

# **A Distributed Clustering Mechanism in HWSNs for Enhancing the Lifetime**

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**ABSTRACT:** A Wireless Sensor Networks (WSNs) is a collection of dedicated transducers with a communication infrastructure that uses radio to supervise and record physical or environmental circumstances. A Heterogeneous Wireless Sensor Network (HWSN) is a network of sensors that uses wireless links with different communication range or those sensors may be used in a number of applications. Because of the limited and non rechargeable energy supply, WSN has a severe requirement regarding its power consumption. Clustering is an effective way that improves the energy effectiveness. Large sized clusters consumes more energy than small sized clusters, As it has long intra cluster distance, i.e., the distance between the cluster members and the cluster head. In this work, a technique Distributed Energy Efficient Mechanism (DEEM) is proposed, which uses multi hop communication links between the cluster members and the cluster heads. Moreover, cluster heads communicate with the base stations in a multi hop manner. So the energy is dispersed equally among all the nodes and this result in considerable conservation of energy. The simulated result shows some improvement in lifetime of sensor compare to existing approaches.

**KEYWORDS:** Wireless Sensor Networks (WSNs), Heterogeneous Wireless Sensor Networks (HWSNs), Distributed Energy Efficient Mechanism, Clustering, Multi Hop, Energy distribution.

## **I. INTRODUCTION**

Wireless sensor networks (WSNs) consist of a large number of low-power sensor nodes and those are characterized by their low energy consumption and low cost. WSNs are used to evaluate environmental circumstances like temperature, pollution levels, pressure, sound, humidity, wind speed and direction, etc. WSNs were primarily intended to assist military operations, later on extended to traffic, health and many other consumer and industrial areas. A WSN consists of anywhere from a few hundreds to thousands of sensor nodes. The sensor node consists of a radio transceiver along with an antenna, an energy source, an interfacing electronic circuit, usually a battery and a microcontroller. The size of the sensor nodes varies from small to large; their prices also vary depending on the functionality parameters of a sensor like energy consumption, computational speed rate, bandwidth, and memory [2] & [6].

Clustered sensor networks can be broadly categorized into two broad types: one is homogeneous networks; in this all the sensor nodes are identical in terms of battery energy and hardware complexity. Another one is Heterogeneous sensor networks, which have different types of nodes with different battery energy and dissimilar functionality are used. By embedding a more complex hardware and extended battery energy in a few cluster head nodes, it is able to reduce the hardware cost for rest of the network. But here, the role rotation of cluster nodes is not possible, as the cluster heads are fixed. When a node interact with the cluster by a single hop, the nodes which are farer from the cluster heads tend to spend more energy than those of which are closer to the cluster heads [2]. when the nodes uses multi-hop to communicate with the cluster head, the nodes that are nearest to the cluster head have a burden of highest energy due to relaying. Hence there exists a non-uniform energy drainage pattern in the network. The main important characteristics for a sensor network are lower hardware cost, and uniform energy drainage. While heterogeneous networks are able to achieve the former, the homogeneous networks have the ability of achieving the latter. However both these features cannot be incorporated in the same network [6] & [12].

In WSNs Energy conservation is an important concept, when the sensors are deployed in hostile environments, replacing or recharging their batteries is not good. In general, a major part of the energy is consumed by the communication

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(An ISO 3297: 2007 Certified Organization)

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electronics in the sensor node. Clustering is considered as a significant energy saving technique in WSN, and the efficiency of the WSN depends on the energy-efficient clustering routing algorithm [1] & [4]. The clustering mechanism aggregates data efficiently and achieves load balance of the network. Clustering algorithm selects a part of the nodes in WSN as cluster heads and classifies all other nodes reasonably. While clustering nodes in WSN, a single cluster must neither be too big nor be too small [11]. There are two approaches mainly used by current clustering algorithms, selecting cluster heads with higher residual energy and rotating the cluster heads in a periodic manner to allocate the energy consumed among the nodes within each cluster and extend the network lifetime [10].

