An Enhanced Clustering Approach For Enhancement Of Lifetime In Wireless Sensor Network

Navpreet Kaur¹, Inderdeep Kaur Aulakh²

¹Research Scholar I.T. Department, UIET Panjab University, Chandigarh & Assistant Professor Chandigarh University, Punjab.
²Professor I.T. Department, UIET Panjab University, Chandigarh.

ABSTRACT: Wireless Sensor Network has always been an attention seeker for the research and other related industries. It faces significant issues related to the battery and energy consumption of the nodes. Due to limited battery capacity, it is required to communicate in significant way for efficient data transfer. Clustering is one of the approaches for the same. This paper proposes a new clustering model which focuses on cluster count and selection of the Cluster Head. The proposed model is evaluated under two types of scalability namely the nodes and the areas. Five different nodes to area distribution is employed and the proposed model is evaluated using Throughput, Lifetime, Energy Consumption and Packet Delivery Rate (PDR).

Keywords: WSN, Clustering, Throughput, Lifetime

1. INTRODUCTION

Wireless Sensor Network (WSN) is a network with ‘n’ number of deployed nodes in a given region. The nodes are powered by a tiny battery and the batteries cannot be recharged during the time of the simulation. The run time of the deployed network is termed as simulation time. The total time which a node serves in the network with one charge is termed as the lifetime of the node and accumulatively it is termed as the network lifetime [1]. If the battery of the node is not sufficient, it soon stops serving the network and is tagged with “dead” label. A serving node is called “alive” node. Since the network can only act if the nodes are alive, network lifetime has been an attention gainer for both the research and the industrial applications [2]. In order to enhance the network lifetime of the network, the concept of clustering was introduced in early 2000 and has received updates over the time [3].

There are two major issues of cluster formation in WSN namely the node distribution and the area of expansion. The communication between the nodes takes place with the help of the Cluster Head (CH) [4-5] as shown in Figure 1. The CH shoulders the responsibility to coordinate among the network nodes and regularly transfers the collected data packets to the
remote node or the sink. Data transfer time could also be reduced by grouping into smaller clusters. In this episodic re-clustering strategy, nodes that possess high residual energy will act as CH. The network lifetime is improved by combining data from the source node to smaller bits to make data transmission a more efficient process [6].

![Deployed Nodes in a given region of Deployment](image)

**Figure 1: Deployed Nodes in a given region**

The very first clustering algorithm is known to be Low energy adaptive clustering hierarchy (LEACH) [7] and with due time, it has received updates like E-LEACH, M-LEACH etc [8-12]. Clustering is of two different architectures namely static and dynamic. If the clustering is done following the proactive static approach, the given region will be divided into ‘k’ number of clusters and k could be any number. This approach is good enough if the network is small as the formation will result into creation cost. Each region has its own CH and any node who aims to transfer the data packet from one end to another, sends the data to its relative CH only. CH of one region, transfers the data packet to the neighbouring CH till the destination is not found. CH to CH data transfer is termed as route formation [13-15]. Different route discovery mechanisms have been proposed till date aiming to improve the performance of WSN. Reactive clustering aims to resolve the issue of cluster formation on the base of node distribution and associated attributes of the nodes.

This paper contributes in the calculation of CH count as well as this paper proposed a new algorithmic architecture of the selection of the CHs over a given node sequence.

The rest of the paper is organized in the following manner. Section 2 illustrates materials and methods whereas Section 3 illustrates the results of the paper. Section 4 concludes the paper.

## 2. RELATED WORK

Clustering based routing approaches forms the best strategy for improving the network lifetime of wireless sensor networks. These strategies work on the basis of cluster heads. Leu et al.
considered the issues adjoining the clustering approach that broadly covers the selection and construction of a cluster head of WSNs. They had postulated a novel Regional Energy Aware Clustering approach that worked by utilizing isolated nodes of WSN. The technique was based on weight calculation that formed the major criteria for clustering head selection and these weights were intern governed by the residual energy of the sensor node. The approach effectively increased the network lifetime based on the distance between sink and sensor that presided over the data transfer to sink or the cluster head [6]. Prabhu and Bala kumar (2016) designed a methodology to evaluate two WSN fields based on distributed clustering technique. The evaluation was based on predicting efficiency of the network in terms of routing, clustering and residual energy along with network life time. The hybrid method majorly focused on improving lifetime while employing rapid cluster formation to achieve improved PDR in WSNs [16]. Bahl and Bhola (2018) proposed an algorithm for the selection of cluster head for WSN. The design was based on the hybrid strategy where the weights used in the clustering design incorporated the parameters that could successfully lower the energy utilization at CH. The designed work was governed by degree of node, residual energy and distance from the reference node or the CH. The design was mainly focussed to enhance the performance of the network lifetime based on the load sharing strategy employed to distribute load among the nodes [14]. Toloueiash tian and Motameni (2018) also implemented fuzzy logics in combination to distance, energy and number of connections with the cluster head. The authors were mainly interested in the designing the clusters and evaluated their work against the existing work. Simulation results of the design achieved improvement in terms of enhanced network lifetime of WSNs [17].

