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# Geographical Grid Based Clustering for WSN

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***Abstract***

*In this work, we have proposed a clustering approach in WSN using grid formation. Clustering is an approach that works on distances thus efficiently conserves communication energy in WSN. In the proposed grid-based clustering approach, the simulation area is divided into several grids and each grid has a coordinator node which is receiving the data from normal nodes. The data is passed in the form of packets. The efficiency of the network also depends on the size of the packet while delivering. This paper also addresses the role of packet size in different grid sizes measuring the suitable cluster size according to the application in WSN based on the percentage of packet loss. Moreover, we have also evaluated proposed techniques on different packet sizes over WSN. Results and simulations prove the efficacy of the scheme and make it attractive and viable for WSN.*

**Keywords:** *Wireless sensor network (WSN), clustering, throughput, grid-based clustering*

## 1. Introduction

Wireless Sensor Network consists of a large number of sensor nodes randomly deployed over a region. In WSN, nodes are usually driven by power sources (e.g. batteries), which are not replaceable. Hence, WSN has limited sensing capability, memory, computational capacity, and energy. So, improvement of the efficiency of energy consumption in a WSN is a crucial issue. WSN is useful for numerous applications like monitoring, surveillance, remote sensing, etc. [1]. In recent past few years, it had become one of the most interesting environments for research work. The main emphasis is given to routing the packets. The traditional approaches like flooding and gossiping prove to be unsuccessful because it results in duplication of packets. These approaches do not concern much about clustering. While clustering techniques prove to be successful as the packets are sent only to an elected cluster head node not randomly [2].

LEACH (low energy adaptive clustering hierarchy) [3] is the first energy-saving cluster formation protocol for WSN. LEACH-E [4] proposes an improvement over LEACH by selecting CH not randomly but considering remaining energy. The work also addresses the energy-efficient issue using the grid-based approach in WSN.

The remainder of this paper is organized as follows: A brief literature survey is given in section II. Problem formulation is described in section III. Proposed grid-based clustering parameters for the mechanism are described in section IV. Simulation results and their analysis are being described in section V. Finally, section VI concludes the work.

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## 2. Related work

In the existing literature, clustering is the most suitable approach to extend network lifetime, energy consumption, and throughput of the network in WSN. It is the process of grouping the sensor nodes intelligently and the classification basis on using algorithms in clustering is hierarchical, partitioning, density, and grid-based algorithms [5] and [6].

The hierarchical-based approach is an energy-saving cluster formation protocol for WSN that implements aggregation in a clustering manner [7] and [8]. Continuous monitoring and periodic data reporting application is the best-suited domain for this category. LEACH, HEED (hybrid energy-efficient distributed clustering approach), and CLUDDA (clustered diffusion with dynamic data aggregation) are an example of such categories.

Partitioning algorithms divide data into several subsets [6]. They are k-mean, Bisecting K means method, Medoids method, PAM (partitioning around medoids), CLARA (clustering large applications), and probabilistic clustering. In the k-means algorithm, a cluster is represented by its centroid, which is a mean (avg. pt.) of points within a cluster. It works efficiently only with numerical attributes and however, it can be negatively affected by a single outlier [9] and [10].

In density-based clustering, clusters are defined as areas of higher density than the remaining of the data set. Two approaches are under this category. The first mechanism pins density to a training data point and is reviewed in the sub-section density-based connectivity. In this mechanism density and connectivity are both measured in terms of the local distribution of nearest neighbors to achieve asymmetric relation. Moreover, all the points reachable from core objects can be factorized into maximally connected components serving as clusters. DBSCAN, GDBSCAN, OPTICS, and DBCLASD are an example of this mechanism in WSN. The second mechanism pins density to a point in the attribute space and is explained in the sub-section density functions. The density is modeled as the sum of the density functions of all objects. Clusters are determined by density attractors means the local maxima of the overall density function. The influence function can be an arbitrary one. DENCLUE is an example of this mechanism [11].

