AN EFFICIENT LOCALIZATION ALGORITHM USING DIRECTIONAL ANTENNA IN WIRELESS SENSOR NETWORKS

A Dissertation submitted

By

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To

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Under the guidance of

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AN EFFICIENT LOCALIZATION ALGORITHM USING DIRECTIONAL ANTENNA IN WIRELESS SENSOR NETWORKS

DECLARATION

I here by declare that the dissertation proposal entitled, **An Efficient Localization Algorithm in Wireless Sensor Networks using Directional Antenna** submitted for the M. Tech. Degree is entirely my original work and all ideas and references have been duly acknowledged. It does not contain any work for the award of any other degree or diploma.

Date: 05/05/2015 **Shalini Gautam**

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ABSTRACT

A Wireless Sensor Network is a group of sensor nodes, which are inside a sensor field. Each sensor gathers data and communicates with other nodes using radio frequency. Sensors use multi-hop links for transferring the sensed data. WSN is a multi-hop network and does organisation of nodes by itself. A sensor node consists of a small memory, a processor, a sensor and a battery. Battery power is important factor to the life of a sensor node. One of the base issues of WSN is being aware of the position of the node because for any application which need information from a specific region of WSN deployment we need location information of the individual nodes. Otherwise the reported data will not be useful. Its applications have attracted the interest of researchers in past years. Its applications have made several innovative and challenging research areas in telecommunication world Applications of WSN range from military, household, medical, tracking patients, detecting snipers, monitoring physical environment, marine, natural disaster monitoring, parking management, early warnings and other emergency situations. Main goal in WSN is to minimize the location error and power consumption. For finding out the position of a sensor node we may equip it with built-in GPS receiver, using directional antenna, by using mobile stations etc. But GPS receivers do not work in dense areas and closed environments and are costly. Wireless Sensor Network must be reliable and scalable. They must be secure against outside attacks on network. It is needed to design localization mechanisms which are low-cost, scalable, and efficient for WSNs.

In this paper, we have used an efficient algorithm using directional antenna having angle of 90 degrees. It consumes less power and localizes the nodes in a network quickly and saves time. This algorithm can work for any number of nodes with lesser errors. One more benefit is that the nodes are localized while they are moving within the network.

CERTIFICATE

This is to certify that **Shalini Gautam** has completed M. Tech. dissertation proposal titled **An Efficient Localization Algorithm in Wireless Sensor Networks using Directional Antenna** under my guidance and supervision. To the best of my knowledge, the present work is the result of her original investigation and study. No part of the dissertation proposal has ever been submitted for any other degree or diploma.

The dissertation proposal is fit for the submission and the partial fulfilment of the conditions for the award of M. Tech. Computer Science & Engineering.

Date: 05/05/2014

Signature of Advisor

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UID: 16920

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Date: 05/05/2015

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INTRODUCTION

1.1 Introduction

WSN in its simplest form can be defined as "a network of nodes that can sense the environmental conditions and transfer the information gathered from monitored field through wireless links to the users." The data is forwarded via number of hops relaying to sink where it is used locally or if connected to another network (internet) through a gateway.

In WSN, localization is one of the most important technologies since it plays critical role in many applications. A sensor network is made up of several sensor nodes positioned in a sensor field. A sensor node has a small memory, a processor, a sensor and a battery. The battery power decides the lifetime of a sensor node. Each sensor node gathers data and transfers that information by making use of wireless radio frequency. Also it makes use of multi hop links for transmitting the sensed data to the base station. Data is best analysed and used at the base station. Memory of the sensors is limited. Memory capacity varies from sensor to sensor. After losing the battery node becomes permanently dead. Sensors which are aware of their locations improve the routing efficiency and forward data only to the selected direction towards the destination.

- Either the nodes are fixed or moving.
- Nodes may be aware of their positions or not
- Nodes may be heterogeneous or homogeneous.

Sensors are very small in size and they have capability to store and forward data. Some of the sensors may be too small as the size of a dust particle so that enemies could not detect

or destroy them. Sensors which are aware of their locations improve the routing efficiency and forward data only to the selected direction towards the destination.

Micro-sensors are not only used in military but also in health care industry, food industry, in agriculture, environmental and weather information gathering. Thus we can make preparations in advance from bad weather and natural disasters. These are wirelessly connected to each other and they at appropriate times send information back to selected nodes. A variety of sensors are there which include acoustic, seismic, image, heat, direction, smoke, temperature sensors etc. Their construction requires highly integrated electronics such as MEMs (micro electromechanical systems).

In WSNs, sensors are positioned in a real environment to examine some physical behaviour. These have several research challenges. These nodes are small devices which have lesser cost and lesser processing capabilities. These are quite different from traditional ad hoc networks and those of mobile networks in a number of ways. Various research issues in WSNs which affect the design as well as performance of entire network such as operating system and hardware, middleware, time synchronization, medium access schemes, deployment, localization, wireless sensors, transport layer, quality of service, network layer and network security.

WSNs are gaining momentum as they have great potential for both research and commercial applications. It is not easy to build efficient and scalable protocols in wireless sensor networks because resources are limited and high scale and dynamics is needed. Geographic protocols take the advantage of the localized position information of nodes and are quite valuable for the sensor networks. In addition to their fast response, the state needed to be maintained is minimum and the overhead is low.

It is quite difficult to localize the nodes estimate and calculate location of sensors using specialized algorithm. Localization is a process of detecting the position of sensor nodes because data and information are of no use if the nodes do not know their geographical positions. Several algorithms have been proposed to solve the issues in localization.

Unknown nodes determine their positions by beacon messages received from anchors, which require high power. If node estimation is wrong, then this error is propagated in the entire network and to the rest of the nodes. Thus wrong information of these nodes location is forwarded. Distance between nodes is the main factor to determine position of unknown nodes.

Some of the technical challenges behind the realization of WSN are:

- Device fabrication
- Power life conservation
- Energy efficient protocols
- Distributed computation
- Scalability
- Data dissemination path derivation
- Security

Mostly sensor nodes are deployed in the field where human beings cannot survive. Sensors are thrown from an airplane in the area of interest. Battery power of the node plays an imporatnt role. Sensor networks gather information from the area of interest and report the occurrence of events to users. To monitor certain area, which also includes identifying, detecting, localizing and tracking objects of interest are the targets of a sensor network. These networks are also of benefit in military and combat fields or in intrusion detection. One of the main needs in WSN is lower consumption of energy. Main energy consumption in the network is due to receiving packets of information location of the nodes.

Wireless networks might be distinguished as two types: (a) infrastructure network and (b) ad-hoc (infrastructure less) networks. Infrastructure network is a type of a network which has fixed and wired gateways. On the other hand, mobile ad hoc network is an aggregation of wireless mobile nodes in which nodes team up by sending packets for each other to permit them to communicate outside range of direct wireless transmission.

Ad hoc networks do not require any fixed network infrastructure such as base stations or access points, and could be rapidly and economically set up as required.

Localization process starts from the anchor node itself. Neighbors of anchor nodes use this information to localize themselves by making use of the techniques AOA, RSSI etc.

1.2 SECURITY IN WSN

Undoubtedly, WSNs are prone to different sorts of compromises that explore known and obscure vulnerabilities of protocols, software and hardware, and threaten the security, integrity, authenticity, and availability of data that resides in these networked systems.

WSNs are vulnerable to different kinds of threats and attacks, like spying, packet relay, intrusion, and nodes trade-offs. While the greater part of dangers could be managed by using cryptographic keys, some different dangers, such as node replication attacks, can in any case go imperceptible. One more popular attack is node duplication, in which an attacker uses node and gets it cryptographic key materials and induces several clones of it into the network.

1.3 LOCALIZATION AND ITS NEED

Localization of the nodes is done via communication between known (anchors) and unknown nodes in a network to determine their accurate location or position. We can find the position of the nodes using GPS which is the simplest one, but it is quite expensive if we have a large network with several nodes in it. It is considered that only few sensor nodes know their absolute positions which may be either via manual configuration or by using GPS systems. Those are called anchor nodes. Using GPS on each node costs a lot. Positions of the anchor nodes are used as a reference to calculate the positions of sensors with unknown locations. Proper placement of the anchor nodes is very necessary to increase localization accuracy. Sensor nodes which are aware of their locations in the network improve routing efficiency, these forward data only in the direction of the destination. If one node’s location is determined incorrectly then this inaccuracy is

propagated in the entire network. Mainly distance is important factor to determine the positions of the unlocalized nodes from anchor nodes.

Location may be determined by distance or angle between the nodes. Main concepts and techniques which come under localization are as:

- **Lateration:** in this the distance between nodes is taken as a factor to estimate the location.
- **Angulation:** in this method angle between the nodes is taken to measure the distance.
  - **Trilateration:** In this the intersection point of any three circles is calculated which estimates the position of a new sensor node.
  - **Multilateration:** More than three nodes are used for localization
  - **Triangulation:** In this technique at least two angles of unlocalized nodes from localized nodes are calculated. After this trigonometric rule, sine and cosine laws are used to determine location of unlocalized nodes.

LOCALIZATION SCHEMES

- **Anchor based and anchor free:** In anchor based, location of some of the nodes is known and those nodes help in determining the location of the other nodes. More is the number of anchors, higher is the accuracy. In anchor free scheme, the only relative positions are estimated not absolute ones.
- **GPS based and GPS Free:** In GPS based scheme, a GPS is installed on each node which is very costly but gives accurate results. In GPS free scheme, no GPS is installed. Results are also not that accurate as in GPS. Only relative locations are calculated. But also some of the nodes can have GPS on them in the network, which are called as anchor nodes. Only anchor nodes start the process of localization.
- **Stationary and Mobile sensor nodes:** When sensors nodes move within the network from one place to another, those nodes are called as mobile nodes. When

nodes are fixed to one position then that scenario is considered as called stationary.

- **Range free and Range Based:** Range-free methods make use of radio frequencies for communication between the nodes to calculate their location. In range-free methods, angle of arrival, distance measurement and special hardware are not used. Range-free methods are distance vector (DV) hop, centroid system, APIT and gradient algorithm.

