Noticeable Key Points and Issues of Sensor Deployment for Large Area Wireless Sensor Network: A Survey

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Abstract- **The objective of many research groups now a days is monitoring of sensitive areas with sensor deployment in large area network. There are many applications that requires wireless sensor network for continuous monitoring such as health monitoring, environmental monitoring, agriculture, industrial use, wildlife protection etc. Some of the research groups are working on real time implementation of wireless sensor network instead of simulation. Real time implementation of WSN faces various issues, and results are also not as good as compared to simulated results.**

Keywords— Wireless sensor networks; Node Deployment; Sensing Model; Coverage type;

I. INTRODUCTION

With the technological advancement now a days, several electronic devices have been introduced in different applications for sensing and observing the area or targets. Single or group of sensor nodes is capable to recognize event and capable to communicate over network by mobile infrastructure or predefined infrastructure. These all devices are capable to perform task and make connection with other nodes using multi-nodes concept to send data to float without human intervention [1]. These emerging machine to machine wireless communication technologies give strength to cover all those area where human reach

is difficult which we called as unfriendly environment. But each beneficiary technology has some constraints and limitations. There are some of the global issues which are trying to solve by researchers: Coverage of the physical for maximizing event detection ratio(positive event detection) [2]; Identifying realistic and optimal sensing range of sensor in outdoor environment with consideration of adverse conditions [3]; Selection of the robust deployment strategy for max coverage and max network connectivity [4]; Energy consumption for individual node or group of nodes in network based topology control [5]; Energy aware protocol [31] etc. The main focus of this paper is to cover all the key points and issues related to deployment which should be considered at the time of designing the blue print for any WSN application.

II. MOTIVATION

Maintaining the topology design of the sensor nodes, coverage and connectivity issues must be considered simultaneously. Correlation between coverage and connectivity will help in constructing design for sensor deployment and will ensure that the area or target or barrier are covered by at least one sensor node for coverage [6] and at least one neighbor is in the communication range which must be able to forward data to sink over the network using point-point or multi hop. There are some of the points and their related issues which motivated to write this survey:

A. \Related to coverage for event detection:

How to deploy sensor nodes in Region of Interest(ROI) to cover all the points? What range of sensing of a sensor node can help in coverage of

ROI in network? How to examine the effect of seasonal changes on the sensing range of sensor in the open environment? How to get that sensing range practically? Would this will help in maximizing sensing and minimizing chance of fail to catch an event?

B. *Related to connectivity of sensor nodes:* Which one of the connectivity in sensor nodes is needed for network? Continuous or Intermittent. Which strategy of deployment can be possible to execute? Random or Deterministic. How many number of hoping supported by network with multi-hoping? How much communicational range will result best cost with the consideration of coverage?

C. *Related to quality of deployment of WSN with Both Coverage and Connectivity*: Which deployment strategy will be good for network for both coverage and connectivity? How to correlate connectivity and coverage for maximum sensing, hard network and good cost?

IV. Sensor Deployment for Large Area Wireless Sensor Network

Sensor deployment for WSN application is required to view all the issues (discussed above) and their successful action of solving a problem to avoid any loss such as cost, energy, event detection, network breakage etc. We have discussed all the above issues in following groups with key points that should consider at the time of sensor deployment.

First group is for WSN coverage of single or group of sensor nodes. This group discusses about coverage type of group of nodes and sensing range for single sensor node (to get high chance to detect an event by each single sensor node in ROI). Second group discusses about selection and recognition of communicational range of single node and which deployment strategy will ensure connectivity of sensor nodes in network. Third group covers the nodes for deployment that help in visualizing and designing the network with better connectivity and coverage.