Balaji et al. (2019) employed the routing protocols for transfer of data packets from one cluster head to another cluster head. The proposed multi-hop based data transmission finally transmits the data packets to the base station. In the process, type 1 fuzzy logic was used to predict the nodes based on distance and the trust factor. A Highly trusted node was selected by Fuzzy logics that increased the network life time along with decreasing the network overhead [18]. Hamzah et al. (2019) designed a model that evaluates each node on the basis of density, residual energy, location and distance with respect to base station in order to qualify to be a cluster head. The design was strengthened by Fuzzy Logics to achieve energy efficient clustering based on least separation distance for WSN. Further, Gini index was also involved. The simulation based evaluation had demonstrated the improvement on terms of enhanced network lifetime and energy consumption [19]. Britto and Selvan (2019) proposed design that was based on soft computing technique to optimize the process of cluster head selection. Authors had implemented a back propagation Artificial Neural Network training approach in their design. The design evaluation had shown enhanced performance for improving network life time in WSN with minimal errors [20].

3. MATERIALS AND METHODS

The proposed work model is divided into two blocks namely the counter block and the selection block. The counter block has the responsibility of calculating the total number of cluster heads in a given region and the selection block is responsible for the selection of desired number of CHs. Figure 2 represents the proposed model as blocked diagram.
3.1 The Counter Block

The counter block takes care of the count of the total number of required CHs in a given region. The proposed work model uses six variations of node and area as mentioned in Table 1.

<table>
<thead>
<tr>
<th>Model Number</th>
<th>Node Count</th>
<th>Deployment Area in meters</th>
</tr>
</thead>
<tbody>
<tr>
<td>Model 1</td>
<td>50</td>
<td>1000/1000</td>
</tr>
<tr>
<td>Model 2</td>
<td>60</td>
<td>1200/1200</td>
</tr>
<tr>
<td>Model 3</td>
<td>70</td>
<td>1400/1400</td>
</tr>
<tr>
<td>Model 4</td>
<td>80</td>
<td>1600/1600</td>
</tr>
<tr>
<td>Model 5</td>
<td>90</td>
<td>1800/1800</td>
</tr>
</tbody>
</table>

Table 1: Deployment Models

The nodes are first deployed with random x and y locations to maintain the dignity or distribution and to check the rigidness of the proposed work model. The pseudo code of deployment is represented in Pseudo Code 1.

PSEUDO CODE 1: Node Deployment

1. Function Node Deployment
2. Input : NodeCount, NetworkLength, NetworkWidth Output: DeployedNetwork // Inputs to the network
3. For each node in Nodes // For each node in the network
4. XLoc,nd = NetworkWidth * Random // Apply a random x location based on width
5. YLoc,nd = NetworkHeight * Random // Apply a random y location based on Height
6. ResidualEnergy = Heterogenous // Distribute Heterogeneous residual energy
7. Transf energy = AggE + Tx * p // A node will consume a total amount of aggregation energy along with the transfer energy per packet
8. DeployNet::nd // Deploy the network
9. EndFor

For the deployed region and nodes, the total number of CH count is calculated using Equation (1).

$$CH_{CountPre} = \sqrt{\sum_{i=1}^{Nodes} \frac{Distance_{NodeToSink} \times \ln(Nodes)}{Area_{A1}}}$$  \hspace{1cm} (1)

Where A1 is the attraction index and is calculated using Equation (2)

$$A1 = 2 \quad \text{if} \quad \frac{Nodes_{DeploymentRegion}}{\text{Nodes}} < .10 \quad \& \quad \text{Nodes} > 50 \quad \hspace{1cm} (2)$$

1 \quad \text{Otherwise}

Based on the calculations made by (1) and (2), the selection block calculates the regions of deployment of CHs.

