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Placement of Sink in Wireless Sensor Networks

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Abstract: **Wireless Sensor Networks are rapidly growing area of research and commercial development. Meanwhile it draws attention of many researchers because of the enormous scope of its applications in numerous areas. A Wireless Sensor Network (WSN) consists of large number of spatially distributed autonomous sensors to monitor physical environment conditions, such as temperature, sound, humidity, pressure, light etc. and pass their data often called raw data through the network to Base Station which is often called Sink. The sink forms the gateway between the WSN and end-user application. In real time applications sensors collect data and transfer to the sink. Generally Sensors have limited range and less battery life. In this paper our main goal is to increase the network life time of sensors and reduce their energy consumption of the network. In this paper two sink placement strategies are implemented along with an existing strategy geographical sink placement strategy (GSP) by placing sink in an appropriate area to cover maximum number no of sensors in the region of an network.. The advantages of these two strategies were analyzed and compare with an existing strategy.**

Keywords: **Wireless sensor network, sink, sensor nodes.**

1. INTRODUCTION

In WSN the nodes not only collect the data within their range but also forward the data which were far away from the sink. This leads to unequal power consumption among the sensor nodes and connectivity of the network may lost. Contemporary research works demonstrate the performance, such as data transmission time from source to sink is improved in multiple sink networks when comparison with a single sinks networks. A suitable sink placement strategy can strongly increase both lifetime of network and decreases the energy consumption by decreasing the distance between the sensor nodes and sinks. Therefore, in this paper we explore sink placement strategies for WSNs in order to reduce their transmitting data time from source to sink, to provide better energy-efficiency and as a result to prolong network lifetime.

In this paper two sink placement strategies were proposed and implemented along with the existing GSP strategy. The analysis of the strategies and their functioning are explained. Placing the sink in a region where more number of sensor nodes are covered is the idea we implemented in the proposed systems. Network area is divided into different regions in order to place the sink in each region to cover the maximum number of nodes. This helps us to decrease the energy consumption for the sensor and increase the network lifetime.

2. RELATED WORKS

The self-organization feature of sensors makes it feasible to deploy them randomly over the region being observed. Without needing a previous exploration, sensors might be installed to the environment in an random way, like dropping them from aircraft. In this manner, large numbers of sensors were spread over the environment without having an prior information where the sink has to been placed individually in area of a network.

In this paper, we have introduced the different sink placement strategies. We have given two strategies consisting of new ideas for the sink placement in sensor networks. We have provided all the information related to these strategies in this paper.

Geographical Sink Placement (GSP)[1] strategy places the sinks at center of gravity of sector of a circle. In case of Intelligent Sink Placement (ISP)[1], candidate locations are determined by sampling all possible regions and depending on the number of sinks, all combinations of these candidate locations are enumerated to find an optimal sink placement. This strategy (ISP) is found to be an optimal one. However, ISP is computationally expensive and it is assumed that the location information of the sensor nodes be provided by some localization system. Another algorithm, called Genetic Algorithm-based sink placement (GASP)[1] is also introduced. GASP provides a good heuristic based on Genetic Algorithm for optimal sink placement.

In sink placement the problems are formulated based on linear programming and optimal location of multiple sinks and data flows in WSNs are proposed. The another solution by using K-mean algorithm. Here the some clusters are defined and then sink is placed in the center of those clusters it helps the sensors to choose the nearest sink to improve the network lifetime.

We propose strategies to start with the network which is partitioned and place the sink in every divided region to cover the maximum number of sensors and region unlike the previous random placement of the sink. While having many strategies we choose GSP to compare our algorithms is that ISP gives an optimal solution is very expensive and GASP gives good results but it has no guarantee that it will reach optimal solution. For that reasons we choose GSP as the existed system.

General architecture of a sensor node:

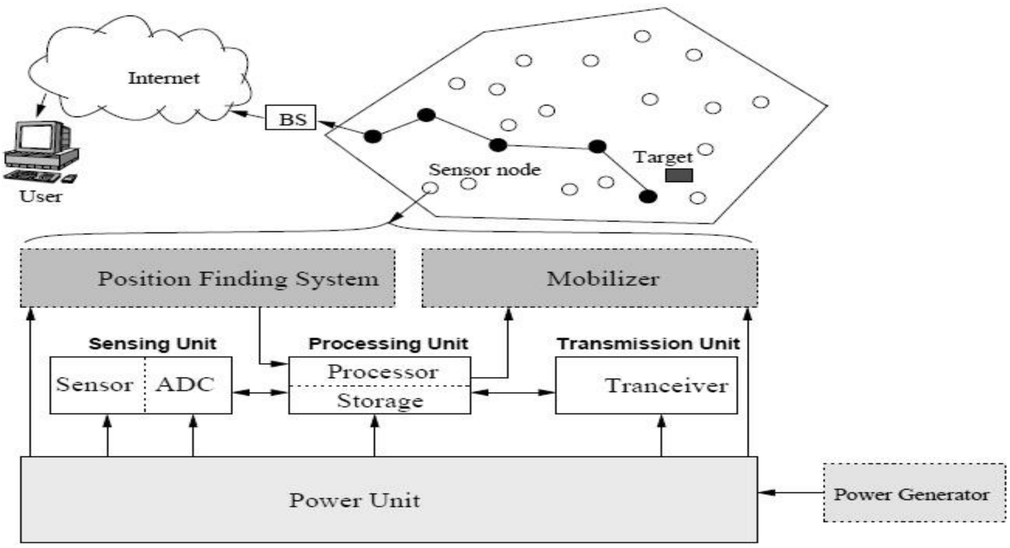

Figure 1: Architecture of sensor node

The major components are sensing unit, processing unit, transceiver, and power unit. The environmental information is retrieved using the sensor and converted with an analog to digital converter (ADC) to digital data. This data is forwarded to the processing unit to become a data packet that is to be sent to the sink node for further examination. The communication between the sensors nodes are carried out with the transceiver. The power unit feeds all these components with the necessary operational power. The Optimal units such as the location finding system, mobilizer and power generator may be embedded to the node depending on the application. Most of the applications require some location information for the sensed data when they reach the sink node. Mobility might also be one of the application specific requirement. Although most of the monitoring applications utilize only static sensor node, for some tracking scenarios mobility might be a major design criterion. Finally, in order to prolong the network lifetime of a sensor node, a power scavenging tool such as solar cells can be attached to the sensor node.

Sink placement strategy:

The objective to place the sink by partition of the region is that for a longer lifetime of the sensor, energy efficiency as well as data transmission from each sensor to sink. So the placement of sink plays a major role in achieving the mentioned tasks. Each sub network is been taken individually placing the sink and all these sub networks together achieve this in a large scale.

If the sink is placed in a region where the number of nodes are less than the nodes near to the sink has more load by transferring the data to the sink. As the result that nodes have more consumption of energy and will soon run out of battery thus the lifetime of sensor becomes shorter. So make the network or sensor have longer lifetime. The placement of sink must be done in appropriate areas.

To find the region which area has a maximum number of sensor nodes we have to divide the network into equal sized grid cells. The cell with more number of sensor nodes in the region or location for placement of sink. It is further described in the proposed system section.

