PROJECT - I

Report on

Target Coverage and Network Connectivity Of Mobile WSNs with Minimum Movements.

Submitted in partial fulfillment of the requirements

of the degree of

Bachelor of Engineering
(Electronics and Telecommunication Engineering)

by

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Certificate of Approval

This is to certify that, the Project - I report entitled

"Simulation Of Target Coverage and Network Connectivity Of Mobile WSNs with Minimum Movements. "

is a bonafide work done by

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and is submitted in the partial fulfillment of the requirement for the degree of

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Examiner | Supervisor

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Abstract

A Mobile wireless sensor network is a set of physically distributed sensor nodes. Sensor node is a small wireless device with limited battery life, radio transmission range and storage size. A sensor node performs the task of collecting important data, processing the data, monitoring the environment, etc. This property of sensors i.e. mobility can be very efficiently used to improve the target coverage quality and network connectivity in randomly deployed mobile sensor networks. Target coverage (TCOV) and Network connectivity (TCON) are two main challenging issues of mobile sensor networks. This project focuses on the challenges of the Mobile Sensor Deployment (MSD) problem and investigates how to deploy mobile sensors with minimum movement and energy consumption to form a WSN that provides both target coverage and network connectivity.

Contents

List of Figures

Chapter 1

Introduction

1.1 A Brief Introduction to Mobile Wireless Sensor Network (MWSN)

A Mobile Wireless Sensor Network (MWSN) can simply be defined as a wireless sensor network (WSN) in which the sensor nodes are mobile. MWSNs are a smaller, emerging field of research in contrast to their well-established predecessor. MWSNs are much more versatile than static sensor networks as they can be deployed in any scenario and cope with rapid topology changes. Basically, Mobile Wireless Sensor Networks (MWSN) are the collection of the small and the light weight wireless nodes.

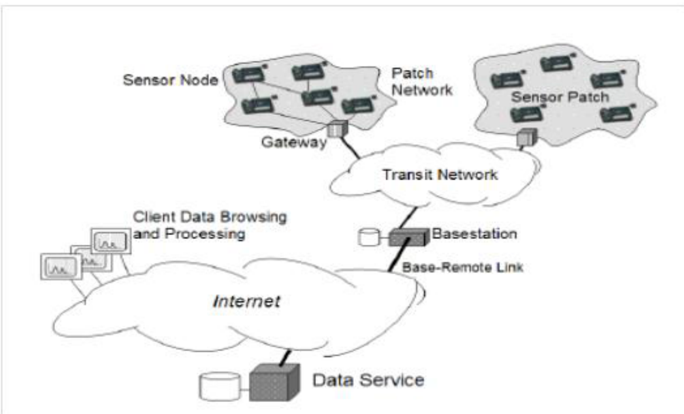


Figure 1.1: Mobile Wireless Sensor Network

A Wireless Sensor Network is comprised of multiple sensor nodes, normally deployed over a two dimensional plane for sensing and transmitting physical parameters. Sensed physical parameters are transmitted to one or multiple sinks. Each sensor is roughly comprised of the following units: transmitter, receiver, sensing and computing.

There is an analogue to digital converter for converting the sensed parameters into transportable form.

Sensors have to transmit in multiple hops to the sinks as the normal transmission range of the sensor nodes is about 100 meters or so.

