

## Cluster Head Election Algorithm for Wireless Sensor Network

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### ABSTRACT

In this paper, a distance based Cluster head selection algorithm is proposed for improving the sensor network life time. This protocol achieves a good performance in terms of lifetime by balancing the energy load among all the nodes. This clustering technique help to prolong the life of wireless sensor network, especially in hostile environment where battery replacement of individual sensor nodes is not possible after their deployment in the given target area. Therefore, the proposed technique to distribute the role of the cluster head (CH) among the wireless sensor nodes in the same cluster is vital to increase the lifetime of the network. This algorithm uses a distance based method for providing the cluster head selection. Clustering techniques also provide good load balancing. This paper based on the distance of nodes and elects the cluster head to be responsible collects the data from nodes, this implementation done in C- Language.

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### Introduction

The continuous enhancement in communication, computation and hardware technologies enable new devices known as sensor nodes [1]. Wireless Sensor Networks (WSNs) are formed by hundreds or thousands of nodes that gather information and forward it to a sink node. These large numbers of nodes, which have the ability to communicate wirelessly, to perform limited computation, and to sense their surroundings, form the WSN [2]. Specific functions can be obtained through cooperation between these nodes; functions such as sensing, tracking, and alerting [3]. These functions make these wireless sensors very useful for monitoring natural phenomena, environmental changes, controlling security, estimating traffic flows, monitoring military application, and tracking friendly forces in the battlefields [2]. We consider a network of energy-constrained sensors that are deployed over a geographic area for monitoring in the environment. Among the sources of energy consumption in a sensor node, wireless data transmission is the most critical.

Obviously, WSNs need to be stable in design and structure to transfer data among the wireless sensors safely and without any problems, because of their use in critical areas and real time systems. Moreover, consuming less energy and increasing the lifetime of the wireless sensor nodes are the main objectives in designing the WSN, because of the limitation of the power resources and the difficulties of replacing the batteries of the wireless sensors.

Wireless Sensor Networks present vast challenges in terms of implementation. There are several key attributes that designers must carefully consider, which are of particular importance in wireless sensor networks.

- Cost of nested clustering
- Selection of Cluster heads and sub cluster heads
- Synchronization
- Data Aggregation
- Repair Mechanisms
- Quality of Service (QoS)

### Clustering

Cluster may be defined as follows:

Definition: Dividing the sensor networks into small manageable units is called as clustering & process known as clustering process. Though the main reason behind the implementation of the clustering approach is to improve the scalability of the network (prolong), it is an important factor in achieving energy efficient routing of data within the network [12].

Study on energy efficient routing in WSN brings this two broad classification of approaches. They are,

- Clustering approach
- Tree based approach

In a wireless sensor network, cluster is a group of sensor nodes in which one node will act as a cluster head (CH) [9, 10], and remaining nodes will act as member nodes. Clustering helps in reducing the number of exchanged communications in wireless sensor network resulting in low consumption of battery power of individual sensor nodes. This increases the life span of the wireless sensor network.

A cluster head is selected for each cluster based on the energy level of that node or distance based also. The main objective is to make only the cluster head communicate with the base station so that the remaining node can be put to a sleep state.

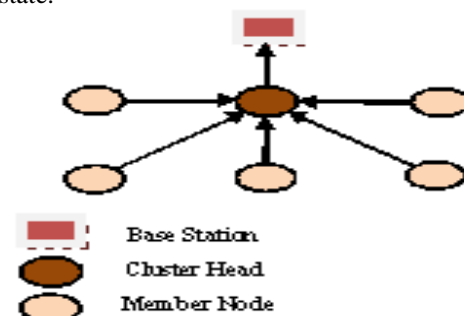


Fig 1. Cluster head model in WSNs.

**Background**

Many greedy algorithms have been proposed to choose cluster heads [13] in ad hoc networks, and wireless sensor networks.

