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# Distributed Energy Efficient Clustering (DEEF) in Heterogeneous Wireless Sensor Networks

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***Abstract: - In this paper, the distributed energy efficient clustering (DEEF) in heterogeneous wireless sensor networks is presented. Distributed Energy-Efficient clustering 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. Here, we evaluate the performance of DEEC clustering algorithms on the basis of stability period, network life time and throughput for different level of heterogeneous wireless sensor networks. DEEC perform well under three level heterogeneous WSNs containing high energy level difference between normal, advanced and super nodes in terms of stability period. Simulation results shows that the number of alive nodes varies as network evolves and first node dies around 1800 round. Result also shows that in Distributed Energy Efficient Clustering in Heterogeneous Wireless Sensor Networks instable region starts very later as compare to other protocols.***

***Index Terms: distributed energy efficient clustering (DEEF), cluster heads (CHs), Wireless Sensor Networks (WSN), base station (BS).***

## I. INTRODUCTION

In many critical applications WSNs are very useful such as military surveillance [1], environmental [2], traffic [3], temperature [4], pressure [5], vibration monitoring [6] and disaster areas [1]-[6]. 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.

Wireless Sensor Networks [1] (WSN) have gained world-wide attention in recent years due to the advances made in wireless communication, information technologies and electronics field. The development of low-cost, low-power, a multifunctional sensor has received increasing attention from various industries. Sensor nodes or motes in WSNs are small sized and are capable of sensing, gathering and processing data while communicating with other connected nodes in the network, via radio frequency (RF) channel.

Wireless sensor network [2] are one of the category belongs to ad-hoc networks. Sensor network are also composed of nodes. Here actually the node has a specific name that is “Sensor” because these nodes are equipped with smart sensors. A sensor node is a device that converts a sensed characteristic like temperature, vibrations, pressure into a form recognize by the users. Wireless sensor networks nodes are less mobile than ad-hoc networks. So mobility in case of ad-hoc is more. In wireless sensor network data are requested depending upon certain physical quantity. A sensor consists of a transducer, an embedded processor, small memory unit and a wireless transceiver and all these devices run on the power supplied by an attached battery.

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) [7], Power Efficient Gathering in Sensor Information Systems (PEGASIS) [8], Hybrid Energy-Efficient Distributed clustering (HEED) [9]-[11].

In this paper, the distributed energy efficient clustering (DEEF) in heterogeneous wireless sensor networks is presented. Distributed Energy-Efficient clustering 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. Here, we evaluate the performance of DEEC clustering algorithms on the basis of stability period, network life time and throughput for different level of heterogeneous wireless sensor networks. DEEC perform well under three level heterogeneous WSNs containing high energy level difference between normal, advanced and super nodes in terms of stability period.

The outline of this paper is as follows. In Section II, we provide Space-Time codes for the multiple antenna communication systems. System model of space time block code is describe in Section III. In Section IV frame error rate and outage capacity is explained for nakagami fading channels. Section V analyzes the performance of the space–time block code. Finally, Section VII presents our conclusions and final comments.

## II. WIRELESS SENSOR NETWORKS (WSN)

Wireless Sensor Networks (WSNs) are ad-hoc networks, consisting of spatially distributed devices (motes) using sensor nodes to cooperatively monitor

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physical or environmental conditions at different locations. Devices in a WSN are resource constrained; they have low processing speed, storage capacity, and communication bandwidth. In most settings, the network must operate for long periods of time, but the nodes are battery powered, so the available energy resources limit their overall operation. To minimize energy consumption, most of the device components, including the radio, should be switched off most of the time [4]. Another important characteristic is that sensor nodes have significant processing capability in the ensemble, but not individually. Nodes have to organize themselves, ad-ministering and managing the network all together, and it is much harder than controlling individual devices. Furthermore, changes in the physical environment where a network is deployed make also nodes experience wide variations in connectivity and it influences the networking protocols [5].

## III. SENSOR NODES

There are four basic components that can be found in all sensor nodes. These components are: a power unit, a processing unit, a sensing unit and a transceiver. Some sensor nodes also contain optional components such as a location finding system, a mobilizer or a power generator. Fig. 1 shows the basic components of a sensor node [2].

The power unit is very important in a sensor node. It is responsible for providing all of the other units with energy so that the node can perform its functions. A power generator or power scavenging unit can support the power unit. Solar cells could be used as power scavenging units.

