Comparative Study of Various Routing Protocols in Energy Distributed Clustering Based Heterogeneous Wireless Sensor Network

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Abstract **- Heterogeneous wireless sensor network (WSN) consists sensor nodes with different computing power and sensing range. Compared with homogeneous Wireless sensor network, deployment and topology management are more complex in heterogeneous WSN. Many routing protocols have been suggested in this regard for achieving energy efficiency and prolonging the lifetime of WSN in heterogeneous scenarios. However, every protocol doesn't fit in this criteria, because in heterogeneous WSN all sensor nodes have a dissimilar energy level and capacity to sense element is different as compare to homogeneous WSN where all the nodes in a network have the same energy level and having same sensing capacity. In this paper, we test Distributed Energy-Efficient Clustering (DEEC), Developed DEEC (DDEEC), Enhanced DEEC (EDEEC) and Threshold DEEC (TDEEC) under several different scenarios containing high level heterogeneity to low level heterogeneity in order to conclude the behavior of those heterogeneous protocols.**

*Keywords- **DEEC, DDEEC, EDEEC, TDEEC.***

1. INTRODUCTION

1.1 Motivation

The unique properties mentioned above become challenges to set up a sensor network. The key challenge in setting up and proper operation of WSN is increase the lifetime of the network by minimizing the energy consumption. Since from last few years' several of changes have been made to limit the energy requirement in WSN, as mainly energy dissipation is more for wireless transmission and reception [1]. Main approaches till proposed were focusing at making the changes at MAC layer and network layer to minimize the energy dissipation. Two more major challenges are how to place the cluster heads over the grid and how many clusters would be there in a system. If the cluster heads are correctly positioned over the grid and sufficient clusters are molded, it will assistance to diminish the dissipation of energy and would help to increase the lifetime of the network to tackle with all the above mentioned challenges clustering have been found the efficient technique [2] [3]. Clustering is always been referred as an effective method to improve the lifetime of WSN.

1.2 Problem Definition

Technological developments in the field of Micro Electro Mechanical Sensors (MEMS) have enabled the development to tiny, low power, low cost sensors having limited processing, wireless communication and energy resource capabilities. With the passage of time researchers have found new applications of WSN. In many critical applications WSNs are very useful such as military surveillance, environmental, traffic, temperature, pressure, vibration monitoring and disaster areas. To achieve fault tolerance, WSN consists of hundreds or even thousands of sensors randomly deployed inside the area of interest [4].

All the nodes have to send their data towards BS often called as sink. Usually nodes in WSN are power constrained due to limited battery, it is also not possible to recharge or replace battery of already deployed nodes and nodes might be placed where they cannot be accessed. Nodes may be present far away from BS so direct communication is not feasible due to limited battery as direct communication requires high energy. Clustering is the key technique for decreasing battery consumption in which members of the cluster select a Cluster Head (CH). Many clustering protocols are designed in this regard [5, 6]. All the nodes belonging to cluster send their data to CH, where, CH aggregates data and sends the aggregated data to BS [7-9]. Under aggregation, fewer messages are sent to BS and only few nodes have to transmit over large distance, so high energy is saved and over all lifetime of the network is prolonged.

Energy consumption for aggregation of data is much less as compared to energy used in data transmission. Clustering can be done in two types of networks i.e. homogenous and heterogeneous networks. Nodes having same energy level are called homogenous network and nodes having different energy levels called heterogeneous network. Low-Energy Adaptive Clustering Hierarchy (LEACH) [8], Power Efficient Gathering in Sensor Information Systems (PEGASIS) [10], Hybrid Energy-Efficient Distributed clustering (HEED) [11] are algorithms designed for homogenous WSN under consideration so these protocols do not work efficiently under heterogeneous scenarios because these algorithms are unable to treat nodes differently in terms of their energy. Whereas, Stable Election Protocol (SEP) [12], Distributed Energy-Efficient Clustering (DEEC) [13], Developed DEEC (DDEEC) [14], Enhanced DEEC (EDEEC) [15] and Threshold DEEC (TDEEC) [16] are algorithms designed for heterogeneous WSN. SEP is designed for two level heterogeneous networks, so it cannot work efficiently in three or multilevel heterogeneous network. SEP considers only normal and advanced nodes where normal nodes have low energy level and advanced nodes have high energy. DEEC, DDEEC, EDEEC and TDEEC are designed for multilevel heterogeneous networks and can also perform efficiently in two level heterogeneous scenarios.