## II. RELATED WORK

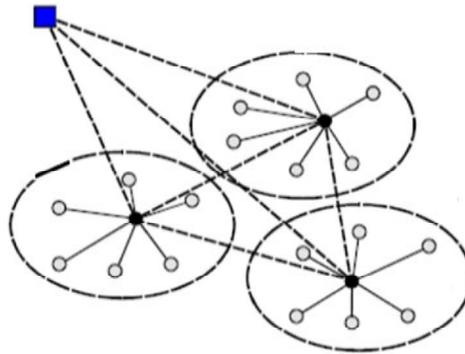
Stable Election Protocol (SEP) is based on weighted election probabilities of each node to become cluster head according to the remaining energy in each node. There are two classical approaches available; they are direct transmission (DTE) and minimum transmission energy (MTE). Sensor nodes are directly communicated with sink by single-hop communication in direct transmission method, whereas in MTE, the data is routed over minimum cost routes. Nodes that are near the sink act as relays with higher probability than nodes that are far from the sink [5].

Hybrid Energy Efficient Distribution (HEED) was designed to select different cluster heads in a field according to the amount of energy that is distributed in relation to a neighboring node. In HEED sensors are quasi-stationary and links between nodes are symmetric. Energy consumption is non-uniform among all nodes. Same or different power levels are used for intra-cluster communication. HEED distribution of energy extends the lifetime of the nodes within the network thus stabilizing the neighboring node. Only two level hierarchies provided but can be extended to multilevel hierarchy [9] & [13].

Energy Efficient Hierarchical Clustering (EEHC) is used in hierarchical wireless sensor networks (HWSN) for electing cluster heads in a strewn manner. The election probabilities of cluster heads are weighted by the residual energy of a node relative to that of other nodes in the network. The algorithm is based on LEACH and works on the election processes of the cluster head in presence of heterogeneity of nodes. Simulation results show that EEHC is more effective in prolonging the network lifetime compared with LEACH [4] & [8].

Distributed Energy Based Clustering (DEBC) protocol for HWSNs Cluster heads are selected by a probability depending on the ratio between remaining energy of node and the average energy of network. The high initial and remaining energy nodes have more chances to be the cluster heads than the low energy nodes. This mechanism also considers two-level heterogeneity and then it extends the results for multi-level heterogeneity. DEBC is different from LEACH, which makes sure each node can be cluster head in each  $n=1/p$  rounds [14].

Distributed Data Aggregated Energy Efficient (DDAEE), clustering protocols are also fit for the multilevel heterogeneous wireless sensor networks. Here, all the nodes use the initial and residual energy level to define the cluster heads. It does not require any global knowledge of energy at every election round. This DDAEE algorithm allows a more data to send from cluster head to a base station in a certain time interval, which improves the life time of WSNs [3]. Single-hop Energy Efficient Clustering Protocol (S-EECP), the CHs are elected based on different weighted probabilities (Fig. 1). The weighted probability is evaluated based on the ratio between residual energy of each node and average energy of network. The nodes with high initial and residual energy will have more chances to become CHs per round per epoch. In Multi-hop Energy Efficient Clustering Protocol (M-EECP), after the election of CHs, the member node interacts directly with the CH using a single-hop communication (Fig. 1). On the other hand, CHs use multi-hopping to reach the BS [1] & [7].



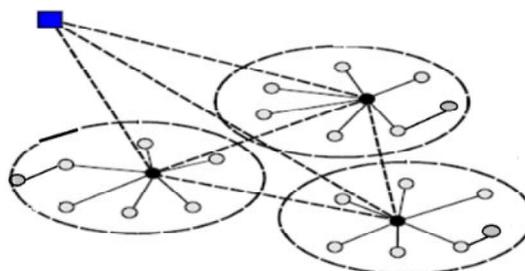
**Fig. 1 S-EECP and M-EECP**

### III. PROPOSED PROTOCOLS

Numbers of ways are there for energy efficient clustering mechanism in heterogeneous wireless sensor networks. To reduce the energy consumption cluster formation and cluster head selection are very useful. A distributed energy efficient mechanism required for cluster formation and energy efficiency. Here we introduced a new mechanism for cluster head selection for enhancing the life time of WSN and a reconfiguration approach to optimize the energy consumption in inter cluster communication.

