# Sensor Node Grouping for Energy Efficient Clustering in Wireless Sensor Networks

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The sensors that consist of a wireless sensor network are massively deployed and operate in unattended environments and harsh natural conditions with restricted battery power supply. It is important to extend the life of the sensors that make up the wireless sensor network. Data is gathered by sensor nodes within a cluster group and forwarded to the cluster's head (CH) node. However, transmission of packets among sensor nodes as well as CH nodes may not succeed if a cluster group is big and the distance from each other to the CH is great. Communication connection failure results in a lot of power loss due to continuous connection attempts. In this paper, a group of clusters of a suitable size is formed on a two-dimensional plane so that the distance between the sensor node and the CH node is not more than an appropriate range, so that cluster uniformity is possible. By communicating with the closest sensor node, sensor nodes were linked to create member nodes in order to guarantee cluster size homogeneity. Adjacent nodes were then grouped together to form clusters. By allowing only the closest sensor nodes that are within the mutual attraction range to be included as cluster members, adjacent sensor nodes that are out of the attraction range will form a new cluster. Based on the formed clusters, we applied multi-hop routing techniques to extend the battery power lifespan of the sensors. In this research, we examined the sensor nodes' power consumption for a one-hop clustering strategy based on a single unit of distance using the suggested cluster uniformity algorithm. Simulation results demonstrated the cluster equalization improvement rate. A network homogeneity improvement of around 20% was attained as a result of cluster homogenization.

**Keywords:** wireless sensor network, cluster uniformity, battery power supply, lifespan, multi-hop routing.

## 1. Introduction

Utilizing diverse sensor devices, wireless sensor networks keep an eye on the environmental state in a range of challenging natural settings. WSNs capture and send data for logistical control, reconnaissance, or surveillance back a base station. They are valuable for environmental, medical, traffic, and catastrophe prediction systems. The main parts needed for these activities are a power supply, a device that sends the data it has gathered to the initial node, and a device that takes the measured physical output from tiny sensor gadgets as analog signals and transforms it into digital signals. Because the sensor nodes that make up a WSN run its constituent parts off of a restricted power supply, they need to be able to guarantee energy-efficient operation. They also provide reliable functioning with restricted power supplies and the transfer of gathered data to the base station. Algorithms based on clusters have low energy usage. A cluster head (CH) node is present in every cluster made up of sensor nodes (SNs). In order to convey data to a base station (sink node), that is more energy- and network-efficient than sending data directly to the base station, the CH node receives the data gathered from the SNs and sends it to its nearby cluster heads.

Geographical factors cause the sensors in wireless sensor networks to be unevenly distributed, therefore they are placed randomly over a vast region. Various numbers of sensor nodes will arise in each cluster in a structure with an uneven distribution of sensors. Because of the uneven distribution of the sensor nodes, there is a difference in the energy consumption when a cluster head (CH) node gathers the information from each of the sensor nodes and transfers it to the destination. [1] By a cluster having a high sensor density, a CH node will use more energy than in a cluster having a relatively low node sensor density. This will shorten the cluster's lifetime and, in turn, the network's lifetime. As previously mentioned, there are two factors that reduce the lifetime of the network: the first is the failure of a communication connection because of the lengthy distance among the CH node as well as the SN node; the second is that the CH node's battery life is depleted more quickly than that of other member nodes because it collects data from the member nodes frequently. The data acquired by the CH node cannot be sent to the CH node in the next cluster when its battery runs out. Consequently, from among the member's other SN nodes, the CH node has to be chosen and substituted. All cluster member nodes' battery lives will be shortened if this operation occurs often [2]. A shorter head node replacement interval will result in a lower cluster lifespan and, ultimately, a shorter network lifetime [3, 4].

The cluster hierarchy LEACH technique is one of the sensor network wireless protocols now in use. It is a single-hop cluster system in which CH nodes speak with the sink node directly. But this approach has a poor energy-saving impact if member nodes are more than a single hop distant toward the CH node, as communication with the CH node fails.

