AN EXHAUSTIVE STUDY ON MOBILE LOCALIZATION APPROACHES TO IMPROVE QUALITY OF SERVICE IN WIRELESS SENSOR NETWORKS

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CERTIFICATE

The research work embodied in the present Thesis entitled "**AN EXHAUSTIVE STUDY ON MOBILE LOCALIZATION APPROACHES TO IMPROVE QUALITY OF SERVICE IN WIRELESS SENSOR NETWORKS**" has been carried out in the Department of Electrical and Electronics Engineering, PSG College of Technology, Coimbatore. The work reported herein is original and does not form part of any other thesis or dissertation on the basis of which a degree or award was conferred on an earlier occasion or to any other scholar.

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ABSTRACT

In Wireless Sensor Network (WSN), mobile anchors based localization play a major role for data exchange. But the existing methods cause huge delay since the mobile anchor has to cover entire network. The maximum coverage of all nodes are difficult to achieve, since maintaining visiting schedule of the mobile anchor node is a difficult process. To solve these problems, a Multiple Mobile Anchor based Localization Technique using Particle Swarm Optimization (MMALPSO) technique is proposed as first work in this thesis. Particle Swarm Optimization (PSO) is used to determine the trajectory of the mobile anchor nodes which is based upon the node density and the distance between the nodes in the network. The mobile anchor nodes broadcast packets to the visited sensor nodes depending on the PSO visiting schedule. The unknown nodes on receiving the packet, calculate the estimated distance between each of the mobile anchors and using trilateration method, they are localized. From the simulation results, it proves that the localization delay and energy is reduced along with increased packet delivery ratio.

To solve the issues of coverage problem, boundary based localization approach is developed as second work in this thesis. Sensor network is used to sense the environmental changes around the world. Most difficult issue in wireless sensor network is to find out the location of the sensor nodes. To overcome those issues a new technique is proposed named as (Localization based on Boundary Recognition) LBR. Hop count is the important factor in finding the location of the sensor nodes. It becomes a difficult process, when the density of the network increases.

The proposed Neighbor Aware Localization (NAL) approach uses the range free mechanism to find the location of sensor nodes. The existing techniques are virtual hop localization and (Distance vector) Dv-hop Localization. Dv hop localization uses hop counts to get the location of a sensor node. Drawback in the Dv hop localization is location error will be high. To overcome that, another existing method is virtual hops localization. Virtual hop localization contains a virtual number of hop counts, it can be filtered using local filtration. The drawback in virtual hop localization is it consumes more power and has high estimation error. This can be overcome by using the proposed neighbor aware approach in localization of sensor nodes. The proposed neighbor aware approach increases the network efficiency compared to the previous techniques.

Range free mechanism results in location error and estimation error due to mobility. To overcome these issues another technique has been proposed that makes use of range based algorithm. Using range based algorithm, proposed technique is known as Localization based on Distributed Clustered (LDC) algorithm has been designed. The proposed localization for distributed clustered network algorithm has three modes of operation. Initially, it generates the nodes with random deployment, second mode is creating the cluster head and third mode is acts on the range based algorithm, in finding the location of sensor node. The existing techniques are Multi Hop Localization (MHL) and Virtual Force Localization (VFL). The multi hop localization is used to attempt the range free algorithm, which has been designed by using hop counts. Virtual force localization finds the location by attractive and repulsive forces of virtual motion paths between the sensor nodes. This has to be overcome by the proposed algorithm of localization for distributed clustered network algorithm. All these techniques help to reduce the localization error, estimation error, distance error, energy consumption delay and to increase the quality of service parameters such as throughput, delivery ratio and routing overhead.

Finally all these four algorithms such as Multiple Mobile Anchor based Localization using PSO (MMALPSO), Localization based on Boundary Recognition (LBR) approach, Neighbor Aware Localization (NAL) algorithm and Localization for Distributed Clustered Network (LDC) algorithm are used to localize the sensor node and also these techniques improve the overall network performance with less energy consumption and control overhead.

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LIST OF SYMBOLS AND ABBREVIATIONS

WSN	-	Wireless Sensor Network
BAN	-	Body Area Network
QoS		Quality Of Service
CTS	-	Cyber Transporation System
RSSI	-	Radio Signal Strength Indicator
AOA	-	Angle Of Arrival
MWBA	-	Minimum Weighted Barrier Algorithm
GPS	-	Global Positioning System
CL	-	Centroid Localization
MO	-	Multi Objective Optimization
LBR	-	Localization Based On Boundary Recognition
OLSR	-	Optimized Link State Routing
AODV	-	Adhoc On Demand Routing Protocol
FML	-	Flooding Mechanism In Localization
NAL	-	Neighbor Aware Localization
DLC	-	Distributed Localization For Clustered Network
RF	-	Radio Frequency
PSO	-	Practical Swarm Optimization
NLOS	-	Non Line Of Sight
RSS	-	Received Signal Strength
L	-	Low Density
H	-	High Density
MN	-	Mobile Node
SN	-	Stable Node
MMAL	-	Mobile Anchor Assiated Node Localization

CBR	-	Constant Bit Rate
DCF	-	Distributed Co-Ordination Function
V-HOP	-	Virtual Hop
DV	-	Distance Vector
MHL	-	Multi Hop Localization
VFA	-	Virtual Force Algorithm

CHAPTER 1

INTRODUCTION

This chapter presents the overview and motivation for the thesis. An overview on Wireless Sensor Network is briefly outlined. The problem statement, objective, outlines of the research work and thesis organizations are also discussed in this chapter.

1.1 OVERVIEW OF SENSOR NETWORK

Wireless Sensor Network (WSN) is a widely distributed network made of small low cost sensors, which collect and disseminate environmental data. This sensor network works like a Mobile Ad Hoc Network. It has distributed architecture with node mobility. It is used to transmit the information through intermediate nodes. These intermediate nodes are sometimes called as co-operative nodes. The architecture of Mobile Ad Hoc Network is same as Wireless Sensor Network but the major difference between the ad hoc and sensor network is that ad hoc mobile network transmit and forward the packets from source to destination and the sensor network will transfer information from source to sink. The WSN consist of one fixed controller (Sink or Base Station) that is able to manage all the communications between other nodes. It has fixed routes. A Mobile Ad-hoc Network (MANET) is a WSN and its scope is sensing the environment around the network. The network consists of nodes continuously moving in any direction and will repeatedly reconfigure its routes, since MANET doesn't have a fixed central controller. The architecture of sensor network is shown in Figure 1.1. The architecture of WSN contains sensor nodes, sink and transceiver antenna. The sensor nodes are colored as black and the sink nodes as green. Remaining nodes are intermediate nodes which are used to carry the information from source to sink.

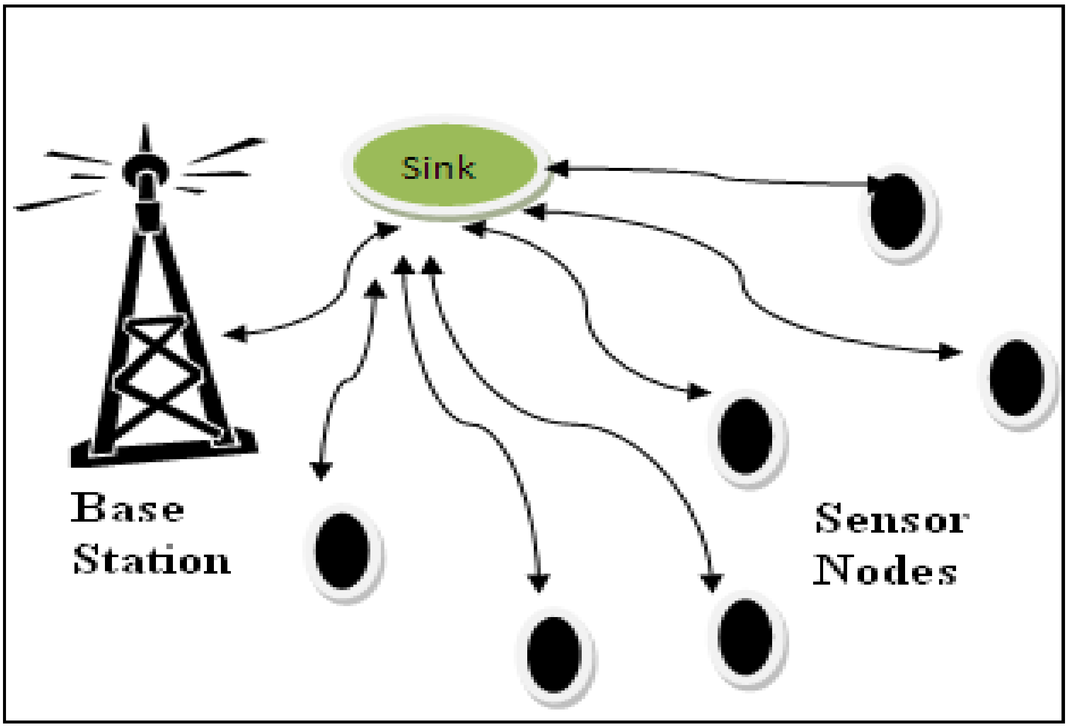


Figure 1.1 Architecture of Wireless Sensor Network

Sensor nodes are used to gather information from the required field. After getting the information from the required field it will pass the information to the sink with the help of the intermediate nodes. During transmission of the information through intermediate nodes, security is of major concern. Sensor networks find it to be widely used in military appliances. In such applications, it is necessary to maintain authenticity of the information. Another important concern in sensor network is the node mobility. All the sensor nodes in a sensor network are mobile. Under stable conditions, the distance formula can be used to calculate the distance and localization is easy but in state of mobility it is very difficult to find out the location. In Wireless Sensor Network, localization of sensor nodes is a major task, which involves collaboration. Collaboration is the process of determining the node location by node themselves without the help of human intervention. The block diagram of sensor node is shown in Figure 1.2.

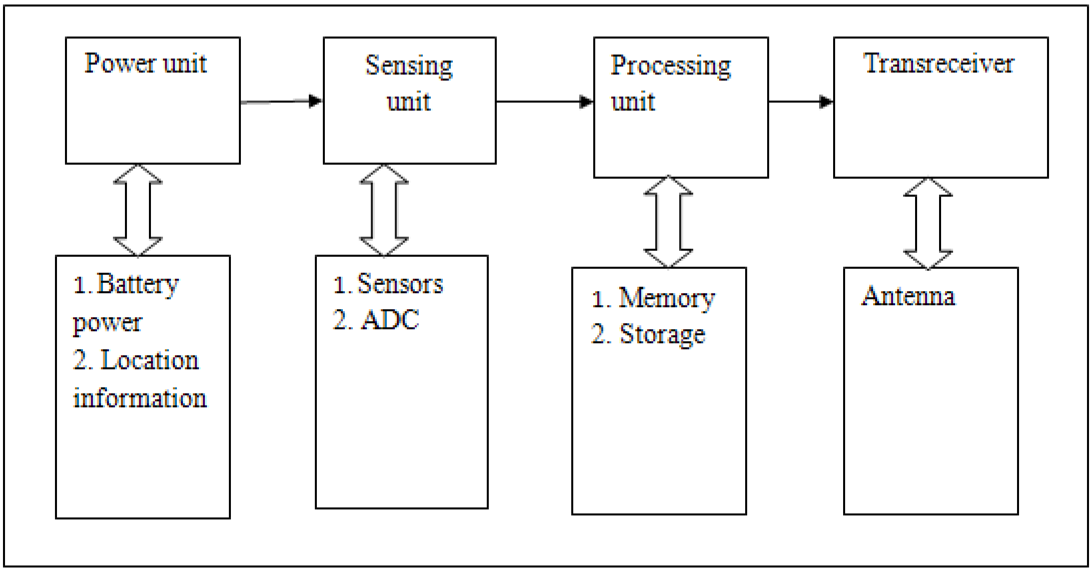


Figure 1.2 Block Elements of Wireless Sensor Network

It consists of the major blocks like power unit, sensing unit and processing unit. The power unit depends on the battery power. Based on the sensor nodes, the battery power of the node varies. The sensor node will be able to move from one place to another place based on the battery power level included in the particular node. Other two major blocks are sensing unit and processing unit. Sensing unit has sensors and analog to digital converter. The sensor senses the information as analog signal, which is converted to digital using analog to digital converter. Then the signal passes to the processing unit where it will send the information from source to sink. Processing unit transmits and receives the information using the transceiver antenna. It also contains memory and storage to store the required information.

1.1.1 Need of Sensor Networks

The Wireless Sensor Networks are used in many applications such as military applications, medical applications, environmental monitoring, industrial applications, infrastructure protection application and miscellaneous applications. In military field, sensor networks are used to monitor the battlefields. In medical applications, sensor networks are used for diagnosis and monitoring the patients. In environmental monitoring, sensor nodes are used to monitor the traffic, wild fire and habitat monitoring. In industrial applications, sensor or anchor nodes are used to sense and diagnose the fire, gas leakage. In infrastructure protection, this network is used in power grids monitoring and water distribution monitoring. Smart sensor nodes are used in home appliances such as oven, refrigerator and vacuum cleaners.

WSN finds itself useful in numerous medical applications such as heart rate monitor, blood pressure monitor and endoscopic capsule. To address the growing use of sensor technology in this area, a new field known as Wireless Body Area Networks (WBAN or simply BAN) has emerged. As most devices and their applications are wireless in nature, security and privacy concerns are among major areas. Due to direct involvement of humans it also increases the sensitivity. It is a concern that the data gathered from patients or individuals are obtained with the consent of the person or without it due to the needs dictated by the system; Misuse or privacy concerns may restrict people from taking advantage of the full benefits from the system. People may not see these devices safe for daily use. There may always be a possibility of serious social unrest due to the fear that such devices may be used for monitoring and tracking individuals without their knowledge by government agencies or other private organizations. Highly scalable cluster-based hierarchical trust management protocol for Wireless Sensor Networks (WSNs) is used to effectively deal with selfish or malicious nodes. For each application, the best trust composition and formation is identified to maximize application performance.

1.2 RESEARCH ISSUES

The major issues in Wireless Sensor Network are reduction in power consumption, cyber-attacks and localization. Here, it is described briefly about the localization issues in wireless sensor network. The issues are difficulty in finding the location of sensor nodes in the networks within high density of nodes. With low density of nodes, it is waste of time to apply the localization algorithms. This technique is applied in networks having high density sensor node. Lack of knowledge about location of sensor nodes often leads to high delay, wastage of power resources and attacks on sensor nodes. To overcome these issues the localization is the most important task. The major drawback of localization is during the identification of location of sensor nodes, where location error may occur due to some algorithms.

