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Issues of Coverage and Connectivity in Wireless Sensor Network

Shruti Pandey, Ashutosh Rastogi

Department of Electronics and Communication Engineering, BBD University, Lucknow-226028, Uttar Pradesh, India

ABSTRACT

Wireless sensor network advert to series of spatial dispersed and consecrate sensors for observing and recording the physiological condition of environment. Wireless sensor network is made up of series of specialized transducers with communication infrastructure. The challenge faced by WSNs developers is the problems of limited battery power issue, small memory and short range communication constraints, and failures of links. Coverage and Connectivity is the two major issues arising in WSNs. These issues are causing severe impact on performance of WSNs. Today many of the researchers are working on the coverage and connectivity issues of WSNs. In this paper we bring brief and quick description of issues faced in coverage and connectivity in WSN.

***Key Words:* Wireless Sensor Network, Coverage, Connectivity, Reliability, Iterative approximations**

INTRODUCTION

Wireless Sensor Network consists of wireless nodes which are equipped with low cost sensors with the ability of sensing, computation, and communication. Sensor nodes are linked via low bandwidth links which are being used in monitoring the environment. The first challenge encountered in WSNs is monitoring region should be covered perfectly. Among several other research problem the coverage issue affects the network performance which defines how well the sensor attendants the monitoring region by its sensing ability. Now after gathering the information from environment, aggregated data is being transmitted from sensors to base station or can be known as processing unit for the monitoring the region [7]. A sensor node does not directly communicate with base station due to its limited coverage area. Therefore the sensor's network can be connected as the information transmitted by each sensor to base station by network either than direct link. A network is known to be fully connected when each and every pair of nodes can communicate among each other either by direct links or through relay nodes [1, 4].

The Coverage of a wireless sensor network distinguishes aspects of how better a deployed location is observed. A typical WSN network with deployed nodes has been shown in fig 1.

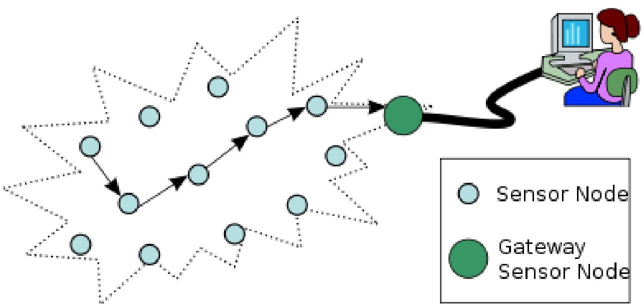

Figure 1: Wireless sensor Network

Coverage is a depreciative issue in infrastructure security application, environment monitoring and military surveillance. A better coverage requires basis for target localization, classification, and tracking as well as intrusion detection. The capacity of wireless sensor network characterizes throughput that can be uninterrupted by network for data teleport to data sink from sensors. It has an undeviating impact on design and performance of the network.

The connectivity of wireless sensor network implies the robustness and existence of network routes from sensor to data sink. The nodes placement increases the lifetime of network as well as bring fault tolerance in it. It's an imaginary thing to keep all the sensor nodes active during communication. The objective is to make work minimum numbers of node so that the maximum or complete coverage can be achieved. The network area coverage can be evaluated when effectiveness of wireless sensor network is being calculated.

The concept of connectivity sometimes provides the fault tolerance to the network. For example, a network with j-connections, if j edge disjoint paths among any pair of nodes in given network at available given time. Similarly, the connection of the network remains until the (j-1) connection breakdown. There are many other methods for conservation of connectivity of network [8].

For the coverage in wireless sensor network reliability degree is guaranteed required for the monitoring of the region. This has been categorized in two ways. The first one is area coverage; over a given area sensor nodes are completely deployed. Another category is target coverage; in this the targets have to be cover with predetermined positions.

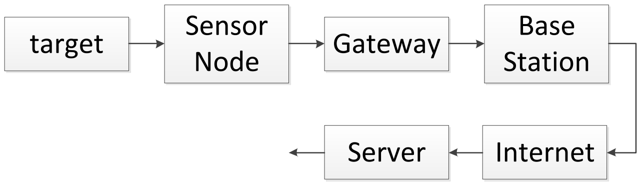

Figure 2: Target tracking application of WSN.

Above figure determine one of the applications of target tracking in wireless sensor network. In target tracking, detection of intrusion and tracking of vehicles requires higher percentage of coverage for accuracy and for applications like environment or habitat, these requires lower coverage percentile [10, 15].

The challenging problem in wireless sensor network is coverage and connectivity. The coverage can also be increased by using mobility in heterogeneous wireless sensor network. There are many protocols for increasing the lifetime and for keeping the stability in wireless sensors. In this paper, we bring the quick view of issues in coverage and connectivity.

ISSUES OF COVERAGE IN WIRELESS SENSOR NETWORK

Some of the distinct characteristics of wireless sensor network are like multi hop communication, operations in energy- efficient, in-network process, collaboration and auto configurations. The performance of wireless sensor network has been influenced by various factors such as transmission medium, scalability, power consumption, fault tolerance etc. There are many other factors which are being barrier for the operation in wireless sensor network such as self-management, ad-hoc deployment etc.