3.2 The Selection Block
The selection block, preliminarily divides the network into four different segments and selects the CH as per each region as shown in Figure 3.

![Figure 3: Division Area](http://www.webology.org)
The regions are divided randomly in such a manner that all the nodes are covered in the network. Keeping a centre in the each region, 25% coverage area is calculated for each zone. K-means is applied for the centroid calculation for each region and a random centroid is initiated first followed by the k-mean centroid formation. For each region, CH is identified by using equation (3)

\[ CH = \text{Max} \left( \sum_{i=1}^{r} \frac{\text{ResidualEnergy}}{\text{Lifetime}} \right) \] (3)

Equation (3) is applicable if no simulation is made. That means for the first simulation round, the node will be considered with high residual energy. Pseudo Code 2 represents the selection procedure for the proposed algorithm.

**PSEUDO CODE 2:**

Function Select CH

Input: Residual Energy, Lifetime

Output: Selected Cluster Heads

1. For each node in the Region // For each node in the region
2. Sort Nodes as per Equation 3 // Sort nodes as per the lifetime and residual energy and select the cluster head
3. For k in Nodes. Region // Now the nodes who will fall in that region are to be calculated
4. if k ≡ node // All the nodes other than the selected CH
5. dist = \( \sqrt{(CH_x - k_x)^2 + (CH_y - k_y)^2} \) (4) // Calculate the distance between the CH and nodes to decide whether the node is to fall under the CH
6. Add node to CHIST // If the 5th step is satisfied, the node is added to the CH List
7. End For
8. End NodeProportion

4. RESULTS AND DISCUSSION

Based on the proposed work model, the following results are evaluated.

a) Throughput = \( \frac{\text{TotalReceivedPackets}}{\text{Per unit Time}} \) (5)

b) Lifetime = Total Served Time with One Single Charge (6)

Figure 4 represents the throughput of the proposed work model.
The throughput of the proposed model is tested under various rigid conditions including increasing number of nodes and varying area size. When the nodes are applied in a small region, the throughput is monitored to be low. As for example, for the node count 50 and deployment area 1000/1000, the attained throughput value is 75 packets/second whereas for same number of nodes, the higher deployed region gets more throughput value. If the node count increases, the packet flow will be higher and hence the throughput will increase for sure. The scenario goes the same when the area increases. The maximum attained throughput is 171 packets/second whereas the minimum is 75 packets per second.
If the throughput of the network is increasing, the lifetime is increases as well because a node can only serve in the network if it is alive and furthermore increasing the lifetime for itself and for the network. But the lifetime also varies due to some other factors like load and routing issues and hence a little variation can be observed as shown in Figure 5. The maximum lifetime in seconds is observed to be 124 seconds and minimum is 77 seconds.

The energy consumed by the nodes in different network scenario is shown in Figure 6. From the figure it is clear that with the increase in the network area along with the deployed nodes, the consumption of energy also increases. Also, it is clear that as the nodes increases, the energy consumption also increases and minimum energy consumption has been analyzed at 50 numbers of nodes.
The parameter PDR (Packet Delivery rate) has been analyzed to determine the rate of packet delivered with respect to the total packet sent by the transmitting node. The graph depicted that with the increase in the nodes as well as size of the network, PDR values decreases. This is because; the data is passed by a number of intermediate nodes.

5. CONCLUSION
This paper proposes a new model for the CH count and the selection of the CH as well. The proposed work model is divided into two sections namely the counter block and the selection block. A new fitness model is designed for both the blocks and different variations of nodes and area is tested. Minimum of 50 nodes are deployed for 1000×1000 meter area and a maximum of 90 nodes are deployed for the same area. The maximum deployment area is 2000×2000. Four quality of service parameters namely Throughput, Lifetime, energy consumption and PDR have been evaluated. The maximum attained throughput is 171 packets/second and minimum is 75 packets/second. The maximum attained lifetime and PDR is 124 seconds and 98.95% respectively with minimum energy consumption of 42.76 mJ. As the region increases, the throughput and energy consumption increases as well. Lifetime has similar kind of propagation value but there are certain other aspects of lifetime and hence it varies a little and does not follow the exact trend of increase.

REFERENCES