Our approach to clustering, which we discuss in this paper, distributes sensor nodes among different densities of irregularly created sensor nodes in WSNs and regenerates them into clusters of comparable size, so maintaining a uniform density of sensor node in a cluster. By using the distance between sensor nodes to create clusters, the suggested technique enhances the consistency of the current cluster size by around 20% while also producing an appropriate distribution of sensor node density.

## 2. RELATED WORK

Existed energy-efficient cluster model EECS is that selected CH node among the member node in the cluster. CHs are elected by competition, considering their transmission radius [5]. After the CH nodes are elected, weights are applied to determine whether to combine the clusters appropriately [6]. To select the optimal CHs, a selection algorithm based on node size, residual energy, and an objective function expressed as the optimal number of CHs was also presented. A method for determining a PSO-based CH based on the distance between nodes, distance from a base station (BS), residual energy, etc. is proposed [7]. An advantageous approach in the case of uneven distributing sensor nodes is that the probability of participating in clustering is adjusted in real time in the network, which reduces and prolongs energy consumption and network lifetime, respectively [8]. High sensor node density locations use the most power and have a higher likelihood of nodes skipping clustering cycles than low sensor density areas. [9] proposed that rather than replacing the CH node after the energy is completely depleted, it should be done when there is still leftover energy. The multi-hop strategy fared better than the other approaches, according to this method. It is more energy-efficient having the CH node to gather information from the member nodes and send it to the destinations (sink node) with regard to of its communication success rate than for every member node to send data directly to the node that serves as the sink, which is located at a distance [10]. By selecting a CH node among the cluster's member nodes and transmitting information to the destination, the LEACH strategy was presented as a means of lowering energy consumption. This process increases the communication's success rate while lowering energy consumption [11]. A new, enhanced version of the LEACH protocol called LEACH-PRO has been presented, which uses a probabilistic approach to pick cluster heads in order to increase the sensors' lifespan [12]. Using a probability function to choose the cluster head node based on the greatest amount of leftover energy and the shortest path to the sink is one of the many novel techniques suggested in LEACH-PRO. An energy-efficient clustering as well as localization technique called a genetic algorithm (ECGAL) emerged. [13]. In order to increase the lifespan of the wireless network, this technique builds a fitness function by integrating residual energy, distance estimate, coverage connections estimation, and coverage connection. In order to create a densely integrated communication system with the shortest possible the routing coming from sensor nodes (SNs) to a cluster head (CH) in an environment involving multiple hops, [14] suggested Fully Connected Energy Efficient Clustering (FCEEC), that builds densely integrated communication using electrostatic discharge algorithms. While employing ESD greatly lowers the number of dead nodes in the network, extending the network's lifespan, the Electrostatic Discharge Algorithm (ESDA) provides complete communication between sensor nodes in an energy-efficient way.

## CLUSTER FORMATION

In a wireless sensor network, sensors are randomly placed over a large area of the wilderness and then neighboring sensors communicate with each other to form clusters. When a large number of sensors are randomly distributed in different geographical environments, the sensors will be unevenly distributed, and if uneven densities of sensors form clusters, clusters of different sizes will be formed. Since sensors within a single hop distance communicate with each other to form cluster members, and these member nodes form a cluster, the number of sense node members in a formed cluster is higher than in other clusters under conditions of high sensor density. Therefore, when a cluster is formed from randomly distributed sensor nodes, all sensor nodes that are connected within a single hop distance are added as member nodes, resulting in clusters of various sizes. Figure 1 shows the simulation result of randomly distributed sensor nodes forming a cluster by adding nodes that communicate within a unit distance as member nodes. This simulation result assumes that about 3000 sensor nodes are deployed within a distance of 100X100 units. The red color indicates the CH node, and each member node in the cluster is connected to the CH node in green. As shown in the figure, when the member nodes are densely located on a two-dimensional plane, each sensor node has more members to add as neighbors, resulting in a large group of clusters. The geographical location of the sensor nodes is simplified to a unit distance along the x-axis and y-axis. That is, a distance of +1 along the x-axis means that they are adjacent by 1unit.

