Object Tracking Using Wireless Sensor Network

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Abstract- Wireless sensor network consists of spatially distributed autonomous sensors to monitor physical or environmental conditions, where each sensors have the ability to collect, process and store information. These characteristics allow WSN (Wireless Sensor Network) to be used in wide range of application such as area monitoring, environmental sensing, battlefield surveillance, NBC (Nuclear Biological Chemical) attack detection and so on. In certain applications where the sensor field is large and the available budget cannot provide enough sensors to fully cover the entire sensor field. This provides the motivation to deploy minimum number of sensors by connecting which the entire sensor field can be fully covered. In this paper we propose an approximation algorithm for grid coverage and a technique namely regular energy efficient monitoring to make the sensors in the minimum size wireless sensor network energy efficient in order to increase the network life time while tracking the object in the network. Simulation shows that the proposed algorithm provides a good solution for grid coverage and energy consumption.

Keywords- *Approximation algorithm, Coverage problem, Object tracking, Sensor deployment, Wireless sensor network.*

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I.INTRODUCTION

Wireless sensor networks are formed by connected sensors that each have the ability to collect, process, and store environmental information as well as communicate with others via inter-sensor wireless communication. These characteristics allow wireless sensor networks to be used in a wide range of applications, including health care, environmental monitoring, battlefield surveillance, intruder detection, and so on. Recently, the study of wireless sensor networks has become one of the most important areas of research. A wireless sensor network must achieve the specified coverage level of the application so that the quality of service provided by the wireless sensor network can be guaranteed. Here, we address the coverage problem in wireless sensor networks and the

Coverage problem in WSN basically is caused by three main reasons;

- Not enough sensors to cover the whole ROI (Region of Interest)
- Limited sensing range and
- Random deployment.

Since the sensors are operated using limited power supply some of them might die out therefore resulting in inadequate sensors to fully cover the whole ROI (Region Of Interest), causing holes to exist. A sensor’s sensing range is restricted to certain radius which consequently brings coverage problem. Of course this problem can be solved by using sensor with larger sensing range, but this type of sensor is more expensive. Hence we go for a technique namely Critical grid coverage which provides a good solution for the coverage problem with minimum number of sensors

In Wireless sensor network, by using an energy efficient technique we can increase the network life time of the sensors while, by which we can prevent the sensors from dying. Hence we can prevent the occurrence of inadequate sensors to fully cover the whole ROI (Region of Interest). The sensor node is a very small device that represents the building blocks of the WSN. These nodes are being produced at a very low cost and yet with high levels of sophistication in terms of computing power, energy consumption savings, and multipurpose functionalities when compared with earlier generations of sensor nodes. WSNs are created by deploying a large number of sensor nodes in a certain area, which is usually called the monitored region, for monitoring purposes. These nodes are interconnected and are used together as a monitoring and reporting device to acquire specific types of data as desired by the application requirements [17],[18], [19].

Object tracking, which is also called target tracking, is a major field of research in WSNs and has many real-life applications such as wild life monitoring, security applications for buildings and compounds to prevent intrusion or trespassing, and international border monitoring for illegal crossings. Furthermore, object tracking is considered one of the most demanding applications in WSNs due to its application requirements, which place a heavy burden on the network resources, particularly energy consumption. The main task of an object tracking sensor network (OTSN) is to track a moving object and to report its latest location in the monitored area to the application in an acceptable timely manner, and this dynamic process of sensing and reporting keeps the network’s resources under heavy pressure [12], [14].

In this paper we propose an efficient algorithm which provides a solution to the coverage problem by a technique termed critical grid coverage. This is done by covering the entire field by deploying certain number of sensors and producing the link between only those sensors that achieves the maximum coverage of the field .In order to achieve good tiling instead of square grids ,here we use hexagon grids to prove the same.Thus by using an efficient algorithm a minimum size wireless sensor networks is constructed in such a way that it fully covers the critical hexagon grids. A Performance evaluation is carried out to prove that hexagon grids provides good tiling and thus good coverage in comparison with square grids etc and evaluate the performance of grid coverage techniques. It also provides an energy efficient technique namely regular energy efficient monitoring (REEM) technique which consumes more energy while tracking the object in the field in comparison with the other energy efficient schemes which is proved by the comparison graph.