1.3 Objective

We perform an investigational comparison among DEEC, DDEEC, TDEEC and EDEEC, so as to find a method which can fulfill the goals set, as follows

1. Minimize the energy dissipation of the network.

2. Increase the network life time.

3. Clusters must be better balanced.

4. Better distribution of cluster heads in the network.

2. DEEC:

Let $p_i = 1/n_i$, which can be also regarded as the average probability to be a cluster-head during n_i rounds. When nodes have the same amount of energy at each epoch, choosing the average probability p_i to be p_{opt} can ensure that there are p_{opt} N cluster-heads every round and all nodes die approximately at the same time. If the nodes have different amounts of energy, pi of the nodes with more energy should be larger than p_{opt}. Let $\overline{E}$(r) denotes the average energy at round r of the network, which can be obtained by as follow:

$$\bar{E}(r) = \frac{1}{N}\sum_{i=1}^{N} Ei\ (r)$$

The probability of the nodes to be a cluster head at per round per epoch will be given by:

$$\sum_{i=1}^{N} P_i = \sum_{i=1}^{N} P_{opt}\frac{E_i(r)}{\bar{E}(r)} = \sum_{i=1}^{N}\frac{E_i(r)}{\bar{E}(r)} = Np_{opt}$$

It is the optimal cluster-head number. The probability threshold that each node s_i use to determine whether itself to become a cluster-head in each round, as follow:

$$T(S_i) = \begin{cases} \dfrac{p_i}{1 - p_i(rmod\dfrac{1}{p_i})} & if\ s \in G \\ 0 & otherwise \end{cases}$$

Where, G is the set of nodes that are eligible to be cluster head sat round r. If node s_i has not been a cluster-head during the most recent n_i rounds, we have s_i 2 G. In each round r, when node s_i finds it is eligible to be a cluster-head, it will choose a random number between 0 and 1. If the number is less than threshold T (s_i), the node s_i becomes a cluster-head during the current round.

3. DDEEC

We find that nodes with more residual energy at round r are more probable to become CH, so, in these way nodes having higher energy values or advanced nodes will become CH more often as compared to the nodes with lower energy or normal nodes. A point comes in a network where advanced nodes having same residual energy like normal nodes. Although, after this point DEEC continues to punish the advanced nodes so this is not optimal way for energy distribution because by doing so, advanced nodes are continuously a CH and they die more quickly than normal nodes. To avoid this unbalanced case, DDEEC introduces threshold residual energy as in [14] and given below:

$$TH_{REV} = E_0\left(1 + \frac{aE_{disNN}}{E_{disNN} - E_{disAN}}\right)$$

Threshold residual energy Th is given as in [14] and given below:

$$TH_{REV} \simeq (7/10)E_0$$

DDEEC implements the same strategy like DEEC in terms of estimating average energy of networks and the cluster head selection algorithm which is based on residual energy Average probability pi for CH selection used in DDEEC is as follows as in [14]:

$$pi = \begin{cases} \dfrac{p_{opt}E_i(r)}{(1+am)\bar{E}(r)} & for\ Nml\ nodes, E_i(r) > TH_{REV} \\ \dfrac{p_{opt}E_i(r)(1+a)}{(1+am)\bar{E}(r)} & for\ adv\ node, E_i(r) > TH_{REV} \\ C\dfrac{p_{opt}E_i(r)(1+a)}{(1+am)^{\sim}\bar{E}(r)} & for\ adv\ node, ml\ nodes\ E_i(r) \le TH_{REV} \end{cases}$$