As shown in the cluster formation example in Figure 1, the density of sensor nodes is not constant because the sensor nodes are randomly distributed in a specific area. Therefore, the size of the formed clusters also varies greatly. In the figure, the red dotted area is Cluster A. Notice the stark difference in the density of sensor nodes in this group and the size of the other cluster, Group B (blue dotted area), that exists around it. To prevent communication failure between sensor nodes and CH nodes within the cluster, the cluster size should be adjusted so that it does not become too large.

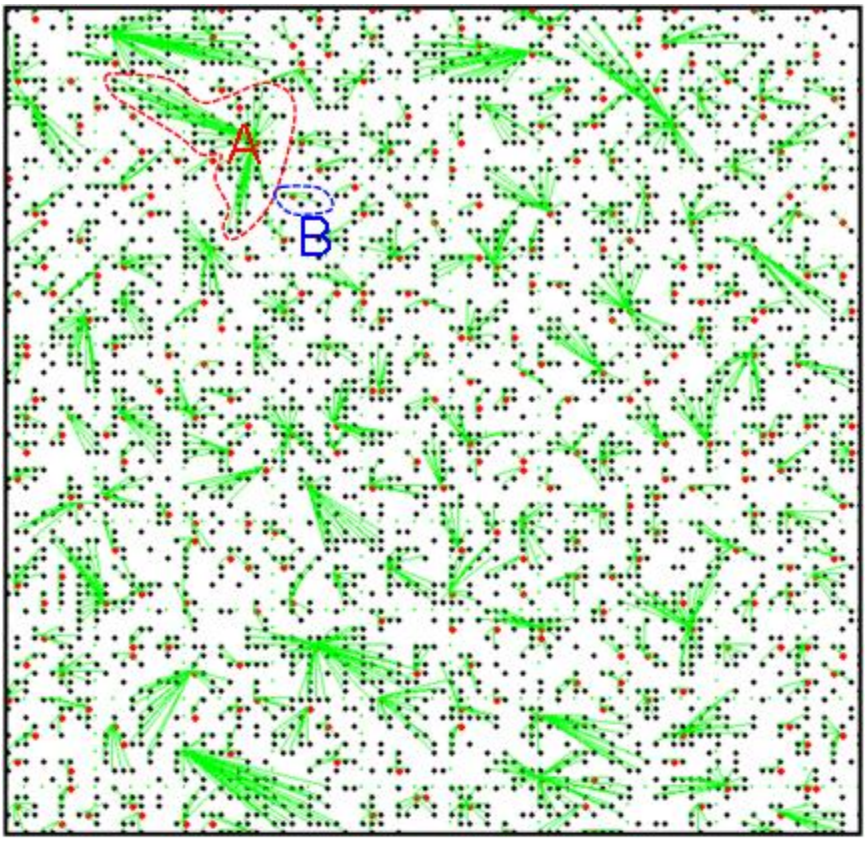


Fig. 1: Example of forming a cluster within a 100X100 unit distance.

Distance-based Reciprocal Attraction Clustering & Uniformization

To reduce the density of sensor nodes, we do not add all sensor nodes within a unit distance as members, but instead add the nodes with the strongest physical attraction per unit distance as members. The strongest mutual attraction is the same as how dust clumps together. When sensors within a unit distance communicate with each other and are added as member nodes, a cluster will be formed as shown in Figure 2, a) to b). Group 1 may be split into two different subgroups by considering node attraction, even if all of the nodes in the group are connected as a single cluster by an element of distance. Similar to cluster group 2 in b), sensor nodes linked by a unit distance can be used to apply mutual attraction to split the group into two server groups. Figure 4 shows the clustering results of applying the mutual attraction within the unit distance suggested for the large number of members in the clusters created in Figure 1. The clusters with more than 15 member nodes were applied, so clusters with less than 15 member nodes represented only sensor nodes. Figure 5 shows the results of cluster equalization across the entire network.

