MOVING TARGET DETECTION IN WIRELESS SENSOR NETWORKS

Enrollment no	-	122202
Name of Student	-	Pawan Kumar Gangwar
Name of Supervisor	-	Dr. Yashwant Singh

May-2014

Submitted in Partial fulfillment of the Degree of

Master of Technology

DEPARTMENT OF COMPUTER SCIENCE & ENGINEERING,

JAYPEE UNIVERSITY OF INFORMATION TECHNOLOGY,

WAKNAGHAT, DIST. SOLAN, (H.P.), INDIA

CERTIFICATE

This is to certify that the work titled **"Moving Target Detection in Wireless Sensor Networks"** submitted by **"Pawan Kumar Gangwar"** in partial fulfillment for the award of degree M.Tech. in Computer Science and Engineering of Jaypee University of Information Technology, Waknaghat has been carried out under my supervision. This work has not been submitted partially or wholly to any other university or institute for the award of this or any other degree or diploma.

Signature of Supervisor: ....23/05/2014........

Name of Supervisor: **Dr. Yashwant Singh**

Designation: **Assistant Professor (Senior Grade)**

Date: 23.05.2014

Acknowledgement

This may seem long but the task of my thesis work both theoretically and practically may not have been completed without the help guidance and mental support of the following persons.

Firstly, I would like to thanks my guide Assistant Professor (Senior Grade), Department of CSE Jaypee University of Information technology Waknaghat, **Dr. Yashwant Singh** sir who provided me the idea and related material for the project proposal. He indeed guided me to do the task for my thesis in such a way that it seems to be research work. His continuous monitoring to support me and my research work encouraged me a lot for doing my thesis in very smooth manner.

Secondly, I would like to thanks **my Parents** who have always been with me for inspiring me and thirdly, I would like to thanks **God** for keeping me energetic, healthy and enthusiastic

Once again thanks a ton to all mentioned people in my life

Signature of the student ......Pawan......................

Name of Student: Pawan Kumar Gangwar

Date ..23/05/14........

Table of Content

CERTIFICATE

This is to certify that the work titled **“Moving Target Detection in Wireless Sensor Networks”** submitted by **“Pawan Kumar Gangwar”** in partial fulfillment for the award of degree M.Tech. in Computer Science and Engineering of Jaypee University of Information Technology, Waknaghat has been carried out under my supervision. This work has not been submitted partially or wholly to any other university or institute for the award of this or any other degree or diploma.

Signature of Supervisor: ……………………..

Name of Supervisor: **Dr. Yashwant Singh**

Designation: **Assistant Professor (Senior Grade)**

Date: ………………

Acknowledgement

This may seem long but the task of my thesis work both theoretically and practically may not have been completed without the help guidance and mental support of the following persons.

Firstly, I would like to thanks my guide Assistant Professor (Senior Grade), Department of CSE Jaypee University of Information technology Waknaghat, **Dr. Yashwant Singh** sir who provided me the idea and related material for the project proposal. He indeed guided me to do the task for my thesis in such a way that it seems to be research work. His continuous monitoring to support me and my research work encouraged me a lot for doing my thesis in very smooth manner.

Secondly, I would like to thanks **my Parents** who have always been with me for inspiring me and thirdly, I would like to thanks **God** for keeping me energetic, healthy and enthusiastic

Once again thanks a ton to all mentioned people in my life

Signature of the student ……………………..

Name of Student: Pawan Kumar Gangwar

Date ……………………..

Abstract

Target tracking is one of the challenging issues in WSN. In Wireless Sensor Networks when a target is noticed in the network, that target is detected through the sensor device deployed over a region. This target detection information is passed to the base station and the appropriate decision is taken. The goal of using the sensor network over a region is to provide location of the detected object and to provide the real time report. We have proposed the solution of tracking a target with homogeneous and heterogeneous sensor networks. Proposed approach based on homogeneous sensor network relies on clustering mechanism. Clustering refers to a group of active nodes that together form a network and one of the node is elected as cluster head. Proposed approach produce a method of clustering which is based on residual energy. In this approach only those nodes are active which are able to sense the target in their sensing range and rest will remain in sleep mode for saving energy. However in heterogeneous sensor networks we proposed the solution of tracking using Wireless Multimedia Sensor Networks (WMSN) as it can provide more information about the moving target than classical Wireless Sensor Networks. In this thesis, we propose a low-cost new solution for tracking a mobile target that runs in heterogeneous Wireless Sensor Networks composed of both scalar and multimedia sensors. The scalar sensors are equipped with a motion detector; their role is to detect the target and then activate the camera sensors (CS) through message exchanges in Heterogeneous Sensor networks. We have taken all parameters with the promising optimal use of energy.

List of Figures

List of Tables

Chapter 1 Introduction

1.1 Introduction

The subject of this thesis is to design the architecture for the detection and processing of target found in the vicinity of Wireless Sensor Networks. Our main focus is in trade-off between detection accuracy and energy savings. The source of power in the sensors deployed in network is battery and is intended for long-term operation. The key issue in system design is energy saving. On the other hand, system is useless if it cannot accurately track the target i.e. accuracy must be high. At the application level such target tracking system is required that can save as much energy as needed with satisfy given accuracy requirements.

In target tracking system, sensor networks are used to detect, track and classify the targets. Accordingly, specific target detection and tracking system is proposed in this thesis. We proposed a fast and efficient target tracking algorithm, a procedure for localize the target and signal strength estimation method.

The Sensor can be defined as a device in which, if we give the input that can be a physical phenomenon like temp, pressure etc. than it will provide the quantitative measurement of that quantity in the form of the output of that device. The WSNs [1] is a collection of small sensors capable of collecting, processing, storing and transferring the information from one node to another. These nodes have the ability to work autonomously and in a network both so it has many applications like environmental monitoring, medical and battlefield [2] etc. In the field of environmental monitoring the global environment problem management is a key area for providing accurate responses wherever and whenever an environmental problem like forest fire occurs to save lives in especially in hilly regions where the fire brigade take much time to reach. So a mechanism is required that can efficiently detect such events which enhances the importance of WSNs in this area.

WSNs consist of autonomous sensors that are spatially distributed over a region to monitor physical or environmental conditions such as temperature, sound, pressure, vibration, smoke or pollutants and send the data to base station. WSNs can be a collection of nodes from a few to several hundreds. Each of these nodes is a collection of several parts that are a) microcontroller b) a radio transceiver c) an electronic circuit for interfacing with sensor and d) battery (energy source) [3]. Sensors are deployed over a vast region in bulk where it is difficult to handle the event manually for a long time. Since the target is movable, energy conservation and tracking of moving object becomes an important metric in the design phase of such systems. Several factors are considered when developing algorithms for tracking moving objects include single vs. multiple targets, stationary vs. mobile nodes, target motion characteristics, energy efficiency and network architecture [3].

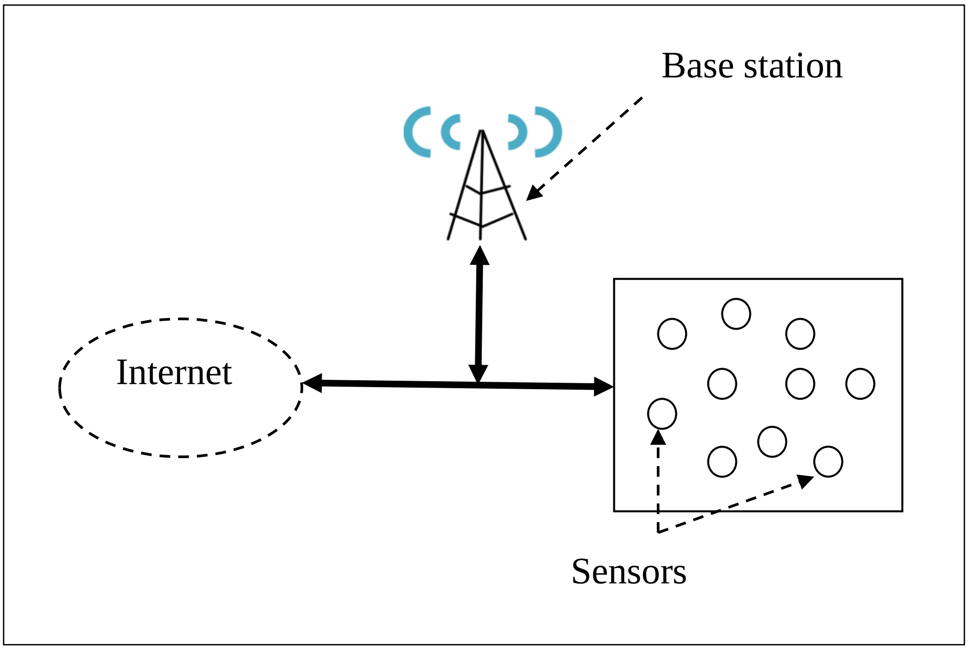

Fig 1.1 Wireless Sensor networks

In a target tracking application, the sensor nodes, which can sense the target at a particular time, are kept in active mode, while the remaining nodes are to be retained in inactive mode so as to conserve energy until the target approaches them. To continuously monitor mobile target, a group of sensors must be turned in active mode when the target reaches for them. The group of active sensor nodes is depending on the velocity and the direction of moving object located by the cluster head. The sensor nodes detect the moving object and transmit the information to the sink or the base station. The figure given below consisting of a large number of autonomous self-organizing nodes reporting to the base station

Recently target detection application of WSNs has attracted much attention. Target detection by WSNs can be applied in various areas. Target detection phenomenon in an application requires spatially distributed sensor node in that field to send information about the target to the sink periodically as the target is detected. The efficiency and the correctness of the target detection approach will rely on the hardware and software capabilities of a small, placed in a robust environment with very less power sensor node

1.2 Genesis of the Problem

The father of ubiquitous computing and late chief scientist of Xerox PARC, Mark Weiser paraphrasing, "Applications are of course the whole point of sensor networking." Wireless sensor networks hold great promise as an enabling technology in a variety of applications. Habitat monitoring is one of the applications which represents the entire data class applications and received great attention in the literature. The data collection problem is closely related to signal reconstruction problem in which the objective is to reconstruct the distributed data centrally with high temporal fidelity. The performance of such signals is measured on the basis of the accuracy and precision of signal reconstruction.

In contrast with data aggregation several sensor network applications like military surveillance continuously observed high frequency signals in the presence of noise. These types of applications required a sensing and signal processing architecture that is different from the data collection problems. For these types of applications a pervasive system is required that must be self-healing, self-diagnosing and maintain operational state to mask component failures from users. On the basis of intended deployment and pervasiveness such systems are required to function autonomously. To this extent in this thesis we explore the integration of autonomic computing principles in pervasive systems and propose an adaptive, self-healing framework.

1.3 Problem Statement and Motivation

Various event detection systems have been used in the past in various projects, but there is no such system exists that perform accurate lightweight and consistent monitoring of a target. The existing systems are application specific and inflexible. They can hardly adapt to different tasks other than the original one for which it is to be designed. However, these systems can perform the target monitoring for a very short interval of time, i.e. these systems are facing the problem of long term deployment. The problem of long term deployment may lead to several other constraints like lack of accuracy and classification problems. The system may crash before completing the monitoring task. However, application specific systems are unable to detect the abnormal behaviour of target as these systems can work only in specific conditions. In our thesis we aim at designing a lightweight and multifunctional target tracking system.

We can divide the current systems into the following categories

Non-Permanent Systems

The subordination of long-term deployment is the important characteristic of such a system, because the requirement of accurate information is temporary. Sniper detection system is the major application of such a system. Such type of systems is temporarily installed. In order to achieve very accurate localization the requirement of energy savings and minimization of communication cost are relinquished. In such type of systems, network is established according to detailed installation plans and redundancy of the sensor node is low. Such systems are not applicable to general applications that aim at long-term operation.

Accurate Systems*:*

The main goals of many accurate systems are localization and classification accuracy optimization area. Research mainly focuses on collaborative signal processing (CSP). For implementation of such systems, high communication and computation load is required. In these systems are hardly consider event tracking, network topology control, and communication optimization type network issues.

Efficient Systems*:*

On the other hand, several target detection and tracking algorithms are proposed that barely address localization and classification tasks. Such systems have better accuracy and efficiency. These systems are able to track and detect the target fast and efficiently. For an observed target, they do not provide sufficient sensor data to make reasonable statements, though. Such systems show greater efficiency if the observed target is well known. However, for making conclusion about the target it there is a requirement to improve the system by enhancing the other features.

So the current state of the art work if specific to some limited applications and provides short-term deployment. In this thesis we aim at an energy-efficient target tracking system with following two major functionalities

***Detection Accuracy**:*

The system must be able to satisfy all target tracking requirements. For example, if we track the building, then all intrusion must be signaled and false alarms are avoided.

Long-term Deployment:

The system must be specifically for persistent monitoring. Hence, the algorithms should be light weight. The system must minimize the consumption of energy wherever possible.

1.4 Objective

The objective of this thesis is to present an energy efficiency target tracking system for wireless sensor network. We present an architecture that is based on clustering approach and signal strength estimation. Moreover, we attempt to minimize manual administration of the network and delegate much of the maintenance task from the human operators to the system itself.

Initially we present the overall architecture of the system. In addition, we look into more detail on individual part like how clustering is performed and cluster head is elected. We proposed the algorithms of target tracking on the basis of individual role of each entity like cluster head and cluster members.

1.5 Report Organization

This report is organized into five chapters. The first chapter presents the introduction, the genesis of the problem, problem statement and motivation followed by different objectives.

In Chapter 2, Introduction of Wireless Sensor network is given. Various fields are identified in which WSN is currently used.

In chapter 3, A Solution for target tracking using homogeneous Sensor Network is given. Literature review presents several existing algorithms for target detection in WSN

In the chapter 4 Use of Heterogeneous Sensor Network is proposed for target Tracking. Heterogeneous Sensor Network consists of a combination of WSN and WMSN (Wireless Multimedia Sensor Network).

Chapter 5 consist of Conclusion and Discussion.

Chapter 2 Overview of Wireless Sensor Network

2.1 Introduction

The development of wireless sensor networks comes into existence as a result of advances in wireless communication technology and development of low cost multifunctional sensor nodes. These tiny nodes are equipped with a battery (energy source), processing unit, a radio module to exchange the data and some memory. The critical factor in these nodes is to save energy, to increase the lifetime of the network. In addition sensor nodes are provided with actuators for interacting with the physical environment. A sensor node has mainly four modules [4].

a) Sensing Module

This low power module is a major component of the sensor. It is responsible for gathering the information from the outside world and sharing it on the network.

b) Communication Module

This module consists of transceivers (short range radios) for communication with the other nodes in the network as well as the outside world. The transceivers work in different modes like to transmit, receive and sleep. Each mode has different power levels. Power consumption in transmit and receive is higher than the power consumption in sleep mode. If the node does not perform any function, it will come into the sleep mode.

c) Computation Module

Sensor nodes use the microprocessor for computation purpose which is the combination of microcontroller and MCU. Since computation needs high amount of energy so for saving the energy in computation module various power levels are defined for the MCU on which it operates.

d) Power Module

Sensor nodes are battery operated so it has limited amount of energy. Due to the deficiency of power supply there is a requirement of monitoring the energy level continuously. The life time of node can be increased by turning it on or off depending on the application. This tuning function is automated.

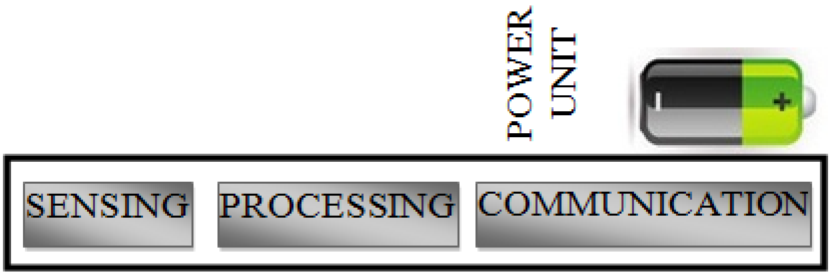

Fig 2.1 Component of a Sensor [4]

Power requirement in wireless sensor networks is high in compare to traditional wireless and wired networks so the network must have following features

Application Oriented

Sensor networks are designed to fulfil the multiple objectives. The single sensor node has the property of gathering and processing the information, but it is not a good choice due to various reasons like energy inefficiency and not able to scale large networks. So localization algorithms are generally used in sensor networks which require the communication among the neighbouring nodes and computation is done locally. The advantage of communication among neighbouring nodes is that communication overhead scale well in large size networks and network is robust

Data- centric

The advantage of using the sensor network is that it does not need any identity or address of node unlike the other wireless network. The major focus is on information gathered by the sensor nodes. However, in some cases like identification of faulty nodes there is a requirement of identifying the node. In these cases, coordinates information of the node is sufficient for identification purpose.

Wireless sensor networks provide a great improvement over a traditional network system. It provides the solutions of various problems in the following context [4].

- Sensors are deployed away from the actual physical process and provide complex techniques to monitor the physical phenomenon.
- Several sensors observed the physical phenomenon and send the sensing result to a centralized fusion centre where the information is processed and appropriate measures are taken in response to the input data.

In contrast wireless sensor networks are composed of randomly deployed sensor nodes that are located close to the physical phenomenon. These nodes are required to operate quickly for fulfil an application. These sensor nodes also have the processing capabilities, i.e. raw data can be processed by the sensor nodes, thus processing at centralized unit can be avoided in case of simple applications.