They are based on the criteria of highest degree, lowest-ID, highest-ID, and node-weight, residual energy, probability, and any combination of these. The clustering techniques can also be classified based on cluster size, namely Single hop, and Multi-hop. LEACH [6] (Low-Energy Adaptive Clustering Hierarchy) elects cluster heads based on randomly generated value between 0 and 1. If this randomly generated value is less than threshold value then the node becomes cluster head for the current round. LEACH [11] is the first hierarchical cluster-based routing protocol for wireless sensor network which partitions the nodes into clusters, in each cluster a dedicated node with extra privileges called Cluster Head (CH) is responsible for creating and manipulating a TDMA (Time division multiple access) schedule and sending aggregated data from nodes to the BS where these data is needed using CDMA (Code division multiple access). Remaining nodes are cluster members. PEGASIS (power-efficient gathering in sensor information systems) [4],[5] is an improvement over LEACH by making only one node transmit it's data only to its nearest/neighbor node in the data fusion phase. PEGASIS starts with the farthest node from the base station. HEED (Distributed Clustering in Ad-hoc Sensor Networks: A Hybrid, Energy-Efficient Approach) [7] periodically selects cluster heads according to a combination of their residual energy, and communication cost. Distributed Weight-Based Energy-Efficient Hierarchical Clustering (DWEHC) [8] is modified version of the HEED. It claims to provide more balanced cluster size and intra cluster topology. HEED uses two clustering parameter to select CH: one is residual energy, and the other is communication cost. The communication cost is defined as an average minimum reach ability power, which means the minimum power levels required by all nodes within the cluster range to reach the CH. The communication cost held by CHs is used to let a node which belong to several CHs choose the best one.

In HEED, each node must be mapped to exactly one cluster, and each node belongs to its only CH within one hop. After a clustering process, each node can either elect to become a CH due to a probability or join a cluster according to CH messages.

Sensors measure real-world conditions, such as heat or light, and then convert this condition into an analogue or digital representation.

To select a cluster head following steps are followed:

- Placing sensor node
- Clustering process
- Selecting cluster head
- Remaining nodes select as child node
- Sensing information from child nodes & sends to the corresponding cluster head

**Proposed Work**

In WSN after creating the clusters we have to decide the cluster head .Here we propose an algorithm for selecting cluster head based on distance.

**Matrix Representation Based Concept**

Step 1: Let we have a set S of n nodes in a cluster viz.  $S = \{S_1, S_2, S_3, \dots, S_n\}$  and let the distance from each node to all other nodes within cluster can be represented as

Step 2: Let the sum of all distances from a single node to all other nodes are represented as

- $d(1,1) \rightarrow$  Distance between  $S_1$  to  $S_1$
- $d(1,2) \rightarrow$  Distance between  $S_1$  to  $S_2$
- .....
- $d(1,n) \rightarrow$  Distance between  $S_1$  to  $S_n$
- $d(2,1) \rightarrow$  Distance between  $S_2$  to  $S_1$
- $d(2,2) \rightarrow$  Distance between  $S_2$  to  $S_2$
- .....
- $D(2,n) \rightarrow$  Distance between  $S_2$  to  $S_n$
- .....
- .....
- $d(i,j) \rightarrow$  Distance between  $S_i$  to  $S_j$
- .....
- .....
- $D(n,1) \rightarrow$  Distance between  $S_n$  to  $S_1$
- $D(n,2) \rightarrow$  Distance between  $S_n$  to  $S_2$
- .....
- $D(n,n) \rightarrow$  Distance between  $S_n$  to  $S_n$

Distance matrix representation from one node to other node in algorithm.

$$\begin{bmatrix} d(1,1) & d(1,2) & d(1,3) & d(1,4) & \dots & d(1,n) \\ d(2,1) & d(2,2) & d(2,3) & d(2,4) & \dots & d(2,n) \\ \vdots & \vdots & \vdots & \vdots & \ddots & \vdots \\ d(n,1) & d(n,2) & d(n,3) & d(n,4) & \dots & d(n,n) \end{bmatrix}$$

Step3: Add all distance from one node to all other nodes. Find the value of D(i).

$$D(1) = d(1,1) + d(1,2) + d(1,3) + d(1,4) + \dots + d(1,n)$$

$$D(2) = d(2,1) + d(2,2) + d(2,3) + d(2,4) + \dots + d(2,n)$$

$$D(3) = d(3,1) + d(3,2) + d(3,3) + d(3,4) + \dots + d(3,n)$$

.....

$$D(i) = d(i,1) + d(i,2) + d(i,3) + d(i,4) + \dots + d(i,n), \quad 1 \leq i \leq n$$

.....