Range Based Localization: In this localization is done on the basis of angle and distance between the nodes. Main techniques in this are angle of arrival (AoA), Time of arrival (ToA), Time difference of arrival (TDoA), Received signal strength (RSSI) etc.

- Time Difference of arrival: The time difference of arrival of radio and ultrasound signal is to localize the nodes and calculate how far they are from the anchor nodes. Nodes are equipped with a microphone and a speaker. On sending signals anchor node wait for certain amount of time, generates *"chirps"* with the help of speaker. These signals are received by unlocalized node at time, it turns on microphone. Whenever chirps are detected by microphone, unlocalized node records the time.
- Angle of Arrival: Uses geometrical relationship for calculating the relationship with neighboring nodes. The angles at which unknown nodes receive the anchors signals. Those nodes make use of triangulation method for estimation of their locations.
- Received Signal Strength Method: In this signal strength is measured by which distance between the anchor node and unlocalized nodes can be estimated. As the distance increases, signal strength gets decreased.
- Time of arrival (ToA): In this the speed of the wavelengths and arrival time of radio signals are measured which help in detecting the positions of localized and unlocalized nodes.

1.4 Need of Localization:

- Nodes cannot be manually configured everytime in large scale WSNs

- Location information is necessary for some applications and services eg. Geographical routing.
- It is not always possible to provide GPS on each sensor node.

Domain Composition Methods:

- Trilateration: It does localization by calculating intersection point of three circles.
- Three Angles: In this nodes position is calculated by using trigonometric rules.
- Multilateral: It localizes the position of a node based on three or more nodes in the network.

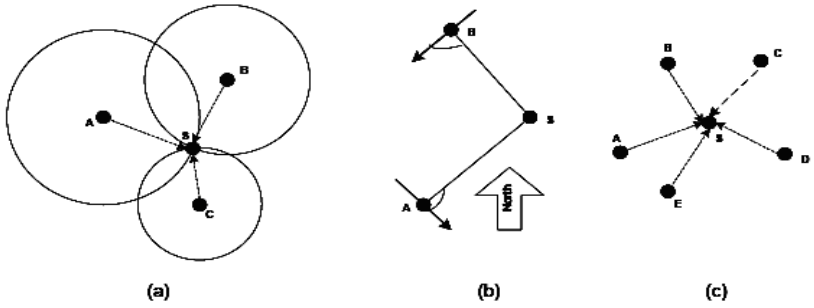

Fig 1.1 Domain Composition Methods

1.5 ANTENNA MODELS

Main purpose of directionality of signals is to improve transmission and reception of communications and to reduce the interference. An Omni directional antenna transmits radio frequency (RF) and electromagnetic signals equally in all directions which can cause interference of the signals and error in messages can also occur. A directional antenna only transmits data in selected direction towards the destination. Their maximum gain is only in one direction. In this case chances of error are very less. Bidirectional

antennas have two high gain directions which are oriented in opposite directions. Types of antenna models are as:

- **Directional Antennas**: Directional antenna make use of point to point transfer of the data. These have the narrowest beamwidth possible. These types of antennas provide better gain than the other antenna models. These are least interfered by noise.
- **Sector antennas:** Sector antennas transger data from one point to multiple points in various applications. In these antennas, beam width is usually taken between 45-180 degrees.

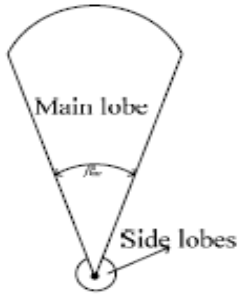

Fig 1.2 Sector antenna

- **Omni directional antennas:** These distribute radio signals in all the directions with beamwidth 360 degree. Biggest disadvantage is that signals are also sent in the directions where no client is present. These increase the problem of hidden nodes.

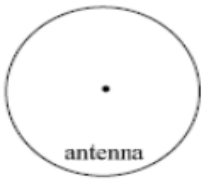

Fig 1.3 Omni-directional antenna

- **Bi-Directional Antenna:** These have two high gain directions oriented in opposite directions. It is mainly used for highway coverage.

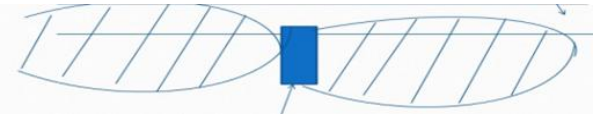

Fig 1.4 Bi-directional antenna

Some localization methods have been proposed by making use of omni directional antennas on anchors because these are simple to mount and are less costly. But the transmitted data is prone to interference by environmental noise as it is radiated in all the directions. This may lead to big localization errors. On the other and directional antenna send data in a single direction which cause lesser interference and give more accurate results. Thus receiver can avoid most of the interference which comes in way and increase signal to noise interference ratio (SINR).

By just focusing the beams in a single direction avoids noise and provides larger free channel space. This in result provides larger spatial reuse. Thus a large number of transmission can be done at a time withot any collision. A sender can send data to the destination with high power. It provides the users two kinds of advantages. Signal can be sent with comparatively lower power towards the destination whereas an omni directional antenna needs higher power. Thus the total amount of energy consumed becomes less. Secondly the range of the transmission can be increased. A beam which has been focused towards the destination covers greater distance and has smaller number of hops. It increases throughput, reduces delay. Beam focusing antennas improve network performance, signal quality, increase system capacity, reduce interference and noise, save power.

A communication model is also there by which the nodes do communication between them. This resolves the problem of location estimation. In the given model, only sensor node S receives beacon message from AS but S_1, S_2, S_3 cannot. Mobile anchors have a predefined trajectory in sensor area. This path is designed in such a way that it can cover all the nodes in its area. When the coverage area of the directional antenna is is localised by a node, then it receives messages from the anchors with higher accuracy.

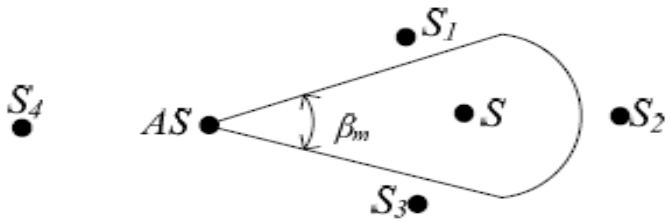

Fig 1.5 Communication Model

1.6 ARCHITECTURE OF SENSOR NETWORK

A wireless sensor is comprised of both software as well as hardware components. Processors, power unit and a radio transceiver.

The basic block diagram of a wireless sensor network is presented in figure

The main components are:

a. Processing unit
b. Power supply
c. Sensing unit
d. Communication/ Transceiver unit
e. Software part

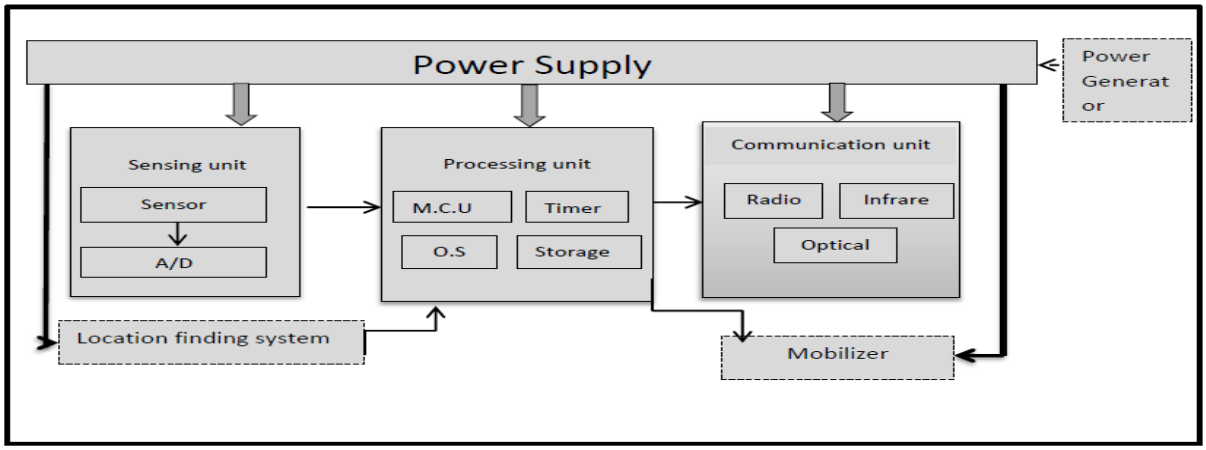

Fig 1.6 Sensor Node Components

a. Processing Unit

Data is collected from various sources and is stored by the processing unit. The CPU of a sensor node checks the consumption of energy and computational capacities. To increase the flexibility of CPU micro-controllers, microprocessors and FPGAs are used.

- **FPGAs** (Field Programmable Gate Arrays) these are used for testing purposes
- **Microcontroller-** is a general purpose processor having non-volatile memory and interfaces. A microcontroller has three states: active, sleep and idle. These states are useful in saving the power consumption.
- **Operating System-** A general purpose operating system consists of millions of lines of codes but WSN makes use of thousands of lines of codes. So, WSN use less complex operating system e. g. TinyOS, SOS etc.
- **Timer/Clock-** For sequencing purpose a timer is needed. There are several types of timers as electronic, electromechanical, mechanical, digital etc..
- **Memory-** As per need of the application, appropriate size of memory should be selected. It also affects the power consumption and cost

b. Power Unit: Battery affects the life of a sensor node. It provides long life, stability of voltage, has ability to recharge under low current, and has low self-discharge.

- **Battery:** Batteries are of two types: primary and secondary (rechargeable or non-rechargeable). To manage the energy two techniques are there. (a) In DPM, three stages of microcontroller are there: active, sleep and idle. Thus devices themselves got shut down when they are not needed and wake up when needed. (b) In DVS, power is lowered by the processor by reducing voltage.

c. Sensing Unit

- **Sensors-** A sensor senses any physical phenomenon which can be speed, temperature etc. Then this information is converted into analog form. Then processing unit processes that data and make human readable. In a sensor network there are large

number of nodes depending upon the application. Two types of sensors can be there: active or passive. An active sensor is one which senses the conditions and manipulates them accordingly e.g. radar. A passive sensor only senses the conditions but does not do any alteration e.g. thermometer.