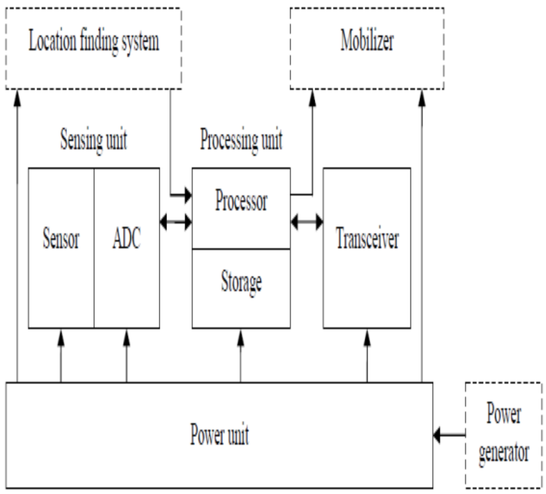


**Fig. 1 basic components of a sensor node**

The processing unit consists of a processor and some storage or memory. This unit is responsible for managing the tasks of the sensor unit. The sensing unit generally consist of a sensor and an analogue to digital converter (ADC). The ADC converts the analogue data from the sensor to digital data that can be processed by the processor. The transceiver connects the sensor node to the network. The transceiver can use either radio frequency (RF) or optical communications, such as infrared, to wirelessly connect to the network [5].

## IV. DISTRIBUTED ENERGY EFFICIENT CLUSTERING (DEEC)

DEEC is designed to deal with nodes of heterogeneous WSNs. For CH selection, DEEC uses initial and residual energy level of nodes. Let $n_i$ denote the number of rounds to be a CH for node $s_i$. $p_{opt}N$ is the optimum number of CHs in our network during each round. CH selection criteria in DEEC is based on energy level of nodes. As in homogenous network, when nodes have same amount of energy during each epoch then choosing $p_i = p_{opt}$ assures that $p_{opt}N$ CHs 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 equal to $p_{opt}N$. $p_i$ is the probability for each node $s_i$ to become CH, so, node with high energy has larger value of $p_i$ as compared to the $p_{opt}$. E(r) denotes average energy of network during round r which can be given as in [19]

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

Probability for CH selection in DEEC is given as

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

In DEEC the average total number of CH during each round is given as

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

pi is probability of each node to become CH in a round where G is the set of node 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 defined below, it is eligible to become a CH else not.

$$T(s_i) = \begin{cases} \frac{p_i}{1 - p_i\left(r \bmod \frac{1}{p_i}\right)} & if\ s_i \epsilon G \\ 0 & otherwise \end{cases} \qquad (4)$$

As $p_{opt}$ is reference value of average probability $p_i$. In homogenous networks, all nodes have same initial energy so they use $p_{opt}$ to be the reference energy for probability $p_i$. However in heterogeneous networks, the value of $p_{opt}$ is different according to the initial energy of the node. In two level heterogenous network the value of $p_{opt}$ is given by

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

Then use the above $p_{adv}$ and $p_{nrm}$ instead of $p_{opt}$ in equation (2) for two level heterogeneous network as

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

Above model can also be extended to multi level heterogeneous network given below as

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

Above $p_{multi}$ in equation (2) instead of $p_{opt}$ to get $p_i$ for heterogeneous node $p_i$ for the multilevel heterogeneous network is given by

$$p_i = \frac{p_{opt} N(1+a)E_i(r)}{(N+\sum_{i=1}^{N} a_i)\bar{E}(r)} \quad (8)$$

In DEEC we estimate average energy E(r) of the network for any round r as

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

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

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

$E_{total}$ is total energy of the network where $E_{round}$ is energy expenditure during each round.

## V. SIMULATION RESULTS

In this section, the distributed energy efficient clustering (DEEF) in heterogeneous wireless sensor networks is presented. Here, the performance of DEEC clustering algorithms on the basis of control parameters such as stability period, network life time and throughput for different level of heterogeneous wireless sensor networks. Simulation is presented using Matlab. We simulate different clustering protocols in heterogeneous WSN using MATLAB and for simulations we use 100 nodes randomly placed in a field of dimension 100m×100m. For simplicity, we consider all nodes are either fixed or micro-mobile and ignore energy loss due to signal collision and interference between signals of different nodes that are due to dynamic random channel conditions.

Performance parameters used for evaluation of clustering protocols for heterogeneous WSNs are lifetime of heterogeneous WSNs, number of nodes alive during rounds and data packets sent to BS.

1. ***Lifetime*** is a parameter which shows that node of each type has not yet consumed all of its energy.
2. ***Number of nodes alive*** is a parameter that describes number of alive nodes during each round.
3. ***Data packets sent to the BS*** is the measure that how many packets are received by BS for each round.

Following Design parameters are chosen to perform the analysis of the Distributed Energy Efficient Clustering (DEEC) in heterogeneous wireless sensor network.

