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# Future Awareness -Based Novel Routing Algorithm for Wireless Sensor Networks

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*Abstract* - **As a booming technology wireless sensor network (WSN)has become a prominent tool for most of the important applications which includes home security, battle-field surveillance, agriculture, biomedical, etc., Energy is a key issue in WSNs as they include battery driven sensor nodes which cannot be instantaneously charged or restored. Hence an energy conserving routing protocol is designed, which minimizes the energy utilization and also improves the life span of the network. Proposed algorithm involves the inter-cluster data transmission, where the cluster head (CH) is selected firstly based on the transmission area in the forward direction, so as to eliminate the backward transmission of data and secondly based on energy density of that area and the next hop node called cooperative node is selected based on the remaining energy of the sensor nodes. The performance of the proposed algorithm is evaluated by comparing with Energy Efficient Uneven Clustering and Low Energy Adaptive Clustering Hierarchy protocols.**

***Index Terms*—Cluster head, cooperative node, routing, Energy Efficient Uneven Clustering (EEUC), wireless sensor network (WSN).**

## I. INTRODUCTION

Due to reliability, low cost, micro size and other such properties of Wireless Sensor Network (WSN), it has been developed as a dominating tool for maintaining and improving the real-time applications. Each sensing device in WSN acts as both sensing and routing element, but it has limitations in terms of storage, calculating ability, connectivity, power-supply and have limited energy. So protocols for particular applications in WSNs ought to be fastidiously designed for optimized utilization of energy so as to improve the life span of the working network.

Routing is one of the more challenging technologies in WSNs because of its inherent characteristics. For the efficient utilization of the energy, it is suitable to design hierarchical or cluster based routing protocol by dividing the randomly distributed nodes in the network called clusters. The nodes in each cluster can be divided as a cluster head node and remaining member nodes. Gathering the data and transmitting it to the sink called cluster head is the function of member nodes in each cluster. Hierarchical routing approach is highly scalable compared to other approaches thus it is used in most of the applications [1].

In greedy routing, for data transmission the sensor node will select the next hop node which is geographically near to the sink among all other nodes in that region [2]. So as to eliminate the possible backward transmission of data, where in some cases the source node will be near to the sink and not to the cluster head. In such cases sending data from source node to cluster head and then to sink will consume more energy and follow the longest path.

In the proposed algorithm the cluster head is selected as per the information about the data transmission area in the forward direction and energy density of the transmission area [3]. An intermediate node called cooperative node is chosen based on the remaining energy of the nodes after each round. Multi-hop routing is followed as it is energy efficient compared to direct transmission of data to the base station [4]. The distance between the sensing elements in the network is analytically computed using maximum Euclidean distance [5]. Route is selected to be shortest, with nodes having highest residual energy in the network so as to utilize the energy efficiently and hence to improve the life span of the network.

The paper is organized as Section II signifies the Related work on LEACH and EEUC protocol. Section III presents the Proposed work. Section IV describes Results and Discussions and Section V presents Conclusion and Future work.

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## II. RELATED WORK

### *A. Low Energy Clustering Hierarchy (LEACH) Protocol*

Out of several hierarchical protocols LEACH is considered as the prominent one based on adaptive clustering technique, which is divided into two phases. First is setup phase which involves the formation of clusters. In this phase the nodes in the network assign random values between 0 and 1. Secondly steady-state phase where data will be transmitted from sensor nodes to the cluster head and then to base station. The node which will have the value less than the threshold function value Y(n) claims to become cluster head. The threshold function is given as (1)

$$Y(n) = \begin{cases} q \Big/ \left(1 - q \times r \bmod \left(1/q\right)\right), n \in H \\ 0, \quad else \end{cases} \quad (1)$$

where q is the required percentage of cluster head. H is the set of nodes that have not been cluster head in the earlier 1/q rounds. r is the current round [6]. In LEACH protocol the data is transmitted from the source node to the cluster head of that cluster and then to base station, then base