- WSNs localization is a crucial research area because of the new localization requirements for emerging application domains such as Cyber-Physical Systems and Cyber-Transportation Systems (CTS). Miorandi et.al [2012] suggests the “Internet-of-Things” is used as an umbrella keyword for covering various aspects related to the extension of the Internet and the Web into the physical realm, by means of the widespread deployment of spatially distributed devices with embedded identification, sensing and/or actuation capabilities. Internet-of-Things envisions a future in which digital and physical entities can be linked, by means of appropriate information and communication technologies to enable a whole new class of applications and services.

1.3 NECESSITY OF LOCALIZATION

The objective of this thesis is to develop an algorithm for localization of sensor nodes in Wireless Sensor Network. The localization algorithms depend on sensor parameters such as radio range, distance, density of nodes and sensor to node ratio. Based on these parameters, the localization of sensor node is performed but it may not be that accurate. To overcome such problems a new localization algorithm is necessary. In this work 4 different approaches are used for localization. Localization is performed based on Anchor Based Method followed by Boundary Recognition, Neighbor Aware Techniques and Finally Clustered Technique is used to design the localization algorithms for getting the accurate localization of sensor nodes. Localization can be classified into two different categories. Centralized localization and distributed localization. In centralized localization, all the sensor nodes in the sensor network depend on the centralized node. When it wants to move from one place to another place, it needs to get the required information from central base station. On getting this type of information it will update the position of the anchors in sensor network. In distributed localization, all the sensor nodes in sensor network will be distributed. It will update the information to their neighboring node after moving from one place to another. This distributed localization depends on three parameters, Beacon Based, Relaxation Based and Co-Ordination Switching Based Distributed Algorithms.

Larios et.al [2012] describes the power availability and the weight are big restrictions, the use of energy hungry devices like GPS or hardware that add extra weight like mobile directional antenna is not a good solution. Due to these reasons it would be better to use the localization's implicit characteristics in communications, such as connectivity, number of hops or RSSI. This technique describes the parameters used in Wireless Sensor Network. This technique is used for the transmission of beacon signals between the two devices in the wireless sensor network. It uses the two algorithm and these two algorithms are combined in the proposed technique. One algorithm is based on the fuzzy logic condition for the partial transmission and another is used in the centroid localization algorithm. The proposed technique merges two algorithms, and it produces the centralized algorithm without using the fuzzy logic condition. The simulation results analyze the performance of the proposed technique and it is compared with the same technique as applied in the ad hoc network.

1.4 PROBLEM FORMULATION

The localization research problem is given below;

- **Input:** Given an (arbitrary) undirected graph.
- **Output:** Estimate the node's position, that is, identify the node's location with minimum number of nodes and control load.
- **Problems:** Obtaining localization with minimum number of nodes is a NP-hard
  problem.

1. Tracking architecture must be a distributed structure.
2. The solution must be local (global solutions are not cost effective)

Most Wireless Sensor Network localization techniques used is infrastructure free, i.e. in distributed architecture. If nodes are equipped with Global Positioning System, it leads to high cost and high power consumption. Major problem in localization is finding the distance and spatial co-ordinates of sensor nodes. Locations of the sensor nodes are called anchors. Self localization indicates that the Wireless Sensor Network can find out the location of sensor nodes by its own. Self localization is mostly used in stable Wireless Sensor Nodes and it gives accurate information. When it is done in the mobile Wireless Sensor Nodes, it is often referred as Target Localization.

Two different techniques are used for localization of sensor nodes. They are Range Based Localization and Range Free Localization. Range based localization is highly suitable for centralized architecture of Wireless Sensor Network. Range free is used in the distributed architecture of Wireless Sensor Network. Range based localization is obtained based on various parameters like distance, signal strength based on beacon signal and angle. Range free is in distributed systems. The error due to range free technique in the distributed architecture can be masked through fault tolerance, redundancy and aggregation. Hence, proposed techniques uses Range Free Distributed Localization Algorithms.

Sengupta et.al [2013] explains the sensor node deployment task, formulated as a constrained Multi-Objective optimization (MO) problem where the aim is to find a deployed sensor node arrangement to maximize the area of coverage and also to minimize the net energy consumption; maximize the network lifetime, and minimize the number of deployed sensor nodes while maintaining connectivity between each sensor node and the sink node for proper data transmission. Liu et.al [2012] suggests the energy storage capability of sensor nodes, it is crucial to jointly consider security and energy efficiency in data collection of WSNs. The Disjoint Multipath Routing Scheme with secret sharing is widely recognized as one of the Effective Routing Strategies to ensure the safety of information. This kind of scheme transforms each packet into several secret shares to enhance the security of transmission. This technique introduced a new method for many to one Wireless Sensor Network. This Wireless Sensor Network is used in sharing the link secretly based on the Multipath Routing Scheme Using Security and Energy Efficient Disjoint Route. The major problem in this wireless sensor network is the optimization of the routing problem. It uses the secret sharing algorithm and it is also used to deliver the packets randomly all over the entire network. It has three phases during the transmission, in the first two phases it will randomly sense and share the data secretly and in third phase all the nodes forward data to the sink node in the Wireless Sensor Network.

1.5 BOUNDARY RECOGNITION BASED LOCALIZATION

Sensor network is used to sense the environmental changes around the world. The major concern in Wireless Sensor Network is localization. Localization is nothing but finding the location of sensors/anchors in the network. A new technique known as Localization Based On Boundary Recognition (LBR) is proposed here. In existing methods hop count is used to find the location of the sensor nodes. Using hop count approach it is difficult to find the location of sensor nodes, when the density of the network increases. Another approach to increase the performance is Flooding Mechanism in Localization (FML); which increases the performance. To overcome all these issues a new technique is needed which must decrease the complexity and increase the performance and should also easily find the location of the sensor node is necessary. The method for such requirements used is Localization Based on Boundary Recognition method.

Zhu et.al [2012] describes the coverage and connectivity as two fundamental issues in WSNs. Optimized Deployment Strategy, Sleep Scheduling Mechanism, and coverage radius not only reduce the cost, but also extend the network lifetime. Barooah et.al [2012] explains the methodology to define the failure nodes in Wireless Sensor Network. Failure nodes are defined as cut nodes and a new algorithm is used to find out the cut nodes among the sensor network. It is proposed to reduce the cut nodes and increase the performance of the entire network using the proposed algorithm.

1.6 ROLE OF CLUSTERING IN WSN

In Wireless Sensor Network, clustering formation is choosing the clustering head in wireless sensor network. Firstly it will divide the network into four regions. For each region assign a cluster head in Wireless Sensor Network. Cluster Head Selection is of more concern in these regions. Each node has different characteristics, power levels and inter-distances. Based on the capacity of the node Cluster Head Selection will have to be made. When any node wants to transmit or receive the data it needs the help of cluster head. Without informing to cluster head, no node can transmit or receive the packets in the network. This type of clustering method affords more secrecy. Likewise if any node wants to enter or leave the network, that information will be immediately updated by cluster head. Using this clustering technique, security and topology maintenance is effectively done. But the major drawback is, always cluster head should be active, hence it consumes more power. At the same time, when the cluster head node goes dead, the cluster head will carry and post to the neighboring node which consumes more power.

Yu et.al [2012] suggests that the energy consumption among nodes is more imbalanced in cluster-based Wireless Sensor Networks. Based on this problem, Cluster-Based Routing Protocol For Wireless Sensor Networks with non uniform node distribution is proposed, which includes an Energy-Aware Clustering Algorithm (EADC) and a Cluster-Based Routing Algorithm. EADC that uses competition range to construct clusters of even sizes. At the same time, the routing algorithm increases the forwarding tasks of the nodes in scarcely covered areas by forcing cluster heads to choose nodes with higher energy and fewer member nodes as their next hops, and finally, achieves load balance among cluster heads. Madani et.al [2012] explains the cluster head selection based on the weight of the node. The node having highest weight compared to other nodes will be assigned as cluster head. Here cluster head only decides the transmission power of the leaf nodes. If any of the leaf node wants to transmit the message to any node within or out of the network, Cluster head knows the receiver's distance and then allocate the transmission power based on the distance to the transmitter node.

1.7 OUTLINE OF DISSERTATION

This thesis is organized as follows: Chapter 2 deals with the literature survey and related works. Chapter 3 presents the Anchor based Sensor Localization. Localization Based on Boundary Recognition is discussed in Chapter 4. Chapter 5 describes Neighbor aware localization approach in detail. Distributed Localization for Clustered Network is analyzed in Chapter 6. Finally Chapter 7 concludes the research work. The outline of the thesis is shown in Figure 1.3.

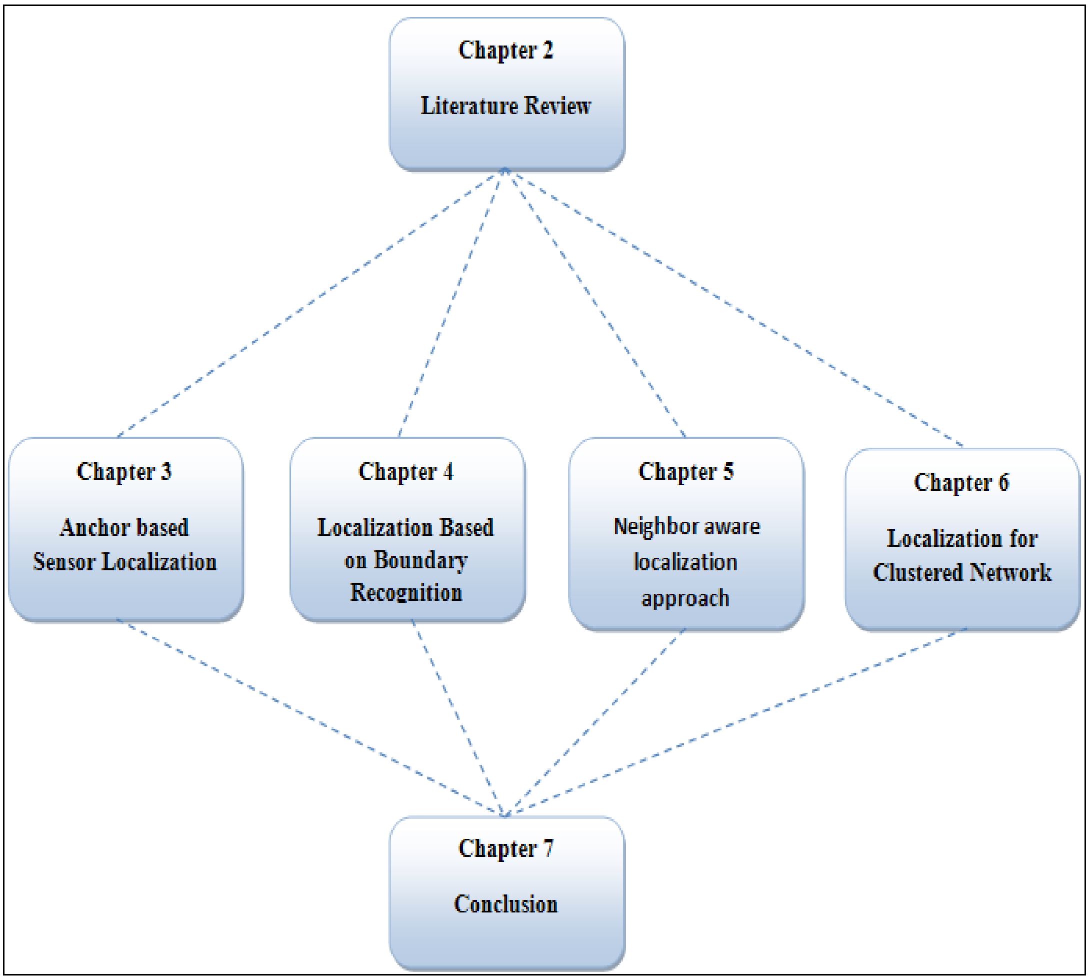


Figure 1.3 Outline of the Thesis

Chapter1 gives the introduction to this thesis. It describes the definition of Wireless Sensor Network with characteristics and explains the concept of Localization. In addition to this a summary of clustering management, the research issues, problem formulation and overview of this thesis are also outlined.

Chapter 2 gives the literature survey about the routing protocols, localization in boundary condition and clustering techniques in localization. Chapter 3 describes the performance analysis in Anchor based Sensor Localization with different mobility models.

Chapter 4 describes Localization Based on Boundary Recognition. Performance of this approach is compared with different algorithms. Chapter 5 deals with Neighbor Aware Localization Approach. Chapter 6 gives information on the reconstruction and maintenance Distributed Localization for Clustered Network.

Chapter 7 relevant conclusions are drawn. The contributions of this work are summarized followed by future areas of research that might be investigated in order to build upon the work presented in this thesis.

CHAPTER 2

LITERATURE SURVEY

This chapter begins with a review of the related literature on localization in Wireless Sensor Networks and then gives the comparison of various localization methods.

2.1 LOCALIZATION IN WSN

Liu et.al [2012] proposed the Approximate Convex Decomposition (ACD) to provide good localization in Wireless Sensor Network. This technique calculates the virtual locations of the node in their random shape. Firstly it will discover the node boundary and the convex dimensions. After that, it fixes the localization using multi-dimensional scaling. Finally using merging algorithm, it develops a location map. Chen et.al [2012] defines the semi definite programming based on Node Localization Algorithm for non-line-of-sight paths. This technique will detect the location of every node based on the distance. Location accuracy is very difficult to achieve for both conditions, LOS and NLOS paths. But using this technique it can increase the location accuracy and decrease the NLOS error. Chu et.al [2012] suggests the Distributed Boundary Algorithm for Wireless Sensor Network. From this network, it analyzes the boundary nodes in three dimensional networks. It does not depend on particular relay model and it produces a constant maximum transmission range. It is applicable for both uniform and non uniform conditions. Tan et.al [2012] suggests connectivity based and anchor free three dimensional localization schemes for large scale sensor network. It contains three features to develop the connectivity of Wireless Sensor Network.