In this example, we analysis the performance of Distributed Energy Efficient Clustering (DEEC) in heterogeneous wireless sensor network along with 4000 number of rounds and 100 nodes. Fig. 2 demonstrates the Dead Nodes during 4000 rounds and 100 nodes. Fig. 3 depicts the Alive Nodes during 4000 rounds and 100 nodes. Fig. 4 shows the Packet sends to BS Nodes during 4000 rounds and 100 nodes. Fig. 5 depicts the Count of Cluster Head per round during 4000 rounds and 100 nodes. Fig. 6 shows the Dead Nodes, Alive Nodes, Packet sends to BS Nodes, Count of Cluster Head per round during 4000 rounds and 100 nodes.

**Table: 1 Control parameters**

| Parameters | Values |
|---|---|
| Network field (Size) | 100m * 100m |
| Initial Energy of normal node ($E_o$) | 0.5 J |
| $P_{opt}$ | 0.1 J |
| $E_{fs}$ | 10nJ/bit/m2 |
| Number of nodes | 100 |
| message size | 4000 bit |
| EDA | 5nJ/bit/ signal |
| $E_{elec}$ | 50 nJ/bit |
| Transmit amplifier ($E_{amp}$) | 0.0013 pJ/bit/m4 |
| Threshold distance ($d_o$) | 70m |

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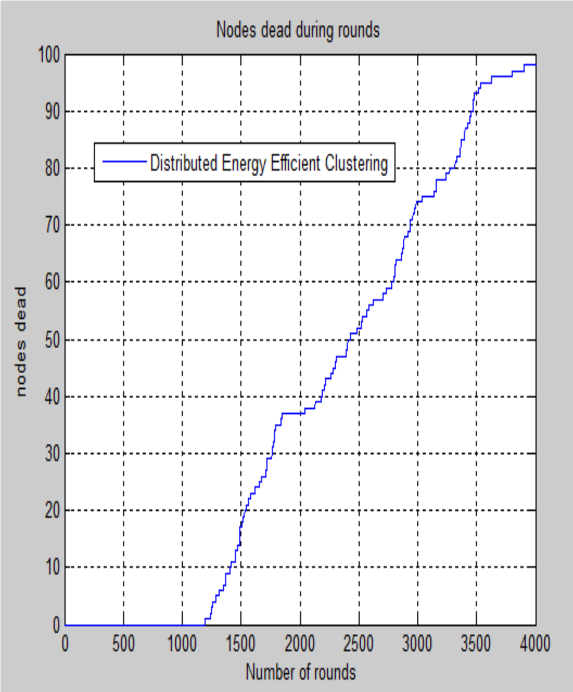