Sensor network consist of different types of sensor nodes such as thermal, visual, infrared, seismic, acoustic, etc. The use of these sensors is to monitor the different type of ambient conditions like Velocity, Humidity, Temperature, Pressure, Noise level, etc. [5]. A typical example of wireless sensor network is described in the figure2.2. In this the network architecture of the sensor nodes is presented. This network is connected to the base station over the internet

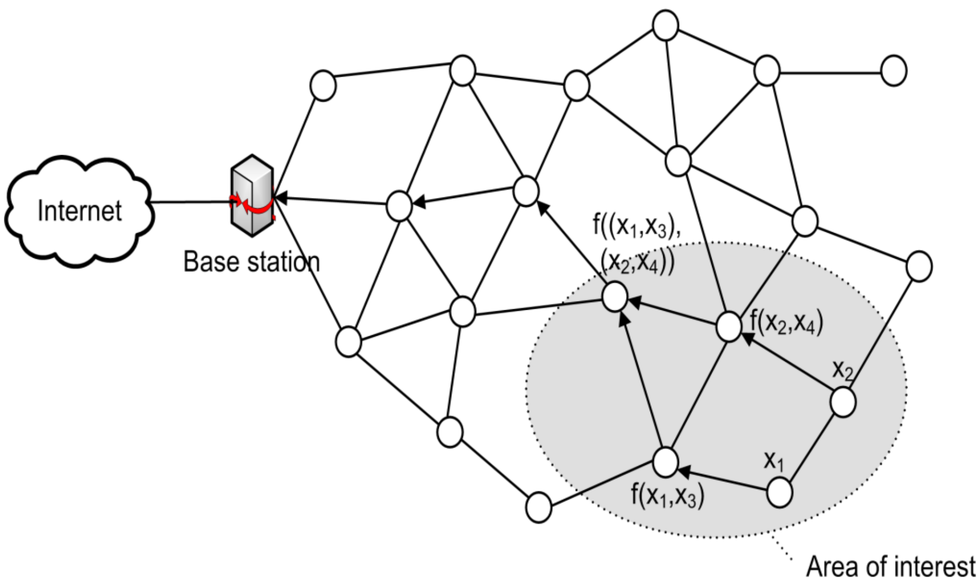

Fig 2.2 Network Architecture of WSN [5]

2.2 Issues affecting Sensor Networks Design

In the following factors are discussed that affects the design and implementation of sensors. Typical factors are hardware issues, network issues and the environment

2.2.1 Hardware Issues

The major component of a sensor node is sensing module, processing module, transceiver, storage module and a power source. In addition a mobilizer service is also implemented. While processing these sensors convert the analog signals into digital output. All these processing must be fitted into small sized node so the size of the node is an important issue. Besides, it some other constraint are also considered [6]

- Minimization of power consumption
- Volumetric densities of the node must be high
- Nodes must be low cost and dispensable
- Operations must occur autonomously
- With respect to environmental nodes must be adaptive

The life time of sensor node is depending on the power supply unit of sensors. According to the estimation of ESB node developer the lifetime of sensor node will be 17 years if 25 bytes will transfer after every 20 Sec [7]. Type of Transceiver unit also affects the sensor networks design. Different node has their different transmission range and reliability and that value vary according to time. Therefore, it is necessary to check the accuracy of transceivers by comparing the reading with those of a standard. The last hardware issue is related to storage capacity as the sensor nodes have limited storage capacity. Additional memory can be implemented, but it consumed more energy so the WSNs protocols are designed to use the limited memory.

2.2.2 Operational issues

The major requirement of a sensor network is the low power operation. Sensor nodes generally contain the limited power source. These nodes are generally placed in the harsh environment where human intervention is generally not possible so replacement of batteries is not practically possible. Due to limited power option the trade-off between quality of service and the energy conservation is always a major concern in Wireless Sensor Networks. However dysfunction of some nodes due to power drainage requires rerouting which leads to more energy consumption of other nodes and decreases the lifetime of WSNs. So for managing the quality of service, energy preserving strategies are required. Quality of service depends on the application scenario, for example, in localization example the trade-off is between the energy saving and the accuracy while in routing the major quality of service is network lifetime. Any application implemented in wireless sensor networks must consider the energy constraint of the node.

Sensor nodes are generally equipped with the three 1.5 V batteries so the total power supply is 4.5 V [4]. If the power depletes at high rate then network connectivity is no longer exists which reduces the lifetime of the network and desired task is no longer performed. Any algorithm design on wireless sensor networks must be power aware due to these circumstances. The power consumption of the sensor nodes can be considered as the power consumption of the individual modules i.e. sensing communication and processing. Energy consumption in sensing is dependent on application. The major energy consumption part is communication. However, energy consumption can be reduced in processing by aggregating the collected data in the network.

The cost of sensor node is relatively low, but deployed in the large number of quantities. In order to make the deployment feasible the cost of sensor should not exceed the cost of deploying the nodes.

2.2.3 Network Issues

In network issues we typically deal with network topologies, scalability and fault tolerance. Sensor networks consist of a large number of deployed nodes so a topology is needed to manage the large numbers of tiny nodes. The deployment can be random or can be placed in a controlled way by placing manually by humans or robots and expense in planning and installation is considered while deployment. However the way of deploying the nodes in the target area is application dependent. Sensor nodes are statically deployed, though there are various reasons by which change in the topology must be incorporated like power depletion of node, attacks on the network or the node failures. However the power level in each node decreases at a different rate which requires the rearrangements in the network topology. Depending on the kind of phenomenon number of nodes can be increased in the network so network must be scalable. The network density in a particular area A is calculated by [8]

$$D = \pi r^2 n / A \tag{2.1}$$

Where n=number of nodes deployed in that region and r= transmission range

The other important phenomenon in network issue is fault tolerance. Various physical or environmental factors must not affect the working of nodes. However, failure of single node should not affect the performance of the network

2.2.4 Environmental issues

Sensors are deployed in different geographical areas so harsh conditions may face like wild animals and other moving objects, harsh environments such as glaciers, hurricanes or oceans, interiors of machinery, biological or chemical contaminated fields. All these things pose challenges in designing the sensor network.

2.3 Application of WSNs

WSNs are an important technology for development of various automated and smart environment system which includes transportation system, smart building, etc. It enables the communication between the real world and smart environment. Beside it WSNs provides greater advantages in different areas like battlefield surveillance, medical and environmental monitoring. Type of sensors used depends on the application like one type of sensor measures various physical parameters like temperature, pressure, humidity etc. so they are used in generally environment monitoring application. The second type of sensor can measure the motion properties like acceleration, velocity, coordinates etc. [5]. So they are used in determining the position of an entity (target tracking application). In this part we will describe the few specific applications of wireless sensor network.

2.3.1 Environmental Applications

Now a day wireless sensor networks is commonly used in various environmental applications such as wildlife monitoring that include tracking the animals or birds, biological monitoring of soil content, forest fire detection, flood and earthquake monitoring [9] and so on.

Today Wildlife protection is one of the major challenging issues. Many Animals are going to extinct. The main reason behind this that their natural habitat is destructed. Forest fire is one of reason of destroying the wildlife. According to a survey [10], total 67,774 forest fires destroyed 9,326,238 acres in the USA during 2012. However, satellite monitored can be performed for detection of forest fire, but due to lengthy scan period and low resolution this technique is not effective. Due to these reasons WSNs are proposed for monitored the forest fire. In this application sensor are deployed in the area which is to be monitored and programmed to detect temperature, humidity, smoke, etc. Sensors collectively send the data to the base station where it is processed. In addition, if sensors detect any abnormal activity like rise in temperature at once or smoke than it send an alert message to the base station about the possibility of fire.

The other environmental application in which WSNs is widely used is flood control. The author of [11] given a method named ALERT for flood control using WSN. In this system various special sensor like rainfall, water level and weather sensors are used. The sensor is continuously sending the data like average rainfall at a particular time or location where the rainfall exceeded the normal. At the centralized base station all data is processed and by querying the centralized database at base station experts can analyze the situation and recommended the appropriate action.

2.3.2 Health Applications

WSNs have greater use of heat application like telemonitoring, patient monitoring telemedicine, etc. [12]. Telemedicine is a revolutionary application in healthcare. Its primary objective is to easy access the healthcare facility and reduces the government's cost in health care. The quality of health care is improved by the telemedicine because of collecting and transmitting the patient data to the medical centers. Another application is in tracking and monitoring the patient status remotely. Small sensors are equipped around the patient and they monitor the patient regularly and report and unusual behavior at the medical center. This gathered data help the doctors to identify the patient health related problems while patient gives freedom.

2.3.2 Military Applications

WSNs are an important part of military surveillance system. Its performance is better than the traditional military surveillance system in a way that in WSNs several sensors work collectively so failure of a single node does not affect the surveillance system as much as a traditional system [11]. It is generally used in location detection of ammunition, Battle field surveillance, hostile target detection, nuclear radiation detection, etc. A WSNs technology for ground surveillance is proposed in [13]. In this author used the hybrid sensor networks for real time tracking of monitoring the area and transfer the gathered data to a monitoring station. Since real time tracking is challenging task in WSNs which require cooperation among the sensor nodes, robust environment and complex signal processing. In this research author has proposed the layered approach to fulfill this function. On the first layer small sensors performed the acoustic sensing and these nodes send the data to more powerful node in the system. At the second layer these nodes send the data to the command center where it is analyzed and appropriate action is taken.

Chapter 3 Homogeneous Sensor Network for Target Detection

3.1 Introduction

Target tracking is an important sensing application and major research issue in WSNs. Based on the raw data collection by the sensor nodes a sensor network has to identify which application-specific incident has occurred. A target can be anything from a small animal to battlefield equipment. The goal is to detect the target efficiently with minimum energy consumption. In this thesis, we have considered a set of randomly deployed homogeneous sensor nodes in an area for efficiently measuring the target entered into that area.

3.2 Literature Review

In this section we give an overview of the literature that is important for the thesis to be carried out. Literature survey present overview of clustering schemes and cluster head selection, various techniques and methodologies used by the different authors for tracking the target.

3.2.1 WSNs Topologies

WSNs topologies are divided into the four categories [14] single hop flat model, single hop clustering model, multi hop flat model and multi hop clustering model.

In single hop flat model all sensor nodes send their data directly to the base station. This type of model is infeasible in the large scale area because communication cost is much higher and in clusters model nodes are divided into clusters and each cluster heads directly send their data to the base station.

In multi hop model all nodes share the similar data such as routing table and network overhead, which increase energy consumption while in a multi hop clustering model data is aggregated by the cluster heads so energy consumption can be minimized. In multi hop flat model instead of directly interacting with the base station some hops nodes are created and all other nodes send their data to these hops, and these

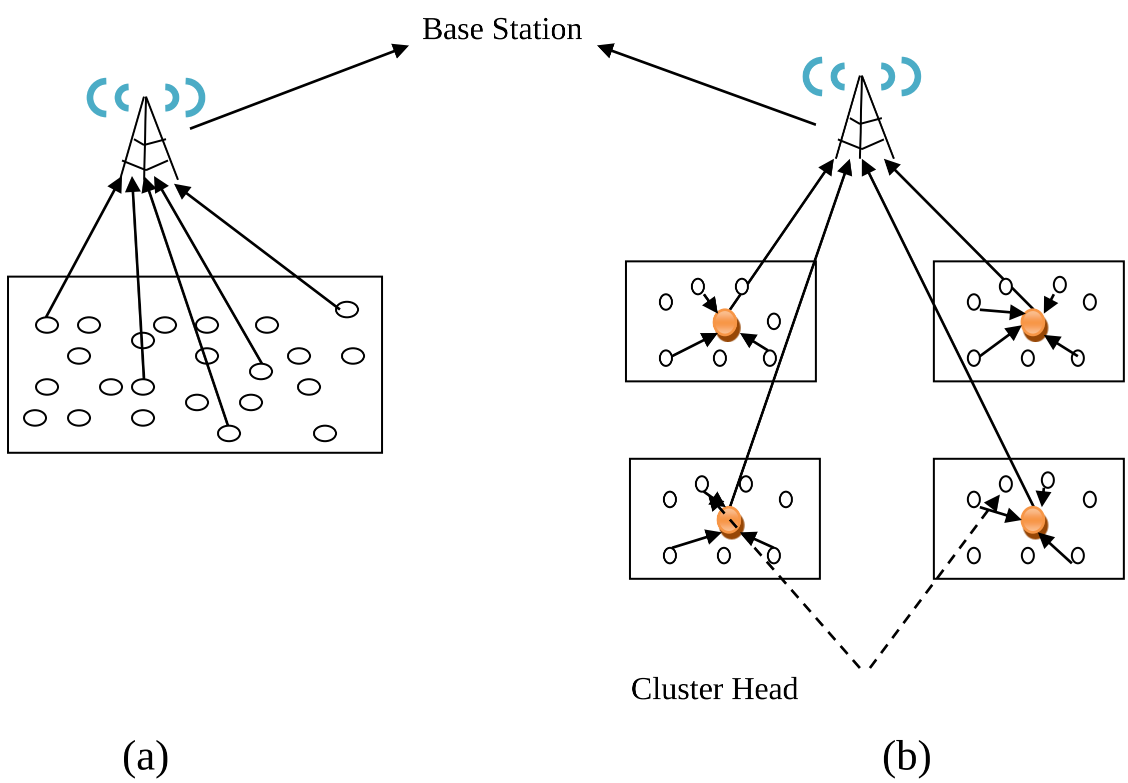

Fig 3 .1 Single Hop Flat Model (a) and single Hop Clustering Model (b)

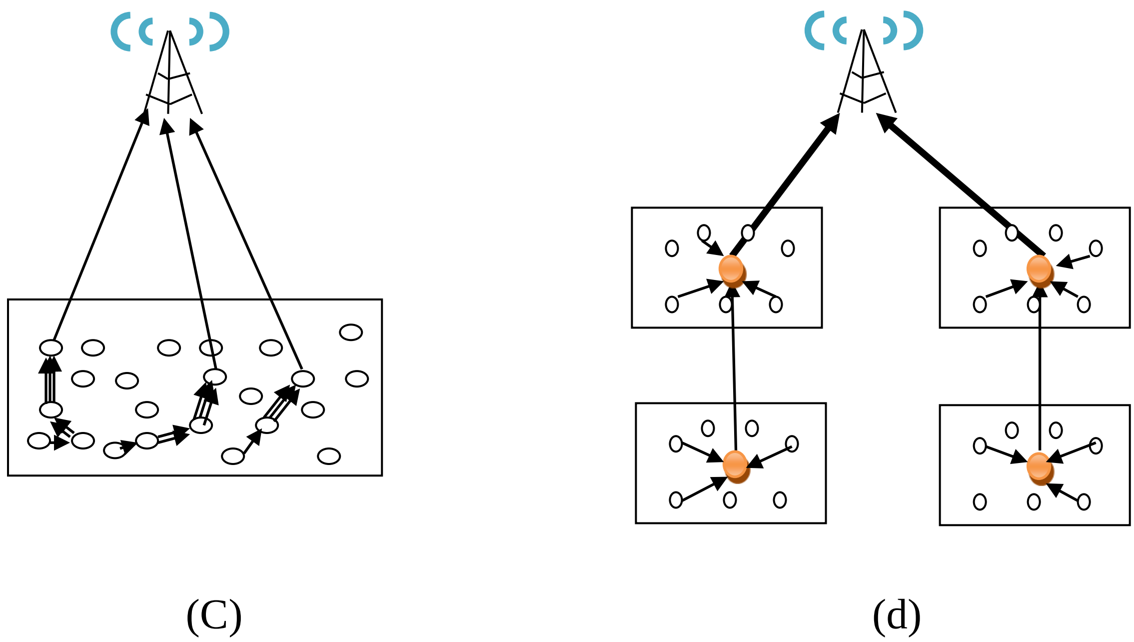

Fig 3.2 Multi Hop Flat(c) and Multi Hop Clustering (d) Model

Hops send the data to the base station. In the similar fashion in clusters model each cluster head is not directly interacted with the base station. Each cluster heads collects the data from the nodes in its cluster and the data to the hop clusters. These clusters hops send the aggregated data of the other clusters, as well as data aggregated by their own member nodes to the base station

3.2.2 Clustering

The life time of sensor nodes in wireless sensor network is the most critical parameter. The method of dividing the sensor nodes into clusters is widely adopted by the researchers for achieving the scalability, high energy efficiency and longer network lifetime in large scale wireless sensor network. In the clustered network structure, each cluster has a leader node which performs some special task and other nodes in the cluster are served as a member.

The clustering process can be considered as a hierarchical process having two levels. The highest level consists of cluster heads and on the lower level cluster member node lies. It is responsibility of cluster members to continuously monitor the data and send it to the corresponding cluster head. Cluster head sends this data to base station either directly or through multiple intermediate hops depending on the distance of the base station to the cluster head. Since cluster heads are continuously involved in sending the data to long distances (communication) so their energy drains at a higher rate in comparison to other nodes in the network which results in the dew of the node. One solution of this problem to periodically perform the re-election, i.e. the role of cluster head is rotating among the nodes of the cluster.

The base station performed data processing tasks on the data received from the cluster heads. The location of these stations is generally fixed and far from the monitored area. The base station is also directly interacted with the end users. So base station can be considered as the sink of cluster heads and cluster heads can be considered as the sink of the cluster members. The structure among the base station, cluster heads and cluster member can be redesigned multiple times and multiple layer hierarchy can be added.

Various schemes are proposed for performing the phenomenon of lifetime expansion like LEACH, [15] which is based on the concept of rotation of role of cluster head among the sensor nodes for distributing the energy consumption over all nodes in the network. In this type of approach selection of cluster head greatly affects the energy efficiency of the network. In this section various cluster head selection strategies are presented which are proposed by different authors and a conclusion is drawn.

In WSNs Sensor nodes generally contain the limited power capacity and recharging of these nodes is very complex, the node's capacity of computing, communicating, and storage is very limited, so there is a requirement of a protocol which can conserve the maximum energy and enhances the lifetime of the network. An energy-efficient communication protocol LEACH, has been introduced which is based on the concept of hierarchical clustering. In LEACH base station periodically changes both cluster head and the cluster membership to conserve energy.

The role of CH is to collect and aggregate information from sensor nodes, which are deployed over a region and passes on information to the base station. By rotating the cluster-head randomly, energy consumption is expected to be uniformly distributed. However, in LEACH more than one cluster head are chosen at a time. Some of them are far apart from the base station. As a result, some of them drain their energy early which reduces the lifetime of the network.