Grid-based clustering where the data space is quantized into the finite number of cells which form the grid structure and perform clustering on the grids [12]. Examples of grid-based clustering algorithms are STING, Wave Cluster, and CLIQUE. Group-grid-based clustering is also a variant of a grid-based clustering energy-efficient routing protocol for WSN. In this mechanism, sensor nodes also can receive query messages from sinks and forward data packets to sinks through the group.

## 3. Problem formulation

In WSN, each sensor node has individual limited power and hence requires saving power of the whole sensor network efficiently. Frequent failure, dynamic network topology, environmental condition, etc are the main problems in WSN. Moreover, heterogeneity, redundancy, flexibility, and scalability required in a WSN make the long-running sensor applications complex. Another problem in WSN is; if the base station is so far from the CH node, it takes more energy to transfer the data, as a result, CH dies frequently and it will affect the lifetime of the network. If cluster head may be selected from the boundary of network, thus increases communication overhead. Antenna height is an important factor, it causes the problem of overlapping or hidden node problem. It is not identified that what should be the size of the cluster. It should contain a small number of nodes or a large number of nodes.

Just as discussed above, this paper presents a grid-based approach to adopt the methods of cluster-head selection based on heterogeneous energy of nodes for the same initial energy and multiple hop data transmission among cluster heads.

## 4. Proposed work

In this section proposed heuristics are presented. The technique is based on location-wise clusters in WSN. It will be application adaptive. If applications use video and images then the number of clusters may be less and if the network senses continually temperature, pressure, etc. then the number of clusters may be large. Figure 1 is depicted by the proposed architecture. In this proposed architecture, a homogeneous environment is introduced and the wireless sensor area is divided into grids. In each grid, communication is taking place between the FFD node RFD node where the FFD node is deployed as Cluster Head.

There are two types of devices in an IEEE 802.15.4 wireless network: full function devices (FFDs) and reduced function devices(RFDs). An FFD can accept all the duties described in the ZigBee standard and can accept any role given to it. While and RFD has only limited functionality. Like FFD can communicate with any device while an RFD can communicate with only FFDs. RFDs suits for simple applications and consumes less processing power and memory size [13].

As shown in Figure 1, the red node is the FFD node which works as cluster head and green nodes represent RFD nodes which work as a non-cluster head. These RFD nodes sense the data.

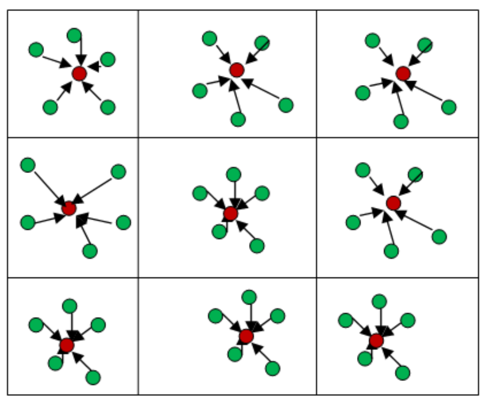

Figure 1. The proposed grid-based architecture for WSN

Now throughput or data loss is calculated during transmission of data packets by varying transmitted packet size and grid size in the wireless environment. Data Loss is calculated by:

$$Data\ Loss\ (in\ \%) = \frac{a-b}{a} \times 100$$

Where $a$ = Number of packets sent and $b$ = Number of packets received.

## 5. Simulation and results

In this section, simulation and results are discussed. We have evaluated grid-based architecture in WSN using the QualNet tool [14]. For simulation 2700 m × 2700 m area is considered and 99 immobile sensor nodes are deployed. Each RFD node is connected to its respective FFD node through the CBR link. These sensor nodes are deployed in :

 

*(i)* 3x3 grid architecture, 11 nodes in each grid.
*(ii)* 3x2 grid architecture, 17 nodes in each grid.
*(iii)* 2x2 grid architecture, 25 nodes in each grid.
*(iv)* 1x3 grid architecture, 33 nodes in each grid.

Simulation is done based on varying different packet sizes and grid sizes as mentioned above and keeping the number of nodes the same. The different packet sizes are 128 bytes, 256 bytes, 512 bytes. In the Qualnet tool by default, antenna height is 1.5 m, in our simulation, it is decreased by 0.3 m i.e; it is 1.2 m. Also, the default packet size is 512 bytes but simulations have been done also for 256 and 128 bytes. Intra grid and inter-grid communication in WSN is shown in Figure2.