#### **A. Distributed Energy Efficient Mechanism**

In DEEM there are two phases, first one is setup phase and the second one is steady state phase. In the first phase, cluster head selection and cluster formation process are completed. In the steady state phase, selected cluster head is identified and the selected cluster head uses the inter cluster communication. In the randomness property of WSN; cluster can be either small or large in their deployed region. The large sized clusters generally consumes more energy than small sized clusters, as it has long intra cluster distance, i.e., the distance between the cluster members and the cluster head. In this paper, an improvised technique that uses multi hop communication links between the cluster members and the cluster heads is proposed (Fig. 2). Moreover, cluster heads communicate with the base stations in a multi hop manner. So energy is distributed equally among the nodes and this result in considerable conservation of energy. The function of distance based probability is the  $e$  distance of the normal sensor to the advanced sensor. The proposed research work developed an algorithm which specifies the energy-efficient clustering on the joint coverage and routing constraint.



-  Normal node
-  Cluster Head
-  Base Station

**Fig. 2 M-DEEM**

# International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 5, Issue 4, April 2016

The following are assumptions for our protocols:

- Base station should be known to all cluster members.
- Base station should be independent of energy resources.
- Sensor nodes are static.
- Sensor nodes locations are not known.

## B. Cluster Head Selection

In the setup phase the main processing works like Cluster head selection and cluster formation processes will be completed. The cluster head sections collect the total data and that will send to base station.

Each sensor node calculates its estimated distance based on the strength of receiving signals. The sensor nodes elect the cluster head according to high energy or threshold. At the beginning, advanced node is elected as a cluster head which consists of high threshold value.

Every sensor nodes separately chooses a random number between 0 and 1. If the number is smaller than the evaluated threshold value  $T^{(i)}$  for node  $i$ , then it becomes a cluster head. Each node becomes a cluster head in one epoch. An epoch is defined as,

$$epoch = \frac{1}{P_{opt}} \quad (1)$$

Where  $P_{opt}$  is the desired percentage of CHs.

In the 3-level heterogeneous nodes (normal nodes ( $m$ ), advanced nodes ( $\alpha$ ), and super nodes ( $\beta$ )), a reference value  $P_{opt}$  has been replaced by weighted probabilities. The advanced node ( $m$ ) has  $\alpha$  amount of more energy than normal nodes.

$$p_{norm} = \frac{P_{opt}}{1 + \alpha m} \quad (2)$$

$$p_{advanced} = \frac{P_{opt}}{1 + \alpha m} (1 + \alpha) \quad (3)$$

$$p_{super} = \frac{P_{opt}}{1 + \beta m} (1 + \beta) \quad (4)$$

In the heterogeneous network the total initial energy of new setting is calculated by the following equations

$$E_{total} = N \times E_0 \times (1 + m \times s) \quad (5)$$

Where,  $s = (\alpha - m_0 \times (\alpha - \beta))$

The values of CHs are chosen from time to time by different weighted probability. Each member node communicates with their respective CHs by using, multi-hop communication (i.e. inter-cluster communication) when the distance between normal node to base station is greater. Then CHs collect the data from the normal nodes in their respective clusters, aggregate it and transmit it to the BS using multi-hop communication.

# International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 5, Issue 4, April 2016

Let distance between transmitter and receiver is  $d$ ; in order to transmit for  $L$  bits data from transmitter to the receiver the energy consumed is calculated by the following equation

$$E_{TX}(L, d) = \begin{cases} L \times E_{elec} + L \times \epsilon_{fs} \times d^2 & \text{if } d \leq d_0 \\ L \times E_d + L \times \epsilon_{mp} \times d^4 & \text{if } d \geq d_0 \end{cases} \quad (6)$$

Where,  $E_{elec}$  is the amount of energy consumption in wireless circuit receiving and sending data.

The energy required for receiving the data is given by the following equation,

$$E_{rx} = L \times E_{elec} \quad (7)$$

The probability of a node to become a cluster head,  $k_{opt}$  which can be evaluated using the following equation,

$$k_{opt} = \sqrt{\frac{N}{2\pi}} \sqrt{\frac{\epsilon_{fs} M}{\epsilon_{mp} d_{BS}^2}} \quad (8)$$

Where,

$$d_{BS} = 0.765 * \frac{M}{2}$$

By using (8), the optimal probability of a node to become a cluster head is constructed. The average energy of the network at  $i^{th}$ ,

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

In the above equation  $R$  is the total number of rounds of the network lifetime. Therefore, every node consumes the same amount of energy at each epoch.