Zhang et.al [2012] explains the process to detect the accurate analysis and decision making quality of WSN. This technique, addresses the quality of Wireless Sensor Network and focus on the outlier detection. This outlier detection in Wireless Sensor Network is based on current statistical method. Zhou et.al [2012] proposed a detection boundary algorithm. This protocol detects only the boundary of the node and not the location and distance of nodes. Using this boundary value, it will find the barrier or obstacles in front of the node. This algorithm is used to detect the obstacle in Wireless Sensor Network. Dong et.al [2012] discusses about the coverage problems in Wireless Sensor Network. To overcome this coverage problem, they proposed a technique as novel coverage criterion and scheduling method based on cyclic partition. It proves the effectiveness of the simulations and comparison of the state of the art approaches. Luo et.al [2012] presents the censoring scheme for Energy Based Localization in Wireless Sensor Network that is used to minimize the bandwidth and energy consumption. Mahmoud et.al [2012] suggests the hotspot locating attack for Wireless Sensor Network. This method is used to detect the localization of the node and the traffic analysis for Wireless Sensor Network. This gives the privacy protection rather than other routing based schemes. Vecchio et.al [2012] proposed a two-objective evolutionary approach based on topological constraints for node localization in Wireless Sensor Networks. The proposed method evaluates both the topology constraints and accuracy of localization. It is simulated with various networks and it is compared with meta-heuristic approach. The result is achieved with accuracy and stability.

Dong et.al [2013] proposed a survey on mobility and mobility-aware MAC protocols in Wireless Sensor Networks. Mobility at the link layer has some difficulty in the protocol design. It surveys the present state of handling mobility and provides a result of comparison with certain mobility aware protocols. Ma et.al [2012] proposed a range-free Wireless Sensor Networks localization based on hop-count quantization. Hop-Count Based Localization technique is a profitable alternate method in Wireless Sensor Networks. The Hop-Count Quantization (HCQ) algorithm is used here for transforming the hop-count integer into a real number for WSN localization issue with MDS method. The simulated result shows that the performance of MDS type algorithm is much better than the hop-count integer values. Singh et.al [2012] proposed a novel energy-aware cluster head selection based on particle swarm optimization for Wireless Sensor Networks. The proposed scheme approaches a Particle Swarm Optimization (PSO) scheme to create energy-aware clusters. The PSO is a cost-effective method for detecting the location of head nodes from the clusters. PSO-C and LEACH-C is the network protocols used for evaluating the proposed scheme. The simulation result shows the effectiveness of the scheme with respect to network period, packet transmission ratio and energy consumption.

Table 2.1 Comparison of Localization Methods

Authors	Algorithm/Method	Description
Wang et. al [2014]	Improved Data Cleaning Algorithm	Improves data compressibility and accuracy. Decreases energy consumption
Cui et. al [2012]	Four-Mobile-Beacon Assisted Weighted Centroid Localization	Outperforms weighted centroid and multi-lateration
Liu et. al [2013]	Mobi-Sync, A Novel Time Synchronization Scheme	Precise estimation on long dynamic propagation delays
Wang et. al [2012]	Improved Noise Model and maximum Likelihood Estimator	Integrates both additive noises and multiplicative noises. Removes the sensing nonlinearity for prelocalization
Javaid et. al [2013]	Away Cluster Head (Ach)	Extends stability period and effectively increases number of packets sent to base station (BS).
Manzoor et. al [2013]	Quadrature-LEACH (Q-LEACH)	Increases network life-time and stability period
Rasheedet. al [2013]	Energy-Efficient Hole Removing Mechanism (E-HORM)	Removes energy holes, maximize the network lifetime and balances the energy consumption
Shah et. al [2012]	Energy Efficient Sleep Awake Aware (EESAA) Intelligent Routing	Evaluates network lifetime, network stability and cluster head selection process. Improves network parameters.
AbdelSalam et. al [2012]	BEES - A Lightweight Bioinspired Backbone Construction Protocol	Mitigates typical challenges like clustering, sensor localization and data aggregation

Authors	Algorithm/Method	Description
Liu et. al [2012]	Energy-Balancing Unequal Clustering Approach For Gradient-Based Routing (EBCAG	Significantly improves the network lifetime and balances the energy consumption among the cluster heads

2.2 NEIGHBORWARE BASED APPROACH

Abumansooret.al [2012] proposes a secure cooperative approach for non-line-of-sight location verification in VANET. The scheme proposes a location verification protocol for secured localization of VANET and also to avoid Non-Line Of Sight (NLOS) condition. The simulated result of the scheme shows the development of neighborhood response during NLOS condition. It also improves the reliability of localization service. Bu et.al [2012] explains co-linearity-aware and conflict-friendly localization for Wireless Sensor Networks. The proposed scheme is introduced to overcome the limitations of graph rigidity theory. The scheme gives two methodologies about conflict-friendly localization and co linearity-aware localization for WSNs. The scheme has been validated for localization accuracy with simulation and real experiments.Panwaret.al [2012] discusses about various localization schemes in Wireless Sensor Networks. The Kang, et.al [2012] explains about several techniques used to determine the location of node sensor in Wireless Sensor Network. The study also compares some algorithm used for localization with its benefit and weakness on Wireless Sensor Networks. Li et.al [2012] explains about Dynamic Beacon Mobility Scheduling for sensor localization. The scheme implemented Deterministic Dynamic Beacon Mobility Scheduling (DREAMS) algorithm, where the beacon trajectory is used as Depth-First Traversal (DFT) of network graph. The Depth-First Traversal acts dynamically with the instructions received from neighboring sensors on the act. Corresponding to RSS (Received Signal

Strength) the mobile beacon is moved from sensor to sensor. To reduce the delay of beacon movement Local Minimum Spanning Tree (LMST) and node eliminations are suggested. Finally the sensors are localized in a common co-ordinate system. The result is simulated and the Deterministic dynamic beacon Mobility Scheduling algorithm promises localization with noisy distance measurements and the result is evaluated with static path-based scheduling method.

Bo et.al [2012] explains about locating sensors in the forest: A case study in Green Orbs. Due to changes in environmental conditions it is difficult to locate the sensor nodes in the forest, which is revealed by Green Orbs. The scheme gives localization method called EARL, which gives ranging quality and accurate node reference. With the help of certain environmental factors like atmospheric temperature, humidity and density of a forest the scheme examines the quality of routing paths. For better localization accuracy, the scheme proposed a power scanning technique and the bad nodes are calibrated with reverse-localization. Larioset.al [2012] and Xionget.al [2012] proposed the LIS localization based on an Intelligent Distributed Fuzzy System which can be applied to a WSN. The availability of power and weight are the major limitations in the wildlife localization applications. So There are two algorithms that is been used, first is a fuzzy based local node algorithm which gives partial solution and the second is a centralized algorithm which combines all other partial solutions of localization.

2.3 LATERATION TECHNIQUES

Bechkitet.al [2012] proposed a new weighted shortest path tree for convergence of traffic routing in WSN. The proposed new weighted path cost function is simple, efficient and fit for Wireless Sensor Networks than the basic Shortest Path routing Tree (SPT) strategies. The Shortest Path routing Tree are the incompatible method for many to one Wireless Sensor Networks. Zhang et.al [2012] discusses on localization in 3D sensor networks using stochastic particle swarm optimization. Xionget.al [2013] proposed scheme provides a localization method with stochastic particle swarm optimization. Here the distances among sensor nodes are measured and by using the stochastic particle swarm optimization the locations are estimated.Zhaoet.al [2012] suggests the optimizing value of the scheme using only 120 iterations which is 80 iterations lower than the Standard Particle Swarm Optimization. Chang et.al [2012] proposed an Anchor-Guiding Mechanism For Beacon-Assisted Localization in Wireless Sensor Networks. Zoghiet.al [2012] prepares a Proficient Path For Mobile Anchor. The Anchor-Guiding Mechanism guides the mobile anchor to travel over an effective path. The experimental study exposes that the proposed method of anchor-guiding mechanism saves the required time for improving the location errors of sensor nodes.

Wang et al [2013] and Wang et al [2012] explain about three-dimensional greedy routing in large-scale random Wireless Sensor Networks. The scheme investigates the design of greedy routing suitable for three-dimensional (3D) sensor network. The 3D greedy routing design protocols are energy efficient and guarantee the packet delivery in a 3D sensor network. Energy efficiency is achieved here by refined 3D greedy routing protocol. Rocha et.al [2012] discusses about WSNs clustering based on semantic neighborhood relationships.

Gholamiet.al [2012] explains about evaluating the alternative approaches on Mobile Object Localization in Wireless Sensor Networks with passive architecture. The Demigha et.al [2013] evaluates the performance of proposed techniques like Kalman filter based technique along with the neural based and trilateration based techniques which are used to oppose the trouble of sensor node tracking in a real-time Wireless Sensor Networks. The Figure 2.1 shows the lateration technique in which the beacon signals are received by the mobile mote with the help of passive architecture of a network to localize itself in the sensor network. Then the Kalman filter and Trilateration Based Techniques are compared by a Neural Based Methodology. The result shows the advanced performance of Neural Based Methodology with good efficiency.

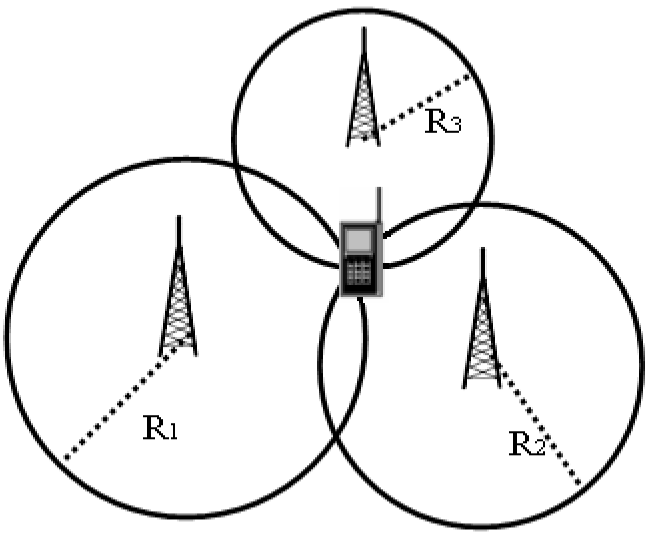


Figure 2.1 **Lateration Technique**

Chang et.al [2012] proposed the tone-based localization for distinguishing relative locations of sensors in Wireless Sensor Networks. Bounding box mechanism is a cost effective localization method for Wireless Sensor Networks but it gives reduced performance for certain applications. The information of location generated by the bounding box method is not differentiating the virtual location of nearby sensors. So a Differentiating Relative Locations (DRL) mechanism has been proposed to find the virtual locations of every two neighboring nodes with the help of beacons aiming and mobile anchor to transmit tones. The relative or virtual location of each sensors with its neighbors are identified by enter and exit tone. A two path planning mechanism has also been discussed giving an assurance for all sensors to locate its relative location. It is also effective in reducing energy consumption of the mobile anchor. Wu et.al [2012] and Arndt et.al [2012] suggest a Novel Range-Free Localization based on regulated neighborhood distance for Wireless Ad Hoc and Sensor Networks. Range-free localization schemes are good for higher range of Wireless Sensor Networks and Ad Hoc Networks because of reduced hardware equipment.

2.4 DISTRIBUTED SENSOR NETWORK

Redondiet.al [2013] suggests an integrated system based on Wireless Sensor Networks for patient monitoring, localization and tracking. The system LAURA delivers the patient localization and monitoring facilities along with tracking of patient by Wireless Sensor Networks. The system is designed with three well-designed blocks where the localization and tracking engine block is used for localization of acknowledged signal strength and tracking by a particle filter. The actions and movements of patients are detected through the personal monitoring module using bi-axial accelerometers. The information is transmitted through the wireless communication substructure. The proposed scheme suggests two methodologies for localization and tracking engine. A centralized application is introduced here to execute the localization centrally rather than collecting information locally and the localization solution is executed at the mobile nodes and the result is transmitted to the central controller. The strength and weakness of methods are compared in terms of traffic loads, accuracy and energy efficiency. With the help of commercial hardware, the LAURA system is verified in a real time environment where the error in localization is lesser than 2 m of 80% cases and the accuracy of movement classification are higher as 90%.

Wang et.al [2012] proposed a Coverage-Aware Clustering Protocol for wireless sensor networks. Sensor scheduling and network clustering are the two effective methods to minimize the energy consumption of the node in an Energy-Limited Wireless Sensor Networks but it has the contest for deciding the better energy-efficient cluster size. It also has challenges on selecting active nodes and cluster heads. Coverage-Aware Clustering Protocol favors the nodes to utilize the wasted energy for selecting the active nodes and cluster heads. Yu et.al [2012] suggests an improved DV-Hop localization method in Wireless Sensor Networks. The DV-Hop method is a simply executable method in real time Wireless Sensor Networks. The method does not require the range measuring tools but it has poor accuracy on localization. To reduce such drawbacks on DV-Hop method, an improved DV-Hop method of localization by means of correcting the distance among the unknown node and anchor nodes to get good accuracy on localization without adding the hardware costs. Li et.al [2013] explains a novel localization algorithm based on Isomap and Partial Least Squares for Wireless Sensor Networks. The localization information is nonlinear due to the error and noise present on the real time environment. So a novel Isomap (isometric mapping) node algorithm is proposed under PLS-Isomap (Partial Least Squares). The critical outliner points are removed for topology stability by equating the contribution rate of data points. The noise sensitivity on Isomap is moderated by the implementation of PLS. A new kernel matrix is constructed among original and new data points by the projection method. This method is compared with Multidimensional Scale Scheme and Isomap scheme and the result specifies the PLS-Isomap method has good positioning accuracy, good topological stability and reduced computational complexity.

Kumar et.al [2012] briefs about the meta-heuristic range based node localization algorithm for Wireless Sensor Networks. Hu et.al [2014] proposed two applications namely Biogeography Based Optimization (BBO) and H-Best Particle Swarm Optimization (HPSO) for Optimal Localization Of Randomly Organized Sensors. The localization problem of WSN is framed as NP-Hard optimization problem due to its complexity and size. Al-Turjman et.al [2012] shows how it improves the life time of network nodes during tough environments and the algorithm is also used to detect the location of mobile node with beacon and range based localization method. Also Kodali et.al [2013] highlights the drawbacks and issues occurred in the method.Ehsanet.al [2012] proposed a survey on Energy-Efficient Routing Techniques with QoS assurances for Wireless Multimedia Sensor Networks. Wireless Multimedia Sensor Networks (WMSNs) is an intelligent system based on a powerful class of sensor improved by the development of electro-mechanical systems. WMSNs are good in Quality of Service but it has routing challenges for resource-constrained networks. So the existing energy efficient methods of routing are surveyed here for overcoming the issues of WMSNs. Anet.al [2013] discusses the design challenges and limitations on existing methods for non-multimedia data transmission and the research trends in future development are also discussed.