- **A/D converter**- Analog signal is converted into digital signal and is send to the microcontroller for processing.

d. Communication or Transceiver unit

A transceiver may send or receive data from sensor nodes by using radio frequency. When a processing unit sends commands to it, then the transceiver passes those commands to the network. A communication channel is also there. Three types of communications are considered which are as optical communication, infrared communication. A transceiver has four modes of operation which are as: sleep, active, dormant.

- Sleep Mode: In this mode, nodes do not accept or receive any data frames. They turn off all their devices. But on listening to data frames they turn on the devices.
- Active Mode: Devices can send or receive data normally.
- Dormant Mode: Low-power mode of the nodes is enabled in this mode.

A sensor network consists of a large number of sensor nodes. Nodes are placed either inside the sensed region or nearby the region.

1.7 APPLICATIONS

WSNs are used in many fields and applications these days. There are several applications of wireless sensor networks in several fields. Some of which are as:

a. In Military

- To monitor forces and the weapons and equipments being used sensor networks are used. These are also used to detect nuclear, chemical attacks etc.
- To target the enemies as well
- To investigate the opposing forces

- To observe the entire battlefield

b. Environment

- Air Pollution Monitoring is a common application in WSN. Level of dangerous gases is monitored using sensor nodes.
- Forest Fire Detection**:** Sensor nodes are also helpful in detecting the fire in the forests.
- Water Quality Monitoring: It includes testing the properties of water in rivers, lakes, oceans, underground water etc.
- Natural Disaster Prevention: WSN can prevent people from harmful consequences of disasters, floods, landslides.
- Water/Waste water monitoring: It may be used to prevent the water wastage.

c. Health Care Monitoring: Monitoring of patients in hospitals as well as at homes can be done by WSN.

d. Home and Office Applications:

- Home and office automation
- Smart environment

e. Automotive Applications:

- Reduces wiring effects
- Measurements in chambers and rotating parts
- Remote technical inspections
- Conditions monitoring e.g. at a bearing

f. Other Commercial Applications:

- Environmental control in office buildings (estimated energy savings $55 billion per year!)
- In museums which are interactive, sensor nodes are used
- To monitor any kind of theft of cars and detect them
- To track the vehicles and detect them.

g. Industrial Monitoring: In industries, the process by which goods are made are monitored using sensor nodes. If there is any kind of fault, then it is reported back.

h. **Traffic Control System:** Sensor nodes are also used in traffic systems for monitoring travelling vehicles and activities of the drivers etc.

1.8 Factors that affect WSN:

There are several factors that affect a wireless sensor network. Some of which are as follows:

- Fault tolerance
- Scalability
- Production costs
- Hardware constraints
- Sensor network topology
- Environment
- Transmission media
- Power Consumption
- Sensing
- Communication
- Data processing

1.9 Sensing in Wireless Sensor Network:

- Periodic Sensing: It is the process of sensing the events and queries periodically i.e. after a certain period of time.
- Query Sensing: It is the process of sensing only the queries and not the events.
- Event Sensing: It is the process of sensing only the events and not the queries.

1.10 Classification of localization for WSN:

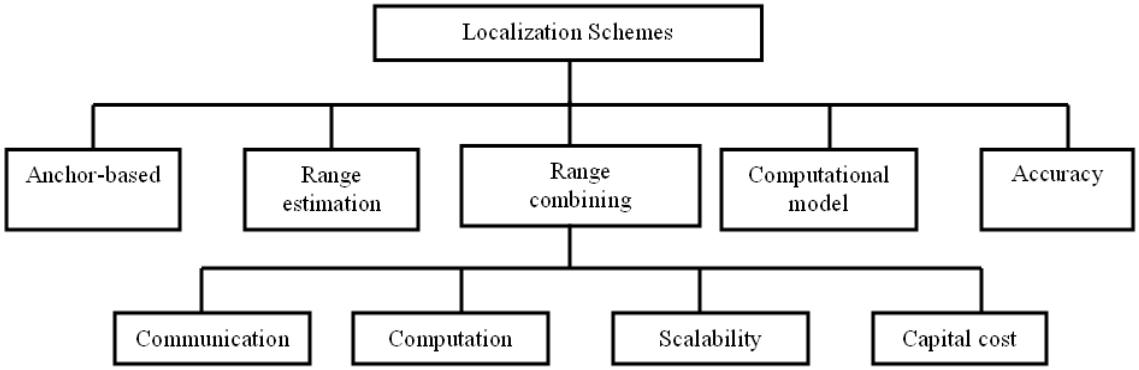

Fig 1.7 Classification of localization

Classification of Localization Techniques

It uses two types of algorithms ranged based algorithms and range free algorithms.

Range-based and Range free

- **Range based** Range based algorithms mainly depend on factors as distance, angle beween nodes etc for localization. These are as received signal strength (RSSI), time of arrival (ToA) and angle of arrival (AoA).In such algorithms extra hardware is needed for sensors which increases the cost and power consumption.
- **Range Free** Range free localization algorithms are of two types: centralized and distributed. Centralized algorithms are those algorithms in which each sensor sends its information to a base station where a map of the entire network is mde to estimate position of nodes. Whereas distributed algorithms depend on the content of message exchange. Example of range free localization algorithm is Distance Vector by Hop counting (DV-Hop).

Table 1: Comparision of localization algorithms

Localization Algorithm	**Modus Operand**	**Accuracy**	**Hardware Cost**	**Computational Cost**	**Communication Cost**

Range Based	Distance Based Techniques RSSI, TDoA	Medium	Low	Low	
	Angle Based Technique AoA	High	High	Low	
Range Free					
	Centralized	High		High	High
	Distributed	Median		Median	Low
	Beacon Based	Very High	High		
	Beacon Free	Median	Very Low		

1.11 CHARACTERISTICS

The main characteristics of WSN include:

- Power of the nodes is consumed with time which use batteries
- Nodes are mobile
- Easy to use
- These can withstand harsh environmental conditions
- Heterogeneous nodes may be used
- Application specific

The sensed information received by base station is used according to the requirement of the applications. Several issues are in WSN networks are as cost, power consumption, complexity, short range, Installation, mobility etc. It becomes costly to place GPS on each sensor node. User usually installs the sensors in those places where he cannot reach so easily for example underwater, country border etc.

1.12 FEATURES OF WIRELESS SENSOR NETWORKS

- WSN replaces the physical presence of human beings.

- It can be easily extended by deploying more sensor nodes.
- These are easy to configure.

1.13 ISSUES IN WIRELESS SENSOR NETWORKS

- Energy of the nodes continuously goes on decreasing. So after sometime nodes may lose their energy and may fail
- Memory capacity of sensor nods is quite low. So limited data is stored in them.
- When the distance between sink and source is very large it becomes expensive to manage the communication.
- Consumption of energy is serious factor for the life of the network.
- To reduce errors in transmission of data.

Chapter 2

REVIEW OF LITERATURE

There are several research efforts that exist in the field of WSNs. Many protocols in WSN have been proposed depending upon particular need of an application and the architecture of the network. Energy efficiency is the most important factor among these factors, since it directly affects the lifetime of a network.

2.1 Review of Literature

Some of the papers have been considered that has been taken as a motivation towards my study.

Ramin Ahmadi *et. Al* (2012) proposed a scheme for localization using mobile station. It is necessary to know the position of a node in WSN. GPS is there on each sensor to determine node's position. By using based stations consumption of energy becomes less but by making use of GPS on each based station can cost higher. In this scheme a mobile station is used to calculate position of a node with good accuracy. A combination of radio frequency and supersonic determines distance. In this scheme a mobile based station is used to locate fixed nodes. Some assumptions which are made in this algorithm are as: Fixed nodes are self- organizing. Position information of mobile node is broadcasted to sensor nodes. A mobile based station has a GPS, radio frequency and an ultrasonic transmitter. Nodes which are fixed contain ultrasonic and RF receiver.
Mobile nodes broadcast radio and ultrasonic signals after fixed intervals. WSN has nodes with low power, low memory and less processing capability. A radio signal has its current position and remainder time (RT). Firstly RT is T and then after localization it becomes zero. A fixed node selects three based points to calculate its position.

After locating the position, sensor node sets RT=0 and goes to sleep. If node could not get three different based points even after RT, it will ask its nearby nodes to send their position information so that it can calculate its own position accordingly. This algorithm

has high performance as it needs three distances to based points. So it is least affected by internal transfer of packages. Less consumption of energy is there in this algorithm and positioning error is less.

Mani B. Srivastava *et. Al* (2010) proposed a scheme in which a practical guideline depending upon the energy histogram has been derived. To enhance the routing in the networks, a new technique spectrum has been presented. First approach combines packet streams robustly resulting in the reduction of energy. Second, more uniform resource utilization has been proposed which is obtained by shaping the traffic flow. Various techniques have been proposed which depend on localized metrics and are evaluated and it has been shown that these may lead to an increase in the network lifetime which may be up to extra 90% which is beyond the achievement in our first approach.

Vijay K. Chaurasiya *et. Al* (2009) proposed this scheme. With the knowledge of location, directional packet forwarding is used which in result will reduce the network load. In WSN it is necessary to design localization algorithm which consume less power. In this directional antenna is used in each sensor node. Sensor network gather information from a certain area and sends that information to the sink node which processes the data and makes available on the internet. Sensors which know about their positions can also improve routing efficiency. Mainly in this scheme few anchor nodes are used which have previous knowledge of their locations. Anchor nodes are fitted with GPS receiver. In this each sensor node collects information from the other nodes and transmits it to a centralized processing unit which as a result calculates the location of every other sensor node. Nodes transmit information of its neighbour and angle of neighbour. The process of localization starts from the anchor node only. In sensing field sensor nodes are randomly distributed. Anchor nodes are distributed such that every other node can get information from them. Finally we concluded that if we increase the number of anchor nodes we get better accuracy and error increases w.r.t. increase in beam width. If we increase the number of hops, the error also increases. The complexity of this

algorithm increases with the increase in number of nodes. One limitation of this algorithm is that it cannot support mobile sensor nodes.