### *B. Energy- Efficient Uneven Clustering (EEUC) Protocol*

In the EEUC protocol, the clusters of uneven size are formed and the dimension of the zones near to sink will be small. The competition range Rk of the clusters can be obtained as, (2)

$$R_k = \left(1 - k\frac{l_{max} - l(i, Sink)}{l_{max} - l_{min}}\right) R_k{}^0 \quad (2)$$

where lmax and lmin are the distant and nearest distance between the base station and the other nodes in the network, l(i,Sink) is the distance between the sink and node i, Rk0 is the maximum possible coverage area of the network. The value of k lies in between 0 and 1 as per the information about the competition ranges [3]. Cluster heads are selected depending on the average energy value of the nodes. Best cluster head for each cluster is obtained from particle swarm optimization (PSO) algorithm [8]. In this protocol the information from the source node is sent to the cluster head of that cluster and the cluster head will transmit it to base station. Base station will transmit data to the cluster head of next cluster; the cluster head will scan the remaining nodes in the cluster to find the destination node. If the destination node is not present in that cluster, data is sent back to the sink and sink will transmit it to the cluster head of next cluster. Each cluster is scanned until the destination node is found.

## III. PROPOSED METHOD

### *A. Network Model*

Following assumptions are made for the Network Model

1) The nodes are deployed in a random manner. Once the nodes are deployed, the location of the nodes cannot be changed.

2) Network is assumed to be homogenous.

Transmission energy for k-bit data packets for distance l is given as

$$E_{Tx} = E_{Tx-elec}(k) + E_{Tx-amp}(k, l) = \begin{cases} kE_{elec} + k\varepsilon_{fs}d^2, l < l_0 \\ kE_{elec} + k\varepsilon_{mp}d^4, l > l_0 \end{cases} \quad (3)$$

where

$$l_0 = \sqrt{\frac{\varepsilon^2{}_{fs}}{\varepsilon_{mp}}} \quad (4)$$

Energy required for receiving data is given as

$$E_{Rx}(k) = E_{Rx-elec}(k) = kE_{elec} \quad (5)$$

where ETx-elec and ERx-elec are power consumed for transmission and reception. εfs, εmp are the energy coefficients of free space model and multipath fading channel model respectively, l0 is the threshold distance [7].

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### *B. Design of the Proposed Method*

Selection of cluster head in proposed method is firstly, depending on forward transmission area which is related to the final data transmission direction and the position of the sink. This helps in the selection of cluster heads which are near to the sink so as to avoid the backward transmission of the transmitted information. Secondly, based on forward energy density. Intermediate node called cooperative node is selected according to the highest residual energy of the sensor nodes in the working network after each round. If there are n nodes in the cluster there is possibility of n-2 cooperative nodes, among them which will have highest residual energy will be considered as cooperative node for best route selection for data transmission. Cooperation between the nodes results in the selection of lower energy consumption route.

Fig. 1 represents forward transmission area, where the region between two arcs represents the transmission area in forward direction. Node i is the source node and node p is selected as the cluster head of that region as it is near to the base station. Fig. 2 is the flow chart representing the route discovery mechanism for the proposed method. Transmission are of node i is given as

$$FTA(i) = \odot O_1 \cap \odot O_2 \quad (6)$$

$$d_{ip} = \max(d_{ij}), j \in N'(i) \quad (7)$$

where N(i) represents the set of nodes having communication link with node i. N'(i) be the set of nodes that have an edge with node i, dij is the distance between node i and any other node j.

The area of FTA(i) is SFTA(i) which is given as

$$\left(\frac{2\pi}{3} - \frac{\sqrt{3}}{2}\right)[max\, d_{ij}]^2 \le S_{FTA} < \frac{\pi}{2}[\max(d_{ij})]^2 \quad (8)$$

Forward energy density is given as

$$FED(i,t) = \frac{\sum_{j \in FTA(i)} E_j(t)}{S_{FTA}(t)} \quad (9)$$

where Ej(t) is node j's energy value at time t and the complete summation term represents all of the neighbors' energy combined in function FTA(i).