1.2 Coverage in MWSNs

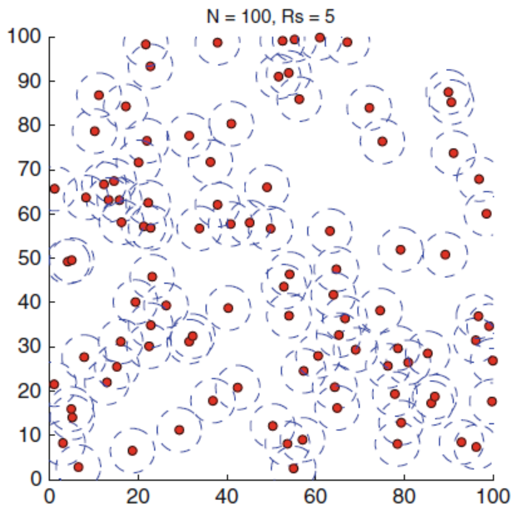
Coverage is the primary evaluation metric for a wireless network. It is always advantageous to have the ability to deploy a network over a larger physical area. This can significantly increase a systems value to the end user. It is important to keep in mind that the coverage of the network is not equal to the range of the wireless communication links being used. Multi-hop communication techniques can extend the coverage of the network well beyond the range of the radio technology alone.

Coverage is a measure of the quality of service provided by a sensor network. Due to the attenuation of energy propagation, each sensor node has a sensing gradient, in which the accuracy and probability of sensing and detection attenuate as the distance to the node increases. The total coverage of the whole network can therefore be defined as the union (including possible cooperative signal processing) of all nodes sensing gradients. It represents how well each point in the sensing field is covered.

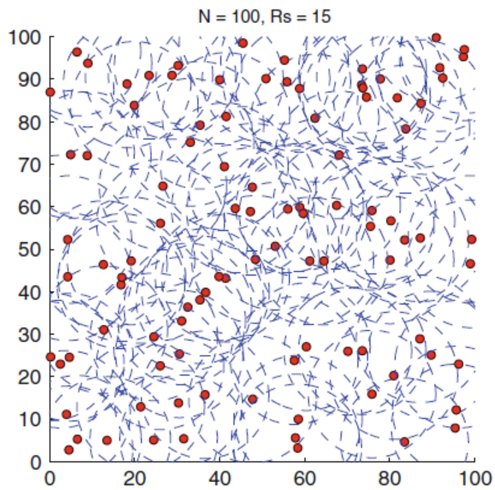
Coverage is a fundamental issue in a WSN, which determines how well a phenomenon of interest (area or target) is monitored or tracked by sensors. Each sensor node is able to sense the phenomenon in a finite sensing area.

A point is covered by a sensor if the Euclidean distance between the point and the sensor is no more than the sensing range r_s according to the Boolean sensing model.

For full sensing coverage, the entire region of application field is covered by at least one sensor and there is no sensing coverage hole in the network.



(a) The field of interest is not fully covered.



(b) The field of interest is nearly fully covered.

Figure 1.2: Coverage in MWSN.

1.3 Connectivity in MWSNs

Connectivity is an important issue in WSNs which concerns with delivering the sensed data from the source sensor to the destination (sink node) via radio transmissions. As sensors are low-cost devices with constrained resources, each sensor node has only limited communication range compared with the size of the monitored area. Multi-hop communications are necessary when a sensor cannot reach the sink node directly. Two sensors are called neighbors if they are within each other's communication range. The sensor nodes and the communication links between each pair of neighbors build the network topology, which is required to be connected by the connectivity requirement.

Connectivity represents how well the sensor nodes in the network are connected to each other. It is a fundamental property of a wireless sensor network, for many upper-layer protocols and applications, such as distributed signal processing, data gathering and remote control, require the network to be connected. Since the sensor nodes communicate via wireless medium, a node can only directly talk to those that are in close proximity to itself (within its communication range). If a sensor network is modeled as a graph with sensor nodes as vertices and direct communication links between any two nodes as edges, by a connected network we mean the graph is connected.