Fig. 2 Dead Nodes during 4000 rounds and 100 nodes

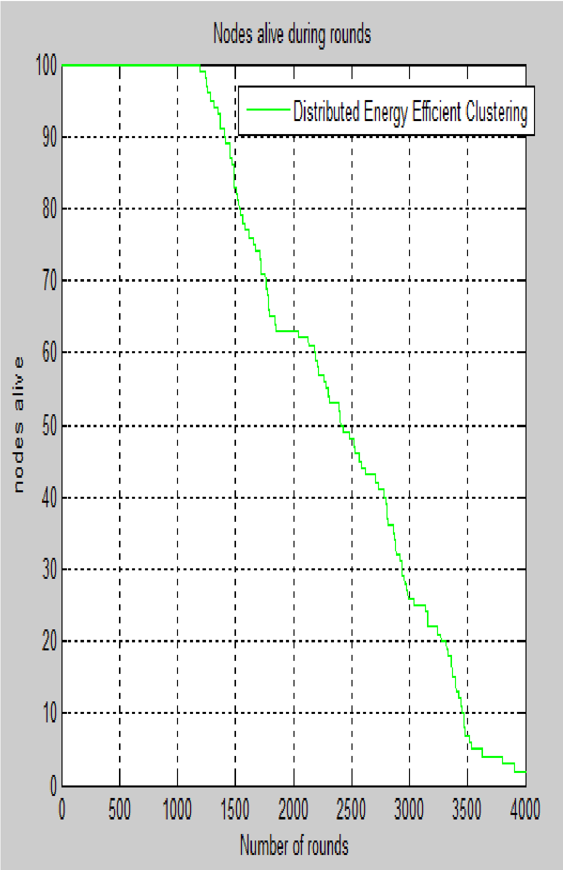


Fig. 3 Alive Nodes during 4000 rounds and 100 nodes

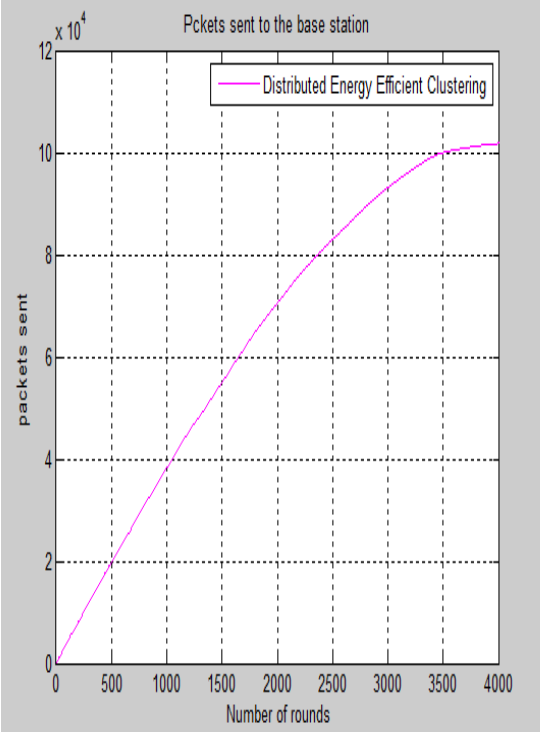


Fig. 4 Packet sends to BS Nodes during 4000 rounds and 100 nodes

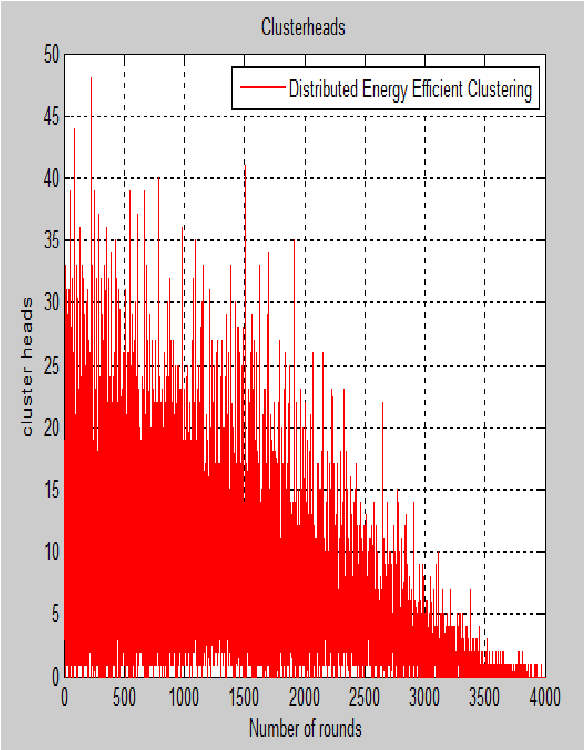


Fig. 5 Count of Cluster Head per round during 4000 rounds and 100 nodes

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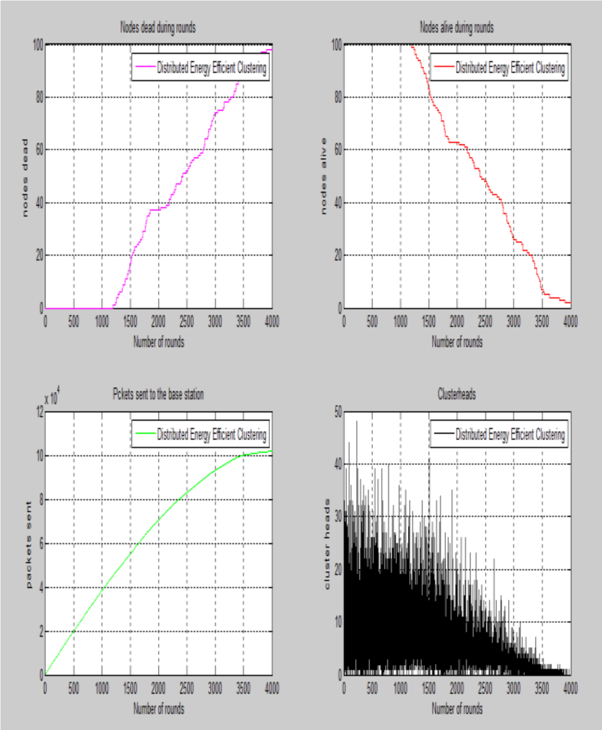


**Fig. 6 Dead Nodes, Alive Nodes, Packet sends to BS Nodes, Count of Cluster Head per round during 4000 rounds and 100 nodes**

## VI. CONCLUSIONS

This paper evaluate the distributed energy efficient clustering (DEEF) in heterogeneous wireless sensor networks is presented. Here, we calculate the performance of DEEC clustering algorithms on the basis of control parameters such as stability period, network life time and throughput for different level of heterogeneous wireless sensor networks. DEEC perform well under three level heterogeneous WSNs containing high energy level difference between normal, advanced and super nodes in terms of stability period. Simulation results shows that the number of alive nodes varies as network evolves and first node dies around 1800 round. Result also shows that in Distributed Energy Efficient Clustering in Heterogeneous Wireless Sensor Networks instable region starts very later as compare to other protocols. Results show that in Distributed Energy Efficient Clustering in Heterogeneous Wireless Sensor Networks nodes die at a constant rate.

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