The main contribution of this paper is to provide an energy efficient grid technique by which the entire sensor field can be covered with minimum number of energy efficient sensors.

The remainder of this paper is organized as follows: Section II presents the grid coverage techniques involved in the performance evaluation. Section III reviews the energy efficient schemes and Section IV provides a performance study among the grid technique's and the comparison results of various energy efficient technique's analysed. Section V concludes this paper.

II.GRID COVERAGE

This section reviews one of the strategy namely Grid based, which is used in solving coverage problem in WSN which are done during deployment stage. Grid points are used in two ways in WSN deployment; either to measure coverage as used in VFA (Virtual force Algorithm) or to determine sensors positions. Coverage percentage as stated before is; ratio of area covered to the area of ROI. Here we have discussed two grid coverage models

A.SQUARE-GRID COVERAGE

One of the node deployment model is the square grid deployment model, Popular grid layouts are a unit square, an equilateral triangle, a hexagon, etc. A grid-based deployment is considered as a good deployment in WSN, especially for the coverage performance [4].

FIG1:Node deployment model

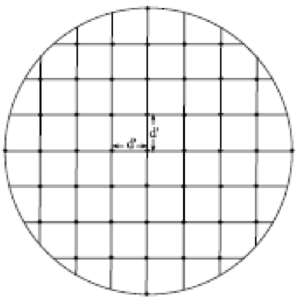
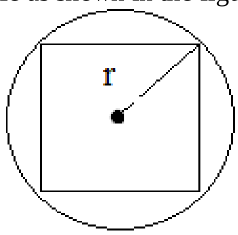


Figure shows a grid deployment of n sensors in a circular field [4], where each of the n grid points hosts a sensor. The approximate length of a unit square, d′, can be calculated in the following way: First, the approximate area of a unit square with length d′ can be computed by dividing the whole area of a given field having radius R, with the number of cells, k. We do not know the value of k, but it is approximately equal to (pn−1)2 for the square grid. From this relation, we derive Equation 1 for rsense, the sensing radius. However, since we consider an initial adjustment for a starting point, Equation 1 cannot be applied directly. Thus Equation 2 gives more precise values than Equation 1. Although we use these equations to find out the rsense (i.e., the length of a square, d′) given n and R, this formula allows the approximate computation of any one parameter out of n, rsense, and R given the other two parameters [4].

$$r_{sense} = \sqrt{\frac{\pi R^2}{(\sqrt{n}-1)^2}} \qquad (1)$$

$$r_{sense} = \sqrt{\frac{\pi R^2}{n}} \qquad (2)$$

FIG2 : To calculate the area of the square when the grid point is placed at the middle as shown in the figure**.**



Area of the square=1/2(2*r) ^2
Where r is the radius.

FIG3: The k-coverage map of all possible exactly k-covered points of a square grid cell with grid points placed at the end points [4]

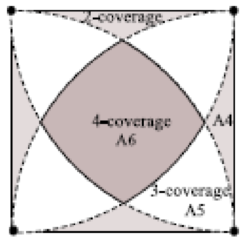


Figure shows the Square cell, where each of the point hosts a node which is placed at the end points [4].Using Equations 3 to 9, we compute the total area of exact k-coverage of a grid cell.

Square=

a1= [(4π-3√3)/6]*r^2 (3)
a2= [(π-2)/2]*r^2 (4)
a3= (πr^2/4)-(0.5*a1) (5)
a4= {(r^2)-[(πr^2)/4]}-a3 (6)
a5= a3-a4 (7)
a6= a2-(2*a5) (8)
Area= (4*a4)+(4*a5)+(1*a6) (9)

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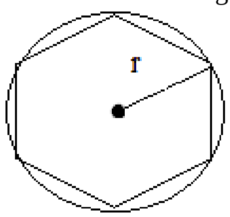
B.HEXAGON GRID COVERAGE