These groups are discussed below:

A. *WSN Coverage:*

Coverage in WSN is defined as how sensors are able to observe the physical area and the value at which sensor can optimally detect an event is called sensing range. Following are the some key points that should be view for avoiding the coverage issues:

B. *Coverage Type:*

Deployment of WSN should be start from the selection of region of interest (ROI) and the identification of what actually you want to monitor in that ROI. For the intention of any WSN application, application can monitor(proctor) an area, points (targets) or a break among a barrier. So on the basis these choices, there are three types of coverage in WSN. They are as following:

First type is full or blanket coverage, every point in 2D area must be covered by at least one of the sensor node [7]. This is used mostly in coverage type in which each point in ROI having significance at the time of event detection. This type of coverage can be seen in military surveillance, area monitoring, localization of event and many more. There are two types of area coverage; first one is Full coverage and second one is Partial coverage. In Full coverage, all the points are covered as blanket by at least one sensor node i.e. one node must be there. This follows the fixed deployment strategy to cover all the points by single or multiple nodes like square, triangular or hexagonal it means that there must be no change in deployment of nodes. Deployment of nodes in full coverage may have higher cost and energy wastage due to overlapped connectivity but higher degree of probability and reliability (reaches to 1) of event detection. So in blanket or full coverage, we can select small antenna to minimize the cost and consumption of energy. In Partial coverage, probability to detection of an event becomes lesser than one and move towards zero due to partial coverage of area. The cost of this deployment is

lesserthan blanket coverage. This coverage type is preferred for monitoring of environment not for highly prone areas.

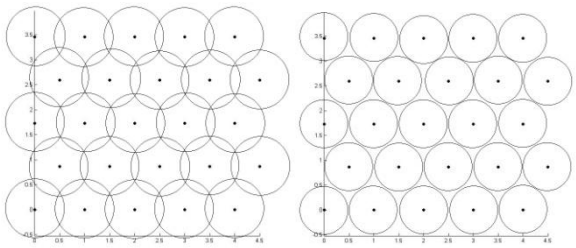

Fig. 1: Area coverage and Partial coverage

Second type of coverage is point coverage. These points are well known and can place sensors in such a manner to cover maximum points by at least one sensor [8]. Point coverage is suitable for those applications that observe highly risky areas such as security entrence using image or video capturing etc. To cover the fixed points, mobile sensors are used.

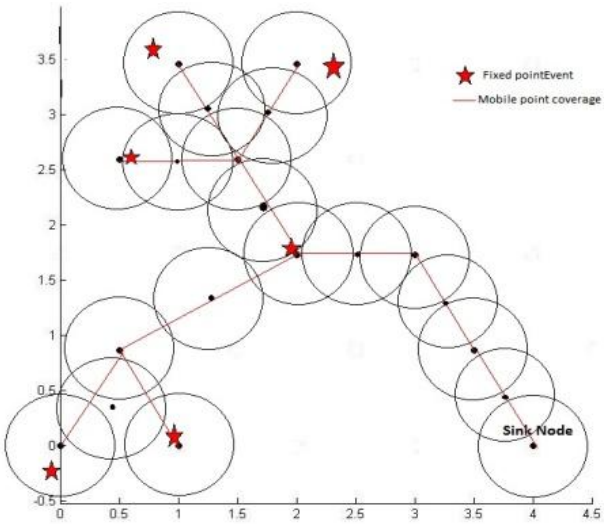

Fig. 2: Point coverage

Third one type is barrier coverage. Barrier coverage is usually covering the points across the barrier [9] [19] because sometimes entry points are monitored except area inside the boundary by intruder like perimeter security or trespassing by the animal or human crossing [22]. So, for protection of boundaries or breach is required to cover by barrier coverage. There are two types of barrier coverage: Full barrier coverage or Partial barrier coverage they are similar to Full area coverage and partial area coverage.