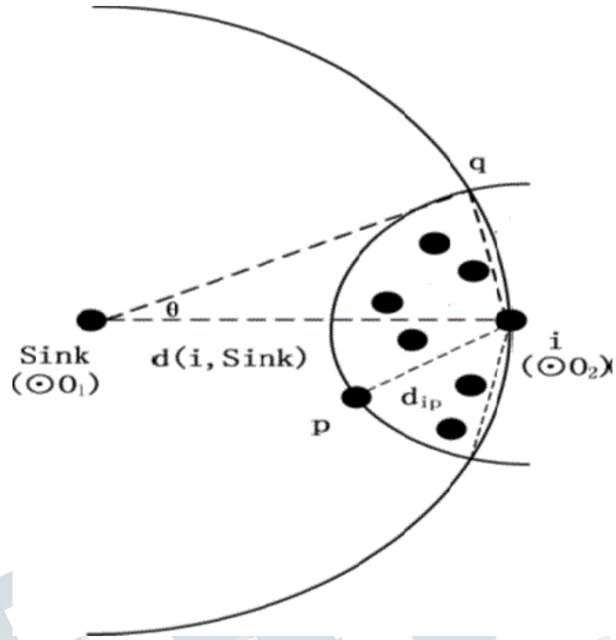


*Fig. 1.Forward transmission area.*

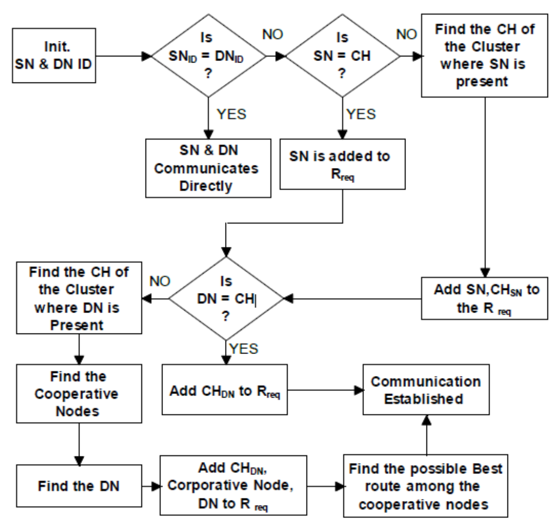


*Fig. 2.Flow chart representing the route discovery mechanism for proposed method.*

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### IV. RESULTS AND DISCUSSIONS

For the experimental purpose we have considered 4 clusters with 15 nodes in each cluster and the location of base station is at (50, 50). MATLAB has been used for simulation and the performance of proposed work is evaluated with LEACH and EEUC protocol with respect to the following parameters.

***1) End to End Delay***

It is the taken for the Route Request to go from the source node to destination node and then send back the Replay Request from destination node to source node. As the count of number of hops in proposed method is less, it will have reduced end to end delay. The end to end delay is calculated as

$$E2E_{delay} = t_{start} - t_{stop} \qquad (10)$$

where $t_{stop}$ is the time at which replay request is received. $t_{start}$ is the time at which route request is sent. The comparison is shown in Fig. 3.

***2) Number of Alive Nodes:***

It is the count of sensor nodes whose remaining energy is greater than B/4 after each round, where B is the energy of the node at the initial phase. The comparison is shown in Fig. 4.

***3) Number of Dead Nodes:***

It is the count of sensor nodes whose remaining energy is less than B/4 after each round, where B is the energy of the node at initial phase. The comparison is shown in Fig. 5.

***4) Lifetime Ratio:***

It is the ratio of number of alive nodes to the number of dead nodes. The comparison is shown in Fig. 6.

***5) Residual Energy:***

It is the amount of energy available in each node of the network after each round. Residual energy of the sensor nodes will remain high in case of proposed method compared to LEACH and EEUC as it involves only source node, destination node, cluster heads of source and destination clusters and one cooperative node. It is computed as

$$\text{Residual Energy} = \text{Initial Energy} - ((2 * E_{elec}) + (E_{DA} * d^{\delta})) \qquad (11)$$

where Eelec is the energy required for sending 1-bit data. EDA is the energy required for data aggregation and δ is the attenuation factor. The comparison is shown in Fig. 7

***TABLE I. ENERGY MODEL CONSIDERATIONS***

| Parameters | Value |
|---|---|
| Initial Energy of the Nodes | 5000mJ |
| Energy for sending data ($E_{elec}$) | 50nJ/bit |
| Energy Coefficient of Free Space Model ($\varepsilon_{fs}$) | 10pJ/bit/m$^2$ |
| Energy Coefficient of Multipath Fading Channel Model ($\varepsilon_{mp}$) | 0.0013pJ/bit/m$^4$ |
| Data Aggregation Energy ($E_{DA}$) | 4nJ/bit |
| Transmission Data Packet Size | 1000-bit |
| Attenuation Factor (δ) | 0.1<δ<1 |
| Number of Rounds | 100 |
| Node Deployment Area | 100x100m$^2$ |