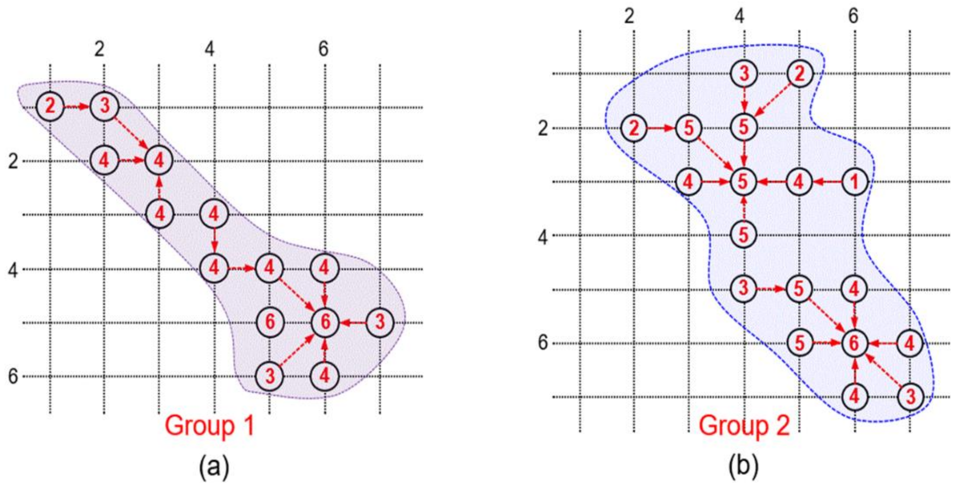


Fig. 2: Example of forming a cluster group.

The mutual attraction between sensor nodes adjacent to unit distance 1 in group 1 in Figure 2 a) is calculated and shown in Figure 3 a). The sensor in row 5 and column 6 is the center of six adjacent sensors alongside a unit distance of 1. This node has an attraction value with an order for magnitude equal to 6, and the mutually favorable rating for each sensor is determined by multiplying the total attraction value by 1. Even when sensor nodes communicate at the same distance of one another, member addition is accomplished by focusing on those nodes with the strongest mutual attraction. The fifth row as well as sixth column node therefore turns into a CH node. In the same way, the node in row 2 and column 3 becomes the CH, and member addition occurs around it. The process of dividing the cluster by adding the nodes with the strongest mutual attraction within the unit distance as members is shown in Figure 3 a). We can also see that group 2 in b) in Figure 2 is separated and re-clustered into b) in Figure 3.

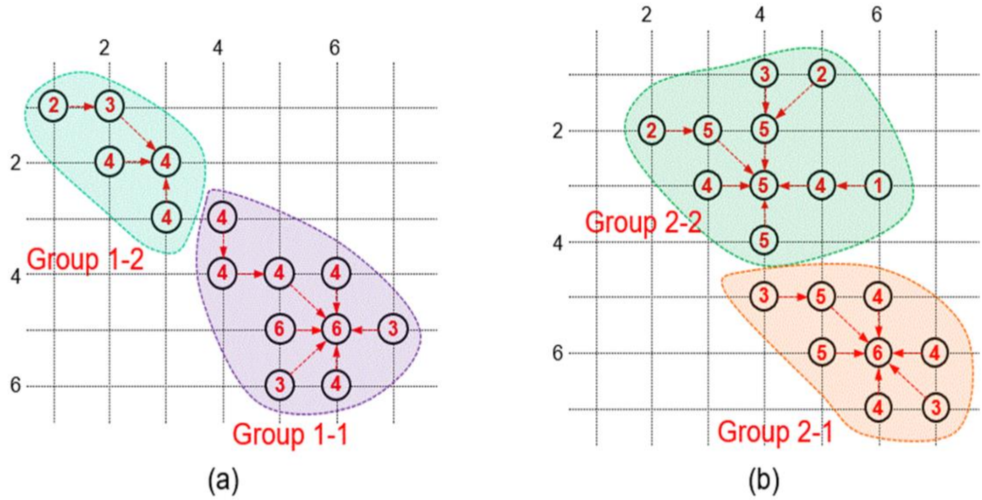


Fig. 3: Example of splitting a cluster group.

