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a New Three Dimensional Clustering Method for Wireless Sensor Networks

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Classification: *GJCST Classification: H.3.3, B.8.1*



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a New Three Dimensional Clustering Method for Wireless Sensor Networks

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I. INTRODUCTION

Recently, the use of Wireless Sensor Networks (WSN) has been greatly expanded. Military, health and medicine, surveillance and even industrial applications are just a few of the fields where a WSN is already used extensively [1]. Sensors are generally equipped with data processing and communication capabilities [2], but the sensors have power limitations for sensing the environment. Using some efficient designs can be assumed as ways to optimize power consumption.

Clustering is a way that only one sensor (Cluster Head (CH)) is in charge of sending information to the base station and other sensors try to connect to CH [3],[6]. Clustering will be causing that all sensors are not sending information to base station but are sending information to CH which is nearer than base station, in other word, by doing such, less power will be consumed to send information. So the chosen CH has an important role on the network performance. CH should be chosen so that: 1) it should be placed at the center of the cluster with almost same distance from all the regular sensors in that cluster. 2) gathering sensors around it is appropriate 3) it has to have enough power for sending information to the base station.

Many attempts have been done to achieve at good clustering methods and selecting best nodes as cluster heads [2, 3, 4, 5]. Many ideas have been introduced for clustering that use geometric shapes to obtain appropriate clusters [5], but most of them have been raised in two-dimensional (2D) space [5, 6, 7], but

always reviewing the space is not just at the surface with same heights. For example during reviewing and controlling the forests, sensors may be sit on tree with different heights or some factors and events that occur among foliage of trees should be considered. Therefore three-dimensional (3D) clustering is introduced. Recently, studying 3D WSNs have been considered, such as [7, 8, 9] but other clustering methods mostly tried to develop methods in 2D. This paper attempts to consider the characteristics of 3D space WSNs performance.

II. THE PROPOSED METHOD

As mentioned, two dimensional diagram shapes have less using in three dimensional areas. So, three dimensional diagram shapes like cube, cylinder or pyramid are to be used so much more in the proposed method. These shapes have different surfaces that are all monoliths and are dependent to each other based on a common law. For example in pyramid the above head has a same distance to all the bottom heads. In other word, the above head can be a cluster head because as mentioned it has one of the most important factors to be a cluster head. In the proposed method we try to use pyramid for partitioning sensor nodes.

In this idea there are three different levels for all the sensor nodes. The main node (sink) is placed at the first and highest level which is known as root. The cluster heads are at the middle level which name is CH level. This level is lower than root while it is higher in comparison with lowest level. The lowest level contains the most number of nodes and has the bigger size of area. This level includes active nodes that are in charge of receiving data from the region. At the rest of this paper we estimate each level and its functionality.

a) The root level

The root level contains some nodes that receive data from lower nodes and make best decisions according to received information. These nodes don't work so much in comparison with active nodes and consequently don't consume so much energy during functioning. The chance of each given node to be selected as a root node is so low.

b) The CH level

This level includes network cluster heads that are in charge of receiving data from lowest level nodes and manage the process of transmitting data from the

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active nodes to the root. Cluster heads should be selected in a way that the distance between each cluster head and every one of its active nodes is the same. By doing such, almost all the active nodes consume a same amount of energy to relate with their cluster head. It is clear that cluster heads have a very important role in designing the three dimensional network because they are between root and active nodes and also they have a same distance with their active members.

c) *Active nodes level*

This level has the most number of nodes that are all active and sense data from the region which is the main task of a sensor network. They are grouped into some clusters according to the position of above cluster heads. These nodes consume so much energy because of their very much activity. There are some energy limitations in WSNs, thus some substitute nodes for each active node can be considered. Substitute nodes should have the smallest distance to their active nodes and they are in waiting state while they receive an activation message from the active node.

III. IMPLEMENTING THE PROPOSED METHOD

We have a brief introduction for the different levels of our new designed network architecture for wireless mobile sensor networks, now we try to explain the detail of implementation. At first we disperse the sensor nodes in the region, randomly and without any denotation about sensor positions. Now, we can divide all the sensor nodes into three different groups and let them know about their duty according to their position. Some pyramids with square bottom are used for grouping the sensors before network configuration.

We begin from the root (higher level). This level has the lowest amount of nodes, so a node with most score is selected as the root. To calculate the score, each node calculates its distance from the center of the region considering symmetry. Based on this factor, the sensor score can be calculated easily, and then the node sends its score to its same level neighbors and mutually receives some scores from them. By comparing all the scores the node decides whether to be active or awaiting. If a node decides to be active then it finds the position of its substitute node and sends it an activation message when necessary. Otherwise, the node sleeps in awaiting mode and listens to receive activation message from its active node. The root sensor divides its lower level sensors into four groups based on the node positions and sends them corresponding messages to inform them about this decision. The mentioned grouping is on the basis of a supposition square where the root position is at a certain height of the crossing of the square

diagonals. Selecting the root node consumes two amounts of energy:

1. the energy that each node consumes to send its score to its same level neighbors, this message is called public message.
2. Consuming energy to inform lower level nodes for partitioning sensor nodes.