The election of cluster head node in LEACH has some deficiencies such as,

- At one time two cluster heads exist and one of them is having large size and other having small size.
- Different nodes have their different residual energy.
- Cluster head drains the energy earlier than its member nodes
- The cluster head node will rapidly fail due to various factors like residual energy, geographic location which are generally ignored in the algorithm

Motivated from this, various clustering proposals are presented in the literature that suggests different strategies of cluster head.

1) Major objectives and issues in clustering

As described previously, clustering in WSNs can improve the overall system scalability, energy efficiency and lifetime, Various methods are proposed in literature for reducing energy consumption within a cluster, performing data aggregation and fusion in order decrease the communication overhead by reducing transmitted messages to the base station, one of which is Hierarchical routing [16]. However a single-tier network can be responsible for overloading the gateway because it increases the sensor density, which causes inadequate tracking of events and communication latency. Another problem associated with the single-tier architecture is about scalability due to incapability of sensors for long-haul communication in the larger target area or larger number of sensors. Hierarchical clustering is generally useful when the target area is large and numbers of deployed sensors are hundreds or thousands. In this type of scenario efficient resource utilization and load balancing is necessary for achieving the Scalability. Applications in which efficient data aggregation is a mandatory requirement (e.g., detection of radiation around a large area) are also natural applicant for clustering. Another application area of clustering is an implementation of routing protocols. In [16], clustering was also used as a useful tool for efficiently finding the location of the object.

Besides scalability and minimizing energy consumption clustering has various other advantages and objectives [14].

- Localization of the route within the cluster, which results in reducing the size of the routing table stored at each node.
- Conservation of communication bandwidth by limiting the inter cluster interactions to Cluster heads and reducing the message exchange among sensor nodes.
- Reducing the topology maintenance overhead by stabilizing the network topology at the sensor level.
- Enhancement of the network lifetime and prolong the battery life of the ice sensor by implementing optimized management strategies.
- Scheduling of activities by the cluster head so that nodes can go into the sleep mode and energy consumption is minimized.
- Limiting the redundancy in coverage and prevention of medium access collision by engaged the sensor nodes in round-robin order.

Clustering process can be described by the three sub processes [14], cluster formation, WSN topologies and clustering strategies classification

2) Classification of Clustering Strategies

Clustering schemes are classified into three categories, Deterministic, adaptive and hybrid [17].

a) Deterministic Schemes

In these schemes special attributes of the nodes such as Node ID (node identification number), Node degree (number of neighbours) are used for cluster head formation. If we are taking into account the communication range, then those sensor nodes are elected as cluster head, which first satisfying the fixed node degree criterion. To decide the cluster head criteria, during each round, all sensor nodes broadcast a hello message to their neighbours and the nodes first receiving the messages greater than a predefined threshold have elected themselves as cluster head and inform other nodes by sending a confirmation message. The sensor nodes on receiving the confirmation message send a joining request to the nearest head and cluster head confirms the joining after receiving this joining message. In these schemes sensor nodes are not allowed to set up a broadcast again and again, which guarantees in exactly one cluster head in communication range.

In [18] a deterministic Scheme ACE-C is proposed. By this author proposed the scheme of cluster head selection which selects the cluster heads in each round on the basis of their node id for avoiding re-clustering. In this scheme initially all nodes are assigned to node id from 1 to N, where N is the number of nodes in the network. Now if there is a requirement of K cluster heads in each round, then in first round 0 to K-1 nodes are selected as cluster heads and in the next round K to the 2K-1 node are assigned the responsibility of cluster heads.

The disadvantage of the scheme was that cluster heads are not evenly distributed in the network. To overcome this drawback ACE-L [19] was proposed. It uses the reference points as the location information to decide the cluster heads in each round. The reference point’s count is fixed based on the number of cluster heads require in each round. The nearest point among all the points is treated as the main reference point (MRP). Now the sensor nodes having same MRP values try to become the cluster head and the nodes with minimum delay is elected as cluster head. After election cluster head sends the beacon message to the other nodes and node receiving the message leaves the contest and become cluster member. However, both the scheme requires reformation of clusters after each rotation of cluster heads.

Deterministic schemes described can be compared on the following parameters like re-clustering (REC), consideration in cluster head selection (CHS), balance clusters creation (BCC) and distribution of cluster heads (DCS)

Table 1 Comparative study of Deterministic Clustering Schemes

Deterministic Schemes	CHS	Parameters	REC	DCS	BCC
ACE-C	Sensor Nodes	NODE-ID	N	N	N
ACE_L	Sensor Nodes	MRP (Reference Points)	Y	Y	Y

b) Base Station Assisted Adaptive Schemes

Adaptive schemes used resource information like the residual energy of the node, the initial energy of the node, the energy dissipated in a particular round for cluster head election. On the basis of who initiated the election adaptive schemes are divided into two categories base station assisted and probabilistic (self-organized).

In these schemes clusters are formed by the base station on the basis of node deployment information. This information can be either priori available or it can be collected from the sensor nodes. Cluster head can be formed by the base station or by the sensor nodes. This information is transferred to the nodes by the base station.

LEACH-C [20] is an example of this type of schemes. In this all sensor nodes first send the information regarding their position and initial energy to the base station and also give some other important information for calculating the average node energy. This average energy value is treated as threshold and the nodes having energy below this value are not considered as becoming cluster head. Base station divides the nodes into clusters. However, it is not guaranteed that all clusters must contain an equal number of nodes.

To avoid the re-clustering LEACH-F is proposed. In this scheme clusters are static, but the cluster heads are rotating. Clusters once formed remain static throughout the network lifetime, but the onus of transferring the cluster information is rotated within the nodes in the cluster.

In LMSSC [21] first the base station divide the network into clusters then appropriate number of cluster heads are chosen on the basis of predefined metric. The metric is the ratio of the residual energy of a concerned node to sum of squared distances of this concerned node to other nodes and squared distance of this node to the base station.

Controlled Density Aware Clustering Protocol (CBCDACP) [22] is also an important base station adaptive protocol where the base station is responsible to perform the cluster formation, other schemes are a Two-Tier Data Dissemination approach [23] that support scalability provide location aware schemes with efficient data delivery, in FZ-LEACH that creates Far-Zone in the area where energies lies below the threshold. It identifies those sensor nodes in that particular area and makes the group of sensor nodes, in Adaptive Cluster Head Election and Two-hop LEACH protocol (ACHTHLEACH) [23]; nodes are labeled as near nodes and far nodes according to their distances to the BS. Greedy K-means algorithm is applied to four nodes to divide into different clusters while near nodes belong to only one cluster. The cluster head is rotated and the node with the highest residual energy in each cluster is assigned the responsibility of cluster head.

An optimal Placement of Cluster Head (OPC) [24] algorithm is proposed for clustering, which is also known as grid sectarian. It is based on load balancing and energy consumption. The advantage of the algorithm is that it works on both types of deployment uniform and non-uniform). The key feature is to handle the load balancing on the basis of transmission range and the density near the sink.

Comparison of base station adaptive schemes is provided in the table 2 given below. In these schemes sensor nodes are exempted from the computation complexity involved in selecting the cluster heads.

c) Resource Adaptive Probabilistic Schemes

In these types of schemes information about the available node resources are analysed and used for cluster head election

Table 2 Comparative Study of Base Station Adaptive Schemes

BSA Schemes	CHS	Parameters	REC	DCS	BCC
LEACH-C	Base Station	Position information And energy level	N	N	N
LEACH-F	Base Station	Position information	N	N	Y
LMSSC	Base Station	Residual energy, CH Two sensor nodes and CH to base station Distances	N	Y	Y
BCDCP	Base Station	Position information And energy level	N	Y	Y
CBCDACP	Base Station	Minimum distance Between node to base station	N	Y	Y
TTDD, FZLEACH	Base Station	Location Awareness	N	Y	Y

A resource adaptive Probabilistic Scheme EACS (Energy Adaptive Clustering Scheme) is proposed in [25].This scheme uses average node energy, residual energy of the node and energy dissipated in the current round as the parameter in selecting the cluster and cluster head. The role of cluster head is decided on the basis of adaptive threshold values.

LEACH –M, Power optimized LEACH , LEACH-B, Energy-LEACH [25] are the other important cluster head selection schemes in which residual energy of the node is the main criteria of election of cluster head. HEED [26] is an important example of these types of schemes. In this scheme residual energy is the criterion which is used to decide the role of cluster head in the network. Optimum percentage of cluster heads and the maximum energy is fixed in starting for data gathering and it is not allowed to decrease below a minimum threshold. Table 3 summarized resource adaptive cluster head selection schemes described above.

Table 3 Comparative study of Resource Adaptive Schemes

Resource Adaptive Schemes	CHS	Parameters	REC	DCS	BCC
EACS	Sensor Nodes (Self-Organized)	Residual Energy, Energy in current round	Y	N	N
LEACH-B	Sensor Nodes (Self-Organized)	Energy	Y	N	N
HEED	Sensor Nodes (Self-Organized)	Optimum Percentage of cluster head and Residual Energy	Y	N	N
ENERGY-LEACH	Sensor Nodes (Self-Organized)	Energy	Y	N	N
LEACH-M, Power LEACH	Sensor Nodes (Self-Organized)	In Range Residual Energy	Y	Y	Y

d) Fixed Parameter Probabilistic Schemes

In these schemes Cluster heads are selected for Current and subsequent round by evaluating some fixed value parameters like node count number of rounds required and probabilistic requirements etc.

LEACH is the example of a fixed parameter probabilistic scheme. In LEACH the cluster head's responsibility is shifted among all the nodes in the network after a predefined number of rounds. In each round cluster formation process is initiated by the cluster heads and nodes on the receipt of advertisement from different cluster heads joins the cluster having highest residual energy cluster head. In each round a random number between 0 and 1 is chosen and if this is less than the adaptive threshold than the node declare as cluster head.

An improvement in the cluster formation process is proposed in ERA [27]. In this scheme cluster member considered the path with maximum sum of residual energy while joining the cluster head. To avoid collision TDMA schedule is applied just after joining the cluster head. Another approach is RRCH in which cluster formation and cluster head selection are carried by LEACH and TB-LEACH [28]. The key features in this approach is that number of cluster head is constant and clusters are balanced and uniform

Table 4 given below summarizes the probabilistic schemes, according to the features described above.

Table 4 Comparative study of Probabilistic Schemes

Probabilistic Schemes	CHS	Parameters	REC	DCS	BCC
LEACH	Sensor Nodes	Number of rounds, Number of Cluster Heads	Y	N	N
RRCH	Sensor Nodes	Number of rounds, Number of Cluster Heads	N	N	N

e) Hybrid Schemes

In these types of approaches clustering schemes are combined with one or more architectures for reducing the energy consumption. M-LEACH is based on hybrid clustering. In M-LEACH for election of cluster head there is a consideration of node's residual energy and its distance from the base station. Simulation study shows that it periodically selects the cluster head and energy consumption is minimized.

The other hybrid scheme is EAMC [29] that minimize the amount of number of nodes used in root tree which results in reduction in number of relays used in data transmission. The UCR [30] (unequal routing protocol) divide the sensor nodes into an unequal size of clusters. In this scheme the cluster heads that are nearest to the base station have smaller cluster size. The clusters that are farther to the base station support inter-cluster data forwarding and decision tree algorithm to select the cluster head.

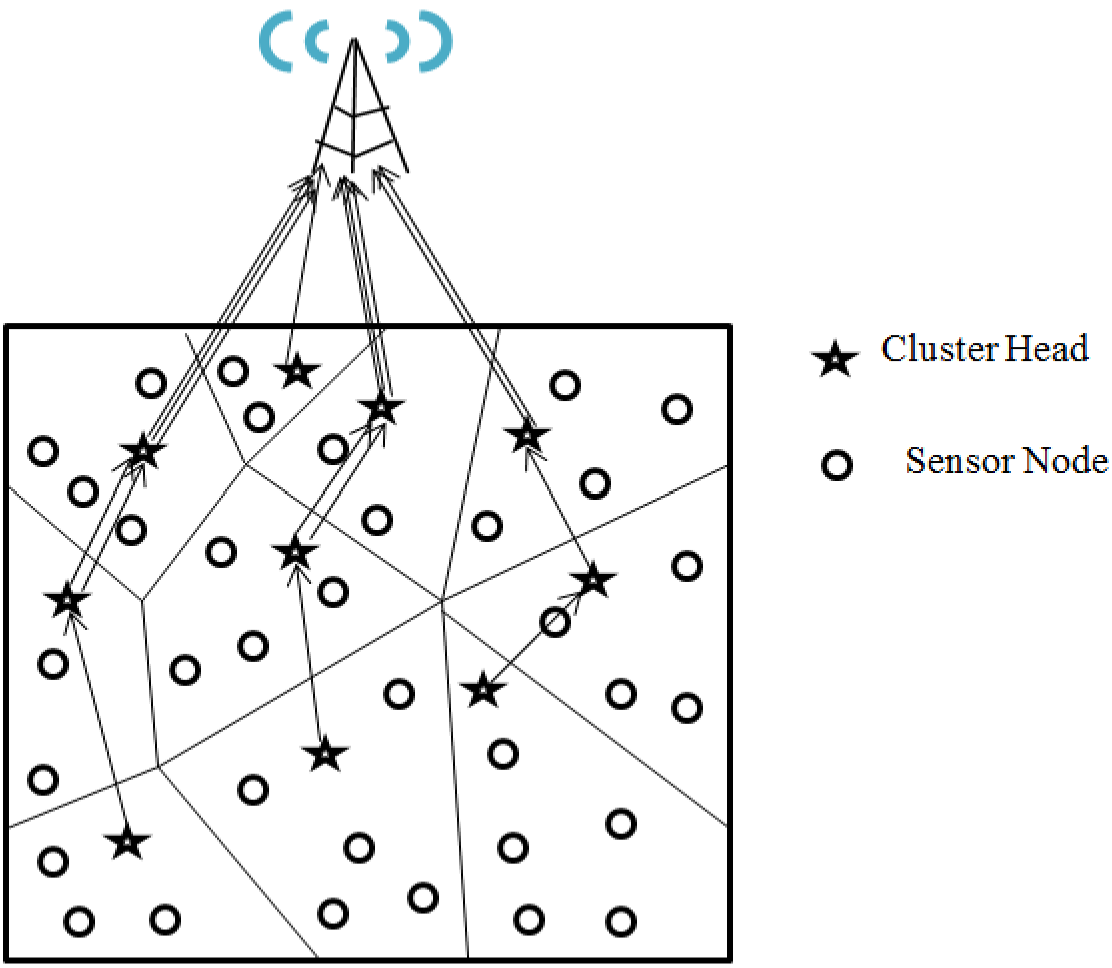

Fig 3.3 UCR Clustering Scheme

The gradual cluster head election is proposed in [31]. This algorithm selects the cluster head on the basis of one hop neighbour information, residual energy and the neighbour proximity. Concentric clustering schemes are proposed in Power Efficient Gathering in Sensor Information System PEGASIS [32]. In this approach, each sensor node assigns it a layer number based on the received signal strength message received from the base station. The nodes in the same layer form a group or clusters and one of these nodes is elected as cluster head.

Table 5 Comparative study of Hybrid Schemes

Hybrid Schemes	CHS	Parameters	REC	DCS	BCC
M-LEACH	Sensor nodes (self-organized)	Location and Threshold	N	Y	Y
UCR, EAMC	Sensor nodes (self-organized)	Residual Energy and Coverage Ratio	N	N	Y
PEGASIS	Base Station	RSS	N	Y	Y

3.2.3 Target Detection and Tracking

Different approaches are presented for detecting the target. Majority approaches are based on cluster based target tracking. The main focus is on network lifetime, reducing the energy consumption, tracking efficiency and minimization of communication load. In most cases, clusters are dynamically formed along the trajectory of the target.

In [33] a framework of randomly deployed sensor nodes is proposed. In this scheme all the sensors are acting as a set of distributed datasets. An approach for finding the temporal patterns and discovering the nonlinear trajectory of target from these datasets is presented. Some assumptions are considered in this approach

- Sensor nodes are homogeneous i.e. they are having the same characteristics
- Node deployment over an area is random
- All sensors have the ability to gather information about a target which include its (x, y) coordinates and time stamps

Based on these assumptions local hypothesis and global hypothesis are calculated. Local hypothesis consist of a set of three points in a line and in increasing timestamp order and global hypothesis consist of a set of local hypothesis. After forming the boot parameters each node broadcast its timestamps and trajectory is located on the basis of local hypothesis, global hypothesis and timestamp.

Yuan Xu, Wei Bao and HongliXu [34] proposed an algorithm for continuous object tracking. They proposed continuous object tracking algorithm (COTA) which can schedule the activities of the sensors on the basis of object movement. The main objective of the algorithm is to improve the efficiency of continuous object tracking and to track the whole event while the characteristics of the object are rapidly increasing. The main idea of the algorithm is that at a particular time the nodes which lies on the target's boundary are in wake up state and the nodes which are away from the target remain in hibernating state and can monitor the internal nodes. External node can capture the change when the target's boundary is spread. When a continuous object lasts for a long time like a forest fire, its diffusion velocity increases. Due to the active state of the external node, it would prevent the object from going out of the monitoring region.

A dynamic cluster based object tracking is proposed by Dan Liu, Nihon Wang and Yi a [35]. In this approach nodes is awakening or slept along the trajectory of the target. Reducing the number of nodes for target tracking minimizes the energy consumption in the network and enhances the lifetime of the network. The next location of the target is calculated on the basis of its velocity and acceleration which can be calculated by following equations.