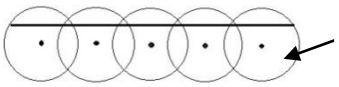

Fig. 3: Barrier Coverage

[1] *Selection and identification of sensing range of sensor using sensing models:*

Sensing range is one of the main key point to achieve coverage in WSN. This should be correlated with communication range of sensor otherwise deployment cannot achieved the reliability and robustness. So firstly select sensor with satisfying sensing range then analyze and identify the effects of outdoor environment on sensing range of a sensor. There are two models discussed for avoiding change of detection of event.

i. *Binary Sensing Model:* This model says that if a point lj positions under the disk of sensing range of sensor (let the sensing range is Rs) then deterministically this event will be detection by the sensor Si that is why this model is also called as Disk Model[26]. Probability for the detection of event will be one if point ri-lj is less or equal to Rs otherwise it will be zero. Means detection of event will be deterministically Yes or No.

$$\mathbf{Pij=} \begin{cases} 1 & if\ ri \cdot \\ 0 & Other \end{cases}$$

ii. *Probabilistic Sensing Model:* Probabilistic sensing model considers all of the factors that can affect the detection of an event because of precision values of the sensing readings [27]. This model suggests probabilistically selection of sensing range for sensors which will be based on level of tolerance for event detection in case of success or failure).

$$Pij= \begin{cases} 1 & if\ ri - lj <= Rs - Re \\ e^{-\alpha a^{\beta}} & If\ ri - lj <= Rs\ and\ ri - ji >= Rs - Re \\ 0 & Otherwise \end{cases}$$

$$where\ a = (ri - lj) - (Rs - Re)$$

Let Re is the radius of error introduced by chances to miss out events due to environmental constraint or physical characteristic of sensor.

Similarly α and β are the parametric values that can be changes for different factors and lies in between 0 and 1. According to this model, there are two concentric circles for sensing range Rs as outer concentric circle and confident sensing range Rs-Re as inner concentric circle for event detection. If li lies under inner concentric circle then value of Pij will be 1 and will be 0 if outside the outer circle but if li lies in the ring Re made by outer side of inner circle and inner side of outer circle then value of Pij can be calculated exponential of Euclidian distance in between sensor and event ri-li.

- *Communication range of Node:*

Communication range is the distance between sensor nodes which can transfer their messages from one place to another. Different variety of trans-receivers are available in the market and each application of wireless sensor network (WSN) uses communication range according to the connectivity they require. Identification of the communication range is the biggest challenge in outdoor environment with the consideration of foliage, temperature, terrain, undulating ground etc [29][30]. The communication range can be represented as rc. This rc should be analyze in varying seasonal constraints for reliable communication links and robust network.

- *Deployment of nodes:*

At the time of decision taking for selecting deployment strategy for WSN, there are the some main issues: To provide coverage, neighbor connectivity and required maintenance to each and every individual node in network after deployment.

The purpose of application can help in the selection of deployment model. There are two types of sensors nodes in WSN: Static or Mobile. Mobile sensor in WSN is referred to as Mobile wireless sensor network (MWSN). MWSN can be seen usually for robotics, vehicle WSN and for highly prone area which is out of human reach. These nodes can able to change their place themselves after deployment. MWSN consist of sensing, processing and transmission unit. MWSN can be homogeneous or heterogeneous i.e. with mobile sensors or mobile device with sensors respectively. MWSN has different benefits because of its mobility such as it can located itself after initial random deployment which sometimes become difficult for human because of heavy foliage, terrain etc; it can also relocate themselves when network changes or sensing needs changes. Relocation of nodes can be required on those stages where few nodes in network are die or detection of event at specific point etc .

MWSN has advantages but it is very difficult to execute it on a ground with the limited energy resources. So Static WSN is generally preferred for deployment for long life of network. There are two broad categories of deployment in Static WSN:

Random deployment.

Deterministic deployment

Random deployment : It can be placed on the ground by throwing it by the flying object. It can be one by one deployment or mass deployment. They can be deployed : by dropping it from flying object it can be airplane or drone, can be placed by human or robots. Random deployment is one of an easiest way to place nodes, less installation cost is required, eliminate the pre planning for organizing the nodes, flexibility is given for deployment and it can raise self deployment of nodes using mobility concept but it can be suffered from connectivity issues and coverage issues. This is good for those applications which are used to collect area monitoring values not an event-driven values.