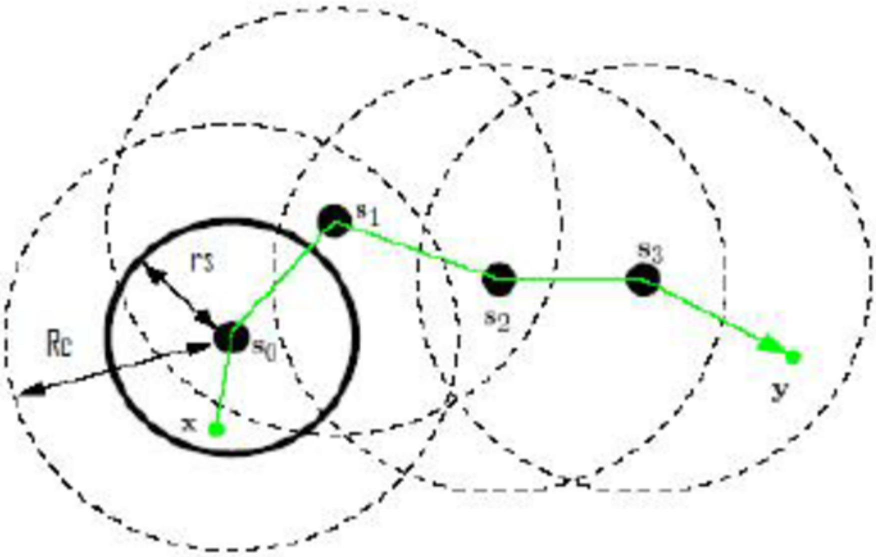


Figure 1.3: Connectivity in Wireless Sensor Network

1.4 ARCHITECTURE

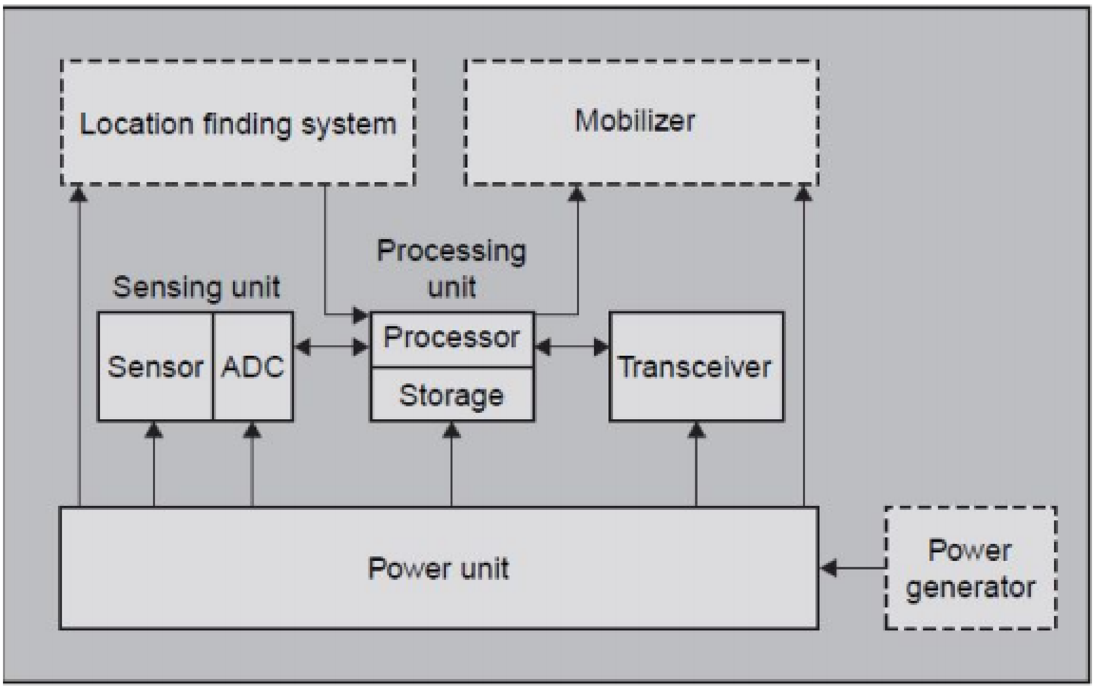


Figure 1.4: Architecture of Wireless Sensor Network

Architecture is divided into three parts:

1. Sensing unit
2. Processing unit
3. Power unit

1.4.1 Sensing unit

1. **Sensor:**
   A sensor is a device, module, or subsystem whose purpose is to detect events or changes in its environment and send the information to other electronics, frequently a computer processor. A sensor is always used with other electronics, whether as simple as a light or as complex as a computer. Sensors are used in everyday objects such as touch-sensitive elevator buttons (tactile sensor) and lamps which dim or brighten by touching the base, besides innumerable applications of which most people are never aware. With advances in micromachinery and easy-to-use microcontroller platforms, the uses of sensors have expanded beyond the traditional fields of temperature, pressure or flow measurement,[1] for example into MARG sensors. Moreover, analog sensors such as potentiometers and force-sensing resistors are still widely used. Applications include manufacturing and machinery, airplanes and aerospace, cars, medicine, robotics and many other aspects of our day-to-day life.

2. **ADC:**
   An analog-to-digital converter (ADC, A/D, or A-to-D) is a system that converts an analog signal, such as a sound picked up by a microphone or light entering a digital camera, into a digital signal. An ADC may also provide an isolated measurement such as an electronic device that converts an input analog voltage or current to a digital number representing the magnitude of the voltage or current. Typically the digital output is a two's complement binary number that is proportional to the input, but there are other possibilities.
   There are several ADC architectures. Due to the complexity and the need for precisely matched components, all but the most specialized ADCs are implemented as integrated circuits (ICs). A digital-to-analog converter (DAC) performs the reverse function; it converts a digital signal into an analog signal.

1.4.2 Processing unit

1. **Processor:**
   A processor, or "microprocessor," is a small chip that resides in computers and other electronic devices. Its basic job is to receive input and provide the appropriate output. While this may seem like a simple task, modern processors can handle trillions of calculations per second.The central processor of a computer is also known as the CPU, or "central processing unit." This processor handles all the basic system instructions, such as processing mouse and keyboard input and running applications.

2. **Storage:**
   Data storage is the recording (storing) of information (data) in a storage medium. DNA and RNA, handwriting, phonographic recording, magnetic tape, and optical discs are all examples of storage media. Recording is accomplished by virtually any form of energy. Electronic data storage requires electrical power to store and retrieve data.Data storage in a digital, machine-readable medium is sometimes called digital data. Computer data storage is one of the core functions of a general purpose computer. Electronic documents can be stored in much less space than paper documents. Barcodes and magnetic ink character recognition (MICR) are two ways of recording machine-readable data on paper.

1.4.3 Power Unit

- **Power Supply**
  A wireless sensor node is a popular solution when it is difficult or impossible to run a mains supply to the sensor node. However, since the wireless sensor node is often placed in a hard-to-reach location, changing the battery regularly can be costly and inconvenient. An important aspect in the development of a wireless sensor node is ensuring that there is always adequate energy available to power the system. The sensor node consumes power for sensing, communicating and data processing. More energy is required for data communication than any other process. The energy cost of transmitting 1 Kb a distance of 100 metres (330 ft) is approximately the same as that used for the execution of 3 million instructions by a 100 million instructions per second/W processor. Power is stored either in batteries or capacitors. Batteries, both rechargeable and non-rechargeable, are the main source of power supply for sensor nodes. They are also classified according to electrochemical material used for the electrodes such as NiCd (nickel-cadmium), NiZn (nickel-zinc), NiMH (nickel-metal hydride), and lithium-ion. Current sensors are able to renew their energy from solar sources, temperature differences, or vibration. Two power saving policies used are Dynamic Power Management (DPM) and Dynamic Voltage Scaling (DVS).[7] DPM conserves power by shutting down parts of the sensor node which are not currently used or active. A DVS scheme varies the power levels within the sensor node depending on the non-deterministic workload. By varying the voltage along with the frequency, it is possible to obtain quadratic reduction in power consumption.