Zhou et.al [2012] discusses the Deflection-Aware Tracking-Principal Selection in active Wireless Sensor Networks. The technique explains about the accuracy on tracking and energy efficiency on Wireless Sensor Networks (WSNs) and it focuses on the problems corresponding to the tracking node selection. Organizing the actions between the sensors is a task which leads to the process of locating the object to be tracked in time and another task is implemented where the nodes are selected by coordination and data fusion method to detect the object that goes beyond the tracking region. It is developed by extending the existing technique where the trajectory of the target is evaluated by straight line segments and also the tradeoffs among the in-node calculations incurred with particle filters, the impression tolerance is selected at successive tracking methods.

Velimirovicet.al [2012] suggests the Fuzzy Ring-Overlapping Range-Free (FRORF) localization method for Wireless Sensor Networks. The range free localization method based on received signal strength is simple and cost effective technique for location-aware systems on Wireless Sensor Networks but this method has poor accuracy and it leads to error on estimation. In order to avoid such weaknesses a Fuzzy Set Based Localization technique is proposed and it is called Fuzzy Ring Overlapping Range Free (FROFR) localization technique. The sensor node exists in the localization space and it is isolated using FRORF method by anchors through a Broadcasted Beacon signal. Before creating the fuzzy set regions from different fuzzy ring set an overlapping ring sets is represented in equal space of RSS value. In Naderanet.al [2012] distance estimation approach, location is estimated using FRORF technique by the degrees of sensor node. Sensor nodes belong to the regions of fuzzy set. Kim et.al [2012] proposed a new scheme that is simulated and its result show the accuracy of localization which is improved even under the radio irregularity and non-radio irregularity.

2.5 CLUSTERING TECHNIQUE

Branch et.al [2013] proposed a network detection mechanism in Wireless Sensor Networks. The Figure 2.2 shows the clustering technique in Wireless Sensor Network. Single-hop communication is used here to minimize the energy consumption and bandwidth therefore it permits node failure detection with reliable assurance mechanisms. The technique is simulated with real time sensor data and the results is determined in such a way that the proposed approach is perfect and executes reasonable communication with energy consumption.

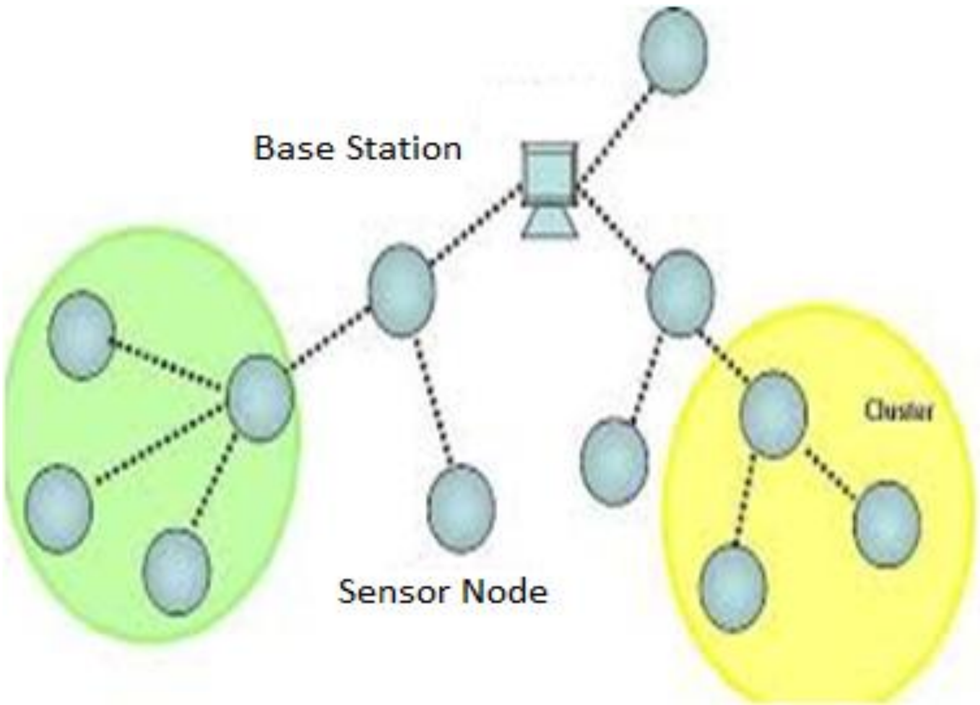


Figure 2.2 Clustering in WSN

Mourad et.al [2012] suggests the algorithms used for localization which is further classified as new perspective algorithm based on the mobility condition of landmarks and undefined nodes to present an analysis report for representative algorithm of localization. Yadavet.al [2012] analyzes the research orders for localization algorithm of WSNs in future. Singh et.al [2012] proposed a novel energy-aware cluster head selection based on particle swarm optimization for Wireless Sensor Networks. The lifetime of networks are extended by clustered nodes with collection of data to the cluster head. To generate energy-aware clusters the Alhmiedat et.al [2013] proposed the Particle Swarm Optimization (PSO) by ideal selection of cluster heads. The proposed PSO method decreases the cost required for locating head node's ideal location in a cluster. To make it as a semi-distributed system a PSO-based methodology is implemented. The proposed energy consumption method reflects the transmission of packets toward the projected path. The simulation result shows the efficiency of the proposed method in terms of energy consumption, packet transmission average, lifetime of network and selection of cluster heads by PSO. Suoet.al [2012] brief about the issues and challenges of Wireless Sensor Networks localization in emerging applications. Localization of WSNs is the major requirement for several emerging applications like cyber-transportation and physical systems. Ahmed et.al [2012] discusses about various node localization schemes and the challenges and drawbacks are pointed out. The measurement based methodologies and some range free localizations like proximity, one-hop, multi-hop localizations are examined deeply.

Ammariet.al [2012] proposed a centralized and clustered k-coverage protocol for Wireless Sensor Networks. Sensing coverage and network connectivity are the major and needed functionality in Wireless Sensor Networks WSNs. The k-coverage problem of WSN is addressed in this algorithm. The k active sensors are connected along with other active sensors present in the monitored field. To generate k-coverage patterns in WSN the duty cycling tricks are explained. For broad k-coverage field a sensor spatial density condition is derived. The connectivity and k-coverage of a field between the sensors are maintained by correlation among the sensing ranges and communication of sensors. A four configuration protocol is proposed here for solving the k-coverage issues on WSNs. It is also proved that the proposed protocol picks only a less number of sensors for achieving complete k-coverage of a field with connectivity assurance. The simulated result shows that the proposed protocol is advantageous then the prevailing distributed k-coverage protocol.

Hackmannet.al [2014] suggests cyber-physical code sign of distributed structural health monitoring with Wireless Sensor Networks. Localization and detections are the two major issues on monitoring the long term structural health of civil structures. In the traditional method there was a split between the structural engineering algorithm and design of WSNs. So a Cyber-Physical code sign method is proposed to monitor the structural health with WSNs. The proposed technique integrates flexibility-based localization method to tolerate a tradeoff among the quantity of sensors and damage in localization resolution. It is also integrated with multilevel computing architecture to power the multi resolution facility of flexibility-based scheme. The simulation truss structure and real time full-scale truss structure shows the effectiveness of the proposed scheme with energy efficiency and localization on damage.Chiweweet.al [2012] proposed a distributed topology control technique for achieving low interference and energy efficiency in Wireless Sensor Networks. Topology control is a major factor in the design of Wireless Sensor Networks And Ad Hoc Networks. So a distributed topology control method is proposed here which in turn improves the energy efficiency and minimizes the interferences on Wireless Sensor Networks. Here the global connectivity is done with the local decisions about the transmission power taken by the network nodes.

The proposed technique is a Smart Boundary Yao Gabriel Graph (SBYaoGG) and it guarantees the network links are energy efficient and symmetric. The simulated result represents the effectiveness of the proposed techniques over the existing methods of topology control.Tenget.al [2012] gives the idea about distributed variation filtering for simultaneous sensor localization and target tracking in Wireless Sensor Networks. Wireless Sensor Networks used for applications based on tracking the moving targets requires the precise position of sensors. But the exact information of sensor position is not available constantly because the generated measurement targets are movable in the network field. The uncontrollable target moving, vagueness of sensor positions and the constrained resources in WSNs are the major challenges faced in using this technique. So a general state evaluation design is implemented to define the dynamical system with the knowledge on behavior of target movement and accurate location of the sensors. To estimate the filtering distribution a variation method is adopted here. It reduces the inter cluster communication and error transmission. Bandwidth and energy consumption are minimized in the network over the centralized scheme by implementing the algorithm on fully distributed cluster methodology. Liet.al [2012] suggests servicing Wireless Sensor Networks by mobile robots. Wireless Sensor and Robot Networks (WSRNs) are the cyber physical systems. The robots have the ability to control a wide range of network and it results in the network performance improvement. Aslamet.al [2012] proposed a survey of extended LEACH-Based clustering routing protocols for Wireless Sensor Networks. Zhou et.al [2012] presents the development of LEACH routing protocol and the protocol is named as energy efficient hierarchical routing protocol. Liao et.al [2012] discussed about how the improved method is increasing the lifetime and quality of WSN protocol. It shows the problems present on conventional LEACH and it also demonstrates how those problems are rectified in the improved version of LEACH.

Liao et.al [2013] suggests the load-balanced clustering algorithm with distributed self-organization of Wireless Sensor Networks. The Wireless Sensor Networks are developed with energy efficient sensor nodes to identify and observe the physical factors around it with self-organization. The general method for employing data aggregation and network management in WSN is to develop a hierarchical network with the help of clustering algorithm. The load balanced clustering algorithm is proposed here for WSNs. Aziz et.al

[2013] proposed a survey on distributed topology control techniques for extending the lifetime of battery powered Wireless Sensor Networks. The modern technology applications like smart grids and Internet Of Things utilizes the self-organizing large scale WSNs and mesh networks. Energy efficiency and battery lifetime plays a major role in support of these developments in technology. Yongwenet.al [2013] gives a complete survey report on topology control methodology and energy efficient issues for increasing the lifespan of battery driven WSNs. The algorithm on significant topology control is reviewed for showing vision about how the efficiency on energy is attained by design. The non-planar topology algorithms are used on applications like underwater environments and multilevel building. Ahmad et.al [2013] gives the idea about density controlled divide-and-rule scheme for energy efficient routing in Wireless Sensor Networks. Cluster based routing technique is a commonly used technique on Wireless Sensor Networks because of its utilization of energy on routing protocols. Savicet.al [2012] proposed a new technique for routing and it is called energy efficient cluster based technique. The proposed technique overcomes the issues like energy hole and coverage hole by setting ideal number of cluster heads along with density controlled uniform distribution on each round.

Yong et.al [2012] proposed an energy-efficient clustering routing algorithm based on distance and residual energy for Wireless Sensor Networks. Ye et.al [2012] presents a distance-energy cluster algorithm which is developed from the existing LEACH algorithm. The proposed algorithm rectifies the issues like limited energy of sensors on Wireless Sensor Networks and also increases the process of data transmission and the cluster head election process. It also decreases the adverse effect that is happening due to the non-uniformity of nodes distribution on network and it escapes from the direct communication among the cluster head and base station. The simulated result indicates that the developed algorithm balances the energy consumption effectively over the classic LEACH protocol and also extends the lifetime by 31% comparatively. Wang et.al [2012] suggests a clustering algorithm based on energy information and cluster heads expectation on Wireless Sensor Networks. The proposed method is a development of Low Energy Adaptive Clustering Hierarchy (LEACH) protocol. It is developed by choosing cluster heads with respect to the energy of the nodes. The electing probability is adjusted by setting up a sliding window and an expected number of cluster heads are kept stabilized by using two constraints. First constraint is the primary energy information of nodes and the next one is the energy information average. The LEACH is modified as a variable with respect to the quantity of cluster nodes present on the network lifetime. The simulation result indicates the advancement on which the First Node Dies by 41% and Half Nodes Alive by 36% comparatively to the LEACH protocol, 17% of improvement of FND and 26% on HNA for Low Energy Adaptive Clustering Hierarchy with Deterministic Cluster-Head Selection (LEACH-DCHS) and similarly 22% and 21% higher than the Advanced Low Energy Adaptive Clustering Hierarchy (ALEACH). Dong et.al [2013] proposed a survey on mobility and mobility-aware MAC protocols in Wireless Sensor Networks. The nodes can be mobile or static in Wireless Sensor Networks. The protocol design on mobility WSNs has some tough challenges especially on the link layer. To predict the link layer quality and mobile node localization on those challenges requires mobility adaption algorithm. An article surveys about the present state-of-art mobility handling which explains the classic patterns and mobility models first and then examines the difficulties initiated on link layer by mobility.

The distributed field reconstruction in Wireless Sensor Networks [Reiseet.al, 2012] based on hybrid shift-invariant spaces are a solution for dynamic topology maintenance. In Wireless Sensor Networks, for reconstructing and sampling of time-varying non-band limited physical field a novel distributed architecture is developed. Mohandes et.al [2012] suggests a hybrid shift-invariant space that simplifies the classic shift-invariant spaces. The global reconstruction is split in to several small problems to solve it freely with the help of shift-invariant spaces along with sustained generator functions. Baghaee et.al [2013] introduces an iterative and direct reconstruction algorithm. The effect of sensor localization error is analyzed for the reconstructed field by mean square error.Latifet.al [2013] proposed a new Divide-and-Rule Scheme for Energy Efficient Routing in Wireless Sensor Networks. In Wireless Sensor Networks (WSNs), it is a tough task for clustering the sensor nodes. The lifetime and stability of the networks are extended with the help of clustering method in routing protocols. Mansouri et.al [2014] also discusses about Divide-and-Rule (DR) routing protocol. It is developed from the dynamic and static cluster head selection method. In the classic methods the cluster heads were selected by probabilistic procedure, but the proposed techniques chooses only a fixed number of cluster heads. The simulation results indicate that the performance of proposed Divide-and-Rule protocol is good over other equivalent type of routing protocols.