4. EDEEC:

EDEEC uses concept of three level heterogeneous networks. It contains three types of nodes normal, advanced and super nodes based on initial energy. p_i is probability used for CH selection and p_{opt} is reference for p_i. EDEEC uses different p_{opt} values for normal, advanced and super nodes, so, value of pi in EDEEC is as follows:

$$p_i = \begin{cases} \frac{p_{opt} E_i(r)}{(1+m(a+m_0 b))\bar{E}(r)} & \text{if } s_i \text{ is the normal node} \\ \frac{p_{opt}(1+a)E_i(r)}{(1+m(a+m_0 b))\bar{E}(r)} & \text{if } s_i \text{ is the advanced node} \\ \frac{p_{opt}(1+b)E_i(r)}{(1+m(a+m_0 b))\bar{E}(r)} & \text{if } s_i \text{ is the super node} \end{cases}$$

Threshold for Cluster Head (CH) selection for all three types of node is as follows:

$$T(s_i) = \begin{cases} \frac{p_i}{1-p_i\left(r \bmod \frac{1}{p_i}\right)} & \text{if } p_i \in G' \\ \frac{p_i}{1-p_i\left(r \bmod \frac{1}{p_i}\right)} & \text{if } p_i \in G'' \\ \frac{p_i}{1-p_i\left(r \bmod \frac{1}{p_i}\right)} & \text{if } p_i \in G''' \\ 0 & \text{otherwise} \end{cases}$$

5. TDEEC

TDEEC uses same mechanism for CH selection and average energy estimation as proposed in DEEC. At each round, nodes decide whether to become a CH or not by choosing a random number between 0 and 1. If number is less than threshold T_s as shown in equation then nodes decide to become a CH for the given round. In TDEEC, threshold value is adjusted and based upon that value a node decides whether to become a CH or not by introducing residual energy and average energy of that round with respect to optimum number of CHs. Threshold value proposed by TDEEC is given as follows:

$$T(s) = \frac{p}{1-p\left(r \bmod \frac{1}{p}\right)} * \frac{\text{residual energy of a node} * \text{kopt}}{\text{average energy of the network}}$$

6. SIMULATION PARAMETERS:

Parameters	Value
Network Field	(100,100)
Number of nodes	100
Eo (Initial energy of Normal Nodes)	0.5 J
Max.No. of Rounds	1000
Message Size	4000 Bits
Eelec	50nJ/bit
Efs	10nJ/bit/m^2
Eamp	0.0013pJ/bit/m^4
EDA	5nJ/bit/signal
do(Threshold	70m
Popt	0.1