1.5 Network Lifetime in MWSNs

Network lifetime is one of the most important and challenging issues in WSNs which defines how long the deployed WSN can function well. Sensors are unattended nodes with limited battery energy. In the absence of proper planning, the network may quickly cease to work due to the network departure or the absence of observation sensors deployed close to the interested phenomenon. Since a sensor network is usually expected to last several months without recharging, prolonging network lifetime is one of the most important issues in wireless sensor networks.

A sensor node is generally composed of four components: sensing unit, data processing unit, data communication unit and power unit. The power unit supplies power to the other three units. Any activity of the other three units - sensing, data processing, data transmitting and data receiving-will consume battery energy. Experiments show that wireless communication (data transmitting and receiving) contributes a major part to energy consumption rather than sensing and data processing. Therefore, reducing the energy consumption of wireless radios is the key to energy conservation and prolonging network lifetime.

Chapter 2

LITERATURE SURVEY

Sonali Karegaonkar and Archana Raut, Improving Target Coverage and Network Connectivity of Mobile Sensor Networks (2015). In this paper, in addition to Basic algorithm and TV-Greedy algorithm, LWZ compression algorithm is applied while sending data from sensor node to sink node, hence the computation speed of transmission is maximized. Simulation result obtained validates the performance of the proposed algorithm. Hence the issues of TCOV and NCON in MSNs are successfully overcomes and increase the network lifetime.

D.Prasad, Enhancing Target Coverage and Network Connectivity of Mobile Sensor Networks (2016). In this paper the issue of Target Coverage (TCOV) and Network Connectivity (NCON) in Mobile Sensor Networks (MSNs) are taken into consideration. To solve TCOV problem, two algorithms are proposed: Basic algorithm and TV Greedy algorithm. TV Greedy algorithm achieves less movement than basic algorithm because it selects the sensor which is very close to target to achieve that target. Hence, the proposed scheme overcomes the issue of TCOV NCON in MSNs increase the network lifetime.

Wei, Kaibin, Energy saving based target coverage algorithm in wireless sensor network(2016).To extend the lifetime of wireless sensor networks and improve the efficiency of node energy,this paper puts forward redundant nodes sleep scheduling mechanism-based node energy saving optimization coverage algorithm in wireless sensor network.This paper also contains simulation results which show that the algorithm improves energy utilization efficiency, maintains the networked coverage rate, effectively extends network life cycle and achieves the object of energy saving optimization.

Liao Z., Wang J., Zhang S., Cao J., Min G.,"Minimizing movement for target coverage and network connectivity in mobile sensor networks"(2015). In this paper the main problem of Mobile Sensor Deployment is divided into two sub problems, Target Coverage(TCOV) and Network Connectivity(NCON). To solve TCOV problem, The Basic Algorithm and TV-Greedy Algorithm are used. And, to solve NCON problem, ECST and ECST-H algorithm are used.

Nguyen N.T., Liu B.H. The Mobile Sensor Deployment Problem andthe Target Coverage Problem in Mobile Wireless Sensor Networks are NP-Hard(2018).This paper highlights that the problem of scheduling mobile sensors to cover all targets and maintain network connectivity such that the total movement distance is minimized, termed the mobile sensor deployment (MSD) problem, has received a great deal of attention. However, the complexity of the MSD problem remains unknown because no exact proof has been provided before. In this paper, we show that not only the MSD problem, but also its special case, termed the target coverage problem, are NP-hard.

Rout Mrutyunjay, and Rajarshi Roy Self-deployment of mobile sensors to achievetarget coverage in the presence of obstacles"(2016).In this paper,a localized self-deployment scheme, named as Obstacle Avoidance Target Involved Deployment Algorithm (OAT-IDA), is proposed for deployment of randomly scattered mobile sensor nodes to cover predefined targets while maintaining connectivity with the base station in the presence of obstacles.The concept of potential field theory and relative neighbourhood graph for self-deployment of mobile sensor nodes in an unknown environment to achieve target coverage while preserving connectivity with the base station.

