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Implementation of Disseminate Region Coverage By Mobile Sensor Node Using Hexagonal Scheme

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Abstract: *Mobile sensor nodes are useful in many environments because they can move to increase the coverage area. After a sensor node failure creates a coverage hole, a mobile sensor node is impelled to cover the hole in a timely and energy efficient way. In this approach, we are using random uniform organization of N mobile sensor nodes. Such that each node has equal prospect of falling at any location in region of interest (i.e. Center of hexagon). Disastrous or hazardous environments where sensor nodes cannot be manually organized. A rectangular region of interest divided in regular hexagon in tessellation patterns. Mobile sensor nodes are randomly placed in the region of interest and coverage should be uniform. Purpose of this work is using Mobile sensor nodes with optimum travelling distance and less coverage overlap.*

Keywords*:* *Mobile sensor node, Hexagon tessellation, Optimum travelling distance, less coverage overlap*

Introduction

A sensor is a device that detects and responds to some type of input from the physical environment. A sensor node is a node in a wireless sensor network that is capable of performing some processing, gathering sensory information and communicating with other connected nodes in the network. Sensor networks are dense wireless networks of small, low-cost sensors, which collect and disseminate environmental data.

Mobile sensor nodes ensure a wide range of applications, starting from security surveillance in military and battlefields, monitoring previously unobserved environmental phenomena, smart homes and offices, improved healthcare, industrial diagnosis, and many more. For instance, a mobile sensor node can be organized in a remote island for monitoring wildlife habitat and animal behavior, or near the crater of a volcano to measure temperature, pressure, and seismic activities. Mobile sensor nodes have received much attention since network performance can be greatly improved by using just a few number of mobile sensor nodes. Mobile sensor nodes have movement capability to collaboratively reinstall the region. Coverage in this approach becomes very useful in situations where static nodes organization mechanisms fail or are not possible. Optimal placement of static sensor nodes might not be possible in disaster areas and urban toxic regions. Mobile sensor nodes might be better option and a significantly fewer number of nodes are required than their static counterparts.

Coverage is usually interpreted as how well a sensor network will monitor a field of interest. It can be thought of as a measure of quality of service (QoS). Coverage can be measured in different ways depending on the application, Depending on the sensing range, an individual node will be able to sense a part of the sensing field. Degree of coverage at a particular point in the sensing field can be related to the number of sensors whose sensing range covers that point. It has been observed and assumed that different applications would require different degrees of coverage in the sensing field. It may be low degree of coverage; it may be dynamically degree of coverage. A network that has a high degree of coverage will clearly be more resilient to node failures.

Implementation

The basic work is concerned with the sensor network is the coverage problem. Typical tasks of sensor nodes in a sensor network are to collect and transmit the data. Monitoring requires much more energy. Sensor nodes are equipped with limited power source. In many cases it is not possible to replace the power sources.

We consider a rectangular field of length L and breadth B which is divided into regular hexagons tessellation pattern of sides R, We consider all mobile sensor nodes having uniform sensing range r and side of the regular hexagon R is taken less than r. The regular hexagon tessellation pattern is further subdivided into different parts: either parallel to L or parallel to B. The whole rectangular area is covered by M×N regular hexagons. The length (L) and breadth (B) of the ROI are related with M,N and side of regular hexagon R by following relation:

$$N = \frac{L}{R\sqrt{3}}$$

$$B = (M-1) \times \frac{3R}{2} + 2R$$

Then

$$M = \frac{2B - R}{3R}$$

Where: L= length of ROI

B= Breadth of ROI

M= number of rows

N= number of regular hexagon in one row

R= side of regular hexagon

Thus, there are N rows of regular hexagon and in each row there are M regular hexagons.

The rows are numbered 1 to N and the columns are numbered 1 to M. For sake of convenience we consider the center of the bottom most left hexagon as origin of reference, x axis along horizontal line and y-axis as the vertical line downwards

The coordinate positions of the centers of regular hexagons dividing the rectangular field are represented as (x, y) = $(R\sqrt{3}i, \frac{3R}{2}j)$, which represent the position of the center of the hexagon in i^{th} row and j^{th} (even) column, and another coordinate position of the center of regular hexagons dividing the rectangular field are represented as

(x, y) = $(\frac{R\sqrt{3}}{2} + R\sqrt{3}i, \frac{3R}{2}j)$ which represent the position of the center of the hexagon in i^{th} row and j^{th} (odd) column, where x= 1…N, y = 1…M and $1 \le i \le N$, $1 \le j \le M$.