Each node placed at the next (third) level informs its neighbors that are positioned on the same square bottom about its score. This score is found on the distance of the node from the head of the square. In the all four mentioned groups a node with most score is selected as the cluster head for all the sensor nodes placed in that area while others can be waiting. Cluster heads assumes itself at the head of a supposition pyramid and divides its nodes into four groups by considering the square bottom of the pyramid. Doing such, has two kind of energy consumption for cluster head:

1. the energy that each node consumes to send its score to its same group neighbors.
2. Energy consumed for partitioning lower level sensor nodes.

At the lowest level sensor nodes evaluate their functionality state (active or waiting) in the same manner. Now, the network starts to work.

During network functioning, the active nodes existing at the lowest level evaluate the regional events and send received information to their cluster heads in certain time slices. When the remaining energy of the active node is going to fall below the threshold energy (energy needed for sending two activation messages) it would be replaced by its waiting node. We select the threshold energy equal to energy needed for sending two activation messages to make sure about receiving activation message which leads increasing the safety factor. Sensor replacement operation is same in all the levels.

IV. NETWORK SIMULATION

We used Matlab software to simulate the proposed network architecture. The pseudo code of network initial configuration is shown in Figure 1 while network shape after configuration can be seen Figure 2. Network performance begins after configuration. The active nodes of the lowest level sense region data and forward them to their cluster heads. In parallel with this operation both of the active node and cluster head lose energy equal to sending energy and receiving energy, respectively.

An important note should be considered by active nodes is to have energy level more than twice needed energy for sending an activation message. If necessary, active node sends two activation messages to the substitute node which is now in waiting mode. Then the substitute node changes its state from waiting

mode to active mode by sending an acceptance activation message and starts its duty as an active node. The last active node turns off or it dies, in other word.

Transmit sensor in space considered for wireless sensor network coverage\\ Regarding a possible z component of each sensor values, the presence of 0,1,2 . Probability that value Z "2" is least likely, "1" is more likely and "0" is highest. Components x,y is determined randomly. Primary power as the same are given to all sensors.

Determine the root\\ In this case the value of Eb (energy spent to send public messages, including points) and Amount of Er (energy spent to send a message to determine the lower level clusters) decrease of primary power active sensors.

Determine the CHs\\ At this stage value Eb (energy spent to send public messages, including points) and value Ech (energy spent to send a message to determine the lower level clusters) decrease of primary power active sensors.

Characterize clusters\\ At this stage, only one value Eb (power spent to send public messages, including points), decrease of the primary sensor.

Figure 1. Pseudo code of the network initial configuration

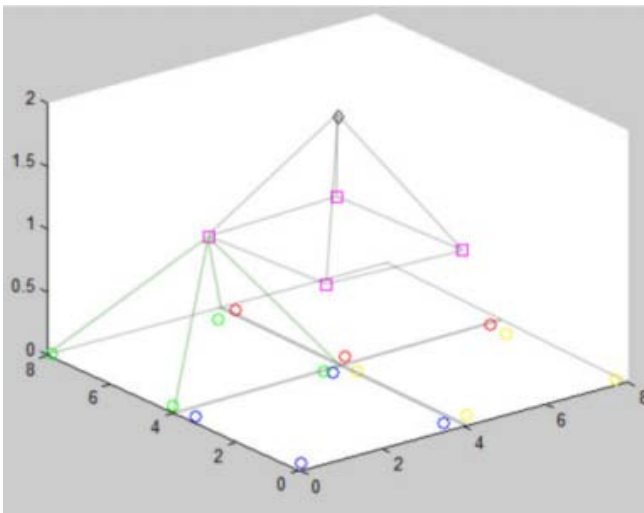


Figure 2. Network form after configuration

The mentioned operations are done until one of the following conditions appear:

1. Root sensors die
2. Cluster head dies or just cluster head is still alive while its members have died.
3. At least two clusters are active. (clusters die when they have just one active node)

The pseudo codes of these operations are written in Figure3.

```

While (true)
{
    The active sensors of lower surface are
    reviewing environment and send self information to their
    CH. CH also sends information to root.
    IF ( only one cluster is active ) OR ( all CH
    sensors are death ) OR (Root sensor is not available)
    {
        BREAK;
    }
}

```

Figure 3. Network operation pseudo code

Now, we estimate network performance. Fig 4 shows the column chart of network lifetime for different number of sensors.