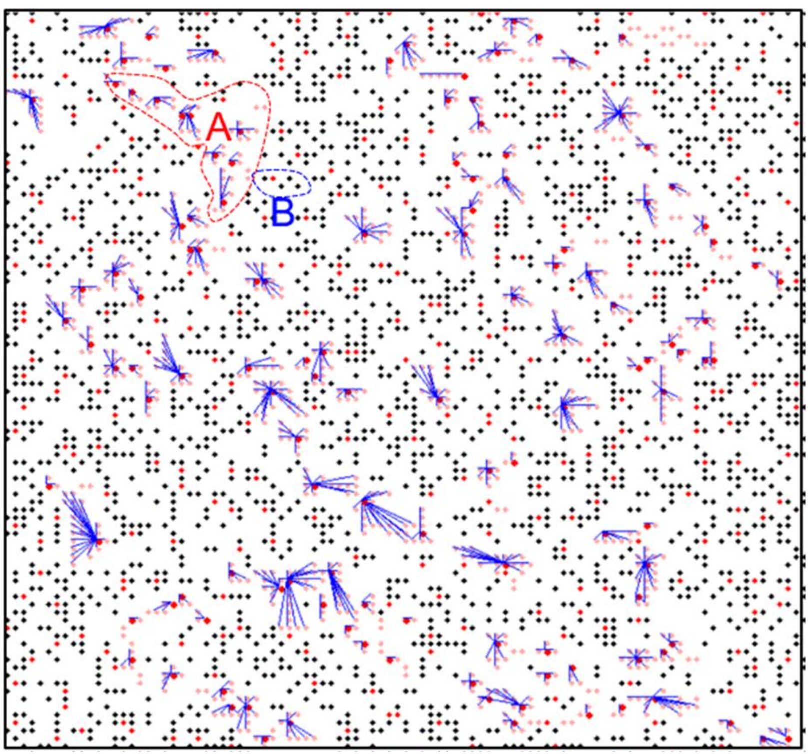


Fig. 4: Equalise clusters with 15 or more member nodes in the network.