We can see that each point in the ROI is covered by MSNs.

Objective:

1. Ensure that mobile sensor nodes cover the whole region without coverage hole.
2. Mobile sensor nodes are traveling optimum distance and less coverage overlap.
3. Minimize the travelling distance of MSNs.
4. Minimize the use of MSNs to cover the whole ROI.
5. Ensure that all MSNs are travelling equal distance.
6. Minimize the time taken by MSNs to cover the whole ROI.

Assumption:

1. All mobile sensor nodes are identical in nature.
2. Sensing range of all MSNs is r.

Solution Methodology:

To achieve the above objects, we develop an algorithm for the MSNs to travel along the center of the regular hexagon. Proper care has to be taken while partitioning the ROI. An improper partitioning may fail to make the MSNs travel minimum distances with maximum coverage and minimum time.

a. Partition of ROI

A rectangular ROI of length L and breadth B for the sake of convenience we consider the origin (0, 0) to be at the bottom left of ROI. X and Y axes originate from here. The ROI is divided in to regular hexagons of side R in tessellation patterns. As shown in figure 1.

The distance between two center points of adjacent regular hexagon is $\sqrt{3}R$. There are N no. of hexagons arranged along the length L and M no. of rows arranged along the breadth of B.

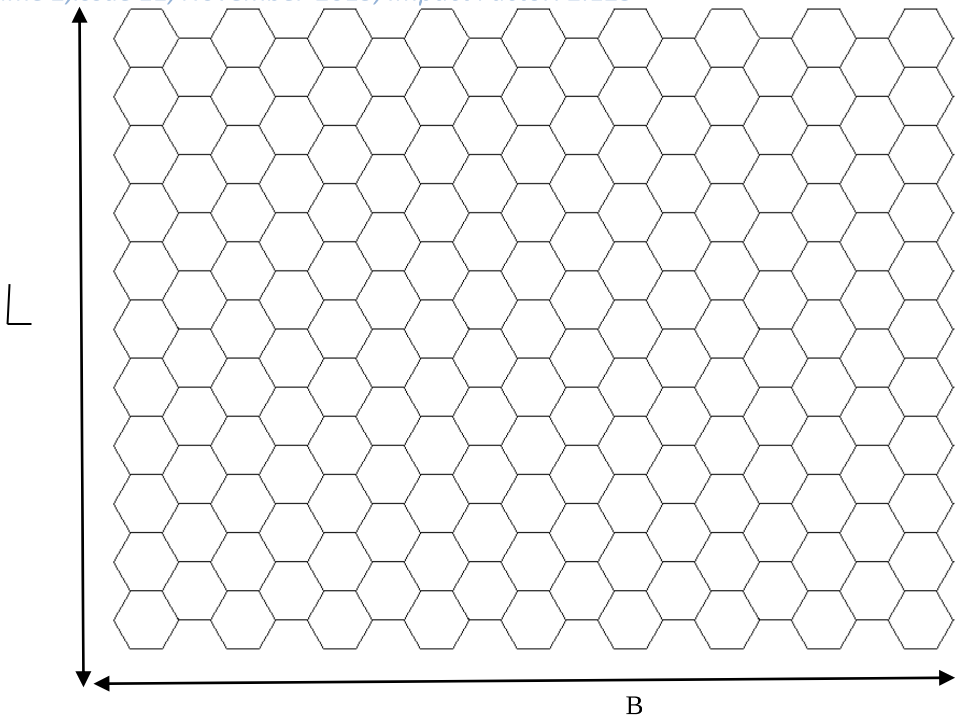

Figure 1: partition of ROI

Following mathematical relations can be established to find out the value of M and N.

Distance between two parallel sides of hexagon is √3R.

$$N = \frac{L}{R\sqrt{3}}$$

b. $B = (M - 1) * \frac{3R}{2}$ +2R

Then

$$M = \frac{2B - R}{3R}$$

Where: L= length of ROI

B= Breadth of ROI

M= number of rows

N= number of regular hexagon in one row

R= side of regular hexagon

Therefore, Total no. of regular hexagons present in ROI after tessellation is M×N;

b. Mobility pattern of sensor node:

The ROI is divided in to regular hexagons of side R in tessellation patterns. Total no. of regular hexagons is present in the ROI after tessellation is M×N. MSNs are placed at center of regular hexagons. And MSNs are travel along the center of regular hexagons to cover the region.