Zhu et.al [2012] proposed a survey on coverage and connectivity issues in Wireless Sensor Networks. The communication and sensing are the basic functions of Wireless Sensor Network (WSN). So it is suggested for applications based on monitoring and detecting. The basic challenge in WSN is to maintain the coverage region for monitoring the task perfectly. The coverage and connectivity impact reflects the overall performance of the WSN. The network life time is improved by the optimized deployment strategy and sleep scheduling mechanism. The problems related to coverage issues are classified. Zhang et.al [2013] discusses the relationship analysis among the connectivity and coverage. Calafateet.al [2013] compares the simulation tools with research challenges and standing problems discussion. Lai et.al [2012] gives the idea on arranging cluster sizes and transmission ranges for Wireless Sensor Networks. Hierarchical routing is an energy efficient method for clusters. Multi-hop communications among data sink and source are effective in energy consumption over the direct transmission but the cluster heads (CH) which are nearer to data sink are loaded by heavy relay traffic which results in drain themselves quicker than other cluster heads. In order to avoid such issues a new technique is suggested, it minimizes the size of clusters closer to the Base Station (BS) and it permits all the CH to consume equal amount of energy approximately. For increasing the network lifetime the network topology is separated into multiple hierarchical levels. Masazade et.al [2012] proposed the technique whose simulated results indicates that the suggested clustering method improves the lifetime of network effectively than Low Energy Adaptive Clustering Hierarchy, Base Station Controlled Dynamic Clustering Protocol and multi-hop routing with low energy adaptive clustering hierarchy.

Srisooksaiet.al [2012] explains about a practical data compression in Wireless Sensor Networks. Energy consumption is a major problem of Wireless Sensor Networks (WSN) which results in disturbing the lifetime of WSN. The data compression technique is a method used to minimize the data transmission on wireless medium. The inter-node communication is reduced in this scheme to save energy consumption in Wireless Sensor Networks. Afolabi et.al [2013] gives the comparative study of classic data compression in Wireless Sensor Networks. With appropriate set of terms the classic methods are classified and determined with practical data. The details are described separately for each compression category. The performance, limitations, issues and applications for each technique are examined and compared with the practical data compression of wireless sensor networks.

CHAPTER 3

MULTIPLE MOBILE ANCHORS BASED LOCALIZATION

3.1 OUTLINE

In Wireless Sensor Network (WSN), several techniques are being used for localization based on mobile anchors, but the existing works incur huge delay in localization since the mobile anchor has to cover the entire network. Also maximum coverage of all nodes is difficult if visiting schedule of the mobile anchor node is not considered. In order to solve these problems, a new technique named multiple mobile anchor based localization technique using Particle Swarm Optimization (PSO) technique has been put forth. PSO is used to determine the trajectory of the mobile anchor nodes based upon the node density and the distance between the nodes in the network. The mobile anchor nodes broadcast packets to the visited sensor nodes depending on the PSO visiting schedule. The unknown nodes on receiving the packet, calculate the estimated distance between each of the mobile anchors and using trilateration method, they are localized.

3.1.1 Need for Localization

- **Localization :**

In Wireless Sensor Network, the localization is used to find out the exact location of the sensor nodes and also for knowing the correct position from where the information is being collected.

- **Localization enables the efficient routing**:

In a sensor network, large number of nodes needs to communicate at a very short distance. The data collected by a node has to be sent to the central unit through several other nodes. Multi-hop routing is used to communicate the information. Hence it is necessary to have nodes of the same locality and to know their relative position with respect to their neighbors. Thus localization is very important.

- **Localization provides the power saving:**

In the scenarios like pollution monitoring, the neighboring sensor nodes of the sensor network may have same data which are not different from each other. Hence to save power, the data from the neighboring nodes are combined. The combined and reduced data set is used for communication in order to conserve the power. The location information is necessary for the local data fusion. It shows the significance of localization.

- **Localization assists in the applications like target tracking:**

In target tracking the range, the speed and the direction of the target is needed to be determined. The sensors are deployed in region which senses the sign and from the moving target its range, direction, and speed can be monitored. Hence the location of the sensor nodes is necessary to calculate the global orientation of the target.

- **Localization useful in locating the source of the data:**

In event based sensor networks, the nodes are normally in sleep mode, the nodes awake only on the occurrence of an event. The data sensed and transmitted by the nodes requires a location stamp and hence localization is necessary.

3.1.2 Issues in localization of WSNs

The shortest path is used for unavailable distance measurements in centralized localization algorithms such as the MDS method. The shortest paths usually do not correlate with their Euclidean distances in irregularly shaped sensor networks. Hence it leads to severe deterioration in the localization performance. The GPS installation on each sensor node for location discovery is impractical due to its significant power consumption, cost and line-of-sight condition requirement. The GPS receivers are also susceptible to jamming and attenuations. The current generations of sensor nodes are smaller and cheaper. As a result the nodes have reduced memory and processing capacities within limited battery power. In addition the nodes can only communicate with its local neighbors due to its short transmission range. Some localization algorithm cannot be applied to low density WSNs as they cause considerable localization errors whereas the localization can be an expensive process using some algorithms in high density WSNs due to its high cost and high delay. Some of the localization algorithms have steps involving the process of finding the shortest path between a pair of nodes and is calculated using the Euclidian distance.

This method of calculation is valid only if the shortest path is a straight line. This is not valid for network having concave topology as it gives distorted results. Some nodes give good approximation whereas for others, the Euclidean distance differs significantly from the length of the shortest path. The nodes positioned in the limits of the WSN area may not deal with localizing the nodes using some existing localization algorithm. Hence the distance information of each node obtained is less accurate and of low quality. These localization solutions have low accuracy in obstructed environment as there is existences of obstacles obstructing the line-of-sight between the nodes. Signal reflection is caused by multipath propagation which leads to wrong distance estimations. Both indoor and outdoor environments face this problem. Most solution uses radio signals to measure the distance between the nodes based on the received signal strength. It may cause less accuracy or less reliability results as these signals are deeply affected by the environment due to the presence of obstacles or multi-path phenomenon. The heterogeneity of the channel depends on the propagation direction that cannot be ignored; atmospheric condition like temperature has less effect on the signal whereas rain has more effect on the signal. WSNs can make use of ultrasounds by overcoming two challenges. They are as follows:

- Localization schemes designed for static sensor network runs periodically to update the location results. Hence the communication overhead increases dramatically.

- Distributed localization scheme designed for small scale underwater acoustics network is not suitable for large-scale underwater sensor network because of their slow convergence speed and high communication overhead.

3.2 PROBLEM IDENTIFICATION

In most of the existing works on mobile anchor localization, single mobile anchor node is used for localization of the network. This causes a huge delay in the localization of the network, since the single anchor node has to cover all the sensor nodes in the network. The visiting schedule of the mobile anchor node is also not taken into consideration to obtain maximum coverage of all nodes in the network. Hence it indeed increases the computational overhead. The decrease in energy of the sensor nodes may affect the efficiency of the whole network. To solve the above problems, a multiple mobile anchor based localization technique using Particle Swarm Optimization (PSO) technique is proposed for Wireless Sensor Networks (WSN). It consists of a set of three mobile anchor nodes for localization of the network.

3.3 PROPOSED WORK

The proposed technique uses PSO to determine the trajectory or visiting schedule of the 3 mobile anchor nodes based on the node density of the network. The 3 mobile anchor nodes traverse through the network based on the PSO based visiting schedule in which they broadcast packets containing information on their id and location of the visited sensor nodes in the network. The unknown nodes having less Received Signal Strength (RSS) value than the mobile anchor nodes on receiving the packet calculates the estimated distance between each of the mobile anchors to the unknown node. Each unknown node maintains anchor list having the anchor coordinates and estimated distance. The localization of the node is done using trilateration method. The unknown node will get two anchors from the list and localize them using trilateration method with the reference node. Reference node is the mobile anchor node having least distance to the unknown node. The main advantage of the proposed solution is the usage of multiple mobile anchor nodes resulting in reduced delay in the localization of the network. Hence the localization of the network is carried out quickly. The PSO based approach for the visiting schedule of the mobile anchors enables it to traverse through the dense and sparse network with the same easiness. Hence the localization of anchors in both these networks is improved and thus the cost of localization is also reduced to a great extent.

3.3.1 Estimation of Node Density

A network consisting of several anchor nodes is considered and the local density is determined using the number of neighboring nodes. The node densities are classified into low, medium, and high. The ratio between expected hop distance and the transmission range for a particular local density is defined as the range ratio. The accuracy of the estimated hop-distance increases due to increase in number of categories at the cost of higher number of exchanged messages. Connectivity can be maintained using k number of neighbors in the wireless network. Classification of density region depends on the number of neighbors. The region is identified as a low density region (L) when the number of neighbors is less than k. The region is identified as high density region (H) when the number of region reaches l. The region is considered as medium density neighbors (M) when the nodes are between k and l. In the sensor network, Reference Nodes (RNs) contain a priori location information. The locations of other nodes are determined based upon the RNs.

In the sensor networks, when the hop-counts are propagated, the density awareness needs to be incorporated. Range ratio is represented as a function of local density of nodes which is defined as the connectivity per unit transmission coverage. The RNs broadcast the hop-count and the nodes which hear the broadcast from which they learn that they are one-hop neighbors of RN. Node's local density determines the distance associated with each hop. The hop-distances at different node densities are gathered together using Range Ratio λ. If a node within the hearing distance from RN finds that it has high local density, it stores the range ratio, $\sum\lambda_1 = \lambda_H$. On the other hand, if the node finds that it is located in medium or low density region, it maintains $\sum\lambda_1 = \lambda_M \, or \sum\lambda_1 = \lambda_H$ respectively. The gathered range ratio in the node gets forwarded to their neighbors. The process is repeated when the range ratio is larger than the existing value. Here the nodes uses their own local density to estimate range ratio and are gathered for forwarding. The received packets are discarded when the range ratio is higher than the existing value. When all the RNs broadcast their range ratio the process ends. If (n-1)th node is the previous node of (n)th node along a shortest multi-hop propagation path, then, the total range ratio accumulated by the (n)th node is given by the equation.3.1

$$\sum\lambda_n = \sum_{i=1}^{n-1}\lambda_i + \lambda_n, where\lambda = \lambda_L, \lambda_M, or\ \lambda_H \tag{3.1}$$

The node has a higher probability of forwarding hop-count packets, if the number of neighbors is higher. All the nodes located at different directions close to transmission boundary receive the hop-count packet. The probability for the hop-distance closer to transmission range and at the direction that constitute shortest end-to-end path increases. The distance navigated becomes less than the transmission range when the number of neighbors is less. In this section, the Euclidian distance of one hop is estimated when an anchor node receives beacons from several other anchors. This is known as the Correction Factor. The equation 3.2 gives the Correction Factor handled by the anchor which is positioned at (x_i,y_j)

$$CF_i = \frac{\sum_j \sqrt{(x_i - x_j)^2 + (y_i - y_j)^2}}{\sum_j K_j} \tag{3.2}$$

Where $K_j$is the number of hops between the current anchor, positioned at (*xi*, y_j), and the anchor positioned at (x_i, y_j). The location of the sensor node can be estimated using the first Correction Factor. The consequent correction factors are disregarded. The sensor nodes which are in the neighborhood of the anchors provide the Correction Factor. The probability grid is quoted to the sensor nodes once the sensor node receives the Correction Factor. The hop-count to the set of neighbors, anchor node's position, unit length of grid, and Euclidian distance estimate of one radio hop are the information contained in the sensor nodes at any given time. Each node constructs the grid of arbitrary size which uses the position of at least three anchors and the unit length of the grid. The node density and the nodes in the network are specified for constructing the grid of optimum size. Smaller grid sizes are adequate for higher densities of anchors in the network. The distances between the nodes are calculated using the following equation 3.3

D = Distance between grid point and anchor / Correction factor (3.3)

Based upon the swarm intelligence, the Particle Swarm Optimization (PSO) algorithm solves the optimization problem in a search space. It also models and predicts the social behavior in the presence of objectives. It proves to be a stochastic, population-based computer algorithm which is based on the swarm intelligence model. The applications of swarm intelligence include socio-psychological principles, approaches to social behavior and engineering applications. The fitness function is provided for evaluating this new solution. This communication structure or social network assigns neighbors of each individual for interaction. The population of individuals is initialized and they are considered as random guesses at the problem solutions. These individuals are called the candidate solutions or particles. In order to improve these candidate solutions, an iterative process is set. The fitness of the candidate solutions are evaluated by the particles and the information about the locations of best success. This information is also made available to their neighbors. The locations of successful neighbors are also known. These successes guide the movements of the populations converging at the end of a trial. This is used efficiently for a non-swarm approach. A candidate solution is given for each particle for optimization problems. The best position of the particle is judged by the particle itself. The neighboring particles also determine the position of the best particle in its neighborhood. The global best particle is the best position in the neighborhood when the neighborhood of a particle is in the entire swarm. This algorithm is named as gbest PSO and pbest PSO is used for smaller neighborhoods. The fitness function measures the performance of each particle and varies depending upon the optimization problem.

Each Particle in the swarm is represented by the following characteristics:

- The current position of the particle.
- The current velocity of the particle.

The population of the particles is used in the latest evolutionary optimization technique which is known as Particle Swarm Optimization. In this algorithm, the particle corresponds to an individual and its position vector and velocity vector are updated by moving through the problem space. It is given as equations3.4&3.5

$$V_i^{k+1} = wV_i^k + c_1 rand_1 \times (pbest_i - s_i^k) + c_2 rand_2 \times (gbest - s_i^k) \qquad (3.4)$$

$$s_i^{k+1} = s_i^k + V_i^{k+1} \qquad (3.5)$$

Where,

V^i_k is the velocity of i at iteration k,

s_i^k is the current position of i at iteration k.

C 1 and C 2 are positive constants and rand1 and rand2 are uniformly distributed random number in [0,1].

3.3.2 Optimization Function

Here the optimization function is calculated using node density and the distance between the nodes in equation 3.6

$$f(\eta) = A.\sum Di + B.\frac{1}{\sum \lambda i} \quad (3.6)$$

Where λ represents range ratio and D is the distance between the nodes. A and B are the smoothing constants. The node density should be maximum and the distance should be minimum for the optimization function.