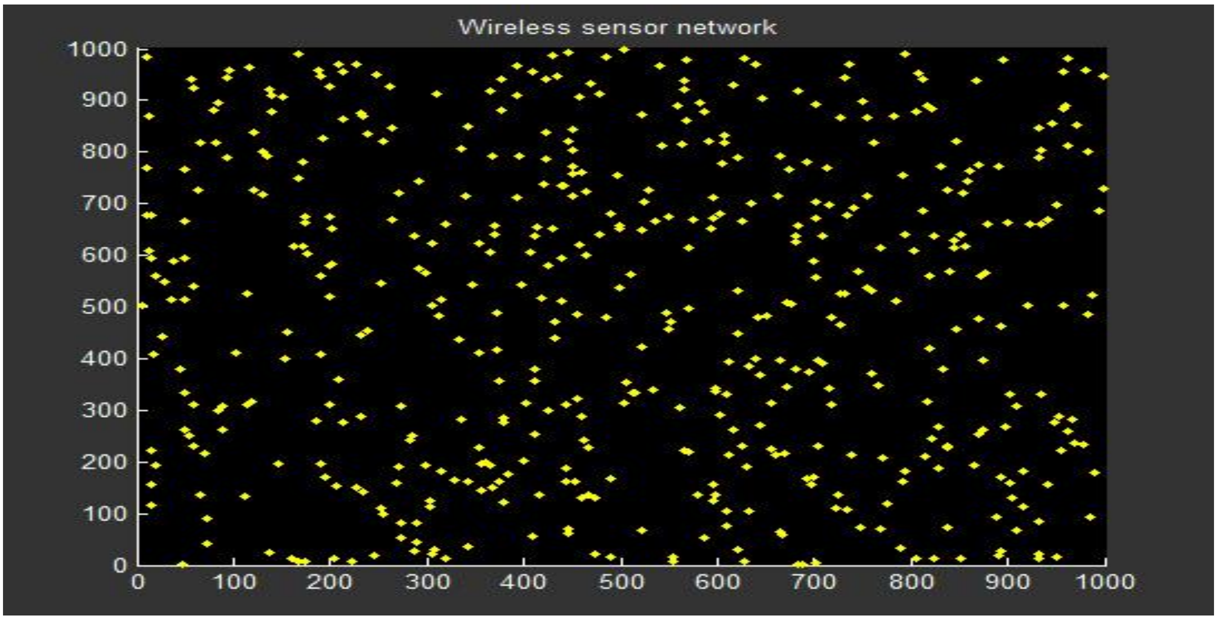

Figure 2: wireless sensor network

Geographical sink placement strategy (GSP):

Geographic sink placement has been considered as a simple sink placement strategy in wireless sensor networks. Since Geographical sink placement require the size of the sensor field and the center of gravity of a sector (CGS)[3] with angle α.

The two equations are required to calculate the ratio and where to place the sink at the middle radial line of a sector and the center of gravity is simply found by multiplying with radius R. It can be calculated with the Equations below. The value of α must be within the range 0 to π/2, if it is in radians[3].

$$CGS = F(\alpha) \times R \qquad (1)$$

$$F(\alpha) = (4/3 \sin(\alpha/2))/\alpha \qquad (2)$$

Where α is in radians, $0 \leq \alpha \leq \pi/2$,

R = radius

The above equations are allowing us to compute the center of gravity of a sector and the degree of a sector can be obtained from Equation 3. The degree depends on the number of sinks that shall be deployed. Obviously, a single sink WSNs places the sink at the center of the circle. For two sinks placement, sinks are placed at the center of gravity of the semi-circles. In fact, the center of gravity is approximately between 0 to 2/3 of the radius on the middle radial line of each sector (0 to 360 degree).

The following simple formula gives a sector degree (sDegree) for a given number of sinks[2].

$$sDegree = \frac{2\pi}{\#sinks} \qquad (3)$$

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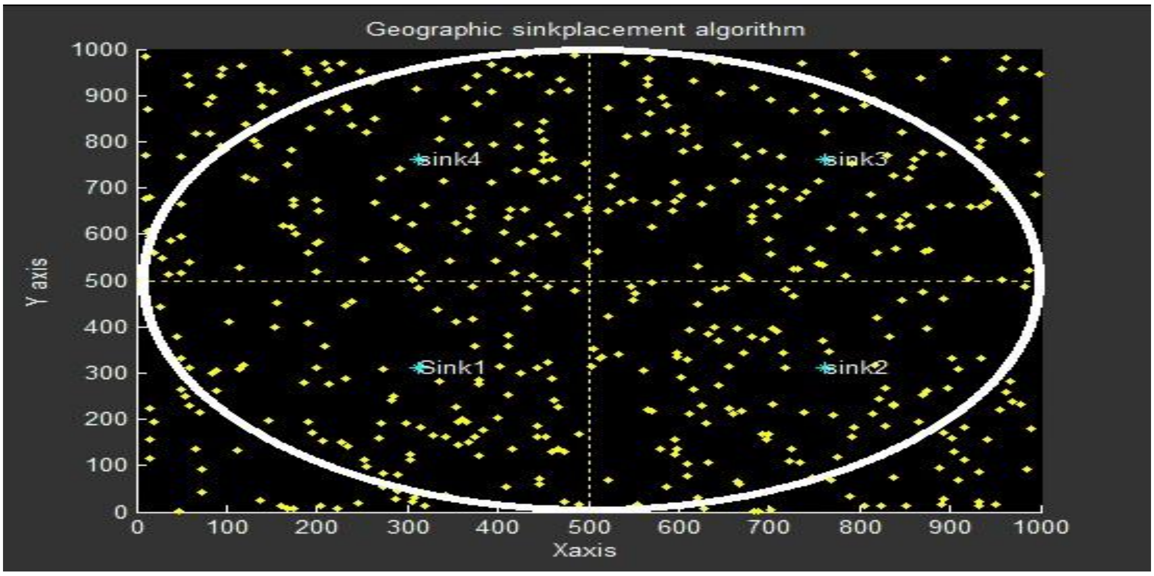

Figure 3: Geographic sink placement

Candidate Location with Minimum Hop:-

Here the region of WSN is divided in to the equal number of grid cell the size of the grid cell must be same for all in the region. Then we assume that the initial position of sink is placed in the centroid of the cell which is having the more number of sensors. However the locations of the sinks are refined to the boundaries of the two or more cells to cover the more number of sensor nodes, the sink must actually be positioned in the dense region which is spread over the two or more grid cells. To find such location all grids are considered together.