Kemal Akkava *et Al* (2003) Routing protocols in sensor networks have been surveyed in this paper. It shows the classification for different approaches. Data-centric, hierarchical and location-based categories have been explored in this paper. Under apt category each routing protocol has been elaborated. Protocols those use contemporary technologies as the network flow and quality of service modelling have also been discussed. The papers deals with open research issues.

Ahmed A. Ahmed *et Al* (2006) In this paper a new hybrid localization scheme was proposed by Ahmed A. Ahmed et Al by referring three localization algorithms, which are as: ad-hoc positioning system, multi-dimensional scaling and semi-definite programming. Networking properties have also been taken under consideration which is supposed to affect the localization performance. These are as: (a) Network topology, (b) Average connectivity, (c) Measurement error, (d) Anchor ratio, (e) Anchor placement.

In this method, adaptive localization system is implemented either by a centralized or distributed manner. Firstly, by exchanging the information between the sensor nodes, networking properties are discovered. Then above three algorithms are run to obtain at least three estimated position of each sensor node in the network. Then a final position estimation is done based on networking properties by combining three location estimates by making use of a predetermined weighted-sum formula. Localization error for any non-anchor node i, $e_i' = ||x_i - x_i''||$

Mean error $\bar{e}_k = \Sigma\, e_i/N$ for every run k

Final mean localization error $\bar{\bar{e}}_k = \Sigma\, e_k'/R$, & R= number of runs.

Measured distance d_{ij}' between the nodes is

$d_{ij}' = d_{ij}\{\max[0,(1+Xe_r)]\}$

where d_{ij} = true distance between the nodes

e_r = ranging error.

It was concluded that weight of APS is almost zero in several cases. Resultant is only combination of MDS-MAP and SDP. In ALS, weight of SDP is more than MDS-MAP for sparse network and less for denser.

SungHwi Kim *et Al* (2012) have explained the issues of hole problem which is faced by the data dissemination protocol in Wireless Sensor Network. They described that whenever sensor nodes are failed due to energy consumption or any physical destruction then holes are generated. Hole masking algorithm is proposed in this paper to deal with various holes in WSN and to reduce the energy consumption and to increase the lifetime of wireless $sensor network by avoiding complicated computation and selecting the dynamic node in the grid cell. Hole masking algorithm explains that in each grid, residual energy i.e. node with larger energy level is selected as the head node. In Wireless Sensor Network, this head node is responsible for dissemination of data. Whenever any event takes place, the data is sent to head node for generation of data report and then that data report is forwarded to the sink. The queries of the sink are also handled and managed by the head node. So the energy of the head node is consumed at high rate. When this node dies or fails, the nearest node with largest residual energy is selected as the new head node.

Ahad Jahangiry, Ramin Ahmadi, *et. Al* (2011) is focusing on the localization of methods in Wireless Sensor Network like trilateration method, three angles and multilateral method to find the location of the node. It is very easy to find the location of the other nodes using this techniques, it uses the mathematical parameters like angle, radius, distance, so it can be calculate using the formulas that are already mentioned in the method description. This paper author is identifying the location of the node by a technique in which four nodes are deploying on such place that it forms a square. Sensor node identifies their location after receiving data from the particular station. Once t it gets the data from the station as a centre of the field which are coordinated edge of the area and according to the author simulation is shown that it takes short time to locate the unknown station and have small average error rate and high success rate.

B.T. Lee, S. Kim *et. Al* (2008) as the author described in the paper, author is emphasis on to reduce the cost of the communication. As we know localization has two types of the algorithms. Range based and range free algorithm. The sensor nodes based on range based schemes uses special devices and that are not suitable for the measurement in Wireless Sensor Network. So, author is proposing algorithm named SDV-Hop algorithm for the communication to reduction of the cost and improve its performance. It has less complexity than DV-Hop localization algorithm. This algorithm is dividing networks in to multiple cells and flooding is also limited so communication cost is reduced. So SDV-Hop algorithm is well suited for the network with large number of nodes.

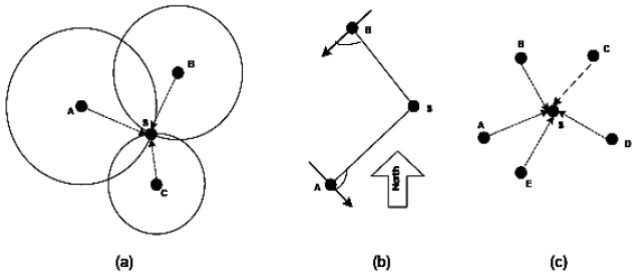

Fig 2.1 domain composition methods (a) Trilateration (b) Three angles, (c) Multilateral

Baoli Zhang, Fengqi Yu *et Al* (2009) in this paper based on beacon messages which are sent by anchor nodes, sensor nodes may calculate their positions. Border line intersection (BLI) localization scheme is used to any size and density of the sensor nodes. A mobile anchor node which is mounted with a GPS system and a directional antenna moves over the network to transmit beacon messages. This scheme is works on the principle that the intersection point of first and last points of beacon messages is location of the sensor node. A beacon message contains timestamp, position of anchor node, α and β_m. This BLI scheme has higher accurate results and lesser power consumption than Ssu's and Yu's localization schemes.

Yao-Hung Wu and Wei-Mei Chen (2009) in this paper rectangle overlapping scheme has been introduced. The positions of the nodes are calculated by the present state of the moving beacons, which includes rotation angles and positions. Sensor node has been

defined in four states as in state, out state, arrival state and departure state. A mobile beacon regularly broadcasts beacon messages towards destination and nodes do not have interaction with other nodes for their localization which leads to low power consumption.

Yong Zhou *et. Al* (2010) In this algorithm positions are determined in a hop by hop manner. It consists of mainly three steps. Firstly, all the nodes in network are made to know distances to the landmarks in hops. Then, average size for one hop is estimated. At the end, rest unaware nodes calculate their locations by using trilateration method.

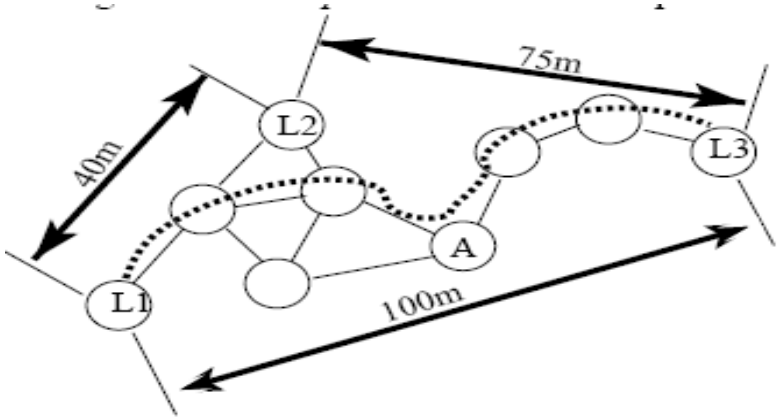

Fig 2.2 Example of DV-Hop

$HopSize_{L1}$= 100+40÷6+2=17.5

$HopSize_i = \sum(x_i - x_j)^2 + (y_i - y_j)^2 \div \sum h_{ij}$

d = AvgHopLength * HopCount

Where (x_i, y_i), (x_i, y_i) are coordinates of anchor i and j, h_{ij} is the hops between i and beacon j.

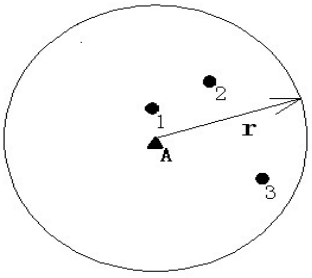

Fig 2.3 Neighbour nodes of the anchor node

By control flooding method, the anchor nodes' hop size is broadcasted to the network. Nodes unaware of their locations get this hop-size and save first one. Also they transmit the hop-size to their neighbour nodes. In the end, distance to anchor nodes is calculated based on hop lengths and hos to beacon nodes.

Improved DV-Hop Localization Algorithm:

Only third step of DV-Hop was changed by making unknown sensors to use the 2D hyperbolic trilateration. This method improves the localization accuracy without any increase in the cost of hardware of the sensor nodes. It performs better than DV-Hop algorithm. It was concluded that as beacons are placed more regularly, the error gets lower and location coverage becomes high.

$\text{Hop Size}_{avg} = \sum(\text{ Hop Size}_i) \div n$

Where n = number of anchor nodes

D_i = distance between unknown nodes and beacon nodes, then

$D_i = \text{hops} * \text{HopSize}_{avg}$

CDV-Hop localization algorithm:

Whenever any unknown sensor tries to trilaterate their positions, a constrained optimization is used in this method. Constraints are based on the fact that the communication range of unknown sensor restricts the distance between anchor and that sensor. eg if D is the communication range, then that sensor who's distance is 1 hop from anchor has its distance less than D from that sensor.

Estimated distance (D) between anchor node and unknown node is:

D = Hoplength * Hopcount

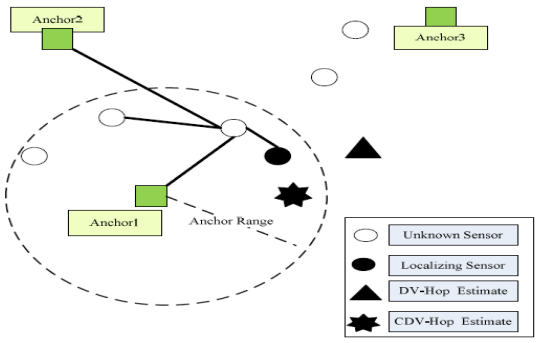

Fig. 2.4 Illustration of the position constraints in CDV- Hop algorithm

Hybrid DV- Hop (HDV) localization algorithm: It targets at minimizing flooding, minimizing consumption of power and number of anchors in the network.

NLLS trilateration technique is used in HDV-hop which is computationally expensive. It is used to determine the errors in distances from the sensor to the perimeter anchors.