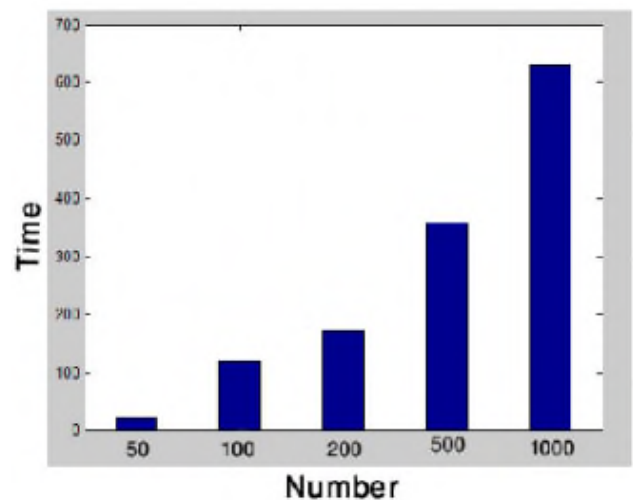


Figure 4. Network lifetime for different number of sensors

As can be seen in Figure 4, in parallel with increasing number of network nodes, network lifetime increases. It is natural because when the number of network nodes increases then the number of substitute nodes increases, consequently. In this situation when a node dies a substitute node will replace it quickly. The most important factor of the proposed architecture which is shown in Figure 4 is that similar to raising the number of sensors network lifetime raises. The rate of this similarity is very high. This can be considered in Figure 5 with more accurate rate. The slant of increasing network lifetime in respect of the number of sensors is almost constant. This leads network lifetime to be less dependent to the number of nodes.

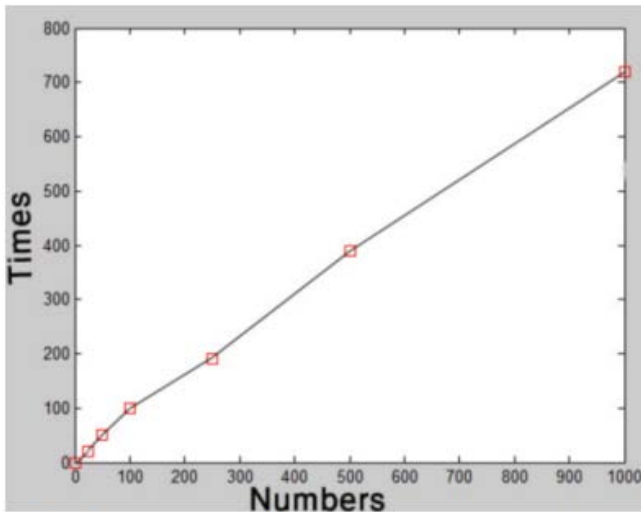


Figure 5. Increasing network lifetime in respect of the number of sensors

V. MATHEMATICAL MODEL

A very good point of the chart shown in Fig 5 is its almost constant slant which means network lifetime has lowest dependently amount to the number of nodes in the proposed architecture. To be more accurate, we propose a mathematical model using Newton-Raphson method. In this model, some calculated results in different states are needed. For this purpose, we calculate the network lifetime to the number of sensors in different moments. The problem is that the network lifetime is not always the same for the alike number of sensors because the network sensors are dispersed randomly. To solve this problem and to count the most exact amount for network lifetime, the algorithm is to be executed several times for the constant number of sensors and then we assume the average counted amounts as the network lifetime for each state. The formula (1) presents the mathematical mode of the algorithm.

$$T = 0.734 * N + 13.32 \quad (1)$$

T : Network lifetime

N : the number of network sensors

The TABLE I shows the average amount of the network lifetime for different number of network nodes. In this table, the average amount of the network lifetime is resulted from simulation. Difference between simulation and mathematical model mentions the difference of the lifetime to result of (1).

Table I. Comparison Between Simulation Value And Mathematical Model Value

Difference between simulation and mathematical model	Mathematical model value	Average life time of network	Sensor number
17.7	50.2	32.5	50
3.28	86.72	90	100
15.68	196.82	212.5	250
4.68	380.32	385	500
4.82	747.32	742.5	1000

As can be seen in the table there is not so much difference between the results of simulation and mathematical model. This shows the appropriate approximate of the mathematical model. The formula (1) has a constant slant which shows the lowest dependent of this slant to the number of nodes.

VI. CONCLUSION

As mentioned, to achieve at a good clustering or designing a three dimensional network areas, three dimensional diagram shapes can be used when two dimensional diagram shapes are not satisfying where these estimated areas don't have a same level. Also the diagram shapes can be used to simplify the network configuration. In the proposed design we achieve at good results by using pyramid diagram shapes with square bottom. First network lifetime has been calculated and then the dependent rate of network lifetime to the number of sensors achieved at its lowest amount which is the most important score of the proposed design.

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