3.3.3 Weight Function

The inertia weight can be dynamically varied by applying a scheme for the setting the PSO, where *w* decreases over the whole run. The decrease depends on the start and end value of the weight given.

The Inertia term *w*, provided in the equation 3.7 makes the convergence faster and easier.

$$w = w_{end} + (w_{start} - w_{end}) * \beta \quad (3.7)$$

where

$$\beta = (\frac{1}{1+(\alpha x/ x_{\max})})$$

w_{start}, Start value of the inertia weight

$_{nd}$, end value of the inertia weight

x, current iteration number

$x_{\max}$, maximum iteration number

α, used to manipulate the gradient of the decreasing factor

The inertia term should linearly decrease in order to facilitate exploitation over exploration space in later states of the search.

3.3.4 Visiting Schedule scheme

Each particle is represented in visiting scheduling scheme which uses *n* visiting schedules and *m* number of anchor nodes. x_i^k is the position value of ith particle with respect to n dimension and s_i^k is the sequence of tasks of ith particle in the processing order with respect to the n dimension. The position vector x_i^k has a continuous set of values and then the operation vector r_i^k is defined as in equation3.8

$$r_i^k = s_i^k \bmod m. \tag{3.8}$$

The Initial population of particles is constructed randomly for PSO algorithm. The initialized continuous position values and continuous velocities generated by the formulas are defined as in equations3.9 &3.10

$$X_k^0 = x_{min} + (x_{max} - x_{min}) * r \quad (3.9)$$

$$V_k^0 = V_{min} + (V_{max} - V_{min}) * r \quad (3.10)$$

The flowchart for the scheduling algorithm is given in Figure 3.1. β is the iteration value and Ti is threshold for maximum number of iterations.

3.4 LOCALIZATION USING TRILETARATION

In this section, DV-hop (Distance Vector) algorithm is executed initially and the average distance per hop and anchor list for unknown nodes are found. In DV-hop the position information is included in the packets which are generated by the anchor nodes. The numbers of hops away from the packets are denoted using a flag. In WSN, packets are broadcasted in the flooding mode. The hop number increases by one when the packets are transmitted through the relay nodes. Using this, hop number from a node to any anchor node can be determined. In the same way, the anchor nodes compute their hops to other anchors also. The receiver estimates its distance to the anchor node when the information is sent to the unknown node. The location of the anchor node is determined only after getting three or more estimated values from the anchor nodes. The anchors are chosen such that unknowns will get two anchors out of the list. Then the two nodes are combined with a reference node and are localized by trilateration. The unknown nodes receive average distance per hop initially from the reference node. During iteration, the reference node becomes unknown node, the unknown node becomes known node for which the coordinate is computed as depicted in the previous step. The trilateration gives N results which are compared with the actual coordinate. The coordinates which has the smallest difference after iteration, is saved. Ultimately unknown nodes also determine their positions. Based on the PSO based visiting schedule, the mobile anchor nodes traverse through the network which broadcast packets containing information regarding their id and location to the visited sensor nodes in the network. The unknown nodes having less Received Signal Strength (RSS) value than the mobile anchor nodes on receiving the packet calculates the estimated distance between each of the mobile anchors to the unknown node.

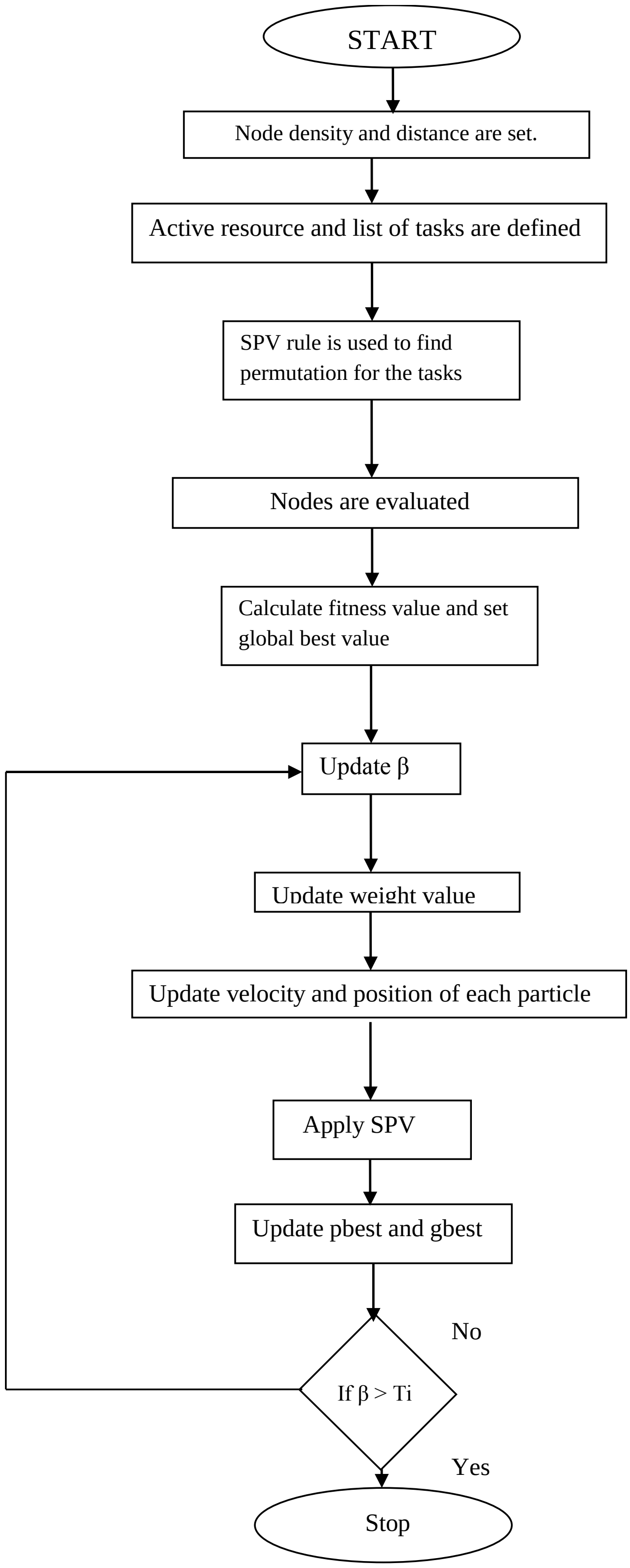


Figure 3.1 Flow chart for Scheduling Process

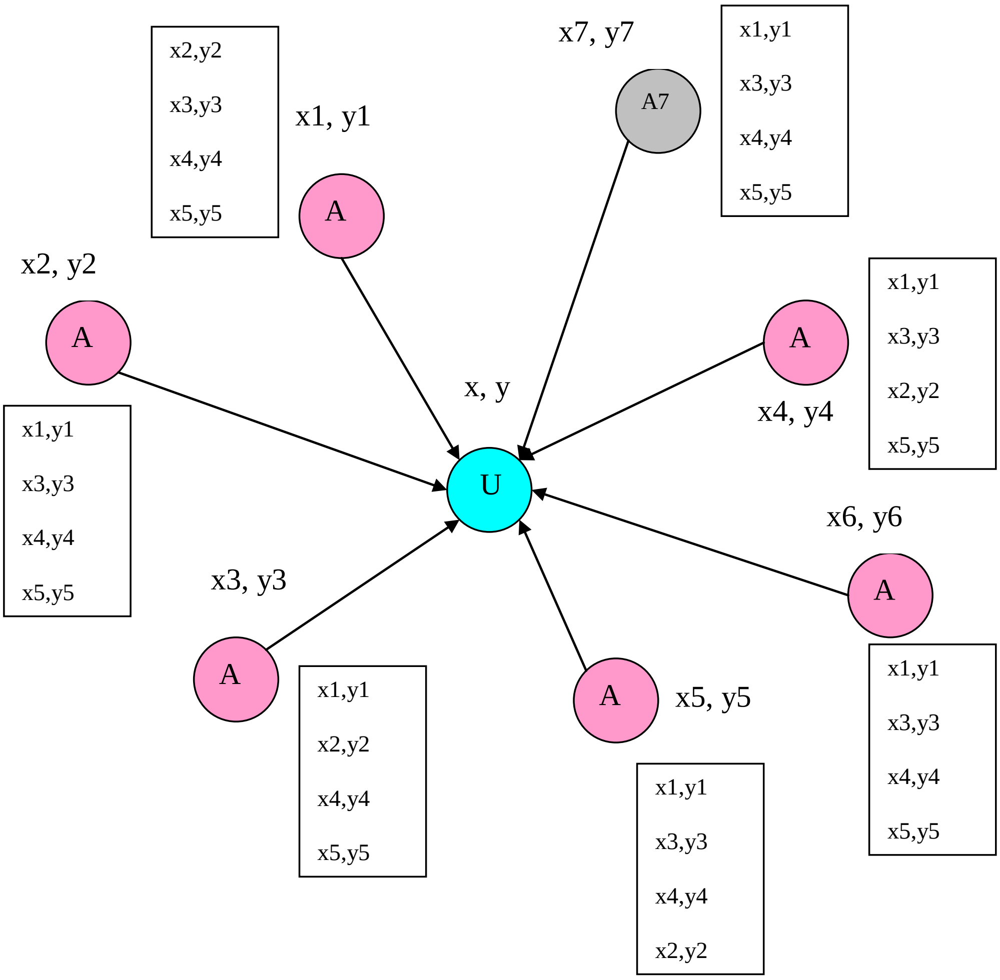


Figure 3.2 Trilateration

Each unknown node maintains the anchor list having the anchor coordinates and estimated distance. From Figure3.2 initially consider node U as the unknown node and it has seven anchor nodes around. Assume that U receives value from A7 initially. So, A7 is considered as reference node. Each node consists of an anchors list that records all other node's coordinates and the estimated distances from them to U.

Node U randomly chooses two anchors among the other anchors and together with R it executes trilateration, and records the result. Then consider A7 as unknown node, and U as known node, and then execute trilateration again. On Comparing these results with A7's actual coordinate, pick out the one which is the nearest to the actual value, and send it to U. Therefore, U will understand which result is the best, and its coordinate and hence the error will be recorded.

Step 1: Initially the DV-hop algorithm is executed. The average distance per hop is computed and the unknown node saves the value which it received first and this is considered as the reference node. Each unknown node creates an anchor list and the anchor's coordinates are recorded. The distance from it to these anchors are also recorded.

Step 2: Any two anchors out of the list for each time is chosen and localized by trilateration together with the reference node. The result is recorded.

Step 3: Consider that D1 =4, D2 = 3, D3= 7, D4 = 6, D5 = 10, D6 = 9. Consider A7 as unknown node and U as known node, and displace A7 with corresponding unknown node along with other two anchors to localize by trilateration.

Step 4: Compare these coordinate's error at R with the formula given below. The two coordinates are (x_r, y_r), (x, y) is the estimated value obtained from the computations:

$$\frac{\sqrt{(x_r - x)^2 + (y_r - y)^2}}{x_r + y_r} \times 100\%$$

After this step's comparison, anchor node A7 will pick out the value which has the least error, assumed as A2.

Step 5: A7 will back trace A2 to unknown node U.

Therefore, the node U will know A2 is the best result, and it will consider A2 as its coordinate. Each unknown node will obtain their positions. Since multiple mobile anchor nodes are used, it reduces the delay due to the localization of the network. Hence the localization of the network is carried out quickly. The PSO based approach for the visiting schedule of the mobile anchors enables it to traverse through the dense and sparse network with the same easiness.

3.5 SIMULATION PARAMETERS

The proposed Multiple Mobile Anchor based Localization using PSO (MMAL-PSO) technique is evaluated through NS-2. Simulation uses a bounded region of 500 x 500 Sq.m, in which nodes have a uniform distribution. The numbers of nodes are varied as 100,200,250 300, 450 and 500. The following Table 3.1 summarizes the simulation results of various parameters.

Table 3.1 Simulation Parameters for PSO

No. of Nodes	100,250,350,400,450 and 500
Area Size	500 X 500
Mac	802.11
Simulation Time	50,100,150 and 200 Sec
Traffic Source	CBR
Packet Size	500
Transmit Power	0.660 w
Receiving Power	0.395 w
Idle Power	0.035 w
Initial Energy	18 J
Transmission Range	250,300,350 and 400 m
Routing Protocol	AODV

Assign the levels of the nodes such that the transmission range of the nodes varies from 250 m to 400m. In simulation, the channel capacity of mobile hosts is set to 2 Mbps. The Distributed Co-ordination Function (DCF) of IEEE 802.11 for wireless LANs is opted as the MAC layer protocol. The performance of MMALPSO method with the Mobile Anchor assisted node Localization (MAL) method is compared and evaluated based on the following metrics:

Packet Delivery Ratio: It is the total number of packets received by the receiver during the transmission.

Average end-to-end delay: The end-to-end-delay is averaged over all among the surviving data packets from the sources to the destinations.

Average Energy Consumption: The average energy consumed by the nodes in receiving and sending the packets.

