Area Coverage With Heterogeneous Sensors In The Presence Of Jammers In A Wireless Sensor Network Environment

Thesis submitted to Indian Institute of Technology Kharagpur

for the partial fulfillment of the requirements for the award of the degree of

Master of Technology

in

Computer Science & Engineering

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**Certificate**

This is to certify that the thesis titled **Area Coverage with Heterogeneous Sensors in ihe presence of Jammers in a Wireless Sensor Network environment**, submitted by **Major Jaydeep Bodwadkar**, Roll no: **14CS60D01**, in the *Department of Computer Science and Engineering, Indian Institute of Technology, Kharagpur*, India, for the award of the degree of **Master of Technology**, is a record of research work carried out by him under my supervision and guidance.

The thesis fulfils all the requirements as per the regulations of this institute. Neither this thesis nor any part of it has been submitted for any degree or academic award elsewhere.

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**Dr. Arobinda Gupta**

**Acknowledgments**

I would like to express my sinsere gratitude towards my supervisor Dr. Arobinda Gupta for his immense help, motivation, and guidance to carry out this work. His continued support in the form of discussion, constructive criticism, and clear understanding has helped me to proceed in the right direction.

I am really indebted to him for giving me a wide exposure to the field of wireless sensor networks and its various coverage issues and enable me to contribute constructively to this field. Without his invaluable advice and supervision, it would not be possible to complete this work.

Finally, I would like to thank all professors & lab administrators for their continuous and unconditional support.

Major Jaydeep Bodwadakr

**Abstract**

The Area Coverage problem is a fundamental problem in Wireless Sensor Network. In this thesis the use of wireless sensor network (WSN) technology for ground surveillance for military applications will be investigated.

A solution to the area coverage problem in WSN provides the total number of sensors that are required to cover a given area of deployment. While previous work in this field has proposed many solutions, these studies have not addressed the issues concerning coverage in the presense of Jammers.

The goal of the project is to develop an algorithm for optimal placement of heterogenous sensors at locations which are from a given set of feasible locations and in the presense of adversary Jammers.

# Introduction

Wireless Sensor Network (WSN) are spatially distributed autonomous sensors which are used to monitor environmental or physical such as temperature, sound, pressure, etc. The sensor placement could be pre-planned or totally random depending on the application. Once deployed these sensors cooperate to pass their data through the network to a central location. The more modern networks are bi-directional, also enabling control of sensor activity. Use of wireless sensor networks was first mostly for military applications such as battlefield surveillance, but, today such networks are used in many industrial and consumer applications, such as machine health monitoring, industrial process monitoring and control, disaster management and so on.

A key advantage of WSN is that the network can be deployed on requirement basis and on the fly and doesn’t need an operator or an attendant. It works without the need for any pre-existing infrastructure and with little maintenance. The easiest way to deploy these sensors is at fixed locations so that connectivity is maintained. These sensor nodes can be deployed randomly (e.g., via aerial deployment), and are expected to self-organize to form a multi-hop network. A sensor node is capable of sensing some physical phenomenon (e.g., detect tank vibrations or sniper gun noise), processing the sensed data and communicating the observed measurements to other nodes. The sensor nodes may also have the capability to compress the data before coomunicating it to other nodes.

## Applications of WSN

Applications of WSN are varied and in different fields ranging from Agriculture, Environmental monitoring to Military applications. Some of the important applications are highlighted as follows:-

1. **Agriculture** – Intel’s Wireless Vineyard [1] is an example of using ubiquitous computing for agricultural monitoring. In this application, the network is expected not only to collect and interpret data, but also to use such data to make decisions aimed at detecting the presence of parasites and enabling the use of the appropriate kind of insecticide. Data collection relies on data mules, small devices carried by people (or dogs) that communicate with the nodes and collect data. In this project, the attention is shifted from reliable information collection to active decisionmaking based on acquired data.
2. **Environmental Monitoring** - Through joint efforts of the University of California at Berkeley and the College of the Atlantic, environmental monitoring is carried out off the coast of Maine on Great Duck Island by means of a network of Berkeley motes equipped with various sensors [2]. The nodes send their data to a base station which makes them available on the Internet. Since habitat monitoring is rather sensitive to human presence, the deployment of a sensor network provides a noninvasive approach and a remarkable degree of granularity in data acquisition [3]
3. **Military Applications -** Military applications are plentiful. An intriguing example is DARPA’s self-healing minefield [4], a self-organizing sensor network where peer-to-peer communication between anti-tank mines is used to respond to attacks and redistribute the mines in order to heal breaches, complicating the progress of enemy troops.