So we propose the following algorithm to relocate the sink to appropriate region. For every partition in the region the algorithm identifies the grid cells that contain the more number of sensor nodes. Then the sink is initially placed in the centroids of the each grid cell. And later is refined as follows:

In first step, we calculate the total number of regions for candidate locations. We are interested in the intersection regions of sensor nodes' transmission ranges. Nodes are connected if they are within each other's transmission range. To find the appropriate area for placement of sink number of 1-hop neighbour nodes of the initial sink position is counted. Next find the centroid of these 1-hop sensor nodes and this position of centroid is called as NEXT_POS and it is not permanent. Next, number of 1-hop neighbour nodes of NEXT_POS is counted. If number of neighbour nodes of NEXT_POS is higher than that of the sink, then the sink is placed in the current NEXT_POS position and the centroid of the neighbour nodes of the current NEXT_POS position is calculated and termed as the new NEXT_POS. This process continues until number of neighbour nodes of NEXT_POS is same or less than the number of neighbour nodes of the sink. Then the sink remains at the same position, otherwise the sink is placed at the position where nodes of NEXT_POS neighbour is found to be higher.

Once the candidate locations for each grid cell are determined, final location of the sink is selected amongst these candidate locations. Some candidate locations may be on the boundaries of one or more grid cells or may actually be shifted to another grid cell while finding the dense region. The reason for choosing the candidate location with minimum hop distance from farthest node is that this candidate location gives the minimum distance to all other nodes in that partition. This is because while redefining the sinks position it moves sink towards dense region of the partition.

Wherever we place a sink within an area will not alter the routing topology and thus we can just choose any point inside the area as a candidate location. We provide the formula to calculate the total number of regions for multi-circle intersection in equation (4)[2]

$$\boldsymbol{N(n)} = \left(\sum_{\boldsymbol{n=1}}^{\boldsymbol{nodecount}} \boldsymbol{2 * nb} \right) + \boldsymbol{1} \qquad (4)$$

Now we Construct a virtual square grid uniquely defined by two parameters: a cell size *C*, and a if the INITIAL SINK position be (X_0,Y_0)

$$Xi = Xo + i.C, Yj = Yo + j.C;\ where\ i,j = \cdots - 2, -1,0,1,2 \ldots.$$

First the sink is positioned at 1 (centroid of a grid cell) in Figure and NEXT_POS is found at 2 which becomes the new sink position. In the next iteration, NEXT_POS of position is found, but the sink remains in its old position (2) because there is no increase in 1-hop neighbour node count Figure Thus, the candidate location is 2 which is shown in Figure.

Algorithm (CLMH):

1. Read sensor nodes positions
2. calculate total number of regions from (4)
3. adjust sampling granularity and map a candidate location for each region
4. for all (n)
5. if (candiposTonodepos < txRange && originTocandipos < radius)
6. candidate locations ++