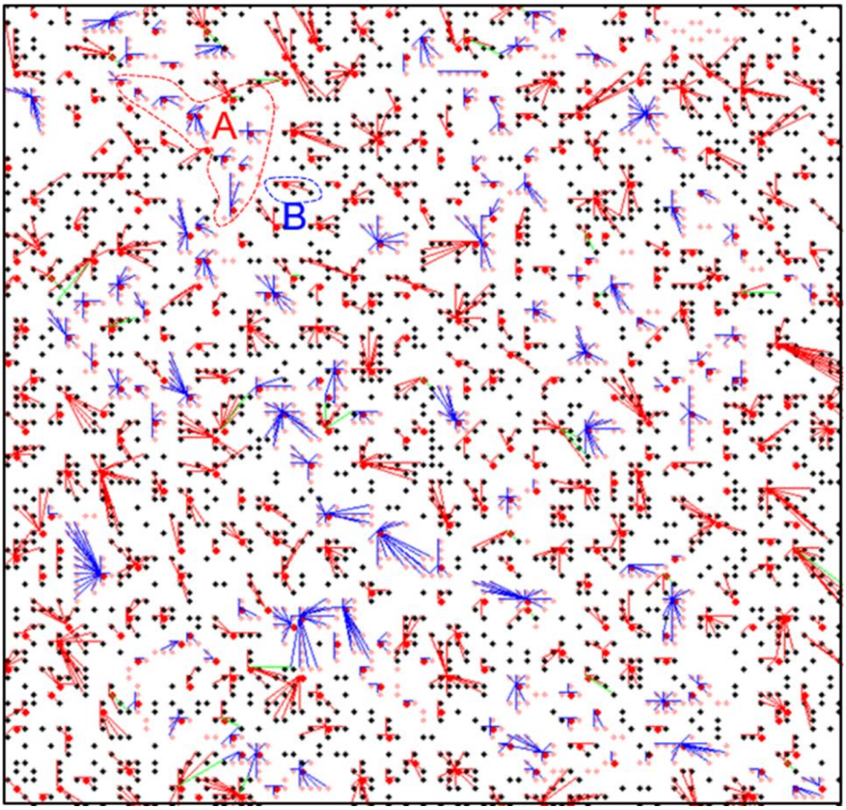


Fig. 5: Simulation results for a clustered uniformized network

## 3. SIMULATION RESULT

A rough estimate of 3000 randomly dispersed nodes in a 100 by 100 unit area was used to conduct the simulation. Group rearrangement was carried out and compared for clusters with 15 or more sensors in order to achieve cluster equalization. Mutual attraction was implemented within a unit distance. Prior to and during cluster equalization, the comparative findings are displayed in Figure 6. The x-axis represents the cluster groups with an equal number of members, while the y-axis shows the number of clusters with the same number of members.  The simulation results for 100 runs are cumulatively averaged, as shown in Figure 6. The percentage of clusters with 15 or more members rose by almost 20% compared to the pre-equalization condition when cluster equalization was applied to clusters with 15 or more sensors. A cluster grouping with less than fifteen members has been replicated, as can be observed.

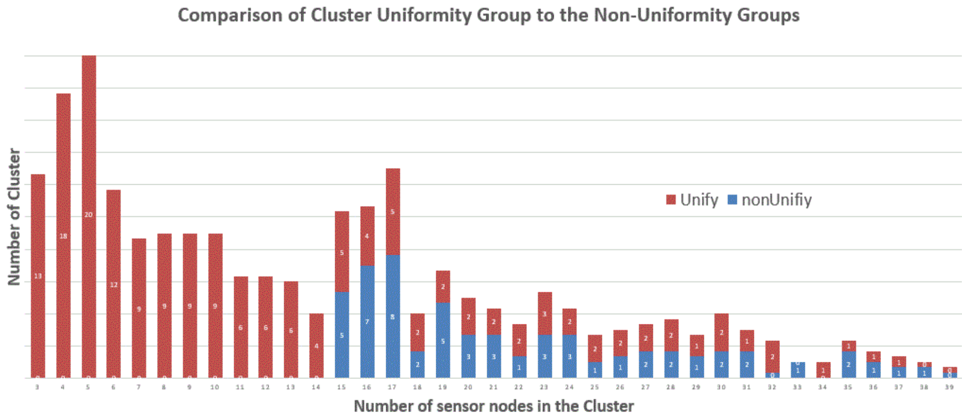


Fig. 6: Comparison of uniform and non-uniform clusters

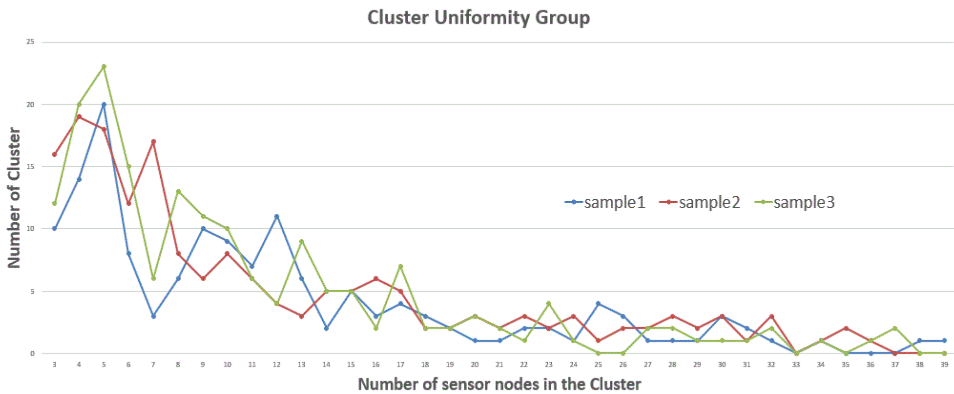


Fig. 7: Number of member nodes per cluster in the uniform cluster sample

## 4. CONCLUSION

In this paper, the mutual attraction of sensor nodes within a unit distance is used to enable cluster uniformization. Based on the mutual attraction between nodes (mutual attraction), in this paper, we find the node corresponding to the center of gravity of the cluster group, which can be elected as the CH node. Cluster uniformization can reduce the number of abnormally large clusters and thus increase the lifetime of the network. The simulation used in this work allowed for an increase of 20% in cluster homogeneity. To increase the consistency, repeat the clustering process. and displays the clustering simulation results in Figures 5 and 6.

Because it is low-power and easy to implement, the suggested clustering method is anticipated to perform well for clustering in WSNs.

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