In HDV- Hop algorithm,

- Anchors broadcast their hop counters (initialized to zero). Now all nodes know how far they are from the anchor nodes (in terms of hop counts).
- Anchors calculate the average hop distances from their perspective
- Anchors unicast average hop distances which were calculated, to the base station
- Sensors report observed data to the base station
- By trilateration the base station estimates the positions or reporting sensors.

  Thus simulation results of this concluded that,
- HDV yields quite lower localization error
- Lower consumption of energy than rest of the algorithms
- HDV can be used to monitor hostile environments.

Ramin Ahmadi *et Al* (2012) proposed a scheme for localization using mobile station. It is very important to know the position of a node in WSN. GPS is there on each sensor to determine node's position. By using based stations consumption of energy becomes less but by using GPS on each based station can cost higher. In this scheme a mobile station is used to calculate position of a node with good accuracy. A combination of radio

frequency and supersonic determines distance. In this scheme a mobile based station is used to locate fixed nodes. Some assumptions which are made in this algorithm are as: Fixed nodes are self- organizing. Position information of mobile node is broadcasted to sensor nodes. A mobile based station has GPS, radio frequency and an ultrasonic transmitter. Nodes which are fixed contain ultrasonic and RF receiver.

Mobile nodes broadcast radio and ultrasonic signals after fixed intervals. WSN has nodes with low power, low memory and less processing capability. A radio signal has its current position and remainder time (RT). Firstly RT is T and then after localization it becomes zero. A fixed node selects three based points to calculate its position.

After locating the position, sensor node sets RT=0 and goes to sleep. If node could not get three different based points even after RT, it will ask its nearby nodes to send their position information so that it can calculate its own position accordingly. This algorithm has high performance as it needs three distances to based points. So it is least affected by internal transfer of packages. Less consumption of energy is there in this algorithm and positioning error is less.

VasileiosMekikis, George Athanasiou, Carlo Fischione *et Al* (2010) in described case paper author is focusing on the detection event including water leakages and shutting the water pipes depend on the event detection. This presenting the smart home testbed is used for the accurate distributed event detection by Wireless Sensor Network for applications used in smart homes. Author combines the detection theory and estimation theory to provide more accurate result. And he is using indoor localization to identify the detect event. According to the detection of event the user is alerted through a notification of twitter alarm and probability of the falls twitter alarm is improved by 30% and average error of localization is 1.7%.

Baoli Zhang et Al (2010) in this paper based on the beacon information transmitted from a mobile anchor node having a directional antenna on it, the location of the sensor is determined. To avoid noise interference and to gain best channel quality, sensors make use of omni-directional mode to receive beacon messages and to transmit beacon messages directional mode is used by the mobile anchors. A mobile anchor node contains

its timestamp when the beacon message is broadcasted and its coordinates. It also contains sector boundary lines having angle β_m and an angle α which is between the line L_2 and x-axis.

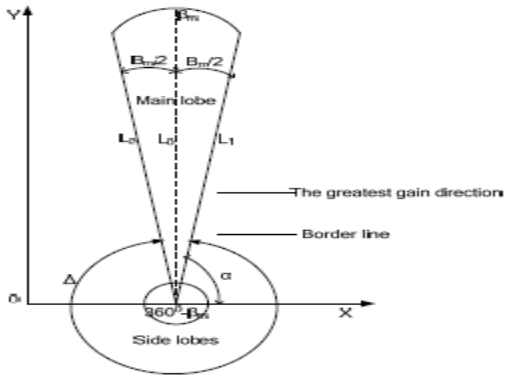

Fig 2.5 Radiation Pattern of directional antenna

Now according to these received messages nodes calculate their positions in the network by making use of geometric characteristics. It includes three localization schemes as GDDI, RROI and BLI.

BLI stands for border line intersection. A sensor node gets the first and last messages from anchor node. On finding two beacon points, then border lines of β_m are determined which are *L1* and *L'2*. The intersection point of these lines is the location of the sensor node. When the sensor node gets at least two beacon points and defines the border lines, it then computes its location. The beacon points are *N1* and *N2*, having location coordinates as (*x1, y1*) and (*x2, y2*).

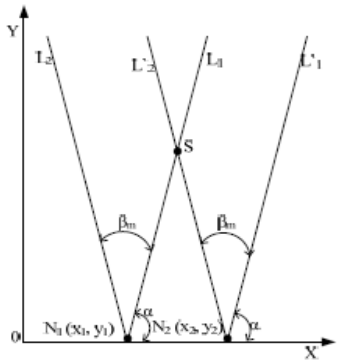

Fig 2.6 Sensor location estimation in BLI

The coordinates of *S* can be obtained by

L_1: $y-y_1 = k_1(x-x_1)$

L_2: $y-y_2 = k_2(x-x_2)$

From the above equation, coordinates of sensor node can be calculated as

$x = (a-b)/ (k2-k1)$,

$y = (a \times k2-b \times k1)/ (k2-k1)$,

where, $a = y1-k1 \times x1$,

$b= y2-k2 \times x2$, $k1 = \tan(\alpha)$, $k2 = \tan(\alpha + \beta m)$.

The other technique used was GGDI which stands for Greatest Gain Direction Line Intersection.

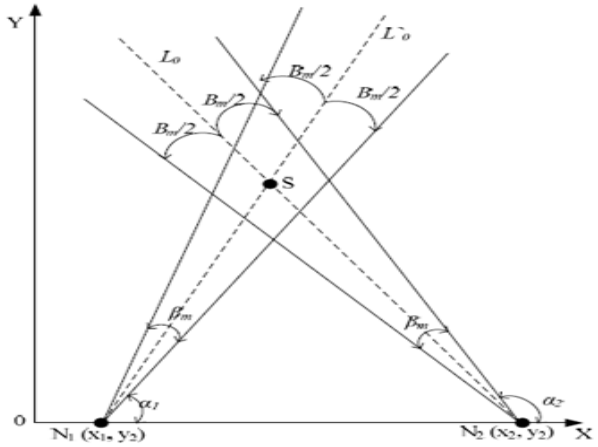

Fig 2.7 GDDI location estimation

When a node gets two lines where the gain is maximum, then their intersection point is the position of the sensor node. One of those points is the position of the node where RSSI was maximum for the first time and the other one is the position of maximum RSSI for the second time. The beacon points are *N1* and *N2* with location coordinates *(x1, y1*) and (*x2, y2*), angle between *L0* and *X* axis is $\theta=\alpha 1+\beta m/2$, angel between *L´0* and *X* axis is $\varphi=\alpha 2+ \beta m/2$.

The coordinates of *S* can be obtained by using the equation of line as follows:

L_0 : $y-y_1 = k_1(x-x_1)$

L_0' : $y-y_2 = k(x-x_2)$

The intersection point *S* of line *L0* and *L´0* is the estimated location of the sensor node having coordinates:

$x = (ab)/(k2-k1)$,

$y = (a \times k2 - b \times k1)/(k2-k1)$,

where, $a = y1 - k1 \times x1$, $b = y2 - k2 \times x2$ and

$k1 = \tan(\theta)$, $k2 = \tan(\varphi)$

Table 2: Classification of Various Localization Schemes

Protocol	**Category**	**Description**
BLI (Border Line Intersection)	Range free	BLI technique uses the principle that the intersection point of first and last points of beacon messages is location of the sensor node
GDDI (Greatest Gain Direction Line)	Range free	Maximum signal strength is in the direction of greatest gain direction line. Thus when node finds two such lines, the intersection point is the position of sensor node.
RROI (Radiate Region of Intersection)	Range free	A sector area is defined by sensor node when it receives messages from beacon node. During a certain (say nth) transmission, to define a sector, sensor selects a beacon point. Intersection of n sectors is calculated. The centroid of intersection is location of S.
ROA (Rectangle overlapping approach)	Range based	Based on a self mobilized device that moves in a predefined path and also has GPS and a directional antenna installed. Moving beacon helps to complete the localization of all the nodes after traversing the path.
DV-Hop	Range free	At first, it employs a classical distance vector

		exchange so that Firstly all nodes get distances (in hops) to the anchors in the network. Then average hop size is estimated. At the end, unlocalized nodes compute their positions by trilateration method.

Chapter 3

PRESENT WORK

3.1 PROBLEM FORMULATION

Sensor nodes are distributed randomly in a certain area without predetermining their positions. Every sensor node is having different memory capabilities. Sensor nodes sense the temperature, sound, pressure etc. in the field. That information is broadcasted to the base station. Anchor nodes help other nodes to detect their locations.

In a wireless sensor network event, nodes should be localized so that any kind of mishappening or suspicious activity can be communicated to the network. In order to localize, nodes should be communicating to each other. In the present case, we are using directional antenna on the nodes so that instead of wasting energy and time in sending data in various directions, we only let our data propagate in a certain direction we it is intended to receive By just focusing the beams in a single direction avoids noise and provides larger free channel space. This in result provides larger spatial reuse. Thus a large number of transmission can be done at a time withot any collision. A sender can send data to the destination with high power. It provides the users two kinds of advantages.

- Signal can be sent with comparatively lower power towards the destination whereas an omni directional antenna needs higher power. Thus the total amount of energy consumed becomes less.
- Secondly the range of the transmission can be increased. A beam which has been focused towards the destination covers greater distance and has smaller number of hops. It increases throughput, reduces delay. Beam focusing antennas improve network performance, signal quality, increase system capacity, reduce interference and noise, save power.

Thus beam focusing antennas improve network performance, signal quality, increase system capacity, reduces interference and noise, save power.

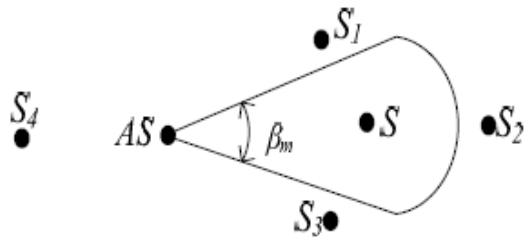

Fig 3.1 Communication Model

In this model, only sensor node S receives beacon message from AS but S_1, S_2, S_3 cannot. Mobile anchors have a predefined trajectory in sensor area. This path is designed in such a way that it can cover all the nodes in its area. After the localization of the area covered by the directional antenna, the node starts receiving beacon messages from anchors with higher accuracy.