Let at $t=t_o$ initial velocity and acceleration is given by

$$V = \begin{Bmatrix} v_o\cos\phi \\ v_o\sin\phi \end{Bmatrix} \qquad a = \begin{Bmatrix} a_o\cos\theta \\ a_o\sin\theta \end{Bmatrix} \tag{3.1}$$

After time $t_o + t$ velocity V_t and location L_t can be given by

$$V_t = \begin{Bmatrix} v_o\cos\phi + at\cos\theta \\ v_o\sin\phi + at\sin\theta \end{Bmatrix} \quad L_t = \begin{Bmatrix} v_o t\cos\phi + 1/2at^2\cos\theta \\ v_o t\sin\phi + 1/2at^2\sin\theta \end{Bmatrix} \tag{3.2}$$

In [36] an auction based adaptive sensor activation algorithm is proposed for target tracking. In this algorithm clustering is done on the basis of a prediction mechanism and an auction mechanism. Only those nodes are activated which falls under the predicted region and rest other nodes remain in sleeping mode. Auction mechanism is used to choose the appropriate sensor nodes for forming the cluster and the node that has the biggest bid is chosen as cluster head. an improved trilateration concept is proposed that uses the weighted mean of the three node's location. Auction based schemes proposed in this research answers the following questions

- How to select the appropriate sensor for forming the cluster for tracking
- How to track the target despite of various environmental issues such as noise
- How to guarantee the tracking quality while scheduled the sensors in an energy efficient manner.

Bid is calculated by the function

$$f(et, d_t) = \alpha\, e_t / e_{ch} + (1-\alpha)\, d_{ch} / d_t \tag{3.3}$$

Where d_{ch} is the distance between the cluster head and previous predicted location of the target, each is the residual energy of cluster head, it is the residual energy of sensor node t, d_t is the distance between sensor node and the predicted location of a target, and α is a weighted coefficient of energy and distance.

FaezehHajiaghajani, MarjanNaderan, HosseinPedram, Mehdi Dehghan [37] proposed a hybrid clustering scheme for multi-target tracking. This scheme is a combination of static clustering and dynamic clustering. Tracking mechanism is switched between the dynamic cluster forms in boundary regions) and static clusters. A merging mechanism is also proposed for reducing the energy consumption. Initially the network is divided into the static clusters. Having received the sensing information from the boundary nodes a dynamic cluster is formed along the target location and when the objects move out from this region this dynamic cluster is dismissed and a new dynamic cluster is formed with the new boundary nodes.

A genetic approach for clustering is proposed by Sudakshina Dasgupta, Paramartha Dutta [38]. In this protocol greater energy efficiency is achieved by reducing the number of cluster heads in each round. it is a base station assisted schemes. The base station uses genetic algorithms for creating the energy efficient clusters. Sensor nodes are treated as a bit of chromosome. Heads are represented by 1 and other nodes are represented by 0. The best fitted chromosome is allowed to generate the next population. An arbitrary weight is assigned to each fitness parameter. After every generation each fitness parameter is updated and the best fitted parameter is used to generate the next population. Base station broadcast this complete network details to the sensors and clusters are formed accordingly.

A prediction based approach is proposed by Fatemeh Deldar, Mohammad Hossien Yaghmaee [39].In this approach target's location is predicted based on its previous location, velocity and direction. For achieving the energy efficiency only those nodes are active that falls under the predicted location and rest other nodes are in sleep mode. Velocity and direction can be calculated by following equations.

$$V = \frac{\sqrt{(r_i-r_{i-1})^2+(s_i-s_{i-1})^2}}{t_i-t_{i-1}} \tag{3.4}$$

$$\alpha = \cos^{-1} (r_i-r_{i-1})/\sqrt{(r_i-r_{i-1})^2+(s_i-s_{i-1})^2} \tag{3.5}$$

On the basis of above information next location of the target can be determined as follows

$$r_{i+1} = r_i + vt\cos\alpha \tag{3.6}$$

$$s_{i+1} = s_i + vt\sin\alpha \tag{3.7}$$

A selection parameter is calculated for each node by the cluster head that is

$$selection_i = energy_i/distance_i^2 \tag{3.8}$$

Three nodes are selected by cluster head for tracking which has the maximum selection parameter.

Sunil Kumar Kashyap, K. R. Kambhatla, Bin Zan, Fei Hu and Yang Xiao [40] proposed energy aware and intelligent cluster based event detection schemes. In this approach for detecting spontaneous and persistent events on the fly in various parts of a spanning network a wireless sensor network relies on a combined effort of several micro-sensor nodes.

Lin Fan, Huanzhao Wang, Hai Wang [41] proposed a solution for multi target tracking that is based on FCM (fuzzy cluster means). They used the LEACH algorithm for routing and FCM for association in cluster head. FCM algorithms are generally used in clustering. The main purpose of fuzzy algorithms is to classify the data into number of known clusters. In this algorithm a degree of relationship is established between each data point to each cluster. In FCM algorithm a set of association point is defined and the sensors are assigned to one of the association points. The algorithm is repeated until all the nodes are not assigned to one of the association points. The flow diagram of the FCM algorithm can be represented in fig 3.4.

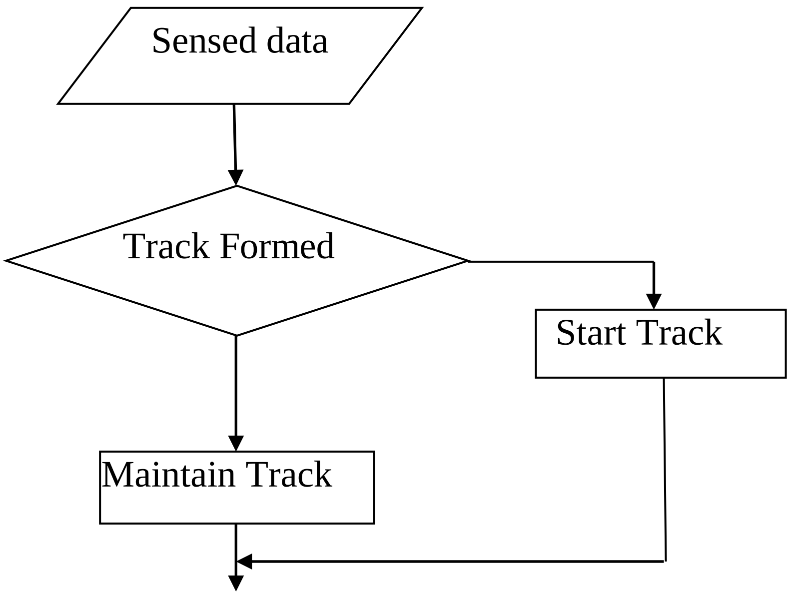

Fig 3.4 Flow diagram of FSM [41]

A hierarchical prediction based strategy is proposed by F, Zhao et al [42]. In this scheme clusters are divided according to the Voronoi division. In each round sensor node can only activate the node near the target. The network considered in this research if hierarchical having two tiers. First, there consist of cluster heads and at the lower level non cluster heads are there. Cluster head nodes have strong computation power while non-cluster head nodes have limited power and communication capacity. The properties of cluster heads and non-cluster heads are defined as follows

- The non-cluster head nodes collect the data from the environment and send it to the cluster heads, but they are not allowed to communicate with each other
- The cluster head gives the direction to the non-cluster head nodes and multiple cluster heads can communicate with each other.

The process works in two states, idle and active. A cluster can switch between the two states, according to the occurrence of target in its coverage area. The mode of the cluster heads based on the probabilistic scheme. Let C be the number of cluster heads, N be the number of non-cluster field and R be the field of interest. $L_{Ci} \in R$ is the location of cluster head and $L_{Ni} \in R$ is the location of non-cluster head than the location of cluster head and non-cluster head can be denoted as

$$L_C = \{Lc_i:\ 1 \leq\ i \leq C\} \text{ and } L_N = \{L_{Ni}:\ 1 \leq\ i \leq N\} \tag{3.9}$$

Centroid localization algorithm and binary sensing model are used in the research. If K nodes are active at time t for detection of target and out of those P nodes detects the target ($P \leq K$) and their location is (X_J, Y_J) where $1 \leq J \leq P$ then the estimated location of the target is

$$L_{Target} = \left(\sum_{J=1}^{K} Xj / P,\ \sum_{J=1}^{K} Yj / P\right) \tag{3.10}$$

A prediction based mechanism is also applied for finding the future path of the target based on its movements in the previous intervals. The approach is based on the recursive least square method

Oualid Demigha et al [43] proposed the scheme of energy efficient target detection. In this research classification of energy efficient tracking schemes are presented on the basis of communication subsystem. The main component defines in the target tracking subsystem are defined by the following diagram

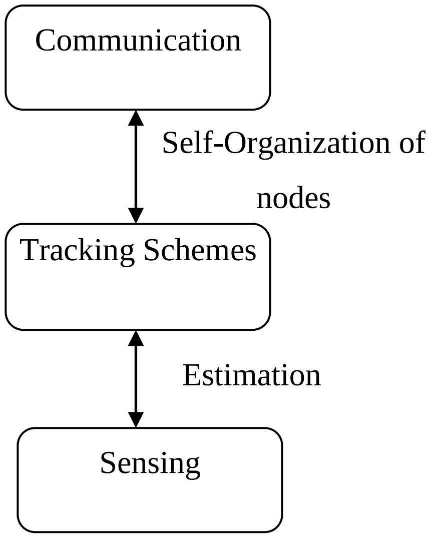

Fig 3.5 Target Tracking Components [43]

According to the author a target tracking algorithm should consider the following elements for making the algorithm energy efficient,

- Detection quality must be achieved. For this depending on the network coverage a target must be watched out by more than one node and nodes must generate correlated reading about the state of the target. The tracking algorithm must clear about few questions like in the next round which node will be selected for tracking, how many nodes are needed to be active for tracking, what should be the communication range of the nodes etc.
- Estimation algorithm should be light weighted because sensors are limited in resources.
- Data reporting mechanism should be efficient. After sensing and collecting the information about the target it is another important issue. It is to be suggested that the nodes which are closer to the target should be selected as reporter node.
- The activation mechanism should be multi-step and dynamic; however activation schemes are generally dependent on target velocity.

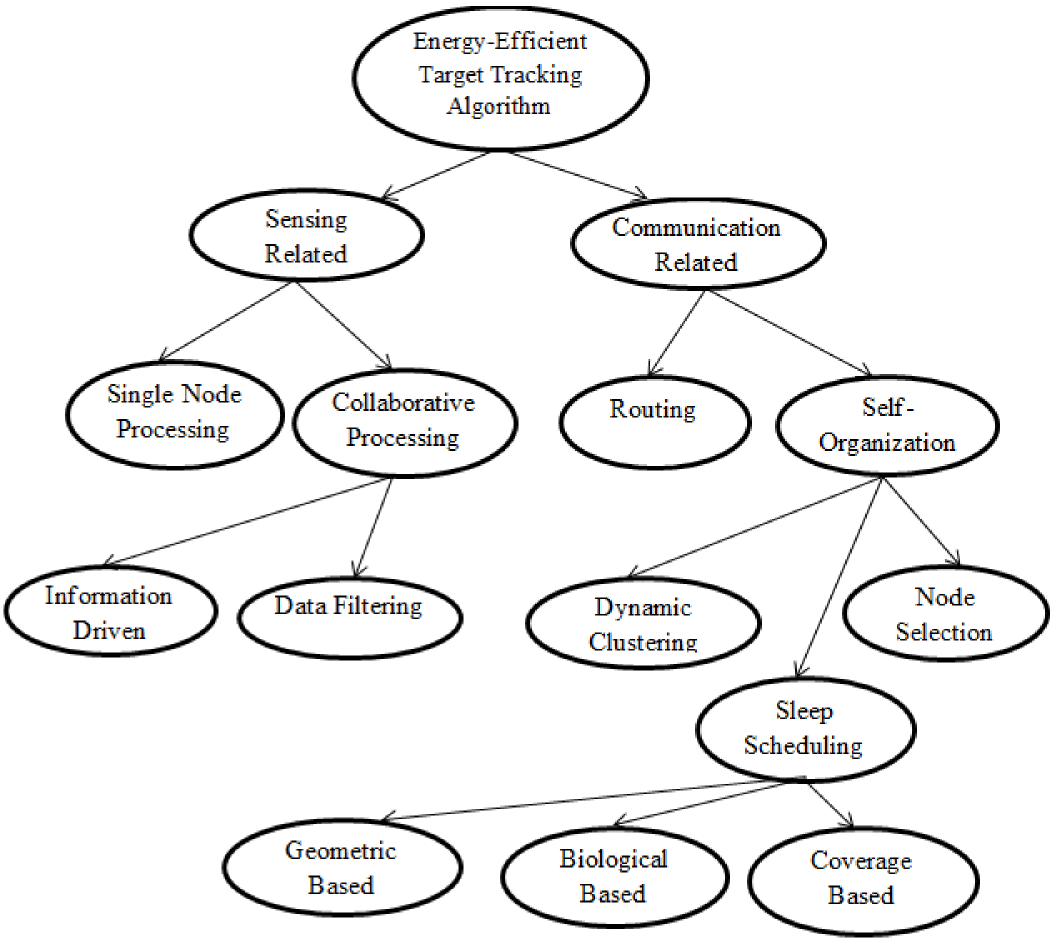

Fig 3.6 Classification of Energy Efficient algorithms [43]

3.3 Proposed Approach

Target tracking applications affect the diverse real life scenario. Target tracking includes drawing a conclusion on object motion with the help of available observations about that object. These observations can be anything from the image of the object to its range etc.

In the proposed approach clustering is performed before detection of target. In what follows, we focus on clustering of nodes and detection of targets. Proposed approach consists of two phases,

1) Construction of cluster and cluster head selection

2) Location estimation of the target.

3.3.1 Construction of Cluster

Clustering of data streams has been always a big problem in order to maintain the efficiency in the autonomous environment. This is because the massive data sets are received at a surprising rate. Traditional clustering approach proves inefficient because of the following problems

- In case of massive data involvement, quality of cluster degrades.
- One pass algorithms were used in these approaches, but it is not very useful as data become outdate.
- Whole data streams are considered at a time for construction of the cluster, which results in early disposed the power of sensor nodes.

Sensor nodes are deployed over a large region so it is not efficient, that all the nodes are active at all the time. This leads to the problem of saving the energy of the nodes as the recharging of sensors is always major issues in the network consist of sensor nodes. So there should be the phenomenon that is able to conserve energy as much as it can while functioning. In proposed approach first a clustering method is defined for making the cluster of the active nodes. In clustering a cluster head is selected that collects all the information from the nodes and transmit the data to the base station. Nodes have the following properties

- All nodes have their unique id that is n_id.
- All nodes have their sensing range. Sensing range of the node is defined as the area around the node or the vicinity of the node in which it can detect the target. If the target lies in this range than only the node become active, otherwise it will be in the sleeping mode.
- When a sensor node detects the target it has the ability to calculate the distance between itself and the target. A node calculates its distance from the target with the help of the phenomenon of RSS (received signal strength).

3.3.2 Signal Strength Estimation

Calculation of signal strength estimation is necessary for the design and deployment of both wideband and narrowband wireless networks. The base of localization and positioning technique is the relationship between the RSSI and distance. A variety of factors influenced the signal coverage like radio frequency of operation and the terrain

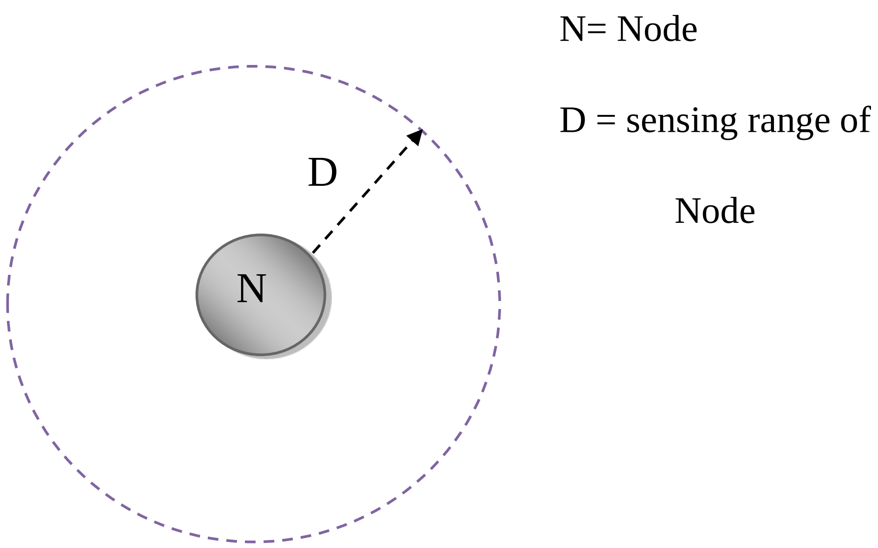

Fig 3.7 Sensing Range of a Sensor

For detecting the event, it might be necessary to detect the emitted signal strength of the node. Computation of signal strength is necessary for characterization and classification of targets. Signal strength estimation falls under the area of collaborative signal processing. The main focus is on increasing accuracy of multi-measurement processing. In the estimation of signal strength, high computation and communication cost is considered. Mostly research focuses on numerical and statistical solution to the signal strength problem. Those regions span a variety of terrain where a wireless sensor network provides services. The strength calculation scenario consists of a variety of operations, which includes the variety of distances and environment exists between the transmitter and receiver. Due to this a single channel model is unable to describe the propagation between the transmitter and receiver and we need various other models for the variety of environments to enable system design. The important part in signal propagation for various environments is a path loss model which represents the relationship between losses of signal strength to distance between two terminals. Using this model coverage is of the base station and access points can be calculated. The other major advantage is that the maximum distance between two terminals can be calculated. In the following we use this model for calculating the distance between the sensors and the targets by treating them as the two terminals in the network

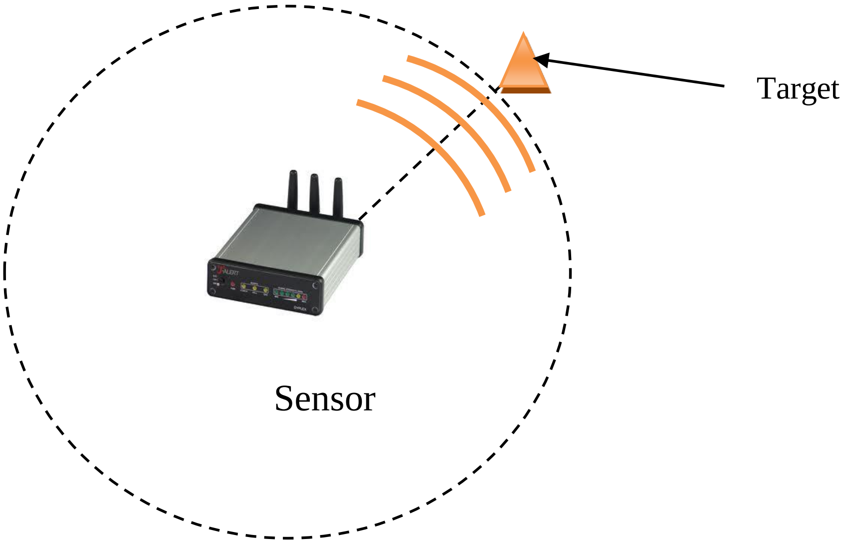

Fig 3.8 Sensor Radiates the Signal for Tracking the Target

When an object enters into the vicinity of the sensor, a node radiates signal which propagates in all directions. The signal strength, density of a sphere of radius d is the total radiated signal strength divided by the area of a sphere which is $4\pi r^2$. If the transmitted power is put after a distance d in meter, the signal strength can be represented as

$$P_t \alpha \ 1/d^2 \qquad (3.11)$$

There are some additional losses also, depending on the sensor frequency. The relationship between the transmitted power P_t and the received power P_r is given by

$$P_r = P_t G_t G_r (\lambda/4\pi d^2) \qquad (3.12)$$

Here G_t & G_r are the transmitter and receiver gains in the direction from transmitter to receiver, d is the distance between the node and the target, λ=c/f is the wavelength of the carrier, c is the speed of light and f is the frequency of the carrier.