.....

$$D(n) = d(n,1) + d(n,2) + d(n,3) + d(n,4) + \dots + d(n,n)$$

Calculate the distance vector for each node representation of step 3 in algorithm.

$$\begin{bmatrix} D(1) \\ D(2) \\ D(3) \\ D(4) \\ \vdots \\ D(n) \end{bmatrix} = \begin{bmatrix} d(1,1) + d(1,2) + d(1,3) + d(1,4) & \dots & d(1,n) \\ d(2,1) + d(2,2) + d(2,3) + d(2,4) & \dots & d(2,n) \\ d(3,1) + d(3,2) + d(3,3) + d(3,4) & \dots & d(3,n) \\ d(4,1) + d(4,2) + d(4,3) + d(4,4) & \dots & d(4,n) \\ \vdots & \ddots & \vdots \\ d(n,1) + d(n,2) + d(n,3) + d(n,4) & \dots & d(n,n) \end{bmatrix}$$

Step4: Now the distance from base station (DBS) to each node, respectively

$$DBS(1) = \text{Distance between BS to } S_1$$

$$DBS(2) = \text{Distance between BS to } S_2$$

$$DBS(3) = \text{Distance between BS to } S_3$$

.....

.....

.....

.....

$$DBS(n) = \text{Distance between BS to } S_n$$

Distance from base station DBS(i), where  $1 \leq i \leq n$ , vector representation to all nodes of step 4 in algorithm.

$$\begin{bmatrix} DBS(1) \\ DBS(2) \\ DBS(3) \\ DBS(4) \\ \vdots \\ DBS(n) \end{bmatrix} = \begin{bmatrix} \text{Distance between } S(1) \text{ and BS} \\ \text{Distance between } S(2) \text{ and BS} \\ \text{Distance between } S(3) \text{ and BS} \\ \text{Distance between } S(4) \text{ and BS} \\ \vdots \\ \text{Distance between } S(n) \text{ and BS} \end{bmatrix}$$

Step5: Now the net distance with base station (NDBS)

Calculate the net distance with base station NDBSi, where  $1 \leq i \leq n$ , vector for each node representation of step 5 in algorithm.

$$\begin{bmatrix} NDBS(1) \\ NDBS(2) \\ NDBS(3) \\ NDBS(4) \\ \vdots \\ NDBS(n) \end{bmatrix} = \begin{bmatrix} D(1) \\ D(2) \\ D(3) \\ D(4) \\ \vdots \\ D(n) \end{bmatrix} + \begin{bmatrix} DBS(1) \\ DBS(2) \\ DBS(3) \\ DBS(4) \\ \vdots \\ DBS(n) \end{bmatrix}$$

Step6: Select the cluster head  
 $NDBS(i) = \text{Min}(NDBS(1), NDBS(2), NDBS(3), NDBS(4), \dots, NDBS(n))$

After performing all steps in above mentioned sequence, we found that node S(i) has smallest distance in comparison to other nodes. So, we can conclude that if node S(i) is selected as a cluster head, node S(i) will consume less energy in comparison of other node.

**Simulation**

The proposed algorithm is successfully implemented in all matrix calculations are implemented in C language resulting, which node is chosen as a cluster head. Fig. 4 shows the set of input and output. In order to perform the computation through C program, firstly the total number of node of a cluster are entered & then corresponding ID of each node. Then distance between each pair of node is entered, which generates the distance matrix of cluster. Then the net distance (by adding the distance from each node to other connected nodes say Di) is computed. And then the distance DBSi from base station (BS) to each node of cluster is entered. And finally by adding the computed distance vectors Di and DBSi, net distance with base station vector (NDBSi) is computed and the node with minimum NDBSi value is chosen as cluster head.

```

NeuTron DOS-C++ 0.77, Cpu speed: max 100% cycles, Frameskip 0, Program: TC
Number of nodes in a cluster-->5
Node name-->1
Node name-->2
Node name-->3
Node name-->4
Node name-->5

Distance between node 1 and 2 : 3
Distance between node 1 and 3 : 4
Distance between node 1 and 4 : 4
Distance between node 1 and 5 : 7
Distance between node 2 and 3 : 1
Distance between node 2 and 4 : 2
Distance between node 2 and 5 : 3
Distance between node 3 and 4 : 5
    
```

Fig 2. Input of Five nodes with distances in between.