In recent years, while solving numerous localization problems, many new ideas and solutions have resulted. However research is still a starting phase. Several hot topics where research is possible in WSN may be as:

- We can deduce a localization algorithm which is suitable for resource-constrained sensor nodes and by thee random distribution of nodes localization error can be reduced.
- On the surface of actual land based, randomly deploy the nodes, and study the localization performance.
- Research in the field of security issue of localization algorithm.
- It can also be used in environments such as underground, body, under water, mobile and multimedia.

In the present paper, we have developed an algorithm using a directional antenna of 90 degrees which localizes all the nodes in the network without repetition and thus saves power consumed and does the localization quickly. One more scenario we have used is that the sensor nodes are mobile.

3.2 OBJECTIVES

The main objectives of the work are:

(a) To reduce the time taken by nodes to localize them.
(b) To use directional antenna for localization of the nodes. Directional antenna will transmit and receive data only in single direction.
(c) To reduce the overall cost of communication.
(d) To reduce the consumption of energy in transmission and reception.
(e) To provide lesser error.

By using directional antenna on every sensor node localization accuracy can be improved. It can also be improved by increasing the number of anchor nodes but it also results in the increased cost of the network. Every mobile anchor node broadcasts messages with single beam directional antenna, which contain the coordinates and timestamp of mobile anchor nodes when beacon message is broadcasted. By reducing the distance between sensor nodes and mobile anchor nodes we can improve localization accuracy. Beacon messages have a timestamp.

3.3 REASEARCH METHODOLOGY

Importance of Wireless Sensor Network

WSNs provide their applications in several fields ranging from aircraft navigation, transportation, emergency systems, geological explorations etc. It has become current hot topic in the field of networking. It is necessary to localize the position of the nodes for all these applications.

Node Localization

Localization of a node means the process of estimating the physical location of sensor nodes that are placed randomly in certain area. There are two types of methods to do so: Range-based methods & Range-Free methods. For localisation, distance and angle between the nodes can be taken as factor to localisation. The angle at which node is located, time difference of arrival of data, received signal strength determine how the

nodes are from each other. Node localization considers many issues such as accuracy, overhead, storage capacity, efficiency etc.

Reason behind choosing Localization of sensor nodes as Research Work

As we all know wireless sensor networks have many applications and how necessary it is to know the physical location of sensor nodes to fulfill the criteria for these applications. Localization or say location discovery is responsible for the accuracy, efficiency and capacity of the application. A lot of work has already been done in this field but still there is no accurate solution for the problem. So, the motivation behind this work is the lack of an accurate solution

Main purpose of directionality of signals is to improve transmission and reception of communications and to reduce the interference. Their maximum gain is only in one direction. In this case chances of error are very less.

Every mobile anchor node sends messages using single directional antenna, which contain the coordinates and timestamp of mobile anchor nodes when beacon message is broadcasted, When a sensor node roams within a network assumptions are made such as each sensor node has a visiting list, they have RSSI values and packet information. Sometimes due to collisions incorrect beacon points are chosen. Also by decreasing the distance between sensor nodes and mobile anchors, localization accuracy can be improved.

In the present work, we have taken a network having moving sensor nodes and some anchor nodes. We have used a sector antenna on anchor nodes having angle of 90 degrees to send the beacon messages. Unknown nodes use single beam directional antenna to receive the beacon messages.

In the present papper, we are working on directional antenna of 90 degrees to send the packets to the destination with high power. Anchor nodes make use of single beam directional antenna for sending beacon messages. On the other hand, receiving nodes make use of omni-mode to receive beacon messages.

This scheme works for localization of maximum number of nodes with least energy consumption.

3.4 SIMULATION TOOL USED

To implement this algorithm MATLAB has been used. It is used in science, mathematics and engineering.

There are several features in it which help users in documenting and work sharing. Its code can be integrated with other applications.

Some features of this include:

- It is a high-level language for technical computing
- It is also used in iterative explorations, design and problem solving.
- IT also provides several mathematical functions such as integration, fourier series, algebra etc.
- Graphic functions in 2-D and 3-D are also available
- To build customized graphical user-interfaces, tool are available.

MATLAB is one of the high-performance languages for technical computing and interactive environment. Technical computings are done faster than C, C++, Fortran. It also offers excellent graphics. It was published by The MathWorks, Inc. One of the limitations is numerical computation. It is also much easier to use than C++ and Fortran. It has a vast standard library.

Chapter 4

RESULTS AND DISCUSSION

WSN has several constraints on it as size of a node, energy and cost. It is necessary to take these constraints into account before we start designing a localization mechanism. Communication between nodes and data transmission between them take much power and energy. Several application specific localization algorithms were proposed. Different kinds of applications cannot use same algorithms. For different applications different algorithms need to be developed.

In our scenario, we have taken a sensor field having one hundred nodes in it. These nodes are randomly deployed in the field and are moving from one place to another within it.

a. Scenario 1

The total number of sensor nodes deployed in the area = 100.

Let us say, 5 are the anchor nodes in the field.