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

The average energy for the different epoch based on residual energy  $E_i(i)$  of each node per round can be obtained as,

$$E_{avg}(i) = \frac{1}{N} \sum_{i=1}^N E_i(i) \quad (11)$$

### C. Multi-Hop Communication Mechanism:

There are two important communication mechanisms, one is single-hop and another one is multi-hop, these mechanisms are generally used in WSNs. In Single-hop communication, it sends the data directly to the BS without any relay, thus the node located away from the BS will consume more energy than the other nodes and drains faster, die out first. To overcome this difficulty, we use shortest path algorithm [1].

A graph is used for direct communication is called Directed weighted Graph  $G = \{V, E\}$ , where  $V$  is a set of nodes represents in circles and  $E$  is a set of edges represented as an arc. Each edge is a pair of vertices of line joining  $(v, w)$ , where  $v, w \in V$ . Edges are sometimes referred to as arcs. If the pair is ordered, then the graph is directed. Vertex  $w$  is adjacent to  $v$  if and only if  $(v, w) \in E$ . In an undirected graph with edge  $(v, w)$ , and hence  $(w, v)$ ,  $w$  is adjacent to  $v$  and  $v$  is adjacent to  $w$ . Sometimes an edge has a third component, known as either a weight or a cost.

A cycle in a directed graph is a path of length at least 1 such that  $w_1 = w_n$ ; this cycle is simple if the path is simple. For undirected graphs, we require distinct edges. The logic of these requirements is that the path  $u, v, u$  in an undirected graph should not be considered a cycle, because  $(u, v)$  and  $(v, u)$  are the same edge. In a directed graph, these are different edges, so it makes sense to call this a cycle. A directed graph is a cyclic if it has no cycles. A directed acyclic graph is sometimes referred to by its abbreviation, DAG [1].

An undirected graph is connected if there is a path from every vertex to every other vertex. A directed graph with this property is called strongly connected graph. If a directed graph is not strongly connected, but the underlying graph

# International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 5, Issue 4, April 2016

(without direction to the arcs) is connected, then the graph is said to be weakly connected. A complete graph is a graph in which there is an edge between every pair of vertices.

### D. Data Communication Phase:

Formerly the clusters are formed and the TDMA plan is set, the data communication phase can begin. The active node periodically collects and transmits the data on the basis of allocated time to the CH, where the remaining node are turned off to minimize the energy consumption. After collecting information from all the nodes, CH aggregate the data and route that to BS via multi-hop communication.

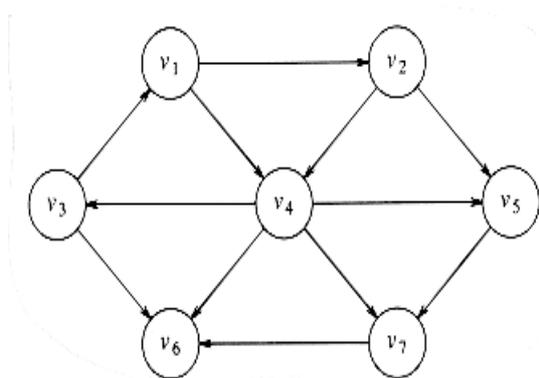


Fig. 3 Directed weighted graph

In this section, 100 heterogeneous nodes have been constructed in  $100 \times 100$  region and one BS.