The proposed approach is based on the concept of residual energy and received signal strength. In this we can assume that the region in which sensor nodes are deployed is divided into zones. Clustering is done in each zone. Each zone has one cluster head and is directly interacting with the base station. Each node broadcast its residual energy to all other nodes in its zone with its id, When a node received the message from its neighbouring node, it first check that whether it's residual energy is greater than the other nodes or not. If it receives the message with low residual energy than itself, it discards the message; otherwise a list is prepared at each node which contains the node id of all other nodes belonging to that zone. If no list is prepared at any node in the zone, it shows that the corresponding node has highest residual energy in its zone and this node is elected as the cluster head. Cluster head informs other node by sending a message. The process can be depicted in fig 3.10

An algorithm for clustering running at each zone

1. While (1) do
2. Switch (event)
3. event 1: broadcast energy
4. Each node broadcast its residual energy to all the nodes in a zone with its id;
5. break;
6. event 2: manage the list
7. If (E_{node}>E_{host})
8. Put it in a list which contain node id;
9. else
10. Discard the message;
11. break;
12. event 3: head selection
13. If (list is empty at any node) then
14. elect it as cluster head;
15. else
16. Consider it as a cluster member;
17. break; }end while

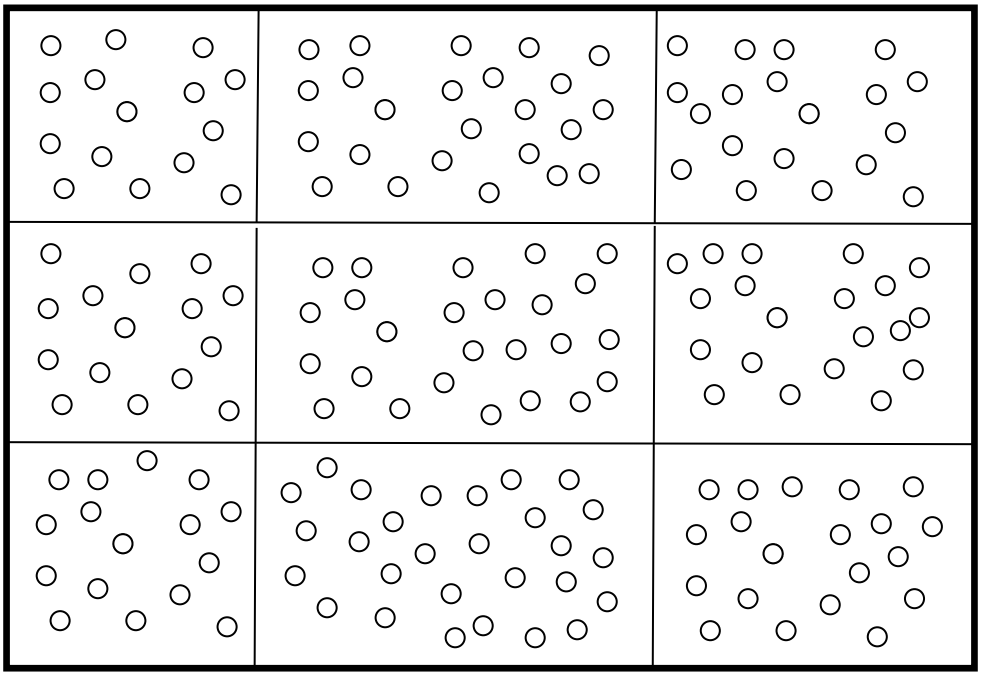

Fig 3.9 Regions of Sensor Nodes Dividing into Zones

3.3.3 Location Estimation of Target

Before the tracking system starts to function, cluster head knows the position of each sensor in its zone. When a target enters into the vicinity of a sensor, it starts functioning. A node calculates its distance from the target with the help of RSS received signal strength which is described earlier). After calculating the distance it sends the information to the cluster head of zone for which it belongs. This process occurs at each node which is able to sense the target when it enters into its sensing range

An algorithm for target detection running at cluster member

1. While (1) do
2. Switch (event) {
3. event 1: Target Sensing
4. if (Target detected)
5. Calculate its distance from the target with the help of received signal strength (RSS);

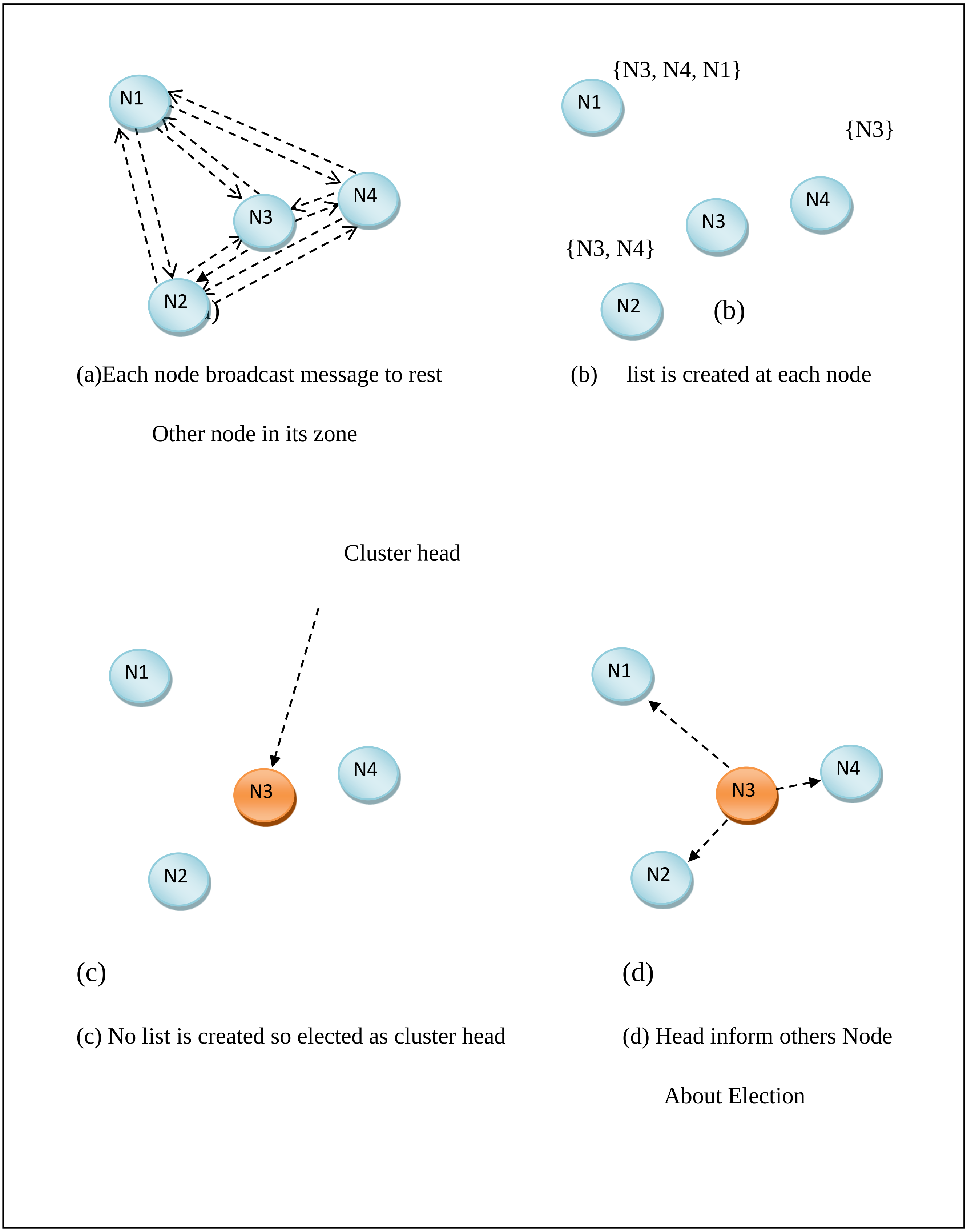

Fig 3.10 Processing Occurs in each Zone

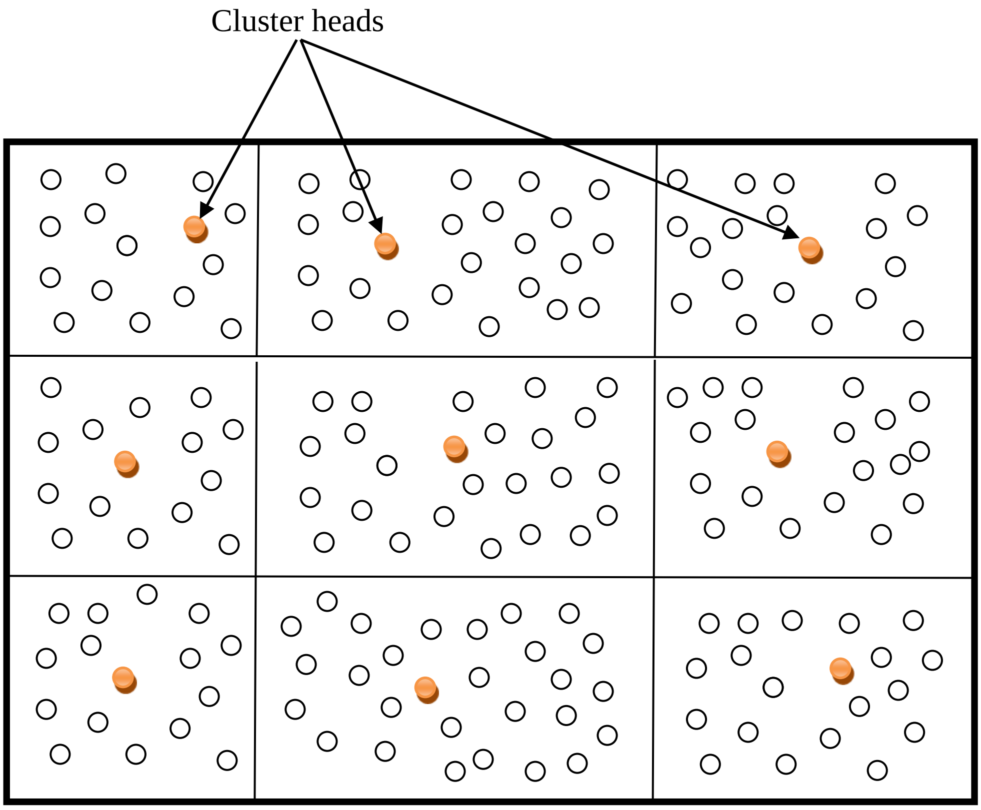

Fig 3.11 Region of Sensor Nodes after Clustering

6. Else
7. Stay sleep
8. Break;
9. event 2: message transfer
10. Transfer message to cluster head of its corresponding zone map (n, d) that consist of its id and measured distance from the target;
11. Stay active
12. break;
13. }end while

It is the responsibility of cluster head to locate the target. For this purpose concept of trilateration is used. It is the concept of geometry in which absolute or relative location of points is determined by measuring the distances.

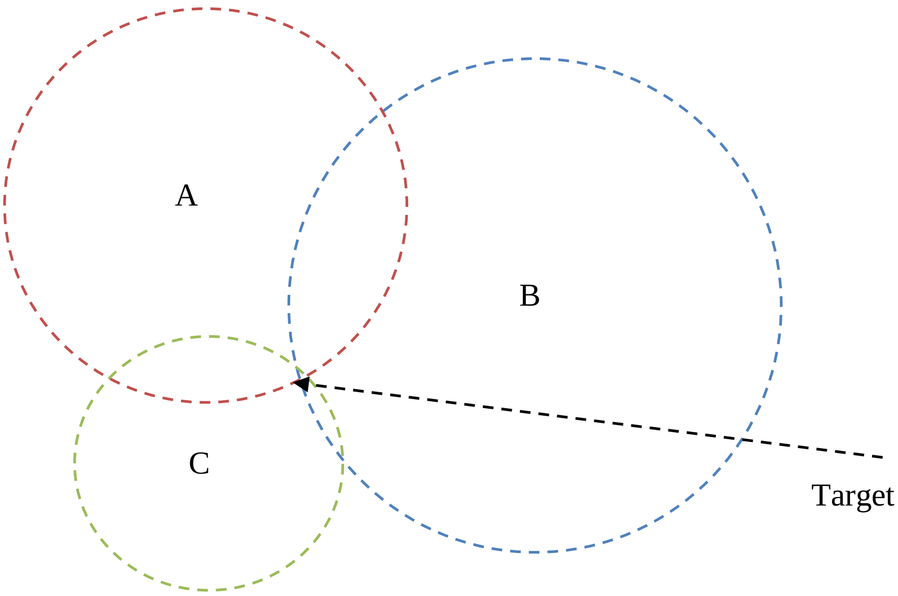

Fig 3.12 Concept of Trilateration

The concept of trilateration uses the geometry of circles, spheres or triangles. The concept of trilateration can be understood by this problem. Suppose there are three houses A, B, C in a city and there is a restaurant in that city. The distance of this restaurant is known from all the houses and we want to locate the restaurant. We can consider the restaurant at the intersection point of three circles whose centres are the three houses A, B, C and the radii of these circles are the distance of the houses from the restaurant

For determining the location of the target active cluster head select three modes which are nearest to the target and calculate the coordinates of the target by the following equation

$$(X_i-Y_t)^2+ (Y_i-Y_t)^2 =d_i^2 \quad , i=1,2,3 \tag{3.13}$$

Where X_i and Yi are the coordinates of the node I and X_t and Y_t are the coordinates of the target and DI represents the distance of the node from the target

The algorithm is running at cluster head

1. While (1) do
2. Switch (event) {
3. event 1: message received
4. Received the message from all the node that has detected the target;

5. break;
6. Event 2: location estimation
7. Compared, Dj, d_k........ d_ni. e. Distance received in all the messages;
8. Select three points that are nearest to the target;
9. Calculate the coordinates of the target with the help of trilateration concept;
10. Transfer the coordinates information to the base station;
11. break;
12. }End while

The proposed algorithm described above shows that how cluster head calculates the coordinates of the target. For this purpose, it uses the concept of trilateration (described in an earlier section). First, it receives the message from all other nodes that has sensed the target. This message contains the node id and the distance of the node from the target. On the basis of smallest distance from the target it selects three points and calculates the coordinates of the target. Fig 3.13 given below shows the Flow Chart of the proposed framework for target detection.

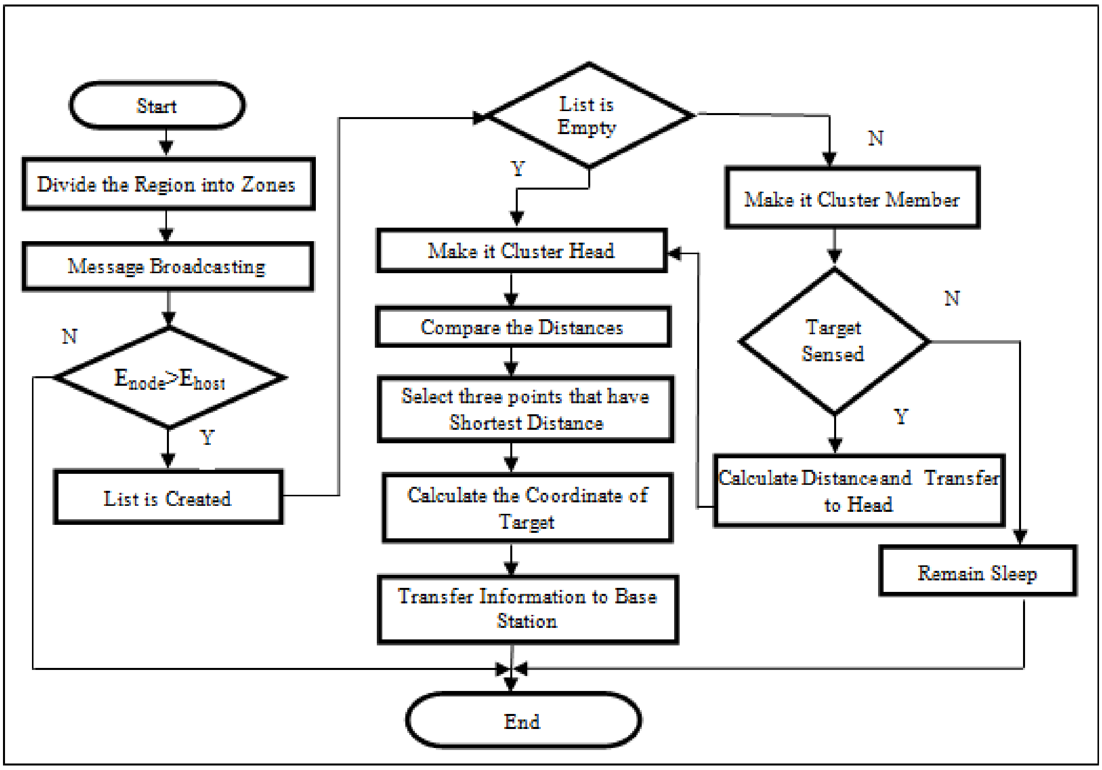

Fig 3.13 Flow Chart of Proposed Algorithm

3.4 Result and Analysis

We have performed the simulation of our algorithm in Java [jdk1. 7.0]. Simulation model consist of 320 nodes. Initially we divide the area into sixteen rectangular zones. A cluster head is elected in each zone on the basis of the proposed algorithm. Fig 7 represents the network area after node placement and election of cluster head.