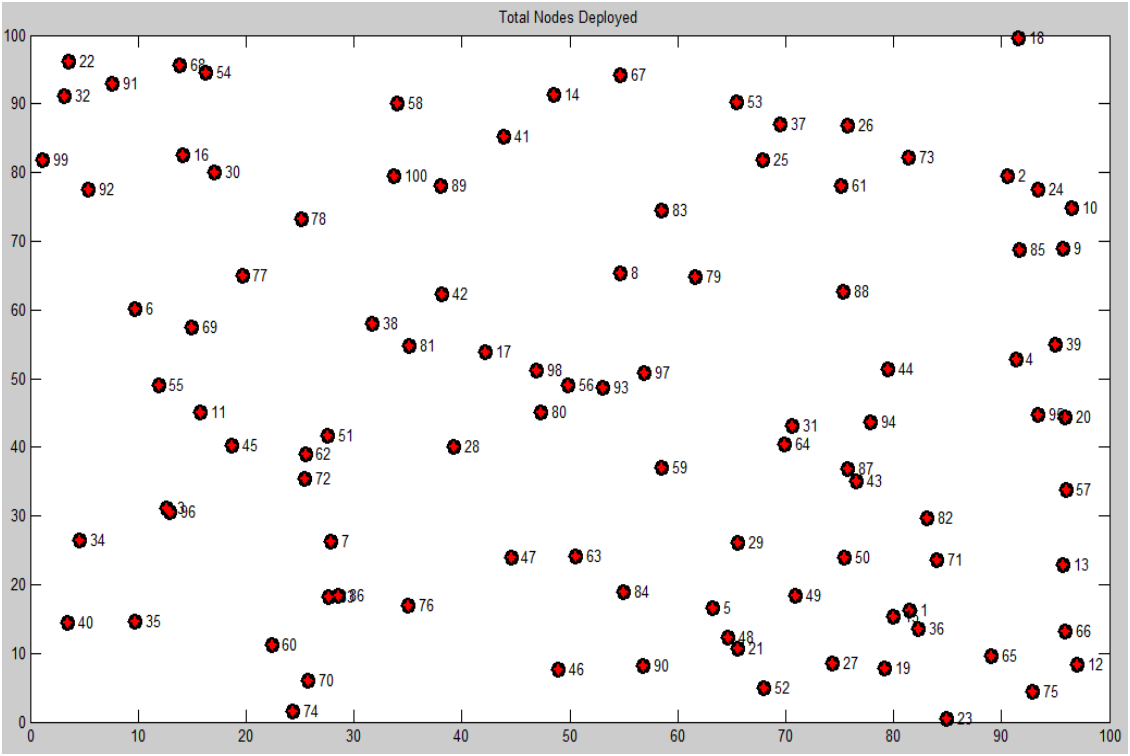

Fig 4.1 Random sensor nodes in field

AN = 94 44 81 61 41

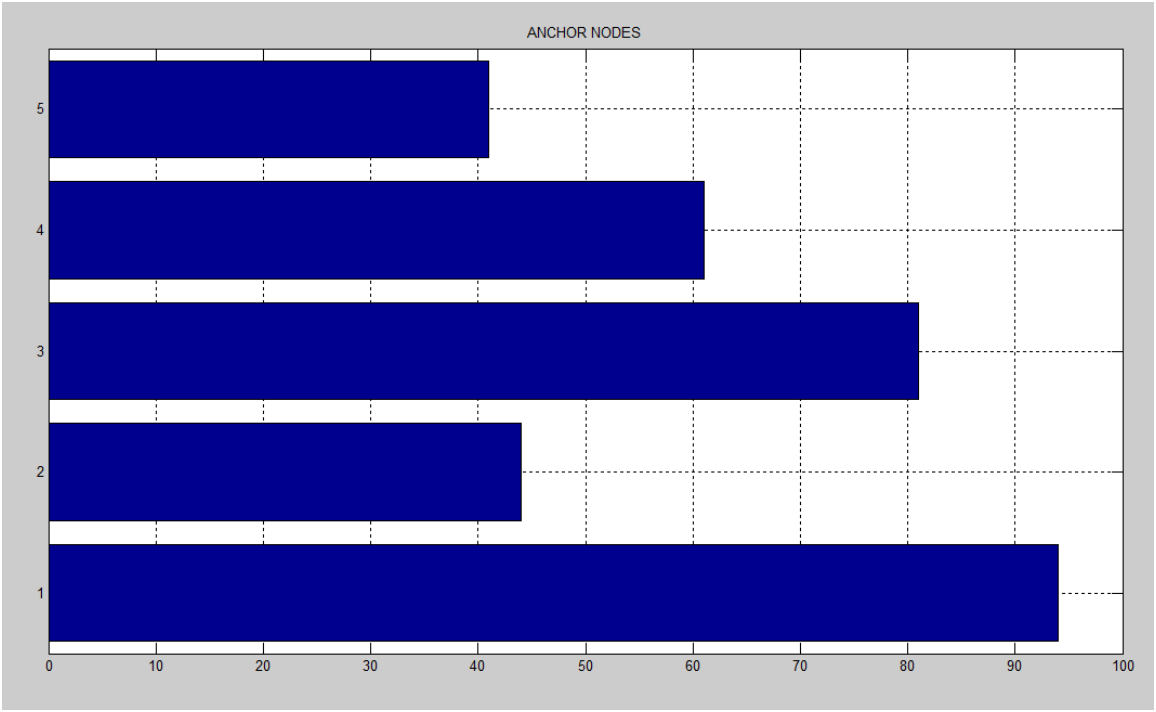

Fig 4.2 Location of anchor nodes

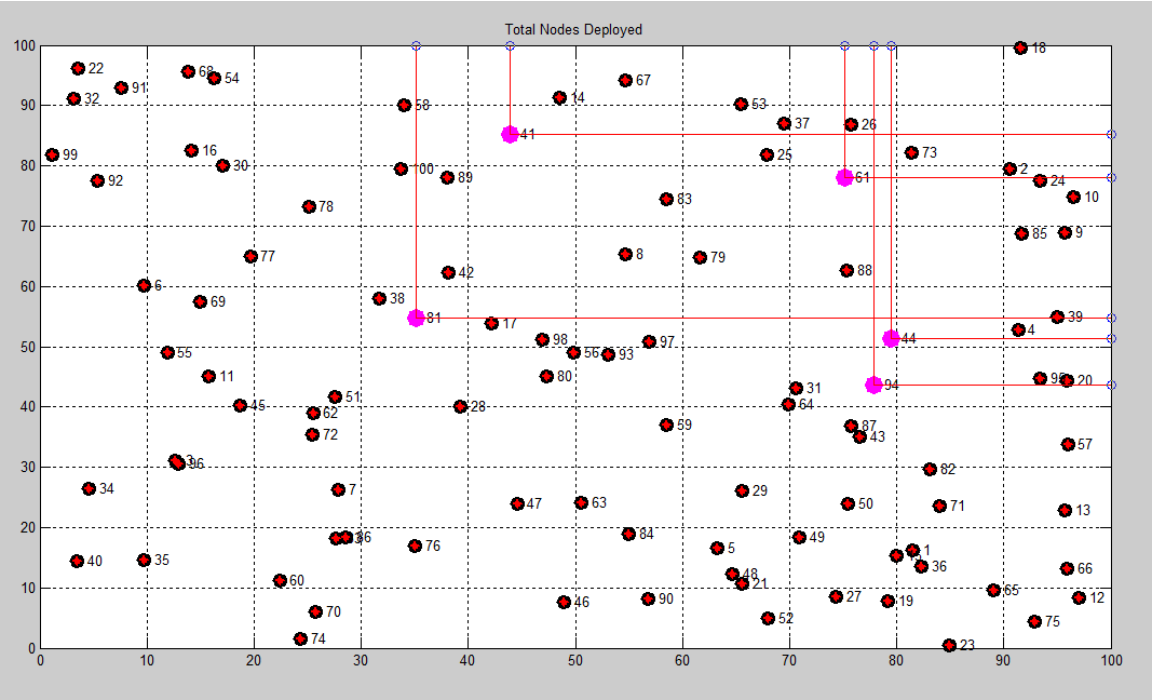

Fig 4.3 Anchor nodes' positions

Anchor node_1 (i.e. 94) coves the following nodes in its area

2 4 9 10 18 20 24 39 73 85 95

Anchor node_2 (i.e. 44) covers the following nodes in its area

2 4 9 10 18 24 39 73 85

Anchor node_3 (i.e. 81) covers the following nodes in its area

Columns 1 through 18

2 8 9 10 14 18 24 25 26 37 39 42 53 67 73 79 83 85

Columns 19 through 20

88 89

Anchor node_4 (i.e. 61) covers the following nodes in its area

2 18 26 73

Anchor node_5 (i.e. 41) covers the following nodes in its area

14 18 26 37 53 67

As we see in the above case, nodes which have been traced once are also localized by other anchor nodes as well when they come in their area.

But now we have, used such an algorithm in which the nodes which have been localized once using directional antenna of 90 degrees, will not be localized again by other anchor nodes.

```
Nodes_M_1 =
    2     4     9    10    18    20    24    39    73    85    95
Nodes_M_2 =
    []
Nodes_M_3 =
    8    14    25    26    37    42    53    67    79    83    88    89
Nodes_M_4 =
    []
Nodes_M_5 =
   14    37    53    67
```