Parameter		Value
Network size		100m $\times$ 100m
Node number ( $n$ )		100
Base station position		50 m, 50m
Initial energy	Normal node ( $m$ )	1nJ
	Advanced node ( $\alpha$ )	2nJ
	Super node ( $\beta$ )	3nJ
Transmitter/Receiver electronics $E_{elec}$		50 nJ/bit
Data aggregation ( $E_{D,a}$ )		5 nJ/bit/report
Reference distance		90m
Transmit amplifier $\epsilon_{fs}$ if $d_{BS} \leq d_0$		10pJ/bit/m <sup>2</sup>
Transmit amplifier $\epsilon_{fs}$ if $d_{BS} \geq d_0$		0.0013pJ/bit/m <sup>4</sup>
Energy dissipated per bit		50nJ
Message size ( $l$ )		6400 bits

TABLE 1: SIMULATION PARAMETERS

## IV. RESULTS AND DISCUSSION

A heterogeneous clustered WSN has been simulated with 100 sensor nodes. The normal nodes, advanced nodes and super nodes are randomly distributed over the remote control area. Therefore the horizontal and vertical coordinates of sensor node is selected randomly. The base station considered to be in center of the sensing field. The simulation parameters are tabulated in Table 1

In the experiment, the cluster members i.e., normal nodes use multi-hopping to communicate with the elected CH. CHs use multi-hopping to communicate with the BS. Comparing the performance of DEEM with the S-EECP and M-EECP,

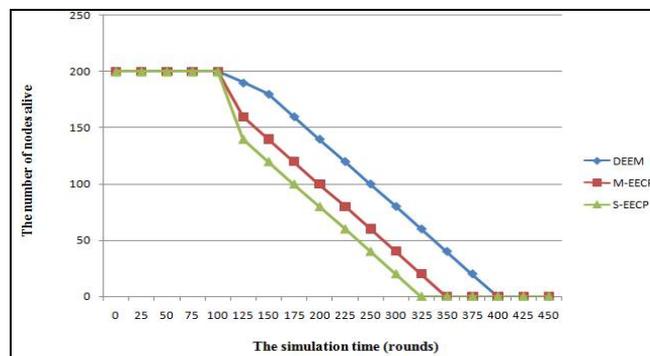
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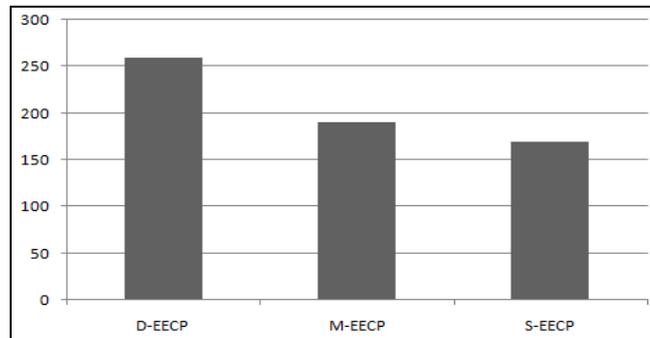
Vol. 5, Issue 4, April 2016

when the first node is dead can be clearly seen in Fig. 5 and Fig. 6. DEEM extends the network lifetime by 65, 70 and 21% against S-EECP and M-EECP. Because in S-EECP, data packets are directly transmitted for long distance (CHs and BS) without relay, hence, the nodes located farther away have high energy burden because of communication long range communication and they die earlier. Therefore DEEM overcomes the imbalance energy consumption problem by using multi-hop communication among all nodes. It achieves balance of energy consumption among all nodes and enhances the network lifetime.

**Fig. 4 Heterogeneous wireless sensor nodes in 100 × 100 regions**



**Fig. 5 Number of alive nodes per round over an area of size 100×100**



**Fig. 6 Network lifetime as a function of first dead node**

## V. CONCLUSION

Using this research work an effort has been made, to suggest an improvised technique that further enhances the conservation of energy than the existing methods. A new method is designed, that uses multi hop communication links between the cluster members and the cluster heads. Further the cluster heads communicate with the base stations in a multi hop manner. WSN has a rigid requirement regarding its power consumption due to the limited and non rechargeable energy supply. So by employing this new improvised technique, the energy is distributed equally among the nodes and this brings about a considerable conservation of energy. This method is helpful when the clusters far from base stations and need to communicate with these base stations and they communicate using multi hop links thereby reducing the energy consumed. Furthermore, the intra cluster communications using multi hop links distributes the energy among the nodes within the cluster thereby further reduction of energy consumed. Hence this method provides an efficient way of conserving energy in wireless sensor networks and thus increasing the lifetime of wireless sensor nodes within a network.

# International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 5, Issue 4, April 2016

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