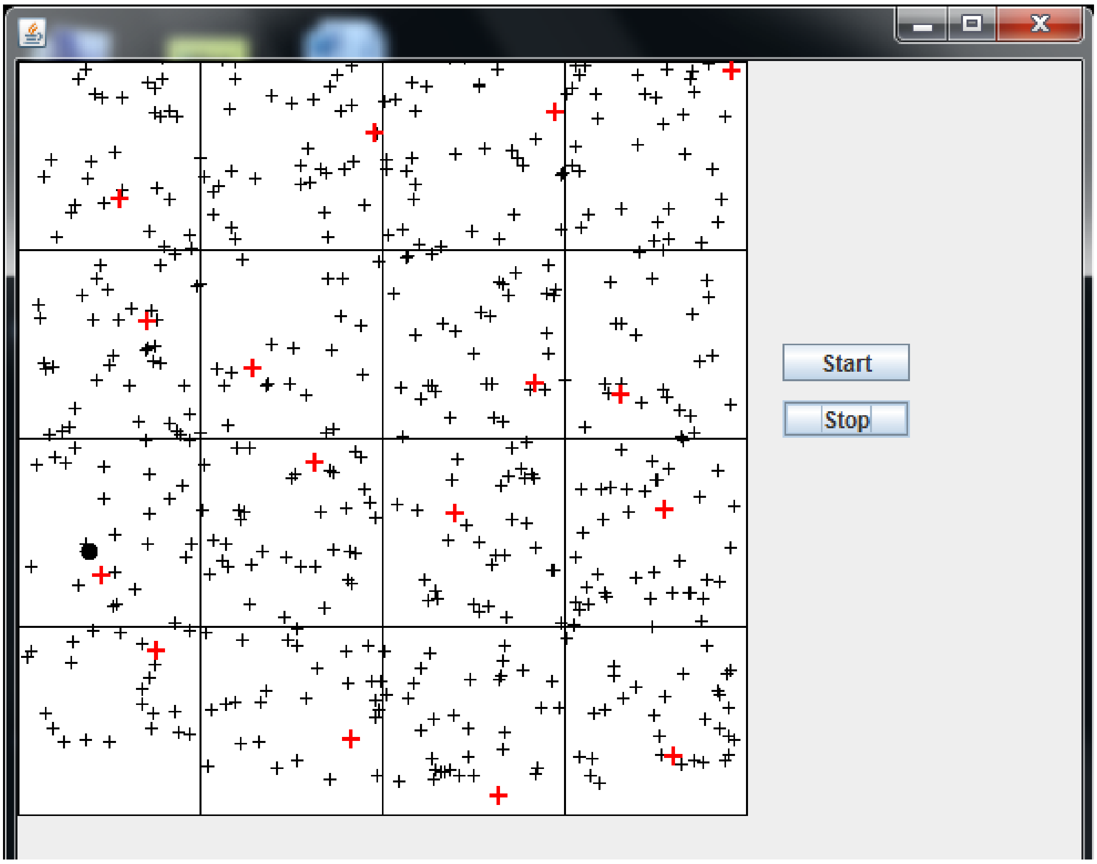

Fig 3.14 Snap Shot of Network after Cluster Head Election

Tracking period is set to 3 Sec. Target trajectory is chosen randomly. Simulation is performed for 30 minutes and the energy model we considered is same as Wendi B Heinzelman et al [18]

$$E_t = (r \times E_c) + (r \times p \times s^2) \quad (3.14)$$

$$E_r = (r \times E_c \times d_i) \quad (3.15)$$

Where E_t represents energy dissipated in transmitting the message, Er is energy consumed in receiving the message, r is packet size, p is amplifier energy, E_C is electronic energy, d_i is the degree of node i and s is the distance between communication entities.

Packet size is varied depending on the sensed data. If we take the example of environment monitoring where there is need to sense the environment parameter like temp, etc. then 8-16 bits may be enough.

On the basis of above energy model we can compute the total energy consumed in one round that can be depicted by the equation

$$E_{total} = (E_t + E_r) \times N \tag{3.16}$$

Where N represents the number of nodes used in one round.

Energy consumed over time it can be estimated as

$$E_{total} = ((E_t + E_r) \times N) \times K \tag{3.17}$$

Where K= number of rounds in time t

Simulation Parameters

Parameter	Value
MAC protocol	IEEE 802.11
Network Size	400 X 400 m^2
Number of nodes	320
Initial energy of nodes	2 j
Sensing range	50 m
Transmission range	100 m
Target speed	0-3 m/s
Node distribution	Random
Target trajectory	Random
packet size (r)	48 bits
Electronic Energy (E_c)	50 nj /bit
Amplifier Energy (p)	100 pj/bit/m^2

We have evaluated our algorithm in two scenarios to calculate the total energy consumption in tracking the target.

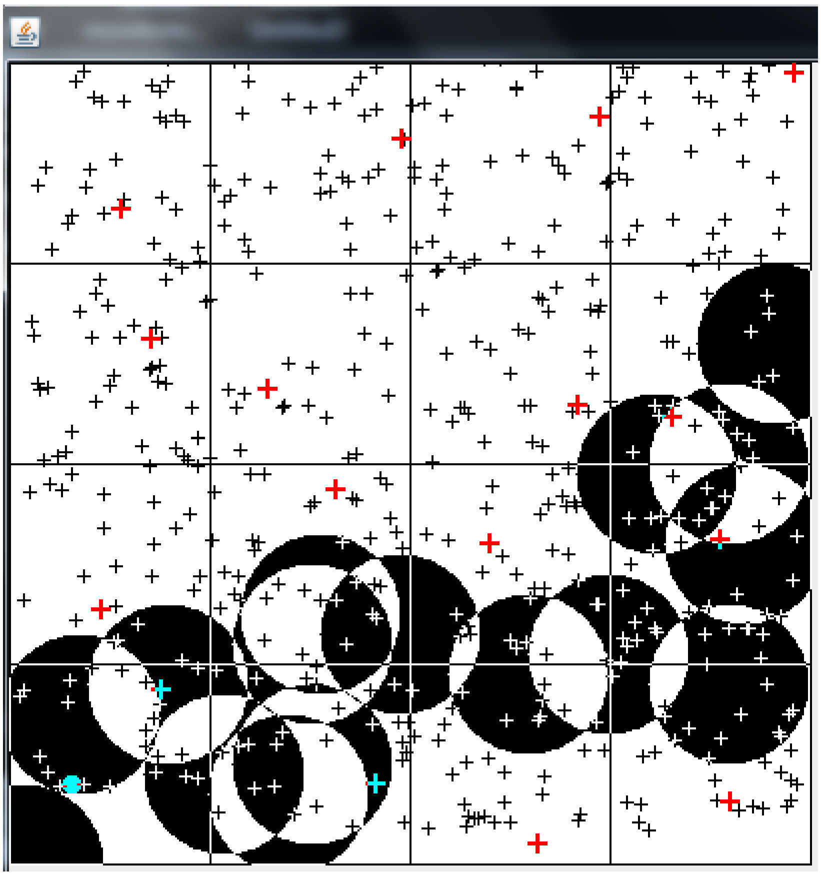

Fig 3.15 Snap Shot of Tracking Scenario

Scenario 1

In this we evaluate the cost of clustering in a single round during the establishment phases. We consider a zone of 20 nodes where a cluster head is elected. We compare our algorithm with LEACH and LEACH-C. Fig 8 shows the energy consumption in a single round of each algorithm. LEACH is simple in nature, but due to the absence of location information, number of control messages is high which leads in higher energy consumption

Scenario2

In the second scenario we have evaluated the average energy consumption of nodes for tracking the target. We have compared our algorithm with the existing prediction based algorithm. Energy consumption is minimized in our algorithm because the number of nodes used for tracking is less in our algorithm as well as energy consumed

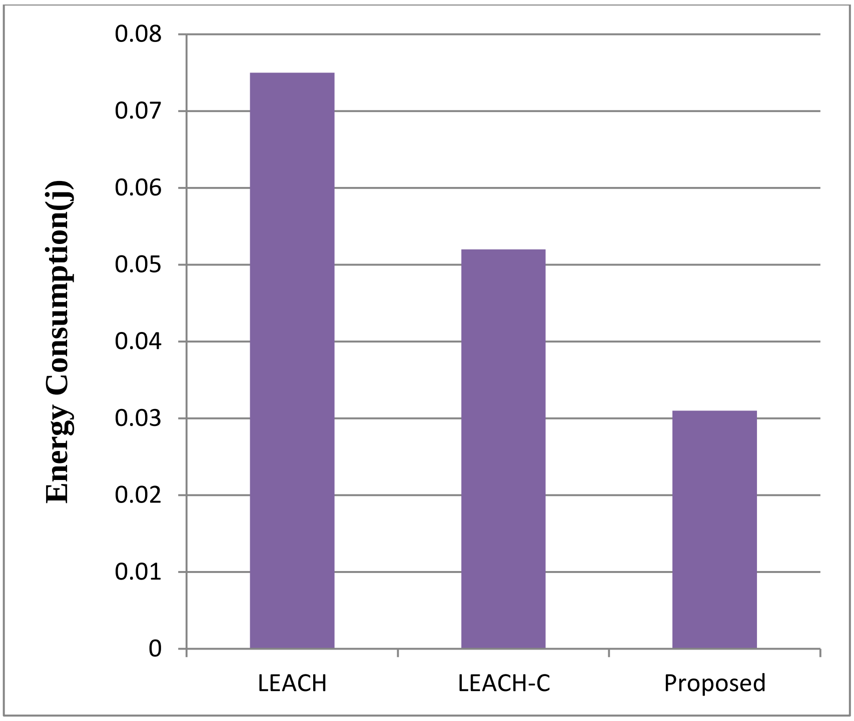

Fig 3.16 Cost of Cluster Head Election

In clustering is also less. Fig 9 shows the tracking environment in jdk environment. In Fig circles show the active nodes (that are able to sense the target in their sensing range). These nodes send the calculated distance to the corresponding cluster heads

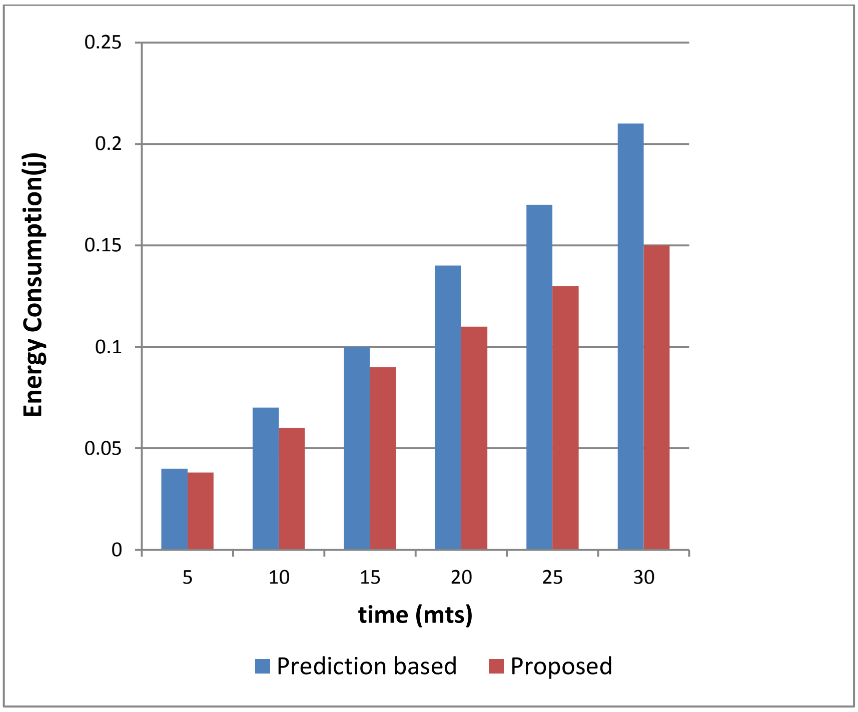

Fig 3.17 Average energy consumption of nodes

As our expectation energy consumption is minimized in proposed approach and network lifetime is also enhanced. Fig 10 shows the average energy consumption of nodes versus time in tracking the target in 30 minutes for both the algorithms.

3.5Conclusion

Proposed architecture tracks the target on the basis of clustering and signal strength estimation. For calculating the coordinates of the target we used the well-known concept of geometry that is “Trilateration”. In this thesis, we proposed an energy efficient clustering scheme for target detection, which is based on zoning. in proposed approach node utilization is minimized for achieving the energy conservation. We have proposed the separate algorithms for cluster head and the cluster member according to their role in the network. Each node has some sensing range and nodes are active only when the target in that range. Simulation results show that average energy consumption is decreased by our method, which enhances the lifetime of the network.

Chapter 4 Heterogeneous Sensor Network for Target Detection

4.1 Introduction

The recent advances in MEMS (micro- electro- mechanical system) technology leads to the development of small, low-power multi-functional sensors that has the capability of communication with each other. Sensing is the elementary function of these sensors. While working alone these sensor nodes are not efficient if there is a requirement of data gathering for drawing any conclusion about any phenomenon in any domain because of limited capabilities. For collection of information in any specific domain these sensor nodes must have worked in groups. The number of sensors in any group can be from several hundred to thousands. This collective group of nodes forms a network while deploying in any application which is named as Wireless Sensor Networks [1].

Now a day WSNs can be effectively used in various real life applications ranging from traffic control, environment monitoring, object tracking to scientific observing and forecasting [10]. In order to provide the functionality of processing, multimedia data these small sensors are equipped with the camera. These cameras equipped sensors also known as visual sensors or multimedia sensors and network formed by these visual nodes named as WMSN (wireless multimedia sensor network) [44]. This tiny battery

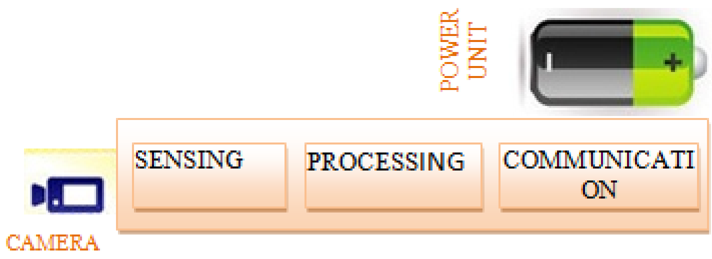

Fig4.1 Components of a Multimedia Sensor

Operated nodes integrate the wireless transceiver, embedded processor and image sensor. Visual data can be captured, processed and deployed over the network for further processing at base station using these visual sensor nodes. Image sensor module of VSN consists of a large number of photosensitive cells for capturing the images regarding the event. The advantage of using VSN is that it produces the better description of areas of interest. Fig 4.1 shows the modules of wireless multimedia sensors. However the way these modules are connected may vary in different platform.

The main task of multimedia sensor is to locate the target by taking its image. Each target lies in the Field-Of-View (FOV) of multimedia sensor can be detected visually. FOV of a multimedia sensor can be assumed as its directional view with angle α and radius ‘d’.

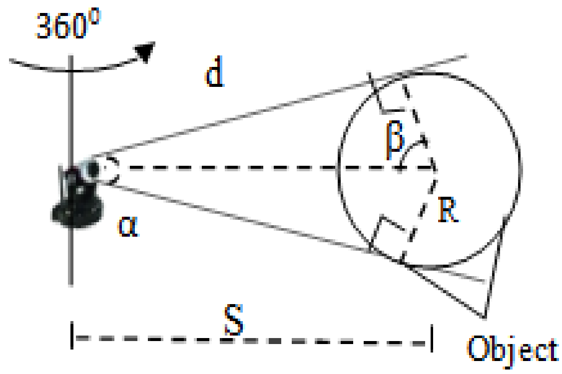

Fig 4.2 FOV of a Multimedia Sensor

In Fig 4.2 ‘S’ is the distance of multimedia sensor from the center of the object and 2β is the captured angle of the object and R the radius of the circular object.

WMSN have some additional features in comparison to traditional WSN like specific QoS requirements, sector sensing range and high bandwidth demand etc. [44]. Camera nodes used in WMSN have the capability to be used in various harsh environments, where energy infrastructure is not obtained and no or very less human intervention is possible

In this thesis, we propose the method for mobile object tracking using WMSN. Our main emphasis on tracking the non-communicating objects like animals. The process of mobile target tracking consists of retrieving the exact location of the target in terms of its coordinates during its presence in the monitored area. With the addition of small camera nodes tracking process has attracted much attention. The main difficulty is to manage the tradeoff between network lifetime and tracking accuracy. However, accuracy can be achieved by having each camera active all the time, but this leads to the problem of conservation of energy as the nodes are battery operated and equipped with limited power. Our main focus is to provide the energy aware tracking using the combination of WSN and WMSN. In order to provide better coverage of monitoring area nodes are placed strategically in hexagonal order. We have proposed the solution for tracking in which camera nodes are activated only when they are able to localize the target.

4.2 Existing Methods

Target tracking is always the challenging issues and major area of concern in WSN. There is a requirement of locating the target at each step in this application. Distinct solutions have been proposed in literature for locating the target in the monitoring area.

P. Pahalawatta et al. [45] describes a prediction based method for target tracking. In prediction based methods future position of the target is estimated on the basis of its current location. The approach is based on the Kalman filter.