There are various other issues in wireless sensor networks, in which the crucial one is coverage problem. In this it tells that how the sensor nodes monitors sensing area. [2] There are many Key concepts and definitions [1,4] related to coverage and connectivity in WSN. Some of the concepts related to coverage of sensor network are:

Coverage Degree

Coverage degree is termed as how many attendants can cover the point or provided location. Its Robustness can be improved; also it signifies redundancy of wireless sensor networks. For example if j-1 node failure can be tolerated, if j sensors covers location.

Coverage percentage or ratio

Coverage ratio is termed as it can be used in different ways in different scenarios and its interpretation can be changed for ensuring coverage techniques. The area covered by active nodes is known as the coverage percentage. This finds target to be covered by wireless sensor nodes which satisfy coverage degree. So for example 80% is covered that means 16 points are covered out of 20. For 100% it is known as complete coverage.

Node coverage fraction:

This represent that some of sensor nodes can be out of target area without affecting the coverage ratio or percentage. This parameter highly affects the protocols of energy efficiency being designed for wireless sensors.

Detectability

Probability of moving objects from target A to target B is termed as detectability. Whenever we talk about sensing any event it does not mean all the time that its static event, it can be anything such as a moving wildlife or intruder in network.

Communication range and Sensing range

Assume S_r and C_r as sensing range and communication range respectively. C_r is used for communication between the sensor nodes. S_r is used for monitoring field. The relation between them depends upon coverage and its application. For achieving complete coverage or j connectivity or coverage has to be greater than sensing range.

Centralized and Distributed Algorithm

During communication power consumption is being decreased in distributed algorithm rather than centralized algorithm. Centralized Algorithm yields large consumption of energy due to communication as attendant node gathers information and send forward to fusion center. In distributed algorithms it must run on all nodes. This permits all the attendants nodes to change its mode through observation.

Condition of Network Coverage

According to survey there have been two conditions of coverage which are necessary and sufficient conditions respectively. These are lower and upper bound probability function of coverage.

Necessary Condition- it's assumed that X nodes are being deployed randomly in unit square area. It can be expressed as -:

$p(s)\ r^2(s) \geq [p(s)/-2\log(1-p(s))]*\log(s)/s$
Where, p(s) = probability of keeping nodes active

r(s) = transmission range

Sufficient Condition- Assume as D1, D2, D3, and D4 are four active nodes, in extreme condition. This can be expressed as:-
$p(s)r^2(s) \geq [1/4\alpha^2].\log(s)/s$[2]

Sensing models

By determining the relation among position of point and sensor in space measuring the sensor ability and quality is termed as coverage model. The coverage models without angles are known as omnidirectional models and those with angles are termed as directional models. The majority of models which are studied more are as: - Detection coverage models (DCM), Estimation coverage models (ECM), Truncated attenuated disk coverage models (TADCM), Boolean-disk coverage models (BDCM) etc.

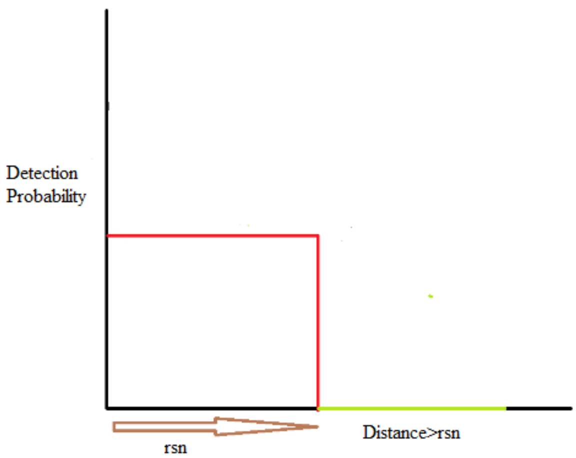

Figure 3: Boolean Sensing Model

Evaluation Metrics:

The major categories for evaluation are- network scalability, energy efficiency, QoS and number of active nodes etc. These are useful matrices for measuring wireless sensor networks coverage performance and must be taken into account for WSN coverage measurement effectiveness.

ITERATIVE APPROXIMATION FOR COVERAGE AND CONNECTIVITY ISSUES

As till now we have seen the issues and matrices related to coverage and connectivity, now we relate them and find iterative approximation based on combination relaxation.

Definition and Notation

let's consider a set of M of t targets mi, i є {1……t} with position to cover the least number sensor as all sensors can transmit information with each other and specially with the sink node with coordinates (i,j). To make a model of WSN, we have to make following assumptions [5].

First of all, we assume that transmission range of all sensors is same R_t and two sensors can communicate to each other directly if their distance is within transmission range.

Second, assumption is that all sensor is having a predefined sensor range known as R_s. Sensors cover target, if it's given Euclidean distance among sensor and target is equal or smaller than predefined sensor range. Let P_s be set of all position of sensors.