The ROI is divided in to regular hexagons of side R in tessellation patterns. After tessellation ROI is subdivided into different part of region. They are either parallel to L or parallel to B in rectangular shape, and thus forming P number of regular hexagon in one region. Similarly K numbers of such region exist in ROI.

Then

M×N=K×P;

$$P = \frac{MN}{K}$$

K= 1, 2, 3, 4, 5, 6…………………., M×N;

Where: M= number of rows
N= number of regular hexagon in one row

P= number of regular hexagon in subdivided region
K= number of subdivide region

Sensing Point:

Mobile sensor nodes will co-ordinate each other to perform required operations such as data collection and localization for pre-determining period of time. Upon completion of the operation they move to another part of ROI.

The location at which the sensor senses the environmental information will be referred to as sensing point. According to proposed approach, ROI is divided in to M×N number of regular hexagon. Each regular hexagon covered with MSNs. So the total number sensing point of MSNs is M×N shown in figure 2.

We consider a square ROI of side 500, and this is divided into regular hexagon tessellation pattern of side 25. After tessellation number of hexagon present in ROI is 156, so the figure 2 shows 156 center of hexagons.

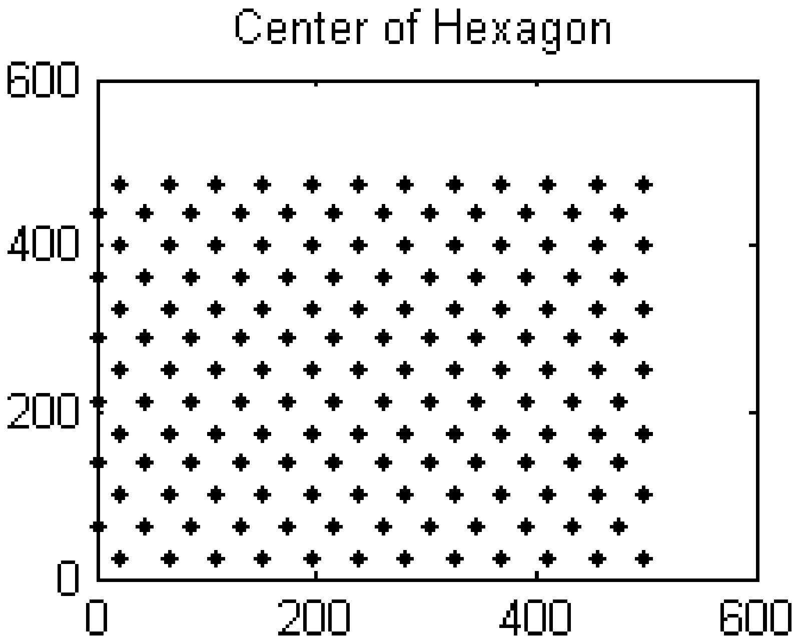

Figure 2

Total distance travel by Mobile sensor node:

$$D = \left(\frac{M * N}{K} - 1\right) * R\sqrt{3}$$

Where: D= total distance travel by MSNs
M= number of rows
N= number of regular hexagon in one row
R= side of regular hexagon
K= number of subdivide region

A square ROI of side 500 andregular hexagon of side 25 is considered, and tessellation number of hexagon present in ROI is 156, for this value center of hexagon present in ROI is shown in figure 3. By colors like red, green, blue, yellow, purple which specifies the movement of MSN. Therefore the colors indicates the total distance traveled by MSNs which is shown in figure 3. In this approach all the MSNs travel at the same time and none of these MSNs are in sleeping mode. The coverage of region is equally distributed in different MSNs which depend on their availability.