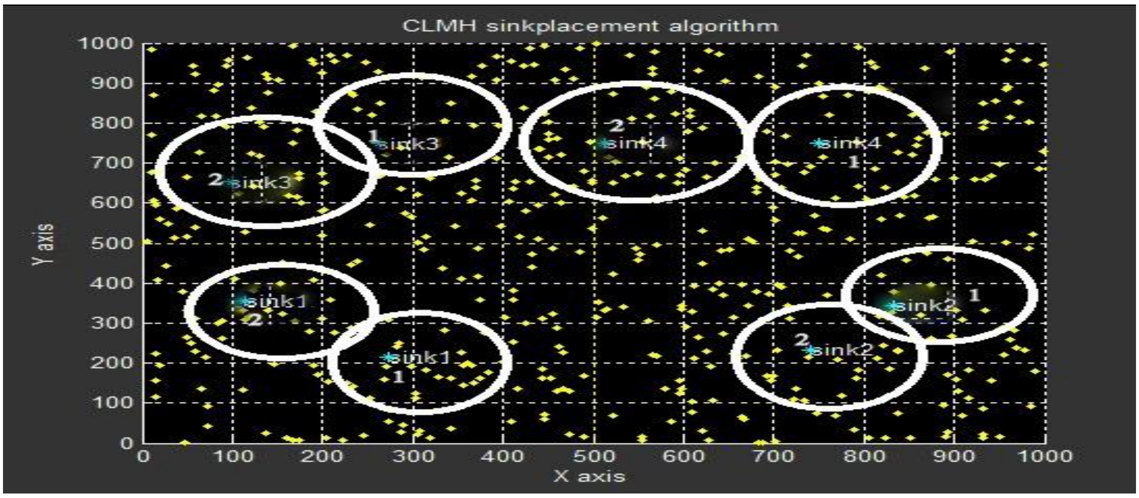

Figure 4: Candidate location with minimum hop

Centroid of Nodes with Minimum Partition:-

The CLMH algorithm[5] is based on the grid cell structure of the network, but while coming to CNP algorithm[1] grid cell structure is not necessary. In CNP initially the sink is placed in the centroid on all nodes in the partition. Next the number of 1-hop neighbours of every sink is calculated and if the number of 1-hop neighbours in the new location is more than the old location then sink is placed in the new location and the process repeats until the maximum number of sensor nodes are covered and that will be the finalized sink location. If the number of 1-hop neighbours in the new location is less than the old location then the old location will be the finalised sink location. To say this in simple perspective it is the combination of both the GSP and CLMH.

Algorithm (CNP):

1. If(tos_node_id==1) then
2. Loop from i=1 to nomber of nodes
3. X_axis=X_axis+coordinates[1][0]
4. Y_axis=Y_axis+coordinates[i][1]
5. Sink_x=X_axis/10
6. Sink_y=Y_axis/10

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First the sink is positioned at 1 (centroid of a the location) in Figure and NEXT_POS is found at 2 which becomes the new sink position. In the next iteration, NEXT_POS of position is found, but the sink remains in its old position (2) because there is no increase in 1-hop neighbour node count Figure Thus, the candidate location is 2 which is shown in Figure(5).

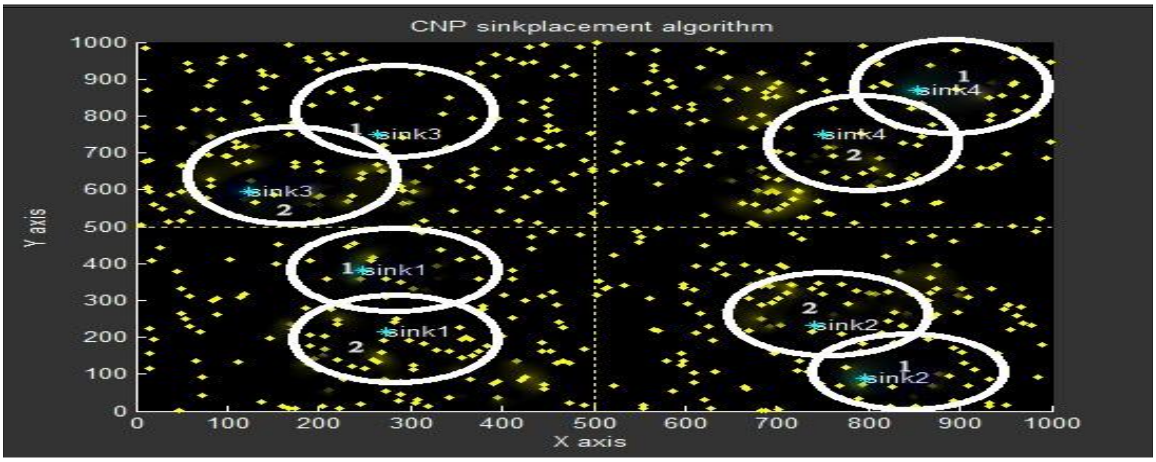

Figure 5: Centroid of Nodes with Minimum Partition

3. ANALYSIS

Performance metrics:

Average energy consumption:

It is the average energy is which is needed to transmit the data from source to sink.