In this thesis, Military Application of WSN pertaining to Border Surveillance is investigated.

## Threat by Jammers to WSN

WSNs are succiptible to attacks by jammers. Jammers try to interfere with the transmission and reception of wireless signals by emitting high power RF signals. There can be two categories of jamming attacks. The first one targets the inter-node communication channel and the other one targets the sensors sensing capability.

The jammers that regress the sensors’ sensing capability have to be very specific type of Jammers. If a sensor uses RF to sense then the jammer against it should be a RF jammer using the same frequency as the sensor e.g. a camera sensor will not be affected by a RF jammer. Hence, if the WSN consists of heterogenous sensors, the adversary would require different types of jammers to deteriorate the WSN.

The jammers which attack the inter-node network are of different types of that try to intentionally inject false data during the inter-node communication which affects the data transmission and also the performance of WSN reduces as it causes the overutilization of the scarce resources like battery power, memory etc.

## Motivation and Objective

WSNs can be used in challenging places where it is inconvenient for humans to be present. We have a long border with our adversary which has large stretches of areas which are inhospitable but important as far as border infiltration is concerned. It is difficult to deploy troops permanently in such terrain and all along the border. But, in case of any infiltration incident, troops can always be sent to such areas for specific operations.

The cross border activities of our adversary have been ever increasing and that makes it important and necessary to have a strong and effective border surveillance of such areas. The task of surveillance in such situations and terrain can be done by sensors and any intrusion detected can be handled individually. The sensors that will be used for such purposes will mostly be static and placed at locations already known i.e. no random placement will be done.

The use of WSN for surveillance will be known to the adversary and methods to disable the sensors, the network or inject false information into it will be used by the adversary. For the purpose of disabling the sensors the use of Jammers by the adversary cannot be ruled out. Hence, to use the WSN effectively, it is required to place the sensors at locations such that there is no effect of Jammers and administrative requirements of the sensors is minimised.

In thesis, we explore and investigate the use of wireless sensor network to create a surveillance grid consisting of a number of heterogeneous sensors like cameras, audio sensors, ground sensors, radars, etc. for providing effective and continuous border surveillance in the presence of adversary Jamming activity to disable the sensors’ sensing capability.

## Problem Statement

It is required to create a surveillance grid consisting of a number of heterogeneous sensors like cameras, audio sensors, ground sensors, radars, etc for providing continuous border surveillance in the presence of enemy Jamming activity.

The area under surveillance is called the Area of Interest. A set of heterogenous sensor types are available with us with and each sensor type has the following information associated with it:-

1. Range of operation which determines the Area of Influence of the sensor
2. Set of feasible locations
3. Cost

For every sensor will have a tuple associated with it as

(

where,

(the current location of the sensor)

There is a set of jammers which are used to jam the sensors in area of interest . The jammers together may jam the area completely, partially or not jam at all. Each jammer is has a circular area of influence and is associated with the following information:-

1. Range of operation which determines the Area of Influence of the jammer
2. Fixed location
3. Cost of operation

Every sensor type in presence of a jammer has a probability of sensing defines as follows:-

The following assumptions will be made while solving the problem at hand:-

* 1. Position of the enemy Jammers remain static.
  2. Area of Interest is a rectangle.
  3. Infinite number of sensors of each type are available
  4. Feasible locations for the sensors is within the Area of Interest.

Our goal is to find a minimum cardinality set where is a sensor such that and is the location of the sensor fixed by the algorithm. For every point following should hold:-

1. If is in the Area of Influence of a jammer then is in the Area of Influence of some sensor with such that =1
2. If is out of the Area of Influence of all jammers then is in the Area of Influence of some sensor

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