Choudhuri, Ritamshirsa, and Rajib K. Das. Efficient relocation of mobile sensors fortarget coverage"(2017) .The coverage of interest points (targets) by mobile sensors in Wireless Sensor Networks is a very important and challenging problem. As the sensors are deployed randomly, initial placements of sensors may not guarantee coverage of all targets. In this paper,the problem of covering all the targets in the surveillance region by relocating a subset of the sensors with the objective of minimizing the sum of the distance moved by the sensors is taken under consideration. An algorithm for the problem which runs in two phases is used. In the first phase a subset of sensors are relocated to new positions to ensure coverage of all the targets(Assigned Sensors). In the second phase some of the unassigned sensors are relocated to ensure connectivity i.e. a path should exist from each assigned sensor to the base station (BS).

Chapter 3

PROPOSED METHOD

In the present work, main aim is to focuses on the challenges of the Mobile Sensor Deployment (MSD) problem and investigates how to deploy mobile sensors with minimum or no movement at all to form a Wireless Sensor Network that provides both target coverage and network connectivity.

As sensor movement consumes much more energy than sensing and communication do, the movement of sensors should be minimized to increase the networks lifetime.

3.1 Methodology

In present work, firstly sensor nodes should be deployed in such a way that they cover the complete area. We prefer to have static nodes. Then divide the complete area into the zones. Each zone will have a zone header. Zone headers should be at a convenient distance from each sub nodes. Then we will select a source and a destination. Information will transfer from sub nodes to headers and then from headers to headers, finally to the destination. A lot of energy will be saved, thus increasing networks lifetime.