Problem Formulation for Iterative Approximation:

For conclusive minimum number of sensors analogous to sensor network graph is connected and each location is occupied by at least one sensor. For this problem, a mathematical expression has been applied in which binary variable is being used,

- Xi, gets value 1, if sensor is placed on position of i.
- Zij, gets value 1 when two sensors are placed on position of i and j and a direct link is set between i and j can be used for connectivity of network.

The minimum total power can be reformulated by integer programming model:

$IP = \min \sum j \in Ps\ xi$

=> s.t.

=> $\sum (i, j) \in Ps\ zi\ j = \sum j \in Ps\ xi - 1$ -(1)

=> $\sum (i, j) \in (S, S\ )(zi\ j) \leq \sum j \in S\ xj - 1\ \forall\ S \subseteq Ps$- (2)

=> $\sum j \in Ci\ xi \geq 1\ \forall i$ – (3)

=> $\sum 2zi\ j \leq xi + xj\ \forall\ (i, j) \in Ps$ - (4)

=> $\sum xi, zi\ j \in \{0, 1\}$

i. Where, the first equation tells that tree on n vertices has n-1 edges.

ii. Second constraint tells that sub – tour elimination constraint prevents solution.

iii. Third constraint ensures the each target is covered by single sensor at least.

iv. Fourth one tells that edge (i,j) is selected only on its endpoints .

This program helps to extend stronger concept of coverage and connectivity.

Iterative Relation for Approximation

Iterative relaxation technique was used successfully for solution of wide range of practical and real time optimization problems. This technique is applied for solving the problem of IP. [9] Speaking about the process, it relaxes second constraint and then solve the remaining problem. After which it produces violated relaxed constraint also known as separation process. Then it add violated constraint and resolve problem. The procedure is iterated until constraint is violated. Finally, optimal solution for IP is yield.

- **Constraint Min – cut Problem:**

Let's take a graph G (V,E) with a source s, a target t, and a set $S \subseteq V$. This problem is solved by solving |S| mini-cut and taking best sub cuts.

- **Separation process:**

A separation oracle finds a violated sub tours elimination constraints and gives a solution for IP.

For this a result has been evaluated in which a polynomial time separation oracle for elimination of sub-tour constraint for IP.

Let S ∈ Ps, E(S) = {(i,j) | i ∈ S, j ∈ S} are set of edges with endpoint in S.

Thus, the result obtained from above in IP is

$Min\ S\ \{x(S) + z(E(Ps)) - z(E(S))\} < x(Ps)$

METHODOLOGY

Due to finite resources of wireless sensor network coverage face extensive challenges. Entirely distinct energy conservation and lifetime optimization approach are presented to maintain network coverage. [18,19] The discrete coverage approaches for coverage in Wireless sensor network are following -:

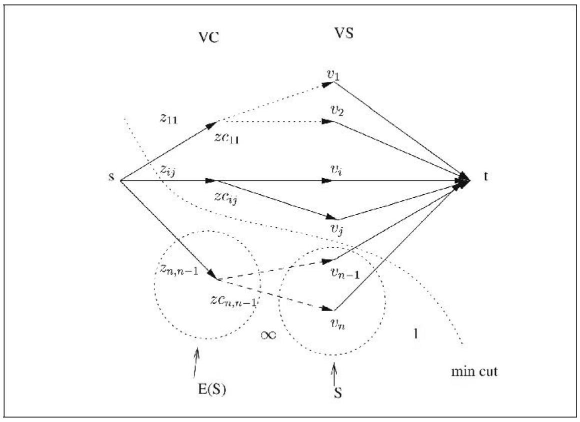

Figure 4: Separation oracle and the associated min-cut problem

a) BEST or WORST case Coverage:

According to author [14], the various sensor network application can be foresighted as best or worst case, in which best case highly covered area for coverage are considered. Whereas worst case lowered area for coverage is considered. In the sensing model, sensors sensing ability decreases as the distance among them increases. They also consider how to discover an optimum best coverage passage that travels a minimum distance and have lowest energy consumption.

b) Probabilistic Sensing:

Probabilistic sensing approach is contradistinctive from deterministic sensing approach which takes into cogitation the effect of distance on sensors sensing ability. In this the diversification in detection probability with distance can be illustrated by concentric cycle drawn around sensor position. Every circle appears as the probability of accurately receiving a signal with capacity and strength above receiving threshold at distance comparable to radius of the circle.

c) Disjoint sets:

In this author states [16], the coverage approach disjoint set coverlet are assembled which is characterized as a subset of sensor that is competent of covering the complete region of interest by itself. Only the peculiar subset of sensor which are in prescribed set coverlet are active at a predetermined time and spare sensor which are inactivated set cover are in sleep mode in order to conserve energy.

This approach of alienate the mandatory sensor increases the network lifetime either also maintain significant coverage while conserving energy of sensors in network.

CONCLUSION

The given issue and matrices are important for measuring performance of WSN coverage and should be effectively taken into account for measurement of coverage. Many researchers have solved the problem with the help of these issues and matrices. It has been proved that the coverage and connectivity may vary significantly with scalability, transmission media, topology dynamics and hardware constraint. Above all there is still scope for more work for improving the WSN coverage as well as connectivity issues.

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