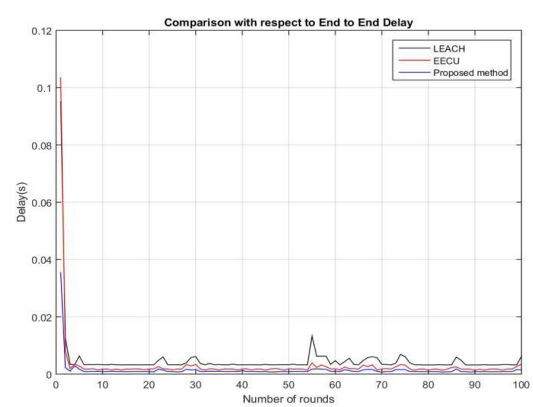


***Fig. 3 Comparison with respect to End to End Delay***

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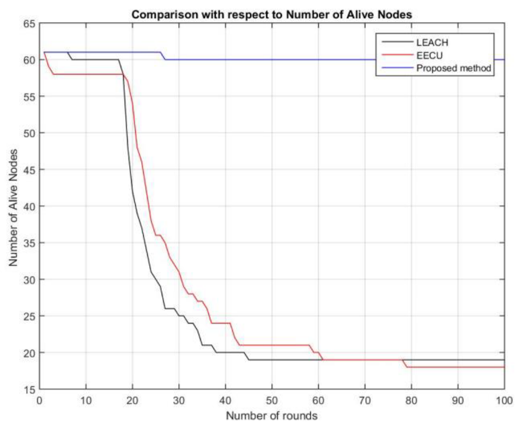


*Fig. 4 Comparison with respect to Number of Alive Nodes*

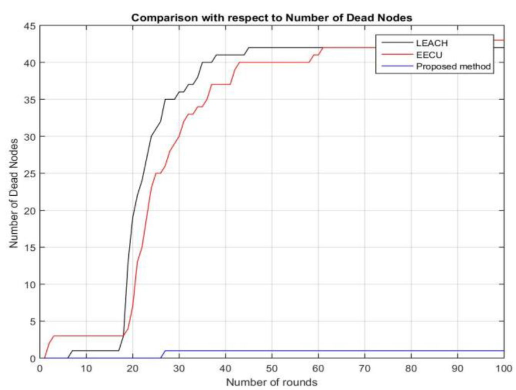


**Fig. 5 Comparison with respect to Number of Dead Nodes**

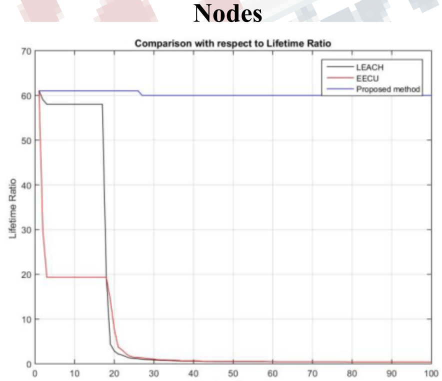


*Fig. 6 Comparison with respect to Lifetime Ratio*

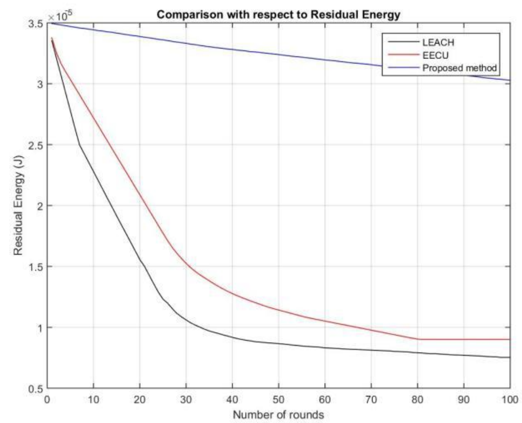


*Fig. 7 Comparison with respect to Residual Energy*

## V. CONCLUSION AND FUTURE WORK

A routing protocol is designed considering the point of effective utilization of energy based on transmission area in forward direction and forward energy density. From the simulation result it is found that the performance of the proposed work is better compared with the LEACH and EEUC protocol in terms of end to end delay, life time ratio, energy consumption, residual energy and throughput. Hence the proposed method will have high throughput, effective energy utilization and improved life span of the network. In future research the proposed method can be implemented for heterogeneous network.

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