A triangle grid uses a larger rsense than a square grid for the same n and R. In particular, the square grid uses about 5% of rsense less than the triangle grid. In a hexagon grid, rsense is about 17% less than in the triangle grid. In this aspect, the hexagon grid seems better than others, but with respect to other performance metrics it does not behave well. For this reason, we consider HT deployment, which uses 13% of rsense less than the triangle grid. In a way similar to the square grid, an approximate formulation for rsense can be found for HT. This approximate solution can be computed using Equation 10 shown below [4].

$$r_{sense} = \sqrt{\frac{4\pi R^2}{3\sqrt{3}n}} \qquad (10)$$

FIG4:To calculate the area of the hexagon when the grid point is placed at the middle as shown in the figure.



Area of the hexagon= ((3√3)/2)*r
Where r is the radius.

FIG5: The HT cell is illustrated in Figure

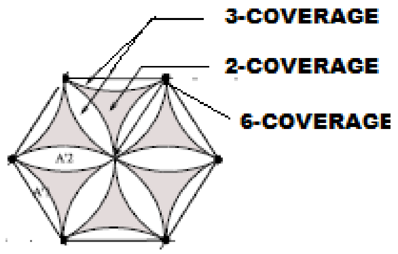


Figure shows the HT cell, which is the regular hexagon, where each of the tiling point hosts a node which is placed at the end points [4]. Using Equations 11 to 16, we compute the total area of exact k-coverage of a HT cell.

AH=[(3√3/2)*r^2], where AH is the Area of the hexagon (11)
AT=[(√3/4)*r^2], where AT is the Area of the triangle (12)
a1′=[((πr^2)/6)-AT]
(13)
a2′=2*a1′
(14)
a3′=9*a2′
(15)
a4′=AH-[a3′+Ɛ]
(16)

III.ENERGY EFFICIENT SCHEMES

The object-tracking techniques are classified into five main classes, which are naive, schedule monitoring, continues monitoring, dynamic clustering, and prediction based. However, in this section, we will focus on the first three techniques as they will be used in the study of energy efficient scheme comparisons. For more details, see [13].

The naive scheme is considered a basic object-tracking technique, where all the sensors in the OTSN are kept active all the time, and therefore, each moving object in the network will be detected by the sensor nodes and reported to the base station every *T* ms [13], [15].

In the scheduled monitoring (SM) technique, all the sensor nodes in the network are allowed to stay in sleep mode; they change their status to active mode for a brief period of time where they start sensing their monitored area and report their findings to the base station, given that both the sensor nodes and the base station are well synchronized. It is obviously clear that, with the implementation of this technique, a major savings in the consumed energy is accomplished compared with the naive technique; this is because all the nodes in the OTSN network are scheduled to stay for a very short time in active mode and continue to operate in sleep mode as long as possible. On the other hand, the main drawback of this technique is that, to avoid missing reports, there are many nodes being activated to participate in the object detection process while those nodes are not actually required [13]

The continuous monitoring (CM) technique differs the naïve and schedule monitoring techniques; it does not involve all the sensor nodes in the OTSN network to track a moving object. As an alternative, this technique allows only one sensor node to continuously stay in an active mode while it detects and tracks a moving object as long as this object stays inside the node's detection area, and the rest of the sensor nodes in the network are kept in sleep mode. The current active node will continue to monitor the moving object in its monitoring area until it leaves its coverage area and begins to enter a neighbouring node detection area. At that time, the current active node will wake up the destination node to start monitoring the moving object; then, the current active node will change to sleep mode while the destination node will become the current active node. This allows the rest of the nodes in the network to maintain their sleep mode status as long as possible, preserving their energy. Nonetheless, to avoid any missing reports, the current active node will have to keep its active mode status during the time when the moving object is still inside its detection area. This eventually will lead to the depletion of the current active node's energy [13], [16].