An autoregressive model is used to predict the future location of targets in [46]. The author used the integration of retrieved mobility parameter with this autoregressive model.

Dynamic clustering is also an important technique and widely used in literature. In this approach a cluster of active nodes is formed around the trajectory of the target and as the target moves further previous cluster is eliminated. Dan Liu, Nihong Wang et al. [35] have proposed an approach of dynamic clustering. In this approach wake up or slept of the sensing nodes is governed by predicting the moving track of the target, this leads to a reduction in the number of tracking nodes and helps to minimize network energy consumption. One other approach based on dynamic clustering is proposed by In-Sook Lee et al. [47]. In this algorithm, there is a description of new cluster head election algorithm which helps to reduce the overlap area between clusters.

L. Liu et al. [48] have proposed a solution of the target tracking problem using the camera sensors. This solution is based on the collaboration of nodes. Authors of [49] propose the two phase algorithm that manages the satisfactory number of active nodes.

When a camera node detects the target it broadcasts the location information. After that each node calculates the detection probability and if it is greater that a predefined threshold node activates its camera. Thus a better trade-off can be achieved between energy consumption and tracking accuracy.

Concept of Heterogeneous network was proposed by P. Kulkarni et al [49]. They propose a three tier camera sensor Sense Eye, in which each tier has its specific task. The limitation of Sense Eye is that it can only be used in the environment where energy is available.

A. Newell et al. propose the use of heterogeneous sensors for event coverage [50]. In this approach scalar sensors are used for determining the event boundary and activate the visual sensors.

4.3 Proposed Approach

In order to detect the target we proposed the architecture of a tracking system that consists of heterogeneous sensor network (combination of WSN and WMSN). Proposed architecture follows the layered approach. The lowest level of the system comprises of sensor nodes, which is responsible for detecting the event. The region of the sensor is divided into small regions that are small in size (patches). Sensors are arranged in a hexagonal fashion to reduce the overlapping area in the Patches. Sensors lies in the same patches are able to communicate with each other. Each patch consist a coordinator node that is multimedia sensor, although there are other multimedia nodes in each patch also. It is the responsibility of coordinating node to transmit the target information to the base station through a local transit network. Periodically awakening and sleeping is done on motion sensors for saving energy consumption

Fig 4.3 shows tracking scenario of the proposed approach in which a prediction based approach based on stochastic analysis is applied for predicting the path of the target based on its previous motion analysis. This analysis is performed on the base station. Based on the previous behaviour of the target base station determine the probable future path of the target and inform the coordinator of the patch where the target will probably move. Coordinator informs the multimedia nodes lie in its patch about the target. Besides it there are the chances that the message does not reach the multimedia node due to various physical and environmental factors i.e. it may be lost. For avoiding this message is also sent to the multimedia node by the motion sensors. The functionality of the system can be elaborated by the following steps

1. When a target enters into the monitored area the motion sensors that are able to locate the target sense the target and transfer a message to the nearest multimedia node.
2. If the message is already arrived then the message which reaches later will be discarded by the node.
3. On receiving the message multimedia node will be activated and waiting for the target to come closer to it. When the target enters into its sensing range it activates its camera and captures the image of the target. The image can be captured only if the target lies in its FOV. The reason behind the strategy is that power consumption in multimedia nodes is greater than the motion sensors so these nodes cannot be activated all the time.
4. This detected information is transmitted to the coordinator node. The coordinator collects all the information from the nodes and transfers it to the base station through a local transit network

4.3.1 Prediction Method

In this section we proposed the prediction method for estimating the future location of the target based on its movements in the previous time intervals. The motion of the target is random.

Let D (t) is the displacement of the target at time t. Consider a time interval (t_1, t_2) in which target trajectory is known. The total displacement of the target in this time interval is [D (t_2) –D (t_1)]. For finding the distribution of the target motion we divide the time interval (a, b) into further small interval, i.e. total displacement in this interval can be treated as sum of random displacement of target over the small intervals as shown in Fig 4.4.

The total displacement of the target in a particular interval depends on the length of intervals instead of boundary points of time ‘a’ and ‘b’ [8]. So it can be concluded that [D (t_2) – D (t_1)] follows the same distribution as [D (t_2+p) - D (t_1+p)] for all $p > 0$.

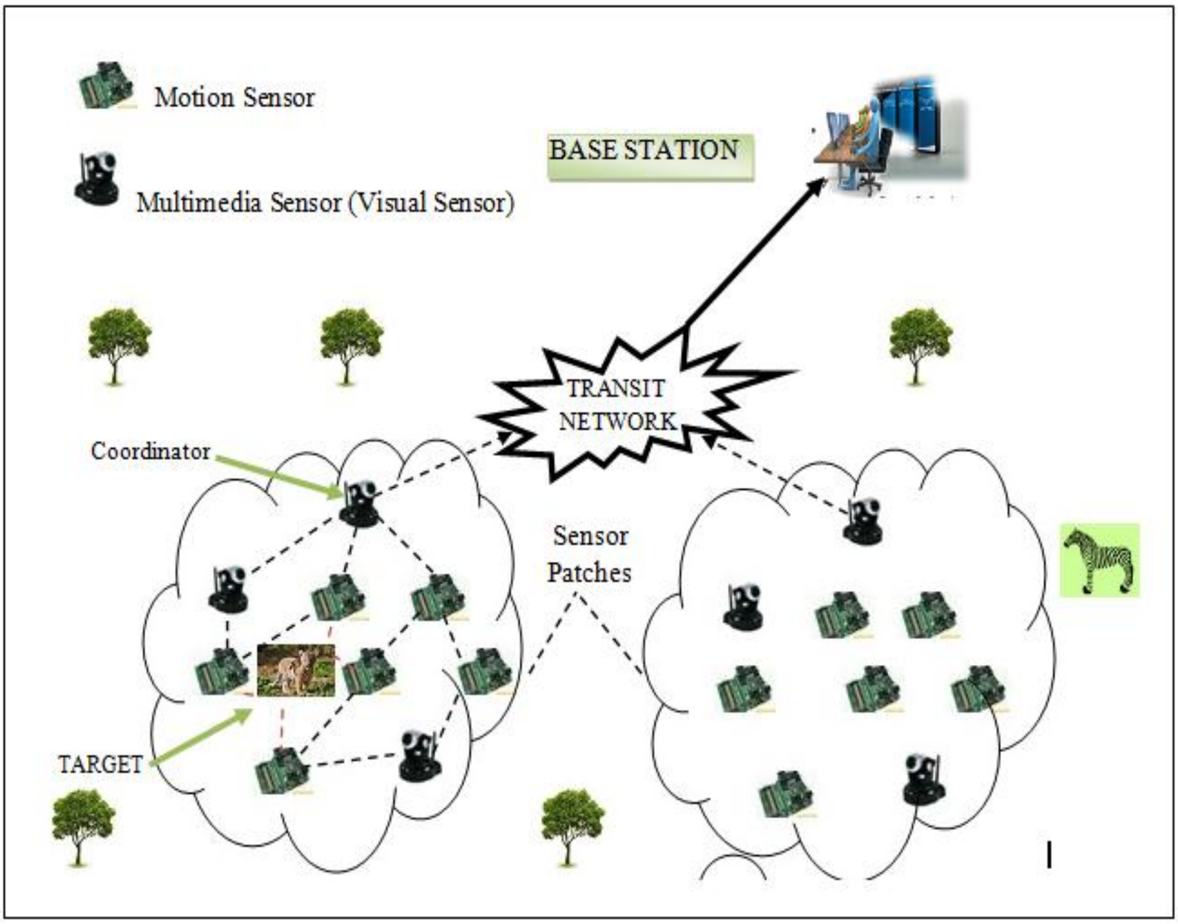

Fig 4.3 Tracking Scenario of Proposed Approach

Suppose random motion of target is independently distributed continuous random variables with probability density function f(s), with ($-\infty< s < \infty$) then

$$D_n = s_1 + s_2 + s_3 + \ldots\ldots s_n \quad \text{or}$$

$$D_{n+1} = D_n + S_{n+1} \tag{4.1}$$

Based on above equations unit step transition density function can be estimated as

$$P(R; D) = P\{ D_{n+1} \le d \mid D_n = R\}$$

$$P(R; D) \quad = P\{ D_n + S_{n+1} \le d \mid D_n \le R\} \tag{4.2}$$

So the distribution of target motion in the time interval t will be

$$f(t) = \int f^{n*}(s)\, f(d-s)\, ds \tag{4.3}$$

Where $f^{n*}(s)$ is the density function of sum of random variables ($s_1 + s_2 + s_3 + \ldots\ldots s_n$) and f(d-s) is the pdf of D_{n+1}

With the help of distribution of target in a particular interval we can estimate the motion of target in the successive intervals.

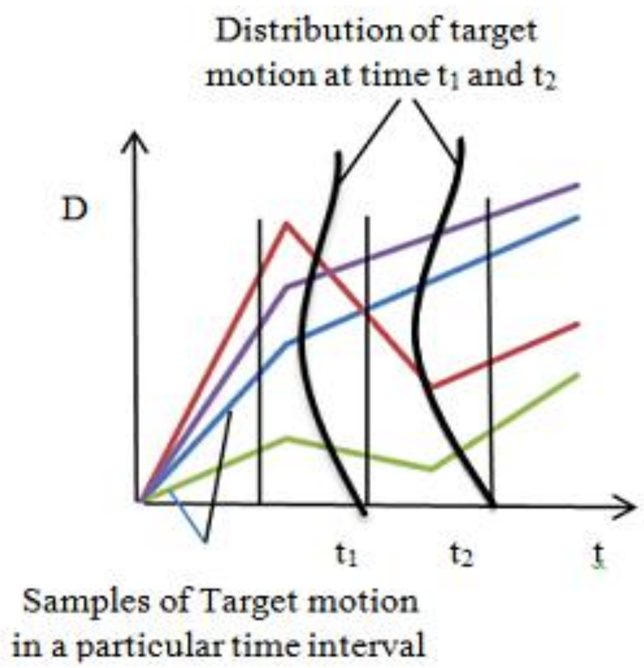

Fig 4.4 Prediction Method

Algorithm for Target Detection

1. **for** each motion sensor detecting the target **do**
2. Inform nearest multimedia sensor about the target
3. **for** each multimedia sensor receiving the message **do**
4. **if** it has already received the message from base station **then**
5. Discard the message
6. **else**
7. Wait for the target to enter into its FOV
8. **if** Target enters into FOV of multimedia Sensor **then**
9. Activate camera and capture the image of target
10. Send the target information to the coordinator

11. else

12. Keep it camera module off

13. **for** each coordinator receiving the message from multimedia sensor **do**

14. Transfer information to the base station through a local transit network

4.3.2 State Machine Model

The complete tracking system is the combination of all the states of the system. These states referred as the possible intermediate states in which system can reside. Fig 4.5 shows the state machine model of the proposed algorithm. One particular state is designated as the initial state and there are transitions from one particular state to other states. Each state is a triplet having three characters, first for the host node, second for the destination node and the third shows the operation in the state. The value 0 indicates that host or destination node is not active and value 1 indicates that a particular entity is active in the operation. In the operation field S shows Sensing, M shows the Message

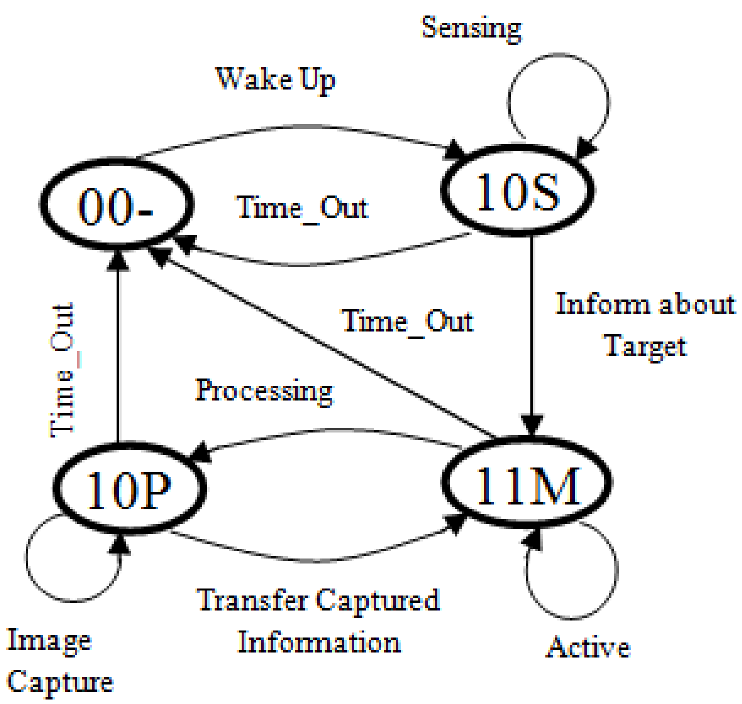

Fig 4.5 State Machine Model

Exchange and P show Processing. Loop in the particular states shows the operation in that state. The initial state is the idle state in which no operation is performed. When node wake up it comes into sensing state and if any target enters in that area, it sense it and come into the message passing state otherwise after them out again come into the idle state. From message exchange it will go into the processing state and if the target approaches towards the node, it will capture image and again enters into the message transfer state for transferring the processed information to the coordinator. In each state node will remain for a particular time interval and after a time out again come into the idle state.

4.4 Analysis

This section consist of detection Probability, Power Consumption by the sensor nodes in target detection and the complexity of the target detection algorithm

4.4.1 Detection Probability

A target can be detected by the sensor nodes if it passes through the sensing range of the sensor nodes. Since multiple sensor nodes are distributed over a region so the sensing area of nodes is overlapped. In this section we assume that target is detected by at least one node before it leaves the area. Fig 4.6 Shows the a sensing area of node and sleeping interval of the node However probability of detection of a target in an area depends on the time and distance travelled by the target in that area

Assuming total sampling time is t and the sleeping time of node is δ then the total detection time can be estimated as

$(t- i\delta)$ where i= 1,2,3. …… (Number of time node goes into sleep mode)

Let the path travelled by the target with Speed V in the sensing range of a node is denoted by P then the probability of detection in that region can be estimated as

$$\frac{\int_S P\,ds}{V\,(t- i\delta)} \qquad (4.4)$$

Where S is the area in which target is detected by the node

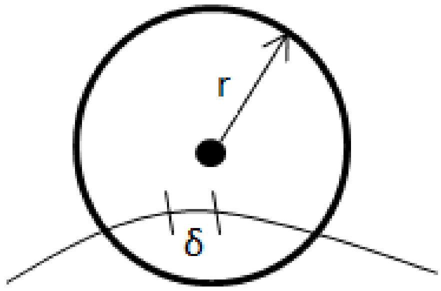

Fig 4.6 Trajectory of Target in Sensing Rang of a Node

If total system area be 'A' then overall probability of detection cam be estimated as

$$\Pr(D) = \frac{S \int_P dP}{V\,(t - i\delta) * A}$$

Where P is locus of the target so

$$\Pr(D) = \frac{\pi r^2 \int_P dP}{V\,(t - i\delta) * A} \tag{4.5}$$

4.4.2 Energy Consumption

WSN follows the multi hop architecture i.e. a path from source to destination consist of multiple intermediate nodes. Total energy consumption in network is based on energy consumed in transmission and reception of packets. However packet size relies on the applications in which sensors are used and the link layer technology. For example in IEEE 802.15.4(Zigbee) maximum packet size is 127 bytes. Periodic wake up and sleep operations are performed by the nodes so sleeping time is also an important factor in estimating the total energy consumption of the network

For a sensor node total power consumption is the sum of power consumed by individual modules like for multimedia sensor total power consumption

$$PC = PC_{Transceiver} + PC_{Microcontroller} + PC_{Camera} \quad (4.6)$$

If total sampling time for a node is t and sleeping time is δ then total active time is (t-iδ).Then power consumption by the node in total active time is

$$E_A = PC_A * (t - i\,\delta) \quad (4.7)$$

Where PC_A is the power consumption by the sensor modules in active mode

So if a node transmits a packet of size r bits at a distance S then total energy consumed in transmitting the message is

$$PC_{Transmission} = E_A * r * S^i + PC_S * \delta \quad (4.8)$$

Where i is the path-loss gradient and PC_S is the power consumption by the sensor modules in sleeping mode

Total energy consumed in reception of packet by the node can be formulated as

$$PC_{Reception} = E_A * r * d_i + PC_S * \delta \quad (4.9)$$

Where d_i is the degree of node I (number of nodes from which packet is received at node i)

So based on above equations total power consumption of node i (PC_T) will be calculated as

$$PC_T = PC_{Transmission} + PC_{Reception} \quad (4.10)$$

4.4.3 Complexity

In this section we have analyzed the complexity of procedure during one round of detection process. In proposed approach when the nodes detect the target it sends the message to the nearest multimedia node. Since WSN follows the multi hop model so the message reaches to the destination through multiple intermediate nodes. This creates a scenario of broadcasting where a random planar graph is created. Broadcasting of message is the major energy consumption part of the process. However if we consider the fault free broadcasting then almost safe broadcasting of message can be possible in time O (D+ log n)[51],where D is the diameter of the graph and n is the number of nodes in graph. After that capturing the image of the target is running in O (1) time as it is independent of the network size. Multimedia sensor transfers the information about the target to the coordinator node in multi hop fashion. Each sensor node has the information about its neighboring node so requirement of selecting the nearest node is exempted. The complexity is dependent on only the number of hops by which information is transferred

Let there are k hop node exists in between the active multimedia node (where $k \leq n$) and the coordinator node then the complexity can be assumed as O (k).

Based on above observations total complexity of the procedures will be given as

$$O(D + \log n) + O(1) + O(k).$$

If we take the number of hops to be maximum that is n then complexity will be

$$\approx O(n)$$

4.4 Conclusion

Reducing energy consumption is always the major research issue in WSN. In this paper we proposed an energy efficient approach of target detection which consists of heterogeneous sensor networks. The major objective of our approach is to utilize the multimedia node in effective manner as it requires high energy in processing. We have applied the prediction based approach on the base station as there is no energy constraint on this. We have provided the analysis of the approach on the basis of detection probability, energy consumption and time complexity. An expression is derived for the total energy consumption of the network in tracking. Detection probability shows the scenario in which target is detected in the monitored area at least by one node and the total complexity of process during one round is given as O (n).