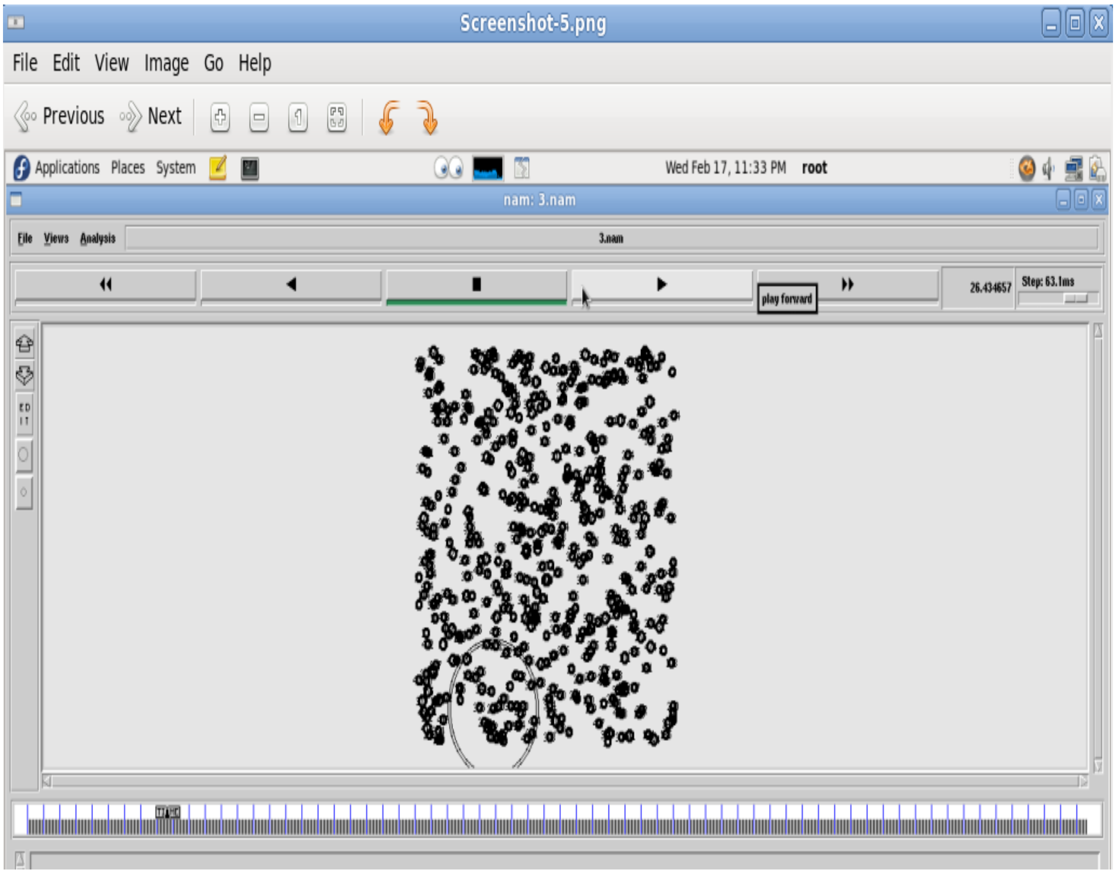


Figure 3.3 Initial Network Formations

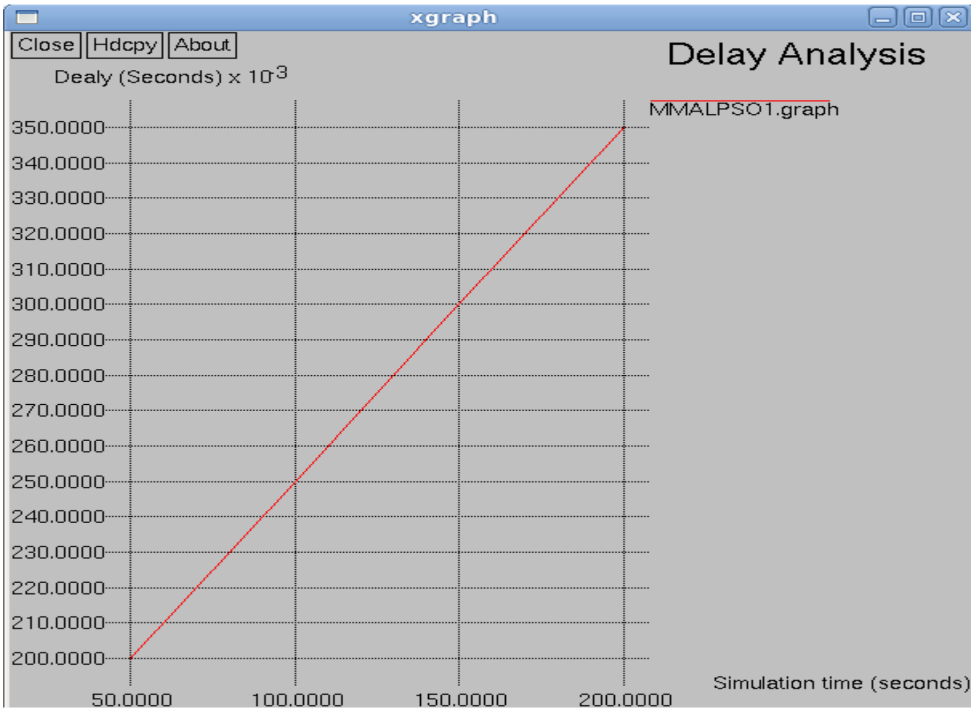


Figure 3.4 Delay Analysis

Figure 3.3 shows the 500 nodes network creation and the sensor nodes are started to transmit. Figure 3.4 shows the delay analysis with respect to simulation time in seconds. These values are extracted using the trace file and xgraph file.

A. Based on Nodes:

In the initial experiment the numbers of nodes are varied as 100,250,400,450 and 500 with transmission range of 400m and simulation time of 200sec.Figure 3.5 show the Packet Delivery ratio for both MMALPSO (Multiple Mobile Anchor based Localization using PSO) and MAL (Mobile Anchor assisted node Localization). The delivery ratio is high for MMALPSO (multiple mobile anchor based localization using PSO), when compared to MAL (Mobile Anchor assisted node Localization) in both mobile node and stable node condition. The proposed MMALPSO has been analyzed in three different stages based on the three iterations. Each iteration has some particular time limit, after that time limit node will start to move somewhere. Again using this proposed algorithm, localization of sensor node has to be done.

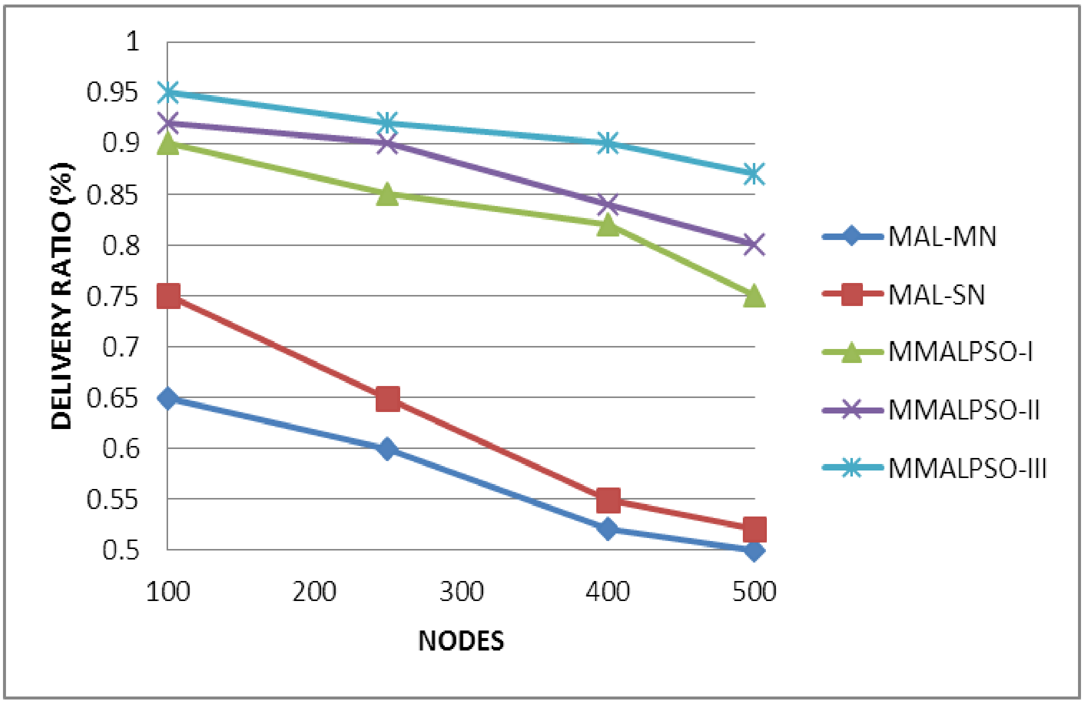


Figure 3.5 Nodes Vs Delivery Ratio

Figure 3.6 shows the average end-to-end delay that occurred for both MMALPSO (multiple mobile anchor based localization using PSO) and MAL (Mobile Anchor assisted node Localization). The delay is less for MMALPSO, when compared to MAL (Mobile Anchor assisted node Localization). Each iteration of proposed algorithm reduces the delay, based on the node mobility and node distance delay level may vary. But this proposed algorithm reduces the delay.

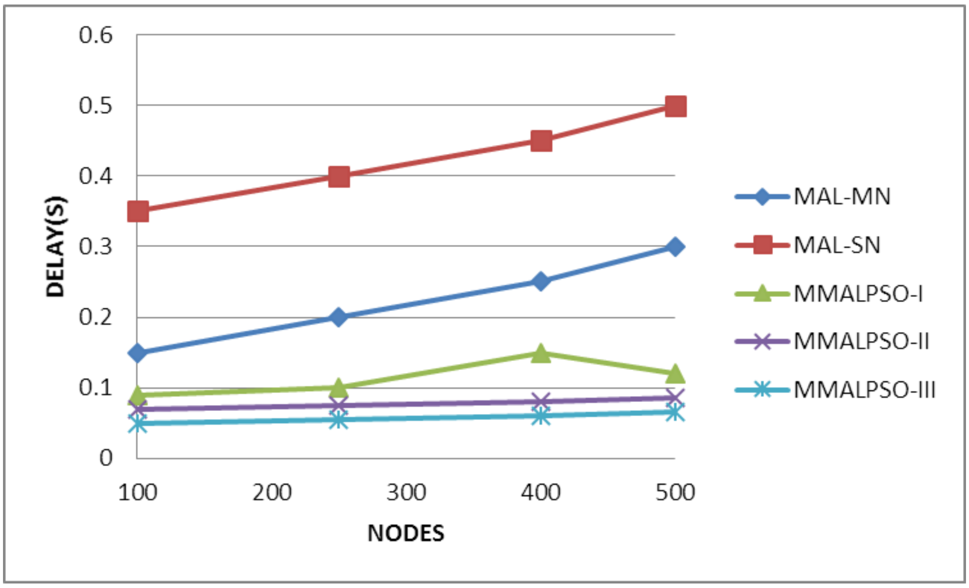


Figure 3.6 Nodes Vs Delay

Figure 3.7 shows the Energy consumption for both MMALPSO (Multiple Mobile Anchor based Localization using PSO) and MAL (Mobile Anchor assisted node Localization). The energy consumption is low for MMALPSO (Multiple Mobile Anchor based Localization using PSO), when compared to MAL (Mobile Anchor assisted node Localization). In first iteration of the proposed algorithm, it has less energy consumption and as the iteration level increases, energy level of the node will be decreases.

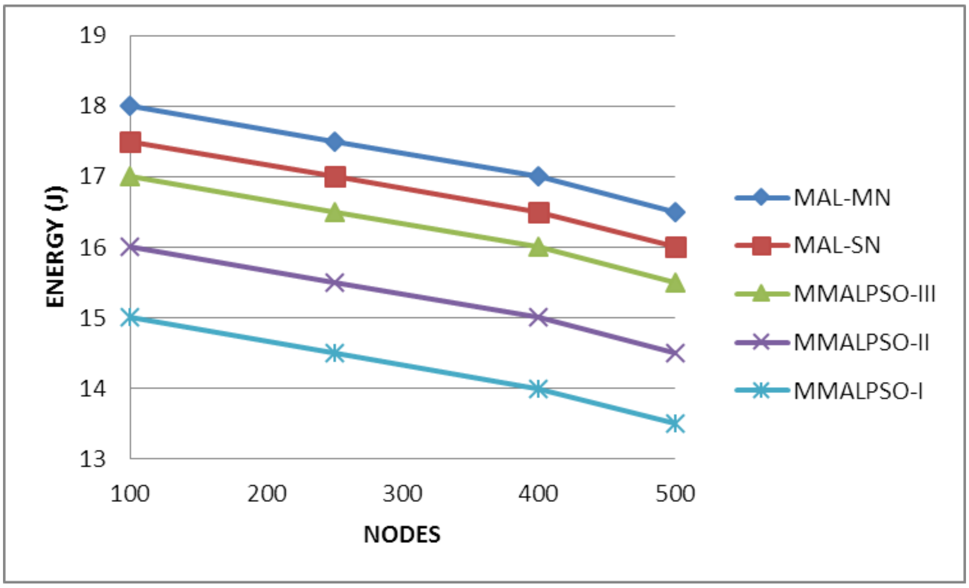


Figure 3.7 Nodes Vs Energy

B. Based on Time

In the second experiment, the simulation time is varied as 50, 100,150 and 200 sec with 300 nodes.Figure3.8 shows the Packet Delivery ratio for both MMALPSO(Multiple Mobile Anchor based Localization using PSO) and MAL (Mobile Anchor assisted node Localization). It is obvious that the delivery ratio is high for MMALPSO (Multiple Mobile Anchor based Localization using PSO), when compared to MAL (Mobile Anchor assisted node Localization) both in stable node and mobile node condition. In each iteration of the proposed MMALPSO algorithm increases the delivery rate with respect to the simulation time.

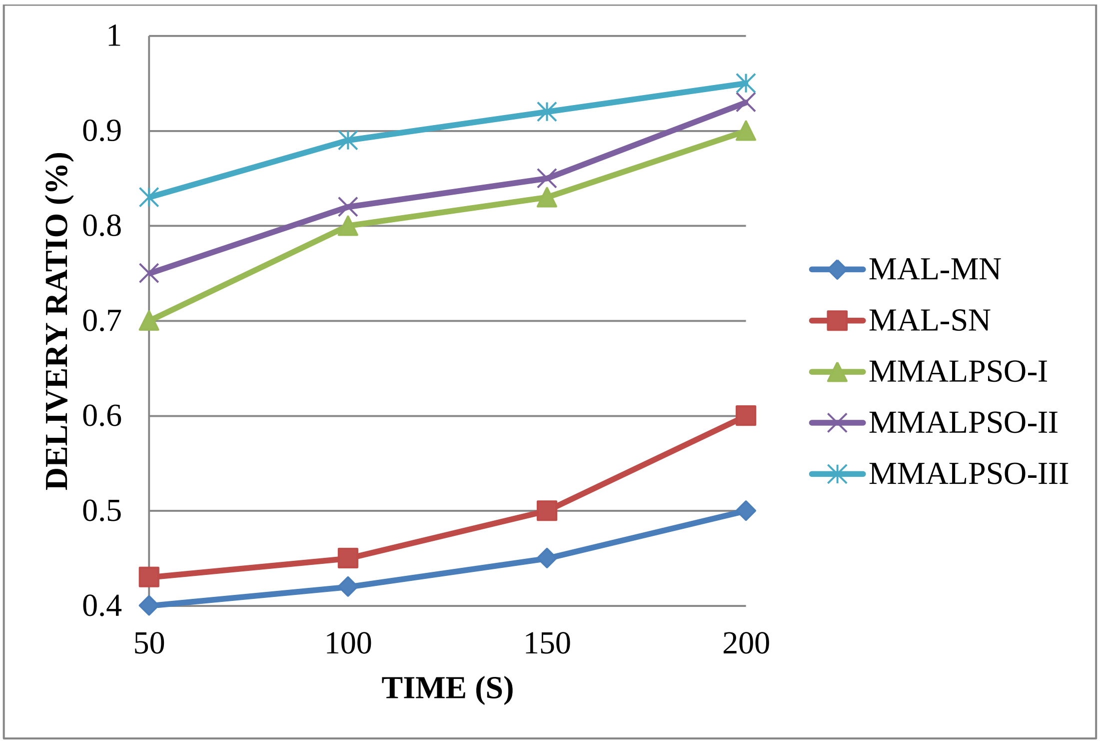


Figure 3.8 Time Vs Delivery Ratio

Figure 3.9 shows the average end-to-end delay for both MMALPSO (Multiple Mobile Anchor based Localization using PSO) and MAL (Mobile Anchor assisted node Localization). It can be seen that the delay is less for MMALPSO (Multiple Mobile Anchor based Localization using PSO), when compared to MAL (Mobile Anchor assisted node Localization) in both mobile state and stable state.