The regular energy efficient monitoring (REEM) technique provides a regular base station at the middle which provides regular power to all the sensors in the network where here all the sensors in the network are in active mode and as soon as the message of tracking the intruder is sent to the base station, the corresponding sensor shuts down its MCU or sensing component and here all the sensors are said to be in static condition thus using this REEM technique maximum power is saved in comparison with all the other naive, schedule and

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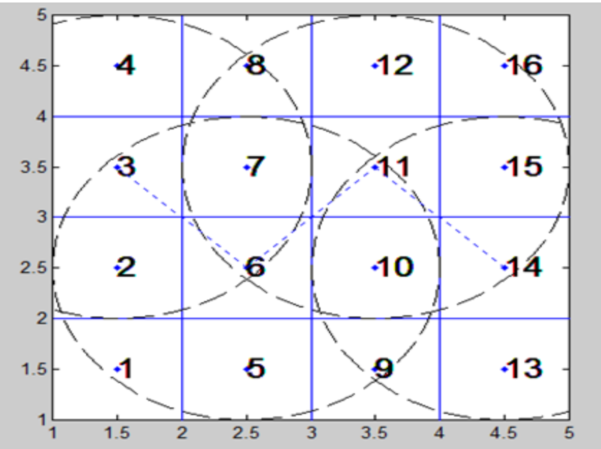
continue monitoring techniques which is proved by the comparison graph

IV.PERFORMANCE STUDIES

A.SQUARE

As shown in Result, node 3 is considered as the starting node and then linked to node 6-11-14 which is said to satisfy the following conditions, Among the nodes within the sensing range, which node is at the longer distance, & Among the nodes at the longer distance, which node has maximum coverage area of the field excluding the area that has already been covered by the previous coverage area of the previous nodes linked and excluding the node that has already been linked.

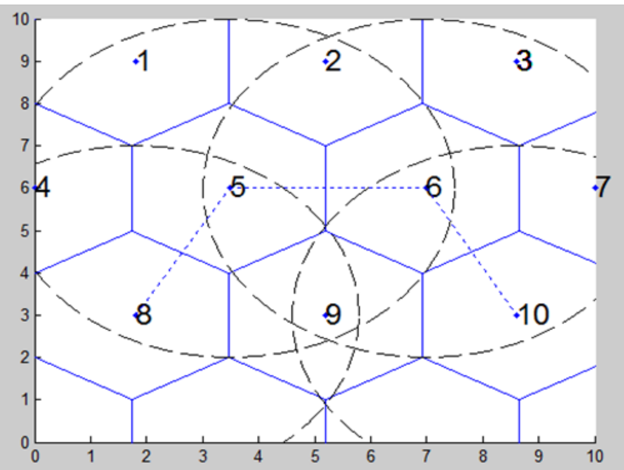
FIG6: Square grid coverage



B.HEXAGON

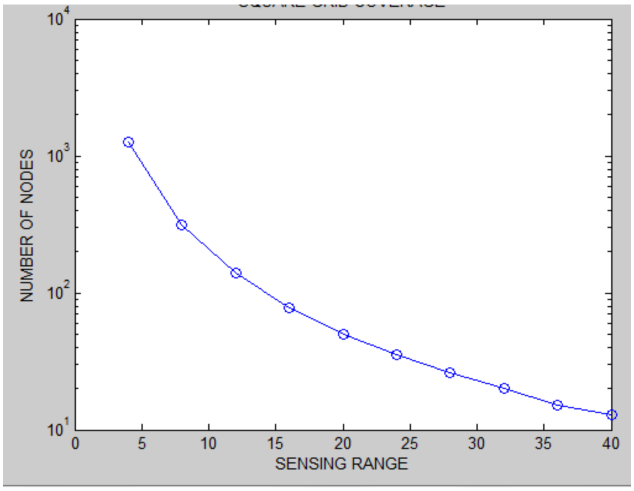
As shown in Result, node 8-5-6-10 which is said to satisfy the following conditions, Among the nodes within the sensing range, which node has maximum coverage area of the field excluding the area that has already been covered by the previous coverage area of the previous nodes linked and excluding the node that has already been linked.

