its working by taking most of the responsibility of the cluster head. Now this back-up node will aggregate the info and forward to the beds base station. Energy Efficient Clustering Routing Protocol Centered on Weight (ECRPW) [7] has prolonged the lifetime of networks. ECRPW takes into consideration the nodes'residual energy throughout the election means of cluster heads. The constraint of distance threshold is employed to optimize cluster scheme. It effectively prolongs the network lifetime by taking advantage of the characteristic of different energy in heterogeneous nodes. **T**he QoS [8] of an energy-efficient cluster-based routing protocol called Energy-Aware routing Protocol (EAP) in terms of lifetime, delay, loss percentage, and throughput, and proposed some modifications onto it to boost its performance. The modified version of EAP is called LLEAP (Low Loss Energy-Aware routing Protocol). LLEAP has the exact same three phases of EAP except some modifications in each phase. LLEAP modifies EAP in terms of some QoS parameters by modifying the weights equations, adding another iteration for tree construction, using schedule technique for nodes sleep and awakening to save lots of nodes energy, and having an aggregation method decreases delay and packet losses. Heterogeneity-aware Hierarchical Stable Election Protocol (HSEP) [9] has reduced transmission cost from Cluster Check out Base Station. This proposed protocol is heterogeneous-aware in the sense that election probabilities are weighted by the first energy of a node relative to that particular of other nodes in the network. This technique enhances time interval before death of first node is refereed as stability period. HSEP uses two kind of CHs, primary CHs and secondary CHs.

A three-tier clustered heterogeneous network has been considered in ESEP [10]; where in actuality the moderate and advanced nodes elect themselves as cluster heads for the increasing quantity of rounds based on the higher initial energy relative to other nodes. A bunch head election process is considered based on the battery and residual energy of the node. The reactive networks [11] are those that respond immediately response to any change in the network, therefore this protocol is quite definitely suitable to the true time applications. TSEP is just a three level heterogeneous network protocol in which the sensor nodes are with different energy levels like normal nodes, intermediate nodes and advanced nodes. Advanced nodes are having energy greater than other nodes. TSEP has increased the stability time frame than other protocols. The unequal distribution of wireless sensor nodes [12] and unbalanced energy consumption has turned into a major problem for Wireless Sensor Networks (WSNs). Traditional clustered networks with fixed sink nodes always suffer with high energy burden during multi hop transmission. Thus mobile sink(s) are introduced to networks with benefits of low latency, low energy consumption, and long lifetime, etc. To be able to guide the process of cluster head election for certain multi-level heterogeneous network, EDCS [13] determines the possibility of node to be always a cluster head through average network residual energy estimation in next round by average energy consumption forecast in ideal state and reference value of historical energy consumption simultaneously. It solves the drawback that the general routing protocols in homogeneous networks can't be directly put on heterogeneous multi-level environment. The EDCS protocol centers on energy heterogeneity. Cluster Heads (CHs) are elected on the bases of residual vitality of nodes. BEENISH [14] has implemented the idea of selecting CH which is dependent on residual vitality of the nodes with respect to average energy of network. BEENISH uses the idea of four types of nodes; normal, advance, super and ultra-super nodes. In BEENISH ultra-super nodes are largely elected as CH as compare to super, advance and normal nodes, and so, on. In this way energy consumed by all nodes is equally distributed. So, nodes with high energy have significantly more chances to get selected as CH, as compare to the reduced energy nodes. Although EDEEC [15] continues to punish advance and super nodes, same is the situation with DEEC, it continues to punish just advance nodes and DDEEC is only effective for two-level heterogeneous network as stated previously in related work. In order to avoid this unbalanced case in three-level heterogeneous network and to save lots of super and advance nodes from over penalized, we propose changes in function which defined by EDEEC for calculating probabilities of normal, advance and super nodes. These changes are based on absolute residual vitality *Tabsolute*, which will be the worth in which advance and super nodes have same vitality as that of normal nodes. The idea specifies that under *Tabsolute* all normal, advance and super nodes have same probability for CH selection.

## 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 |
| Base station(x,y) | 50,50 or 50,150 |
| Nodes(n) | 100 |
| Probability(p) | 0.1 |
| Initial Energy | 0.1 |
| 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 |
| $m_o$ 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.