Table 1.1.Simulation Parameters

7. SIMULATION RESULTS:

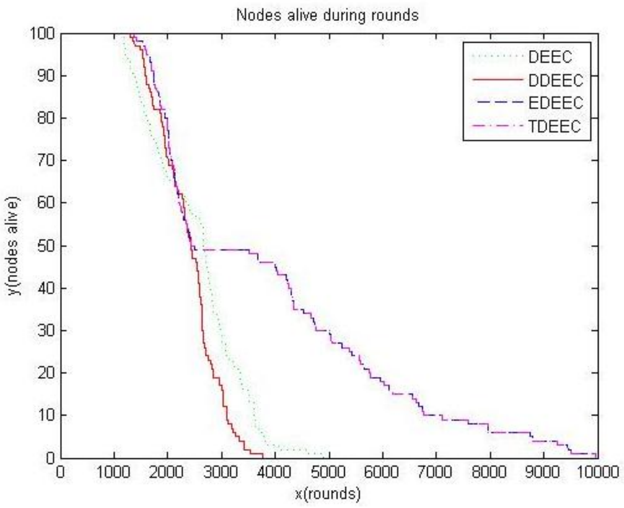

Fig.1.1 Alive nodes comparison

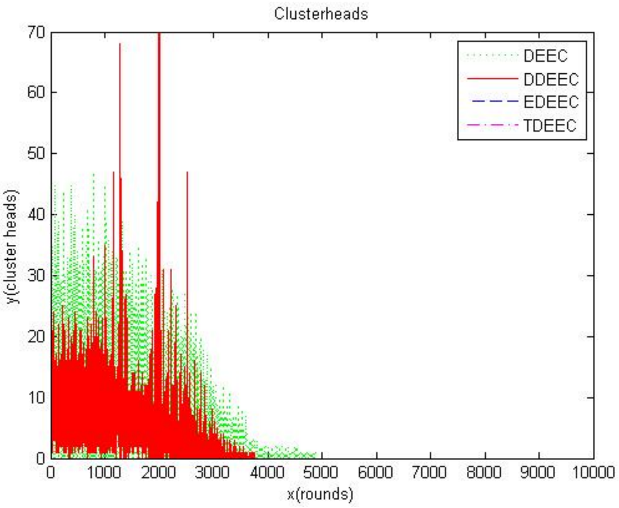

Fig.1.2 Cluster heads formation comparison

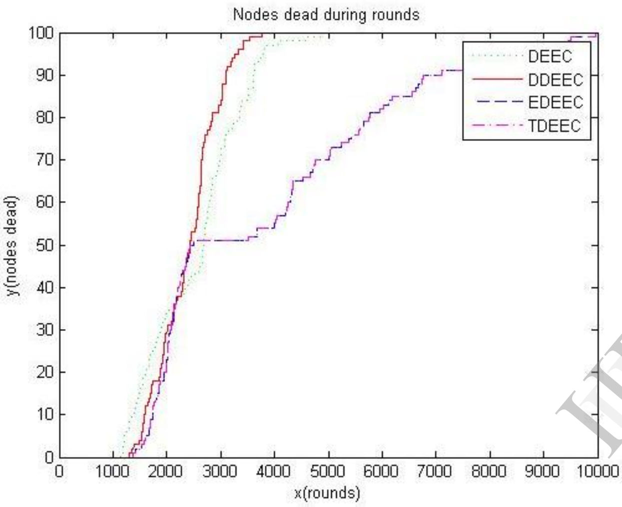

Fig.1.3 Dead nodes comparison

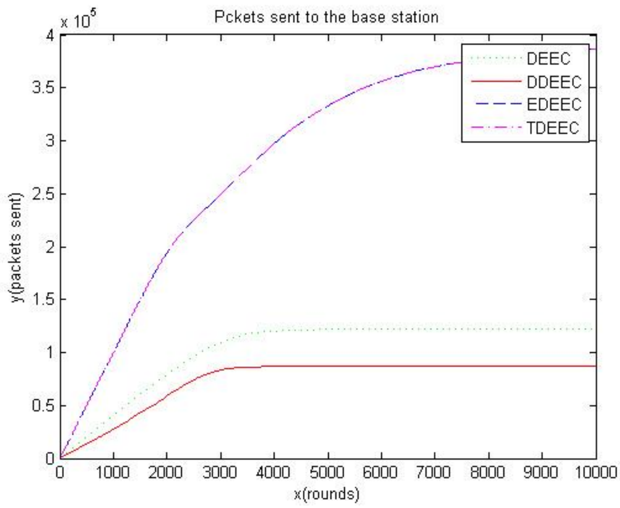

Fig.1.4 Comparison of Data packets reaches to the base station

7. CONCLUSION:

In this paper we have examined the current state of proposed clustering protocols, particularly with respect to their computing power and reliability requirements. In wireless sensor networks, the energy limitations of nodes play a crucial role in designing any protocol for execution or implementation. In this manner Quality of Service metrics such as time delay, data loss allowance and network lifetime expose reliability issues when designing recovery mechanisms for clustering schemes. These important features are often opposed, as one often has a negative impact on the other.

We have examined DEEC, DDEEC, EDEEC and TDEEC for heterogeneous WSNs containing different level of heterogeneity. Simulations prove that DEEC and DDEEC perform well in the networks containing high energy difference and concept used in DDEEC improves the lifetime of wireless sensor network in heterogeneous scenarios. Whereas, we find out that EDEEC uses the concept of super node works very well and it prolong the life time network. EDEEC and TDEEC perform well in all scenarios. Simulation result proves that TDEEC has best performance in terms of stability period and life time but instability period of EDEEC and TDEEC is very bigger we can say larger. So, we can say that EDEEC and TDEEC perform better in terms of stability period while compromising on lifetime.

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