FIG7: Hexagon grid coverage



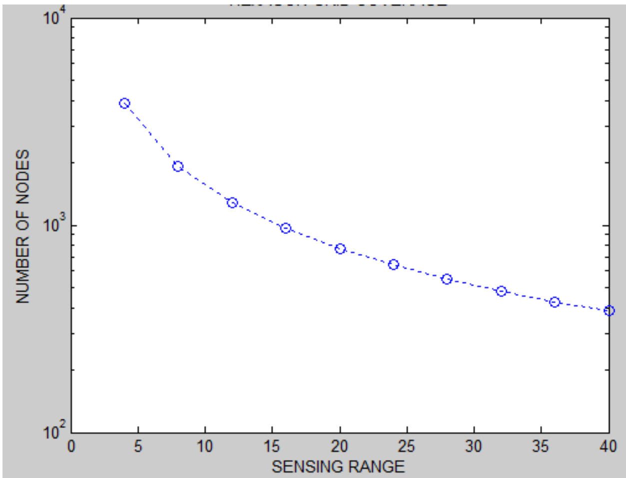
C.PERFORMANCE METRICS OF SQUARE

FIG8: Coverage performance of square



D.PERFORMANCE METRICS OF HEXAGON

FIG9: Coverage performance of Hexagon



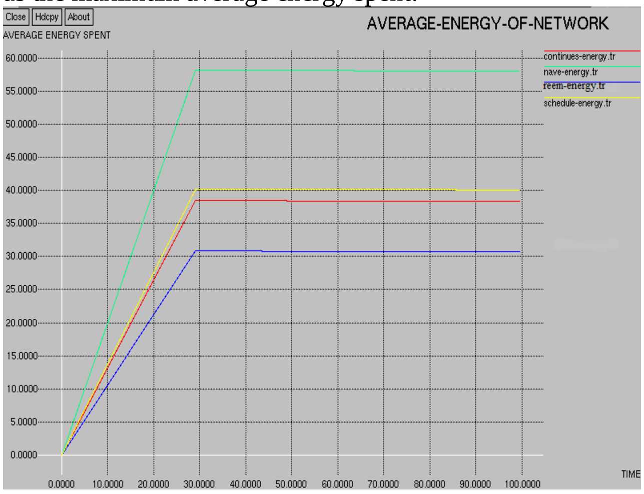
From Fig 6& 7 it is proved that using minimum number of nodes maximum part of the field area can be covered with respect to the proposed algorithm in both the hexagon and square grid technique but in further works we choose hexagon grid deployment since it provides good tilling and thus good coverage which is decided by the number of grids or nodes covered within the coverage area, this is proved from Fig 8 & 9, where fig8 shows the coverage for square and fig9 for hexagon which shows that as the sensing range is increased the number of nodes covered within the sensing range is increased thus number of grids covered is increased therefore the field area covered is also increased hence at the same time the number of nodes examined within the sensing range is more for hexagon in comparison with square therefore using hexagon grid deployment this is proved to be cost effective with respect to same radius & total field area.

E.COMPARISON ENERGYGRAPH

The figure shows a comparison graph of all the four techniques namely

- Naive scheme
- Schedule monitoring
- Continuous monitoring
- Regular energy efficient monitoring technique (REEM)

Thus proved that our proposed technique Regular energy efficient monitoring technique (REEM) consumes more energy in comparison with the other three existing techniques where the average energy spent for naive scheme is 58 joules, schedule monitoring is 42 joules , continue monitoring is 38 joules and REEM technique is 30 joules where 60 joules is set as the maximum average energy spent.



V.CONCLUSION

Thus in the case at which if the sensor field is large, or the available budget cannot provide enough sensors to fully cover the entire sensor field. The proposed technique namely critical grid coverage provides the solution for the problem of deploying minimum number of sensors on grid points to construct a connected minimum wireless sensor network which is able to fully cover the critical grids in a field area

Therefore the entire sensor field is covered with minimum number of sensors by using this proposed technique CRITICAL-GRID COVERAGE and the performance evaluation of various grid techniques is obtained and various energy efficient schemes are analyzed and thus proved that our proposed REEM technique consumes more energy among the all in order to increase the network life time of the sensors in the field.

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