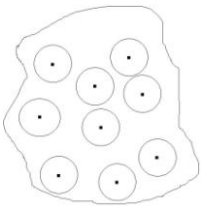

Fig.4: Random Deployment

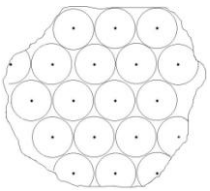

Fig. 5: Deterministic Deployment

Deterministic deployment : It has many beneficiary points over the random deployment except the one which is simplicity of deployment. Deterministic deployment view all the points related to connectivity and coverage. However in some of the cases it becomes impossible to deploy nodes at some of the specified location. But at the timing of maintenance, post deployment issues can be easily solved by human and identification of location becomes cheaper [17].

Both the strategies of deployment have pros and cons, only application type can assist in identifying which one will be suitable for application. Like for environmental monitoring, random deployment will be the good choice but area monitoring is for visual events, deterministic deployment will help to cover point, area or barrier.

There are some of the Deterministic deployment topologies which are widely used. These regular patterns are discussed below :

- Equilateral Triangle Topology
- Hexagonal Topology
- Square Topology with four connectivity neighbor

i. *Equilateral Triangle Topology:* It is one of the best pattern for maximum connectivity with 6 neighbors and minimum overlapping of sensing area. When this one pattern is used for a sensor's deployment strategy it covers the area with minimum number of nodes and each node cover hexagonal cell for sensing that area. In Figure 6, we can see six nodes are in neighborhood if all nodes are placed inside the communication range or at communication range of nodes and with the help of voronoi diagram(partitioning of a plane into regions based on distance to points in a specific subset of the plane), we can see the sensing area covered by a node in equilateral triangle topology. It seems like a hexagonal.

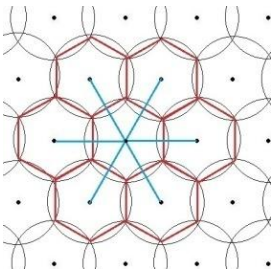

Fig. 6: Equilateral Triangle pattern

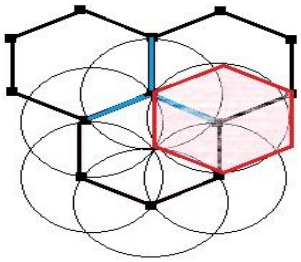

Fig. 7: Hexagonal based pattern

ii. *Hexagonal Topology :* This pattern is shown in the Figure 7. We can see in figure 7 only three communication links can only be created with this pattern but area coverage is somewhere similar to triangular pattern i.e. each area is covered by at maximum 2 nodes. This is one of the best topology pattern for maximum coverage.

iii. *Square Topology* **:** This pattern is consists of 4 or 8 neighbors in grid and based on the number of neighbor requirement it can cover the area for sensing that area[28]. Both of the square based pattern is shown in Figure 8. Square topology pattern is used when the designing of nodes want to cover area in plan of 2D grid.

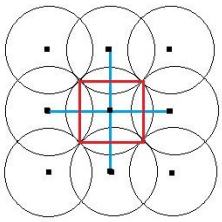

Figure 8(a): Square based pattern with 4-neighbor.

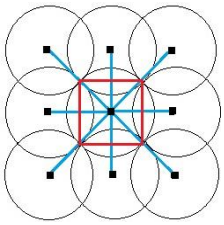

Figure 8(b): Square based pattern with 8-neighbor.

V. CONCLUSION

A wireless sensor network is influenced by many of the factors like communication range (R),sensing range (r) of the sensor of node, selection of deployment strategy, selection of R and r is based on the topology pattern [20], environmental effect will be considered at the time of checking R and r, operating the environment and cost of the network in such a environment etc. We had discussed many factors in this paper which are addressed in this literature and we had listed out all of the factors which should be considered at the time of planning WSN for any of these specific application.

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