Execution time:

Time taken by the each sink placement algorithm to complete the process. The above mentioned metrics are shown in figure below. Figure shows average energy Consumption for a packet to reach to sink. It obvious from the figure that wireless sinks network needs less energy as average distance from source to sink is reduce here. Another metrics is shown in figure. It is also cleared from the figure that execution time of sink is measured on the basics of

Transmission of data to the sink from sensor nodes Since the sink throughout the whole region of the network, loads are distributed among the sensor node. Also average distances are minimized here. So energy consumption is minimized. Thus network lifetime is increased in the wireless sensor networks.

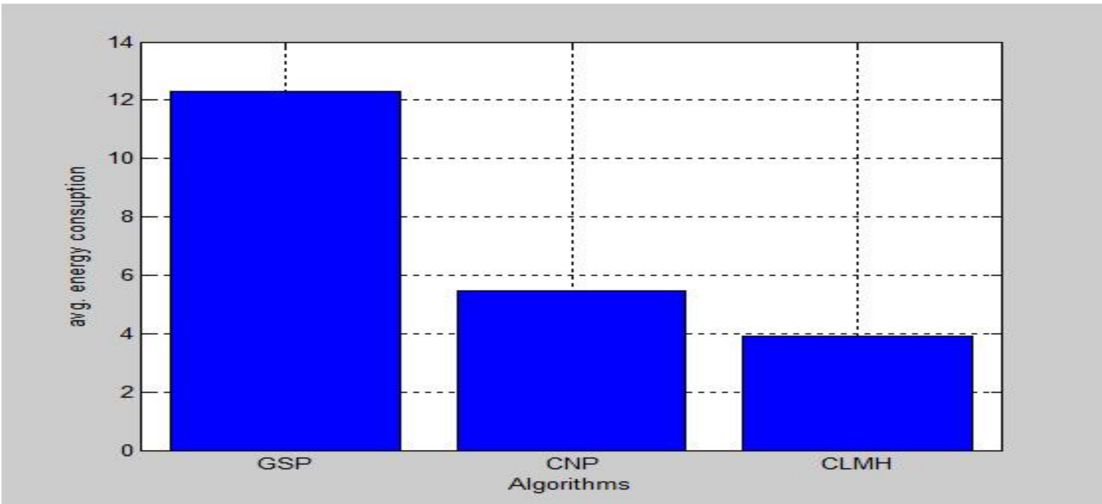

Figure 6: Average energy consumption

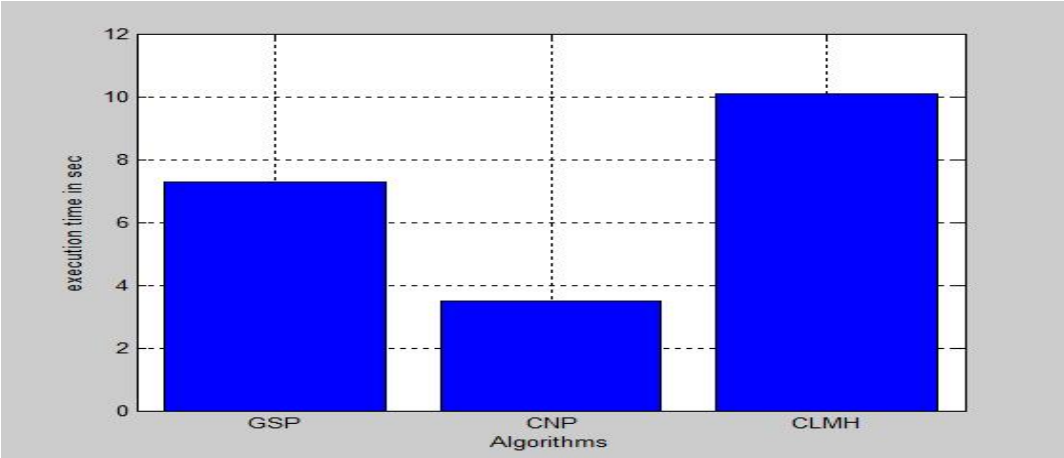

Figure 7: Execution Time of Algorithms

4. CONCLUSION

This paper mainly focuses on the problem of placement of the sink in the wireless sensor network. Here the network is partitioned into equal regions and sink is placed in each region by calculating its centroid. The GSP, CLMH and CNP strategies are implemented and there performance is observed.

After the results it is concluded that the CNP strategy shows better performance than the other GSP and CLMH strategies. For uniform node deployment CLMH shows low energy consumption and longer lifetime. Therefore, considering the network performance, CLHM and CNP strategies appear to be good solutions to the sink placement problem and outperform a benchmark algorithm called GSP, which is used to solve the sink placement problem.

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