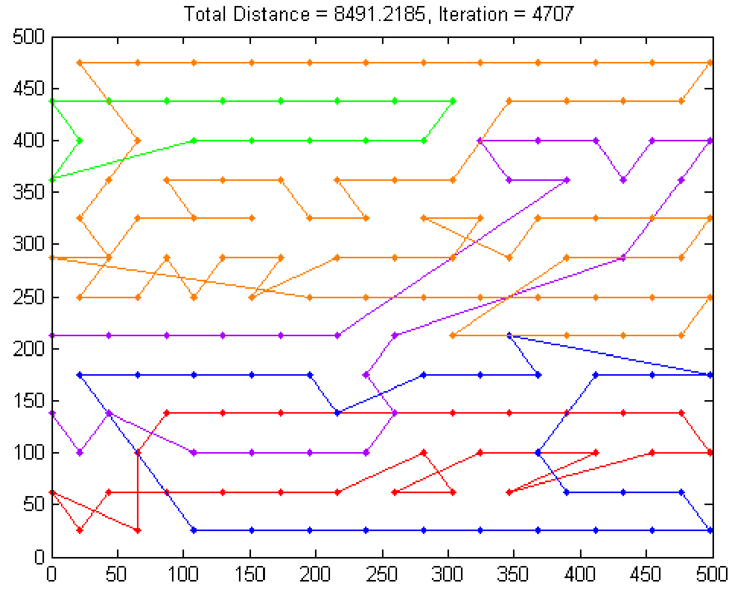

Figure 3: Movement of MSN

Experimental Result

We computed the total distance travelled by the MSNs for higher value of side of regular hexagon which is taken as 50 to 75.

We consider a Rectangular ROI L=4500, and B=2000, regular hexagon side length R=50 units and the calculated total distance travel by the MSNs to cover the rectangular ROI.

$$D = \left(\frac{M \times N}{K} - 1\right) * R\sqrt{3}$$

Where: D= total distance travel by MSNs

M= number of rows

N= number of regular hexagon in one row

R= side of regular hexagon

K= number of subdivide region

Then total no. of hexagon in one row N= 52.

And total no. of rows are M=26.

Total no. of Regular hexagon in rectangular ROI, N×M=1352.

Number of Region	Number of Hexagon in one Region	Total Distance travel by MSNs in one Region
1	**1352**	**117000**
2	**676**	**58457**
3	**451**	**38971**
4	**338**	**29185**
5	**270**	**23296**
6	**225**	**19399**
7	**193**	**16628**

8	**169**	**14549**
9	**150**	**12904**
10	**135**	**11605**

In our approach, we calculated the total distance travel by MSNs with the help of mTSP Generic algorithm. The mTSP can be explained as: we have a given set of nodes, let there be m salesmen located at a single depot node. The remaining nodes (cities) that are to be visited are called intermediate nodes. Then, the mTSP consists of finding tours for all m salesmen, who all start and end at the depot, such that each intermediate node is visited exactly once and the total cost of visiting all nodes is minimized. The cost matrices can be defined in terms of distance and time.

When 100 MSNs are used for the covering the whole ROI, MSNs is used as salesman in mTSP generic algorithm, the best result shown in figure 4.

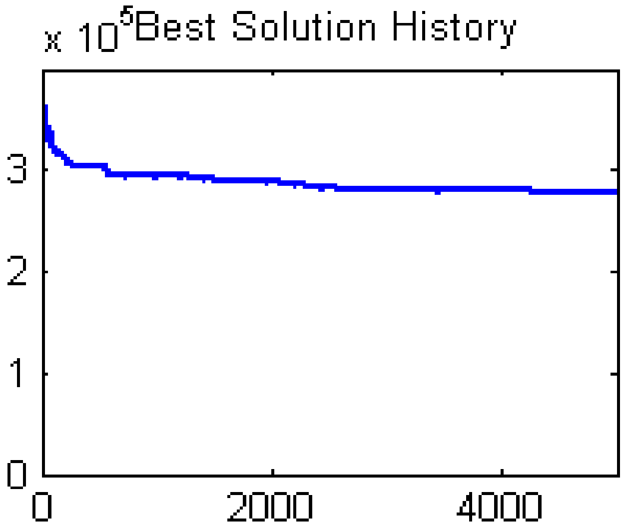

Figure 4: Distance travel by MSN when 100 MSNs are used

Where: D= Total distance travel by MSNs
L= Length of ROI

Conclusion

This approach is suitable in areas where manual deployment of nodes is not possible. This travelling distance must be balanced among all the nodes. By performing the experiments using MSNs for ROI we have observed that mobile sensor nodes cover the whole region without any coverage hole and MSNs travel the optimum distance without coverage overlap. MSNs are disconnected and their travelling distances are minimized. By result we have concluded that we need minimum number of MSN to cover the whole ROI. Since these MSNs are disconnected, we always make sure that they travel the equal distances and minimize the time taken by each MSN to cover the whole ROI.

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