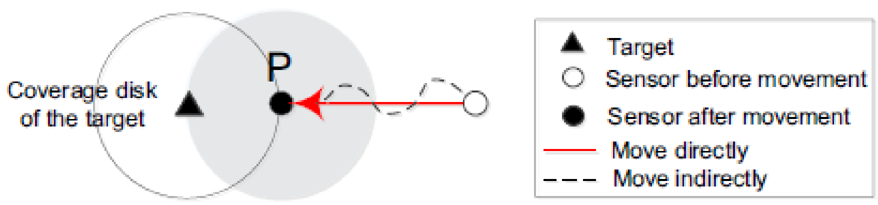


Figure 3.1: Movement of Sensor

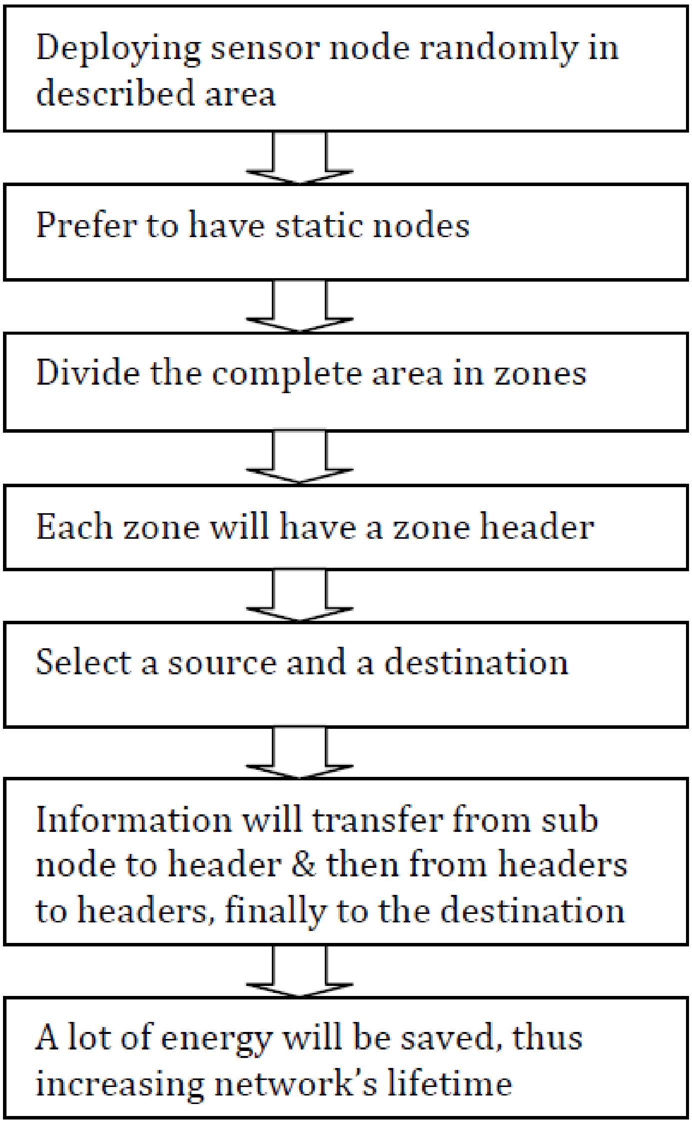


Figure 3.2: Flow chart of methodology

3.2 Basic Algorithm

Input: T = t1, t2, ..., tm;// Positions of targets = s1, s2, ..., sn;// Initial positions of sensors
rs: // The coverage radius
Boundary = f1, ...fa;// The boundaries of the task area
Output: tmc;// The total moving cost
tmc 0; Tinitcov ; Sinitcov ;
for each ti $(1 \leq i \leq m) do$
$Stmp$;
$foreach sj(1 \leq j \leq n) do$
{
$if dist(ti, sj) \leq rsthen$
$Tinticov = Tinticov \cup ti; Stmp = Stmp \cup si;$
$Sinticov = Sinticov \cup sj|dist(ti, sj) \leq dist(ti, si)si \in Stmp$
}
$Tneedcov = T\ Tinitcov; Srest = S\ Sinticov;$
$Movecost = GEOCP(Tneedcov, Srest, rs, Boundary);$
$(Pdest, Smove, tmc) = extended - Hungarian(Tneedcov, Srest,$
$Movecost);$
$returntmc;$

3.3 Tv-Greedy Algorithm

Input: T = t1, t2, ..., tm;//The position of all targets
S = s1, s2, ..., sn;//The position of sensors
rs;//The coverage radius Output: tmc;//The total moving cost
1) Generate the Voronoi diagram (VD) of targets;
2) Determine neighbours for each target according to their Voronoi polygon;
3) Determine the OSG for each target according to S and VD;
4) for each OSGi do
5) Determine the chief server ;
6) Identify the aid server for tis neighbour;
7) for each ti do
8) if ti has already been covered then
9) Return cost(ti)=0;
10) else
11) Produce CSGi of ti;
12) if CSGi = then
13) Move the nearest server to cover ti;

Chapter 4

ANALYSIS

The proposed technique is implemented using Matlab which allows matrix manipulations, plotting of functions and data, implementation of algorithms, creation of user interfaces, and interfacing with programs written in other languages, including C++.

Following is the complete program flow: First step is to create a deployment area with entering the value of length and breadth. Length and breadth are entered according to the desired requirements. Length and breadth of the deployment area is 10. Length and breadth are on x-axis and y-axis respectively.

After deploying desired area, second step is to divide this deployed area into equal zones. Number of zones should be selected as per requirement to divide the deployment area into zones. As shown in figure 4, the deployment area is divided into 5 zones. These 5 zones are equally spaced.

Third step is to deploy the sensor nodes in each of the zone. Each zone will have a zone header. The rest of the nodes are sub-nodes. The number of sensor nodes to be deployed in one zone is selected by desired required. Sensors are deployed in uniform manner. Each sensor node has a sensor id number. The position or sensor id number of each sensor node is saved in Excel file.

After deployment of nodes, fourth step is to select a sender and receiver from different zones. Sender will first communicate with its respective zone header.

The sender zones header will then search for receivers zone header. Once found, receivers zone header will transmit to the receiver node. Sender and receiver can be from any zones available.