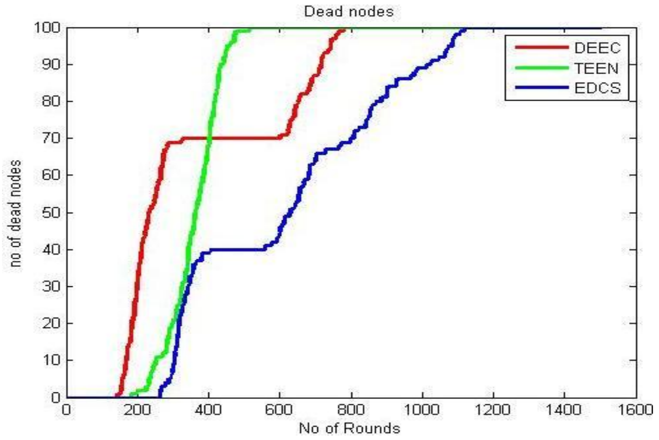

Fig. 2 Nodes dead during rounds

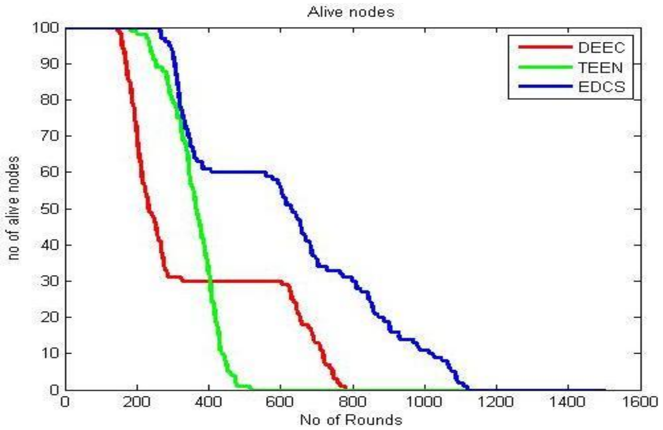

Fig. 3 Nodes alive during rounds

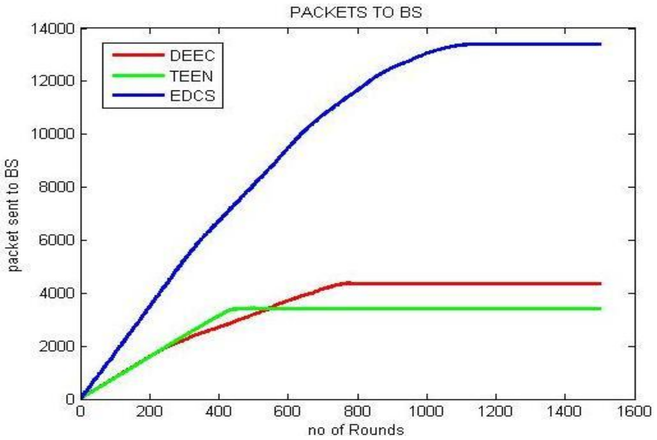

Fig. 4 Packets to BS

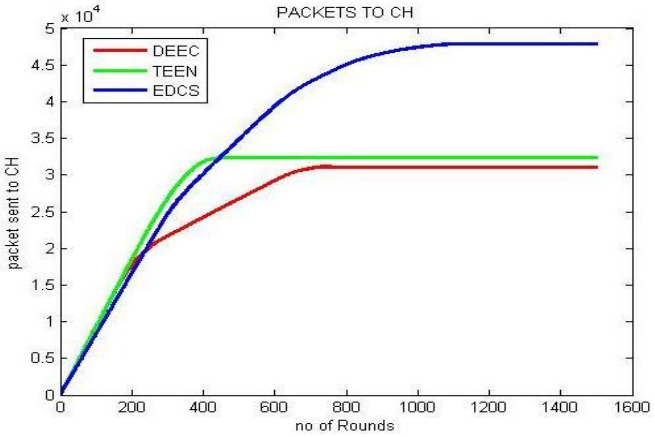

Fig 5. Packets to CH

## V. CONCLUSION AND FUTURE SCOPE

This paper has evaluated and compares the well-known heterogeneous WSNs energy efficient protocols i.e. DEEC variants. The comparison has shown that the EDCS has quite effective results over the other DEEC variants. Although EDCS has shown quite significant results over existing WSNs protocols but it has neglected the use of waiting time of node to become CHs. So may some nodes will not become CHs for a long time even they have more confidence to become CHs. So to overcome this problem in near future we will use minimum allowed distance (MDCH) and waiting nodes between two CHs to divide the sensor field among clusters in the most efficient way. MDCH will have ability to overcome the problem of the too small and too high cluster heads.

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