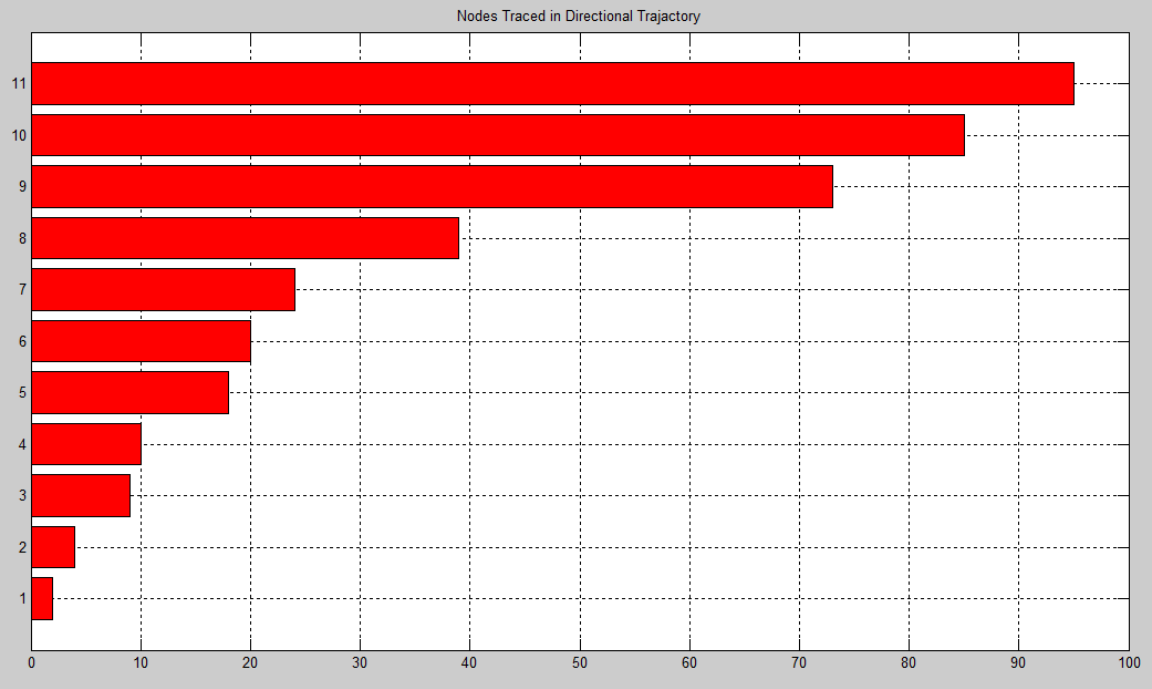

Fig4.4 Nodes covered by anchor node 1

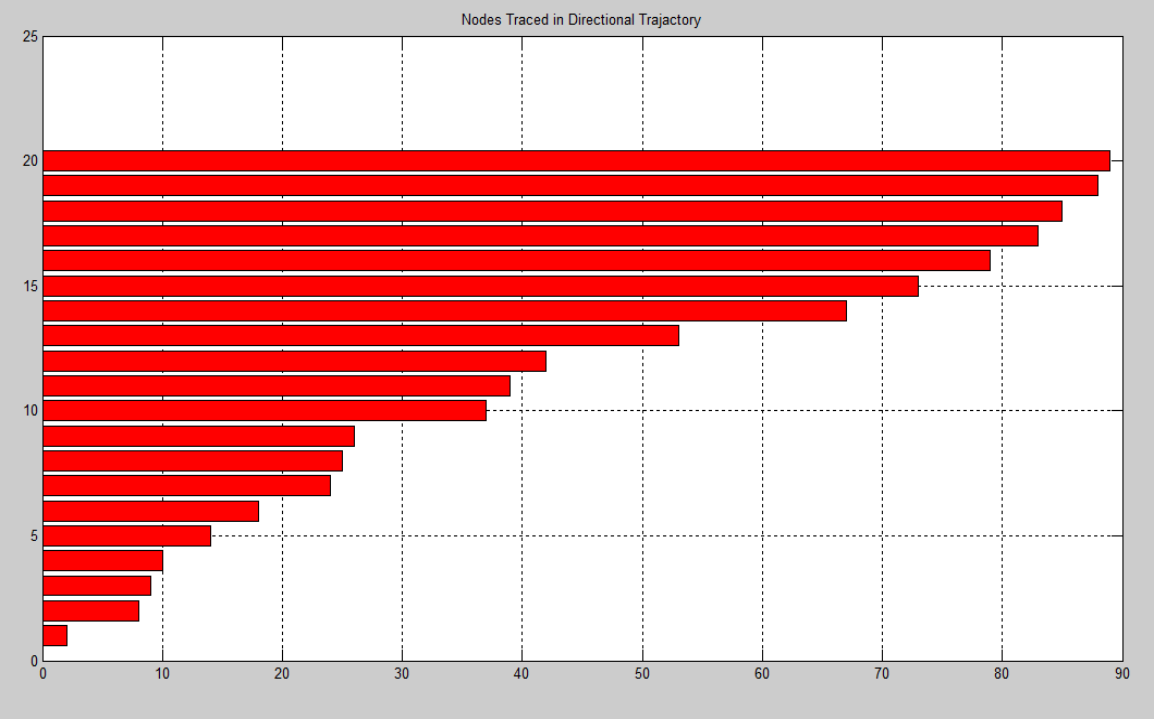

Fig 4.5 Nodes covered by anchor node 2

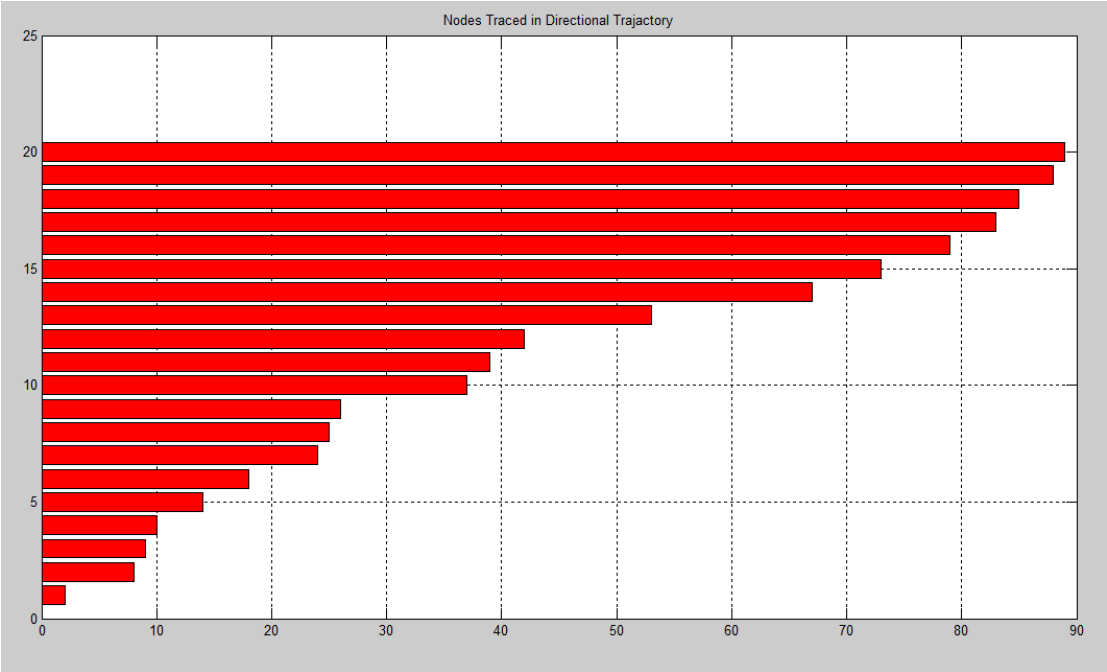

Fig 4.6 Nodes covered by anchor node 3

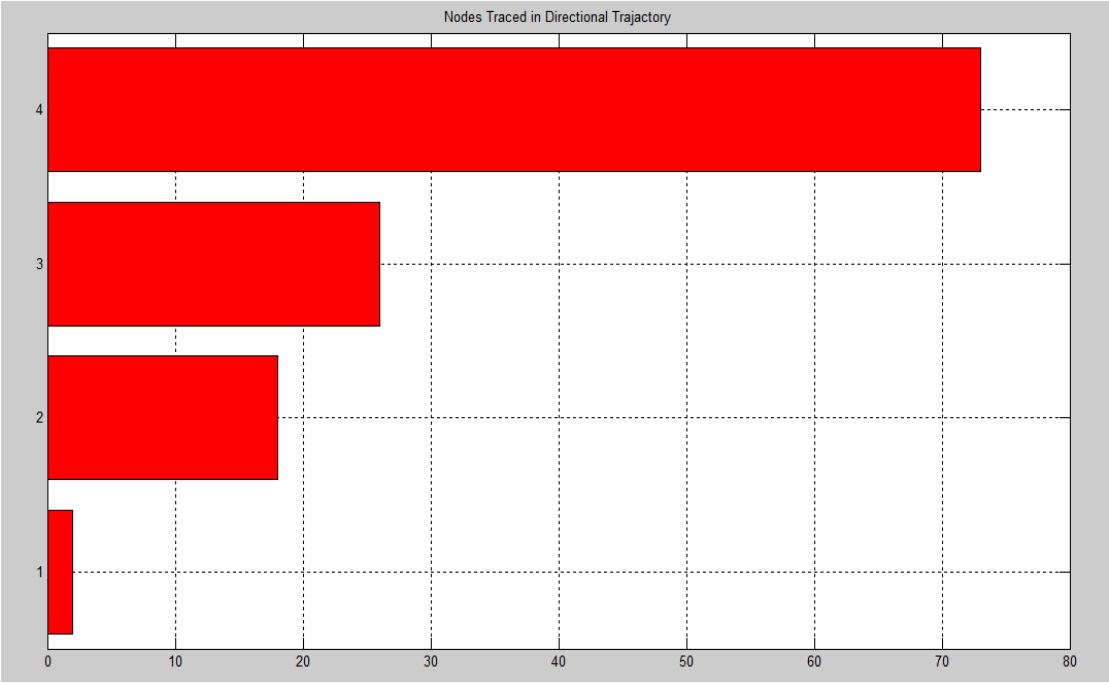

Fig 4.7 Nodes covered by anchor node 4

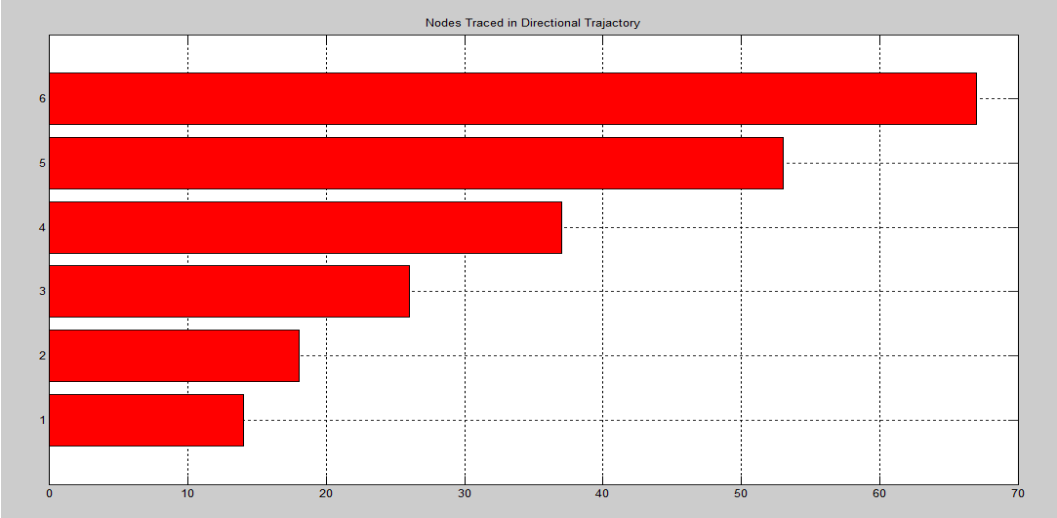

Fig 4.8 Nodes covered by anchor node 5

4.2 SIMULATION RESULTS

From these results, we concluded that

- Energy consumed by the entire network is quite less. Thus a large amont of energy remains unused.
- Execution time of the entire network is very less.
- As nodes are dynamic in nature, a large number of nodes are localized

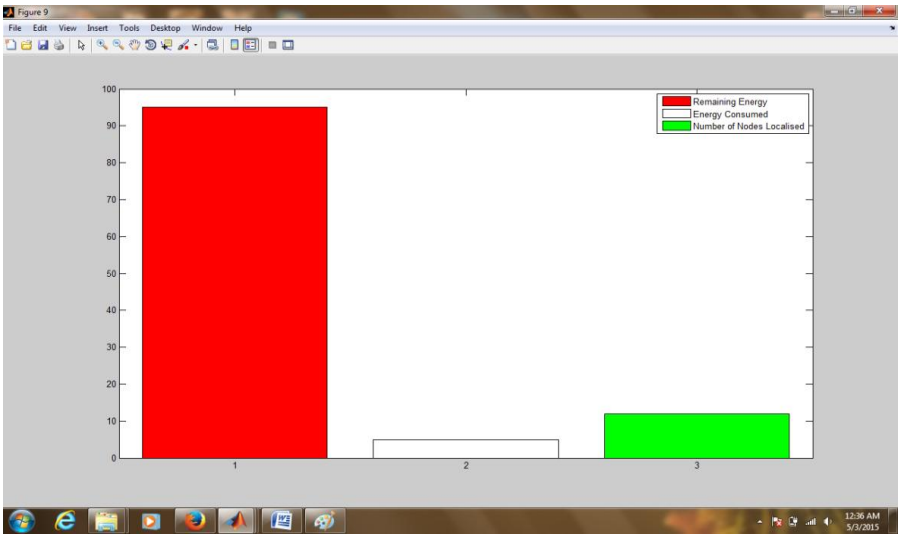

Fig 4.9 Prarmeters utilized

Chapter 5

CONCLUSION & FUTURE SCOPE

5.1 CONCLUSION

In this paper, based on the discussion of sensor nodes which are dynamic in nature, we have proposed an algorithm which is accurate and saves energy and has lower computational complexity. From the analysis we have infered that our algorithm is best suitable for large netwoks having lower energy consumption, lesser time consumed, accurate, higher throughput, lesser prone to errors, lower computational complexity, lesser communication cost. Proposed scheme is suitable for any number of sensor nodes in the sensor network. Our simulation shows that it has higher localization accuracy than other range free techniques and also requires less communication cost.

5.2 FUTURE SCOPE

In out proposed method, we have created a directional antenna at a fixed angle i. e. 90 degrees. But in near future this technique can be further modified by sensing network at different angles to sense dense areas i.e. a single antenna may work at different angles in the same network. It will save energy more then the proposed scheme.

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APPENDIX

LIST OF ABBREVIATIONS

AoA	Angle of Arrival
WSN	Wireless Sensor Network
ToA	Time of Arrival
TDoA	Time Difference of Arrival
GPS	Global Positioning System
RSSI	Received Signal Strength Indicator
ALS	Adaptive Localization Error
APS	Ad-Hoc Positioning System
SDP	Semi Definite Programming
MDS	Multi-Dimensional Scaling
BLI	Border Line Intersection
GGDI	Greatest Gain Direction Line Intersection
RROI	Radiate Region of Intersection
SMDP	Short Distance Movement Pattern
SINR	Signal to Interference and Noise Ratio
RF	Radio Frequency
APIT	Approximate Point in Triangulation
COG	Centre of Gravity
DPM	Dynamic Power Management
DVS	Dynamic Voltage Scaling