Then we can calculate the energy distribution across all the sensor nodes deployed.Here, we can that the energy is consumed only of those sensor nodes only which are involved in the communication or transfer path between source node and destination node. The rest of the sensor nodes which are not involved in communication or transfer path have their full energy.No energy wastage of other sensor nodes is there. Hence, this will lead to increasing the lifetime of whole network as no energy wastage is there.

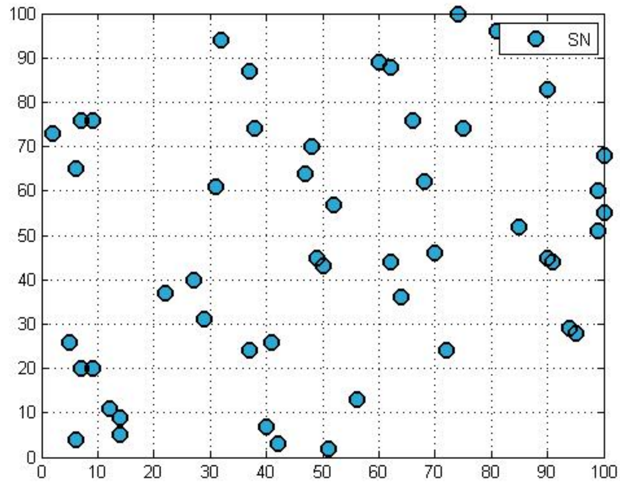
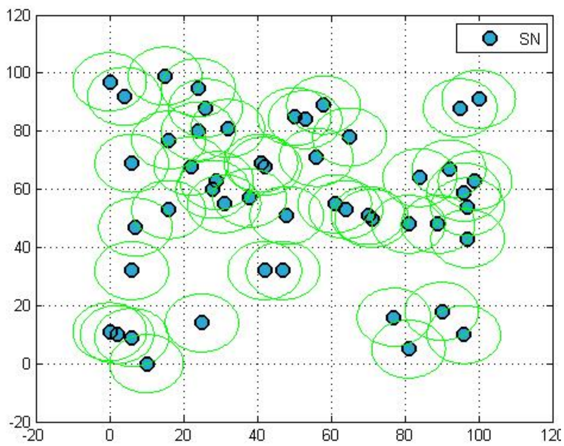
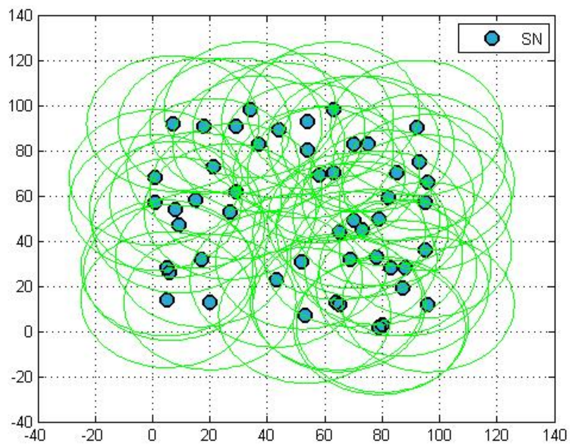


Figure 4.1: Random sensor node deployment.



(a)



(b)

Figure 4.2: Sensor node coverage.

Chapter 5

Conclusion and Future Work

In this project, we have studied the Mobile Sensor Deployment (MSD) problem in Mobile Sensor Networks (MSNs), aiming at deploying mobile sensors to provide target coverage and network connectivity with requirements of moving sensors.

As sensors are usually powered by energy limited batteries and thus severely power-constrained, energy consumption should be the top consideration in mobile sensor networks.Specially, movement of sensors should be minimized to prolong the network lifetime because sensor movement consumes much more energy than sensing and communication do. However, most of the existing studies aimed at improving the quality of target coverage, e.g., detecting targets. Little attention has been paid to minimizing sensor movement. To fill in this gap, next stage of this project focuses on moving sensors to cover discrete targets and form a connected network with minimum movement and energy consumption.

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