Chapter 5 Conclusion and Discussion

The development of an accurate target detection system has led to some ideas for future direction of research. In proposed system, architecture is proposed for detecting the single target. The main focus is on energy efficiency and localizes the target accurately. Current architecture is based on the concept of residual energy. Nodes are deployed randomly and cluster heads are assigned in each zone.

Generally sensor nodes are deployed over the vast area so multiple events occurs in these areas. As a result sensors must have the ability to classify the different events on the basis of their properties. After classifying and aggregating the whole information regarding the different events heads sends the data to the base station for taking the appropriate decisions.

In this thesis the development of an energy-efficient zone based Target detection system has been addressed. The system needs to meet application-specific detection accuracy requirements. Nonetheless, energy-efficient mechanisms are required to support long-term operation. To optimize the trade-off between detection accuracy and long-term operation, a smart integration of the functionality in the system is furthermore important.

We have proposed a novel distributed event representation paradigm and in-network detection technique. As compared to other existing approaches, this algorithm is using concept of residual energy for making the cluster head in each zone which transfers the one hop tree structure which leads to the minimal delay in disseminating information throughout the network. This makes event detection process faster.

When we talk about the distributed view of the network, scalability becomes the major issue. As efficient clustering methods have been used in this approach, node can join any cluster or leave easily. The bottleneck of the sensor network is the limited energy source of the sensor nodes. To deal with this problem, cluster heads in the cluster are changing time to time in this approach. Due to this energy contained in sensor node are optimized.

The energy consumption in WSNs is still an active research area where a huge body of research is produced. In this thesis besides homogeneous sensor networks we have proposed a solution of tracking with heterogeneous sensor networks. The major goal is to preserve the network energy and maintain an acceptable level of data accuracy. The schemes that we described and discussed try to resolve the energy problem by keeping the visual nodes active only when target enters in its field of. However, we believe that the most energy-consuming layer is the communication layer and the optimization effort should be put on it. In addition, we find that an important research track in geographic and geometric-based schemes is handling distances' and nodes' positions uncertainties in cluster construction. Any error in nodes' coordinates may propagate during the computation process which may lead to wrong results. We believe that taking into account these uncertainties may improve the decisions about the target position predictions and the data reporting especially in multimedia WSNs.

References

1. J. Hill, R. Szewczyk, A Woo, S. Hollar, D. Culler, and K. Pister, “System Architecture Directions for Networked Sensors”, ASPLOS, pp.1-11,November 2000.
2. R. Brooks, and S. Iyengar, “Multi-Sensor Fusion: Fundamentals and Applications with Software”, Prentice Hall PTR, Upper Saddle River, NJ.1988.
3. I. F. Akyildiz, W. Su, Y. Sankarasubramaniam, and E. Cayirci, “A Survey on Sensor Networks,” IEEE Communications Magazine, vol. 40, No. 8, pp. 102–114, 2002.
4. “Wireless Sensor Networks: A Survey”, Computer Networks, Vol. 38, No. 4, pp. 393–422, 2002.
5. N. Bulusu, D. Estrin, L. Girod, and J. Heidemann, “Scalable Coordination for Wireless Sensor Networks: Self-Configuring Localization Systems”, In Proceedings of the Sixth International Symposium on Communication Theory and Applications (ISCTA ’01), Ambleside, Lake District, UK, pp.1–6,2001.
6. C. Intanagonwiwat, R. Govindan, and D. Estrin, “Directed Diffusion: A Scalable and Robust Communication Paradigm for Sensor Networks”, In Proceedings Of the 6th annual International Conference on Mobile Computing and Networking, Boston, Massachusetts, United States, pp. 56–67,2002.
7. F. U. Berlin, “Computer Systems & Telematics Group,” December 2008. Available:http://cst.mi.fuberlin.de/projects/ScatterWeb/hardware/esb/powersupply%.htm.
8. J. Medhi, “Stochastic Processes”.3rd addition, New Age International., 2009.
9. L. Yu, N. Wang, X. Meng, "Real-time Forest Fire Detection with Wireless Sensor Networks,", In Proceedings of International Conference on Wireless Communications, Networking and Mobile Computing, vol.2, pp.1214-1217, 23-26 Sept.2005.
10. National Interagency Coordination Center (NICC) Wild and Fire Summary and Statistics Annual Report 2012, http://www.predictiveservices.nifc.gov/intelligence/2012_statssumm/wildfire_charts_tables.pdf.

11. I.F. Akyildiz, W.Su, Y,Sankarasubramaniam, and E. Cayirci , "Wireless Sensor Networks: A Survey," Computer Networks, Volume 38, Issue 4, pp. 393-422, 15 March 2002.
12. D Zubiete, L.F. Luque, M. Rodriguez and I.G. Gonzalez, "Review of Wireless Sensors Networks in Health Applications," Engineering in Medicine and Biology Society, EMBC, 2011 Annual International Conference of the IEEE , pp.1789-1793, 30 Aug. 2011-3 Sept. 2011.
13. T. Bokareva,W. Hu, S. Kanhere, B. Ristic, N. Gordon, T. Bessell, M. Rutten, and S. Jha, "Wireless Sensor Networks for Battlefield Surveillance," In Proceedings of the land warfare conference, 2006.
14. K.Ramesh1 and K. Somasundaram, “Comparative Study of Cluster Head Selection Algorithms in Wireless Sensor Networks”, International Journal of Computer Science & Engineering Survey (IJCSES) Vol.2, No.4, November 2011.
15. W. Heinzelman, A. Chandrakasan and H. Balakrishnan, "Energy-Efficient Communication Protocol for Wireless Micro Sensor Networks", In Proceedings of 33rd HICS, Vol. 2, pp. 10-18, Jan, 2000.
16. K. Sohrabi et al., “Protocols for Self-Organization of a Wireless Sensor Network”, IEEE Personal Communications, 7(5), 16–27, 2000.
17. O. Younis, M. Krunz and A. Ramasubramanian, "Node Clustering in Wireless Sensor Networks: Recent Developments and Deployment Challenges", IEEE Network, pp. 20-25, May-June2006.
18. W. Heinzelman, A. Chandrakasan and H. Balakrishnan., "An Application-Specific Protocol Architecture for Wireless Micro sensor Networks", IEEE Transaction on Wireless Communications, Vol.1, No.4, pp.660-670, October 2002.
19. C. Liu, C. Lee, L. Chun Wang, "Distributed Clustering Algorithms for Data Gathering in Wireless Mobile Sensor Networks", Elsevier Sci. Journal of Parallel and Distributed Computing, Vol.67, pp.l187 -1200, 2007.
20. Li-Qing Guo, Yi Xie, Chen-Hui Yang and Zheng-Wei Jing “Improvement on LEACH by Combining Adaptive Cluster Head Election and Two-Hop Transmission” In Proceedings of the Ninth International Conference on Machine Learning and Cybernetics, Qingdao, 11-14 July 2010.

21. P. Tillaport, S. Thammarojsakul, T.Thumthawatworn and P. Santiprabhob, "An Approach to Hybrid Clustering and Routing in Wireless Sensor Networks", In Proceedings of IEEE Aerospace, pp. 1-8, 2005.
22. Jannatul Ferdous, Jannatul Ferdous, and Tanay Dey, “A Comprehensive Analysis of CBCDACP in Wireless Sensor Networks”, Journal of Communications, Vol. 5, No. 8, August 2010.
23. Fan Ye, Haiyun Luo, Jerry Cheng, Songwu Lu and Lixia Zhang “A Two-Tier Data Dissemination Model for Large scale Wireless Sensor Networks” ACM, MOBICOM’02, September 23–28, 2002.
24. M. Dhanaraj and C. Siva Ram Murthy “On Achieving Maximum Network Lifetime through Optimal Placement of Cluster-heads in Wireless Sensor Networks” In proceedings of ICC 2007.
25. L.Ying and Y. Haibin, "Energy Adaptive Cluster head Selection for Wireless Sensor Networks", In Proceeding of 6th International Conference on Parallel and Distributed Computing, Applications and Technologies (PDCAT), pp. 634-638, 5-8 Dec., 2005.
26. O. Younis and S. Fahm Y,"HEED: A Hybrid, Energy-Efficient, Distributed Cluster Approach for Ad Hoc Sensor Networks", IEEE Transaction on Mobile Computing, Vol. 3, issue 4, pp.366-379, 2004.
27. H.Chen, C. Wu, Y. Chu, C. Cheng and L. Tsai, "Energy Residue Aware (ERA) Clustering Algorithm for Leach-based Wireless Sensor Networks", In Proceedings of 2nd International Conference on Systems and Networks Communications (ICSNC 2007), pp.40-46,25-31 Aug, 2007.
28. D. Nam and H. Min, "An Efficient Ad-Hoc Routing Using a Hybrid Clustering Method in a Wireless Sensor Network" In Proceeding of 3rd IEEE WiMob, 8-10 Oct, 2007.
29. Sandip Kumar Chaurasiya and Tumpa Pal “An Enhanced Energy-Efficient Protocol with Static Clustering for WSN”, International Conference on Information Networking (ICOIN), 2011.
30. Guihai Chen, Chengfa Li, Mao Ye and JieWu “An Unequal Cluster-based Routing Protocol in Wireless Sensor Networks” Springer Science and Business Media, LLC 2007.

31. Sang Hyuk Lee, Soobin Lee, Heecheol Song, and Hwang Soo Lee "Gradual Cluster Head Election for High Network Connectivity in Large-Scale Sensor Networks", ICACT Feb. 13-16, 2011.
32. Lindsey, S. and Raghavendra, C. "PEGASIS: Power-Efficient Gathering in Sensor Information Systems. In Proceedings of IEEE Aerospace Conference, Volume 3, pp. 1125-1130, 2002.
33. Ahmed M. Herd and Walid Osamy, "Nonlinear Trajectory Discovery of a Moving Target by Wireless Sensor Networks", Computing and Informatics, Vol. 29, pp.647-662, 2010.
34. Yun Xu, Wei Bao and Hongli Xu, "An Algorithm for Continuous Object Tracking in WSNs", International Conference on Research Challenges in Computer Science, 2009.
35. Dan Liu and Nihong Wang Yi, "A Dynamic Cluster Based Object Tracking Algorithm in WSN", Second WRI Global Congress on Intelligent Systems, 2010.
36. Shaohua Liang, Md. Zakirul Alam Bhuiyan and Guojun Wang, "Auction-Based Adaptive Sensor Activation Algorithm for Target Tracking in WSNs", International Joint Conference of IEEE TrustCom-11/FCST-11, 2011.
37. Faezeh Hajiaghajani, Marjan Naderan, Hossein Pedram, and Mehdi Dehghan, "Hybrid Clustering for Multi-Target Tracking in Wireless Sensor Networks", 4th International Workshop on Sensor Networks and Ambient Intelligence 2012, Lugano.
38. Sudakshina Dasgupta, Paramartha Dutta, "An Energy Efficient Genetic Approach for Clustering of Wireless Sensor Network", International Journal of Information Engineering, Vol. 2, Iss. 2, pp. 54-58 , Jun. 2012.
39. Fatemeh Deldar and Mohammad Hossien Yaghmaee, "Designing a Prediction-based Clustering Algorithm for Target Tracking in Wireless Sensor Networks", International Symposium on Computer Networks and Distributed Systems, pp.315-318, February 23-24, 2011.
40. Sunil Kumar Kashyap, K. R. Kambhatla, Bin Zan, Fei Hu and Yang Xiao, "An Energy-Aware and Intelligent Cluster-based Event Detection Scheme in Wireless Sensor Networks", Internal Journal of Sensor Networks, pp.1-11,2005.
41. Lin Fan, Huanzhao Wang and Hai Wang, "A Solution of Multi-Target Tracking based on FCM Algorithm in WSN", In Proceedings of the Fourth Annual IEEE

International Conference on Pervasive Computing and Communications Workshops pp.201-206, 2006.

42. F. Zhao, J. Shin and J. Reich. "Information-Driven Dynamic Sensor Collaboration for Tracking Applications". IEEE Signal Processing Magazine. Volume: 19, No.2, pp. 61-72, 2002.
43. Oualid Demigha, Walid-Khaled Hidouci, and Toufik Ahmed," On Energy Efficiency in Collaborative Target Tracking in Wireless Sensor Network: A Review, IEEE Communications Surveys & Tutorials, VOL. 15, No. 3, pp.1210-1222, 2013.
44. I.F. Akyldiz, T. Melodia, K.R. Chowdhury," A survey on Wireless Multimedia Sensor Networks", In Computer Networks, pp. 921– 960,2007.
45. P. Pahalawatta, T. N. Pappas, and A. K. Katsaggelos, "Optimal Sensor Selection for Video-Based Target Tracking in a Wireless Sensor Network," In Proceedings Of IEEE International Conference on Image Process, Singapore,2004.
46. Z.R.Zaidi and B.LMark, "Mobility Tracking based on Autoregressive Models" IEEE Transactions on mobile Computing, Vol. 10, January 2011.
47. In-Sook Lee, Zhen Fu, Wen Cheng Yang, Myong-Soon Park "An Efficient Dynamic Clustering Algorithm for Object Tracking in Wireless Sensor Networks" DCDIS 2007.
48. L.Liu, X,Zhang," Optimal Node Selection for Target Localization in Wireless Camera Sensor Netwoks", IEEE Transaction on Vehicular Technology Vol. 59, No. 7, September 2010.
49. P.Kulkarni, D.Ganesan, P.Shenoy, Q.Lu, "SensEye: A Multitier Camera Sensor Network", In ACM International Conference on Multimedia 2005.
50. A.Newell and K,Akkay,"Distributed Collaborative camera actuation for redundant data Elimination in Wireless Multimedia Sensors networks", Ad Hoc Netwoks, 2011.
51. Andrzej Pelc and David Peleg "Feasibility and Complexity of Broadcasting with Random Transmission Failures", PODC, pp.334-341, 2005.

List of Publications

1. Pawan Kumar Gangwar, Yashwant Singh, and Vandana Mohindru, "An Energy Efficient Zone-based Clustering Approach for Target Detection in Wireless Sensor Networks", Accepted in IEEE ICRAIE, May 9-11,2014.
2. Pawan Kumar Gangwar, Yashwant Singh and Vandana Mohindru," Heterogeneous Sensor Network for Target Detection: A WMSN Perspective", Accepted in ELSEVIER ERCICA, Aug. 1-2, 2014.

Appendix

Java code for proposed algorithm is given below. In this we have used the java swing for creating the target tracking scenario. Nodes are generated randomly and the tracking interface is divided into 16 zones. The code for simulation class is as follows

Simulation .java

```
import java.awt.BorderLayout;

import java.awt.Color;

import java.awt.FlowLayout;

import java.awt.Font;

import java.awt.Graphics;

import java.awt.event.ActionEvent;

import java.awt.event.ActionListener;

import java.util.jar.JarFile;

import javax.swing.JFrame;

import javax.swing.JPanel;

import javax.swing.Timer;

        public class Simulation extends JPanel {

            private static final long serialVersionUID = 1L;

            private int x = 0;

            private int y = 0;

            private int xIncrement = 5;

            private int yIncrement = 5;
```

```
private final int R = 5;
private Timer timer;
public Simulation() {
// TODO Auto-generated constructor stub
timer  = new Timer(25, new ActionListener() {
@Override
public void actionPerformed(ActionEvent e) {
// TODO Auto-generated method stub
Simulation.this.repaint();
}
});
timer.start();
}
public static void main(String[] args) {
JFrame jframe = new JFrame();
jframe.getContentPane().add(newSimulation(),BorderLayout.CENTER);
jframe.setDefaultCloseOperation(JFrame.EXIT_ON_CLOSE);
jframe.setSize(800, 800);
jframe.setVisible(true);
}
public void paintComponent(Graphics g){
super.paintComponent(g);
try {
```

```
                draw(g);
        Color c = new Color(0,255,0);
          g.setColor(c);
                if (x<0||x> getWidth()){
                        xIncrement*= -1;
                }
                 if(y<0||y>getHeight()){
                        yIncrement *= -1;
        }
                x+=xIncrement;
                y+=yIncrement;
                g.fillOval(x-R, y-R, R*2, R*2);
    }           catch (InterruptedException e) {
                // TODO Auto-generated catch block
                e.printStackTrace();
            }
        }
public void draw(Graphics g) throws InterruptedException{
        Color c = new Color(255,255,255);
        g.setColor(c);
        g.fillRect(0,0,800,800);
        Color black = new Color(0,0,0);
        g.setColor(black);
```

```
g.drawLine(0, 0, 800, 0);
g.drawLine(0, 0, 0, 800);
g.drawLine(800, 0, 800, 800);
g.drawLine(0, 800, 800, 800);
g.drawLine(0, 400, 800, 400);
g.drawLine(200, 0, 200, 800);
g.drawLine(400, 0, 400, 800);
g.drawLine(600, 0, 600, 800);
Font font1 = new Font(TOOL_TIP_TEXT_KEY, FRAMEBITS, 15);
g.setFont(font1);
char[] node = {'+'};
char[] head = {'+'};
for(int i=0; i<700;i++){
	int x = xarr[i];
	int y = yarr[i];
	g.drawChars(node, 0, 1, x, y);
}
Font font = new Font(TOOL_TIP_TEXT_KEY, FRAMEBITS, 20);
g.setFont(font);
Color c1 = new Color(255,0,0);
g.setColor(c1);
g.drawChars(head, 0, 1, 95, 215);
g.drawChars(head, 0, 1, 290, 190);
```

```
                g.drawChars(head, 0, 1, 510, 210);

                g.drawChars(head, 0, 1, 699, 195);

                g.drawChars(head, 0, 1, 105, 595);

                g.drawChars(head, 0, 1, 310, 610);

                g.drawChars(head, 0, 1, 520, 600);

                g.drawChars(head, 0, 1, 695, 600);

        }

}
```