In the implementation of proposed algorithm, a cluster of four nodes are considered viz. 1, 2, 3, 4 & 5 and a base station BS shown in Fig. 3 is considered and the node which have minimum net distance (calculated according to proposed algorithm), elected as a cluster head.

```

NeuTron DOS-C++ 0.77, Cpu speed: max 100% cycles, Frameskip 0, Program: TC
Distance between node 4 and 5 : 7
Distance matrix-->
0 3 4 4 7
3 0 1 2 3
4 1 0 5 7
4 2 5 0 7
7 3 3 7 0

columnwise distance addition
node 1 = 18
node 2 = 9
node 3 = 13
node 4 = 18
node 5 = 20
Distance from base station to node 1-->
    
```

Fig 3. total distance calculation.

After plotting a cluster of nodes in C language all matrix calculations are performed, node is chosen as a cluster head.

The energy is calculated on the basis of non-CH approach & proposed algorithm of each node.

Fig. 4 shows comparison, based on energy consumption between non-CH or direct & proposed algorithm, Fig. 5 shows comparison, based on distance coverage between non-CH & proposed algorithm for each node.

To calculate the sending energy with using following formula:

$$E(t) = (E(elec) * k) + (E(amp) * k * d * d)$$

To calculate the receiving energy consumption formula of each node:

$$E(t) = (E(elec) * k)$$

Table1. Radio Parameters

Parameter	Definition	Unit
$E_{elec}$	Energy dissipation rate to run the radio	50nJ / bit
$\epsilon_{amp}$	Energy dissipation rate to run transmit amplifier	100 pJ / bit /m2
K	Data length	bit (8)
D	Node transmission Range	Meter
DA	Data Aggregation	5nj/bit

```

NeuTron DOS-C++ 0.77, Cpu speed: max 100% cycles, Frameskip 0, Program: TC
node 3 = 13
node 4 = 18
node 5 = 20
Distance from base station to node 1-->4
Distance from base station to node 2-->5
Distance from base station to node 3-->6
Distance from base station to node 4-->8
Distance from base station to node 5-->3

node 1 = 22
node 2 = 14
node 3 = 19
node 4 = 26
node 5 = 23

Node 2 selected as a cluster head with minimum distance -->14
total distance = 26
calculate the sending energy.....
Non clustering approach sending energy consumption = 940.799988
Distance based Clustering approach sending energy consumption = 556.799988
    
```

Fig 4. Based on distance CH selection and sending energy consumption for Non-Clustering(direct) & Clustering.

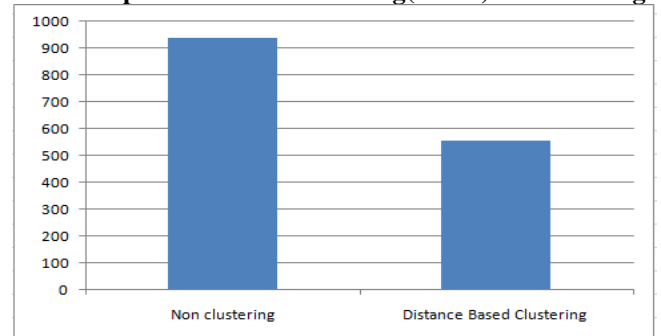


Fig 5. Sending Energy Consumption Graph between Non-Clustering(direct) & distance based clustering.

**Conclusion**

In clustering hierarchy, the cluster head decision is a major challenge. If network is taken as a whole, then the power consumption can be optimized by the rotation of this cluster head inside the individual clusters. Energy conservation is a significant concern in the WSNs, especially as the energy conservation of the cluster head in the cluster-tree network has to be higher because of the different operations, which they control in the network. In this paper, a new technique is proposed to select cluster head among some of the wireless sensor nodes based on net distance with base station. The proposed technique aims to increase the lifetime

of the whole network, and to increase the number of nodes, which will remain alive for the maximum period of time.

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