It is observed that in Figure 3, when packet size is between 128-512 bytes, with less number of grids packet loss also decreases. When grid size is 4 and 3 then packet loss is constant at 256 and 512 bytes respectively. So, results show for sending multimedia data fewer grids should be taken without considering packet size. Since the data sent in terms of video and audio requires continuous transmission. However, packet loss is different in the same parameter in terms of percentage. Figure 4 shows the packet loss in terms of percentage in the same parameters.

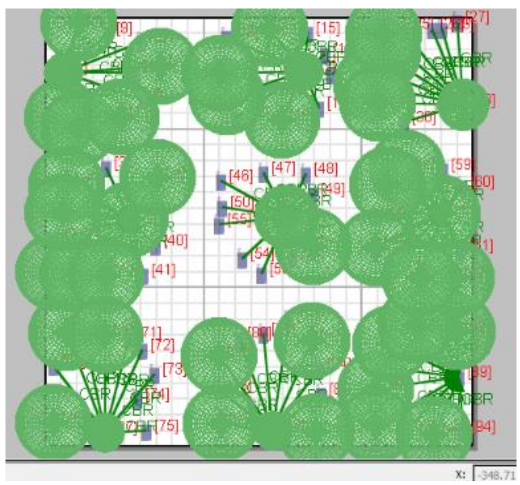

Figure 2. The inter grid communication using 3×3 grid architecture in WSN

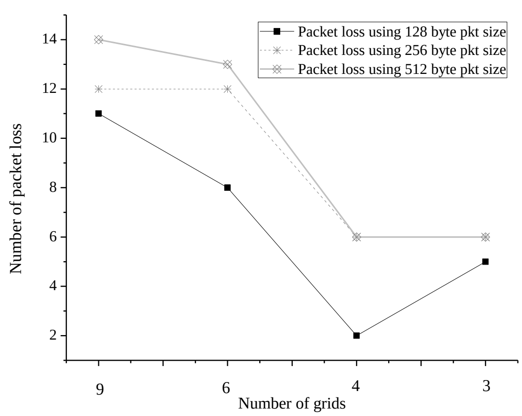


Figure 3. Packet drop in different grid architecture in WSN

In Figure 4, if the packet size is more than 256 bytes then it is observed packet loss is around 50% at several grids less than 6. Moreover, if the packet size is less than the number of the grid is not required. The outcome of this work is if the application of WSN required a large data rate or more packet size then grid-based architecture is most suited in WSN.

## 6. Conclusion

In this work, we have devised an approach for a homogenous network using a grid environment due to its scalability. Data loss is calculated by varying different grid sizes. Network simulation experiments showed that significant performance gains in terms of packet loss using grid-based clustering in WSN are presented. By decreasing antenna height and varying packet size, it is also concluded that the rate of data loss is low when packet size is small and it is also varying with grid size. In the simulation result, it is observed that by increasing the grid size packet sent increases and as a result, throughput is improved. This is also proved that the efficacy of grid-based clustering in WSN.

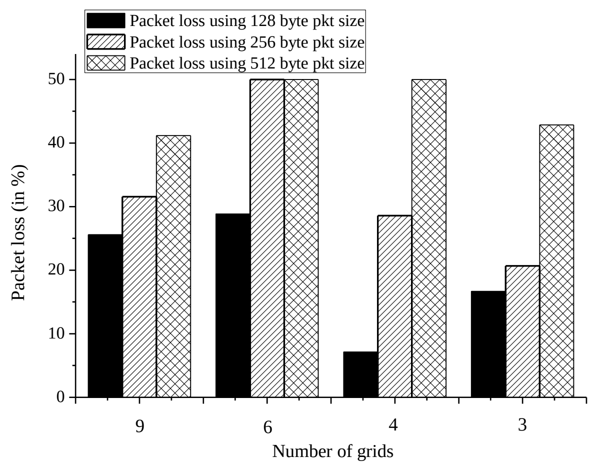


Figure 4. Packet loss (in %) upon different grid architecture in WSN

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