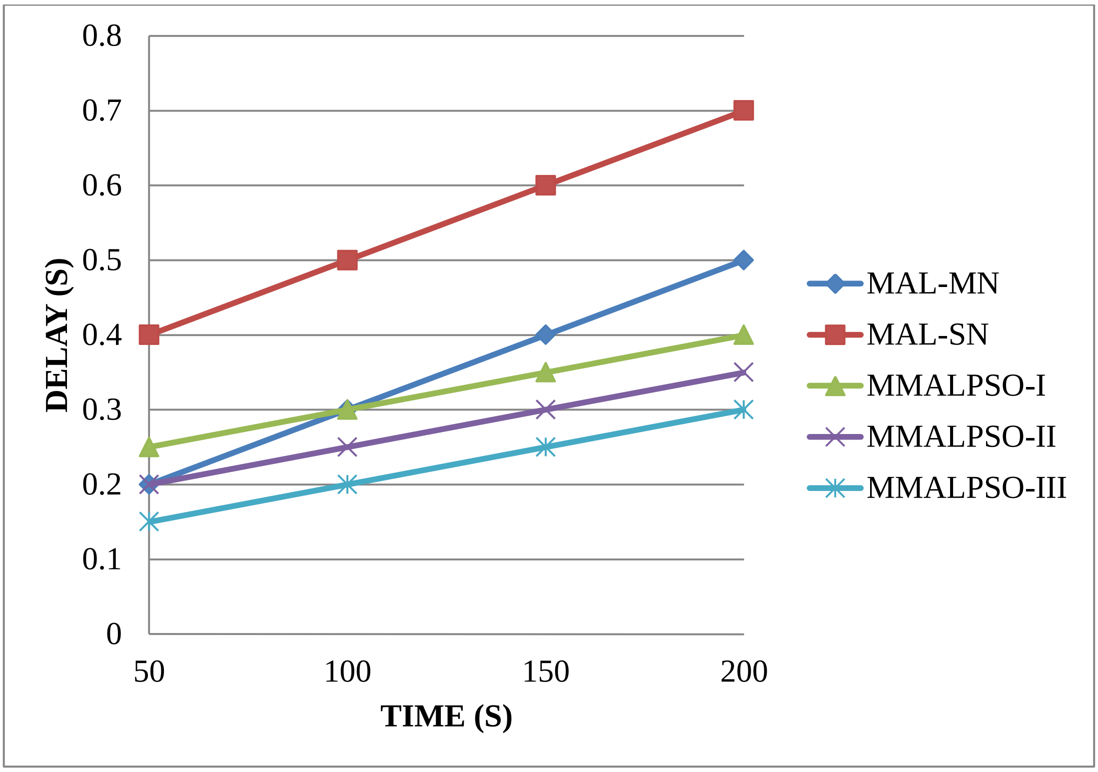


Figure 3.9 Time Vs Delay

Figure 3.10 shows the Energy consumption for both MMALPSO (Multiple Mobile Anchor based Localization using PSO) and MAL (Mobile Anchor assisted node Localization). The energy consumption is low for MMALPSO (Multiple Mobile Anchor based Localization using PSO), when compared to Mobile Anchor assisted node Localization. The proposed MMALPSO reduces the energy consumption in each iteration level with respect to the simulation time of 200 seconds.

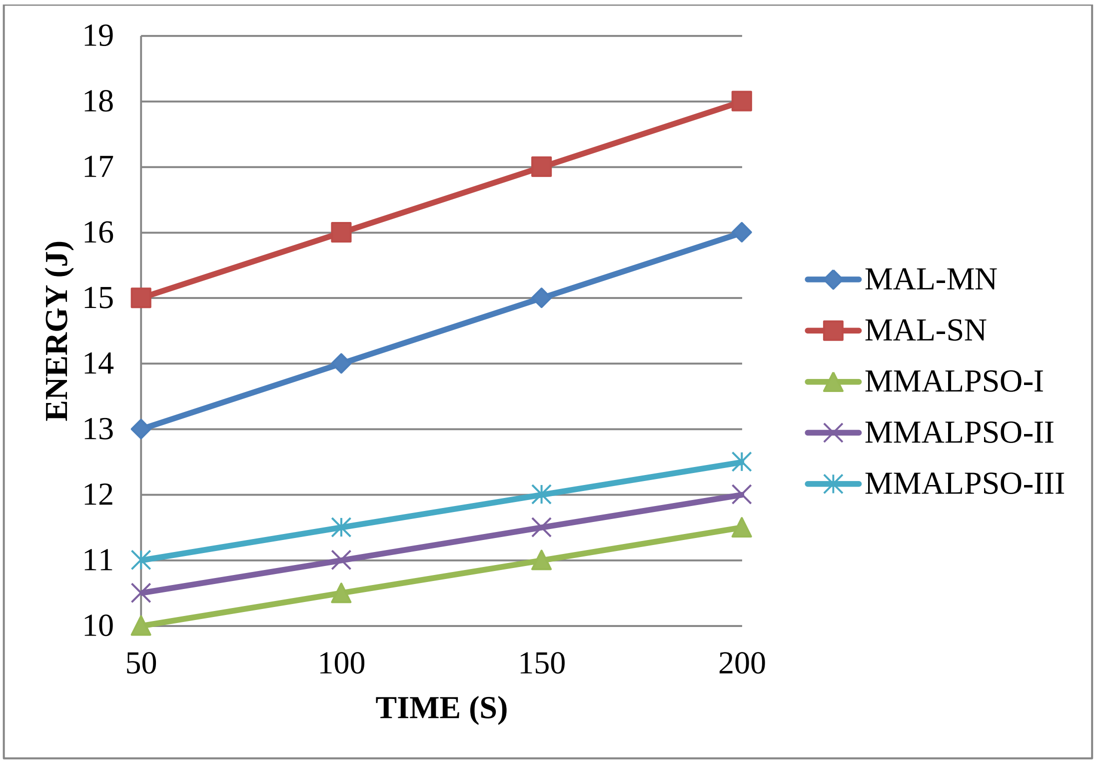


Figure 3.10 Time Vs Energy

C. Based on Transmission Range

In the third experiment the different transmission ranges are set as 250,300,350 and 400m for 300 nodes are used. Figure 3.11 shows the Packet Delivery ratio for both Multiple Mobile Anchor based Localization using PSO and Mobile Anchor assisted node Localization. It can be seen that the delivery ratio is high for Multiple Mobile Anchor based Localization using PSO, when compared to Mobile Anchor assisted node Localization. The proposed MMALPSO algorithm has a higher delivery rate with respect to the different transmission range.

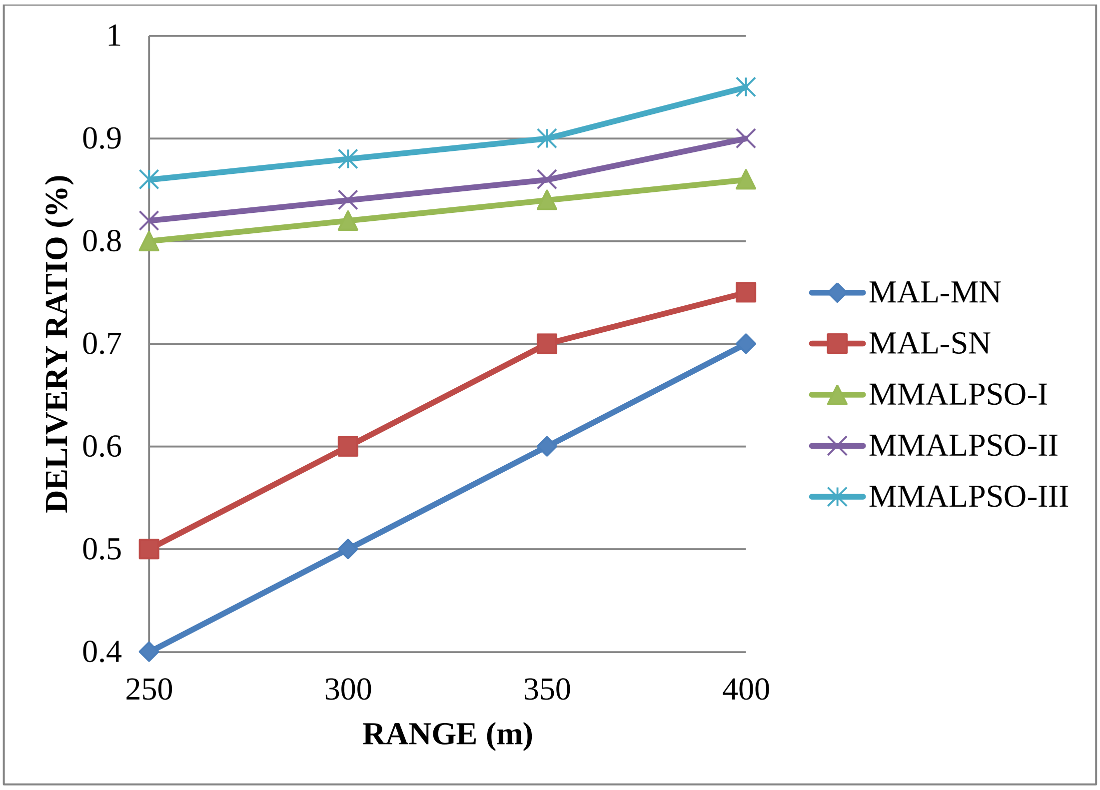


Figure 3.11 Range Vs Delivery Ratio

Figure 3.12 shows the average end-to-end delay for Multiple Mobile Anchor based Localization using PSO and Mobile Anchor assisted node Localization. The delay is lesser for Multiple Mobile Anchor based Localization using PSO, when compared to Mobile Anchor assisted node Localization in both mobile state and stable state condition. In each iteration, level of MMALPSO proposed approach decreases the end to end delay by varying the different levels of transmission range.

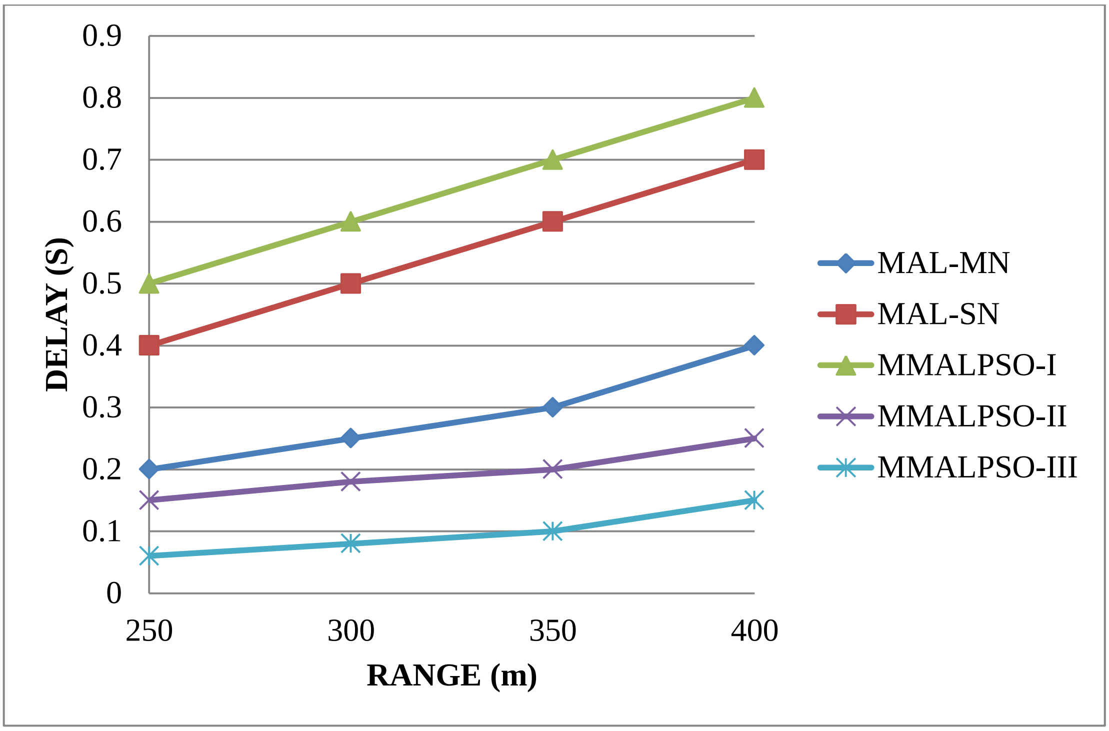


Figure 3.12 Range Vs Delay

Figure 3.13 shows the energy consumption for both Multiple Mobile Anchor based Localization using PSO and Mobile Anchor assisted node Localization. From the graph, the energy consumption is lower for Multiple Mobile Anchor based Localization using PSO, as compared to Mobile Anchor assisted node Localization. The energy consumption has reduced in each stage of the proposed MMALPSO algorithm. The existing MAL algorithm has been analyzed in two different stages based on the mobility condition.

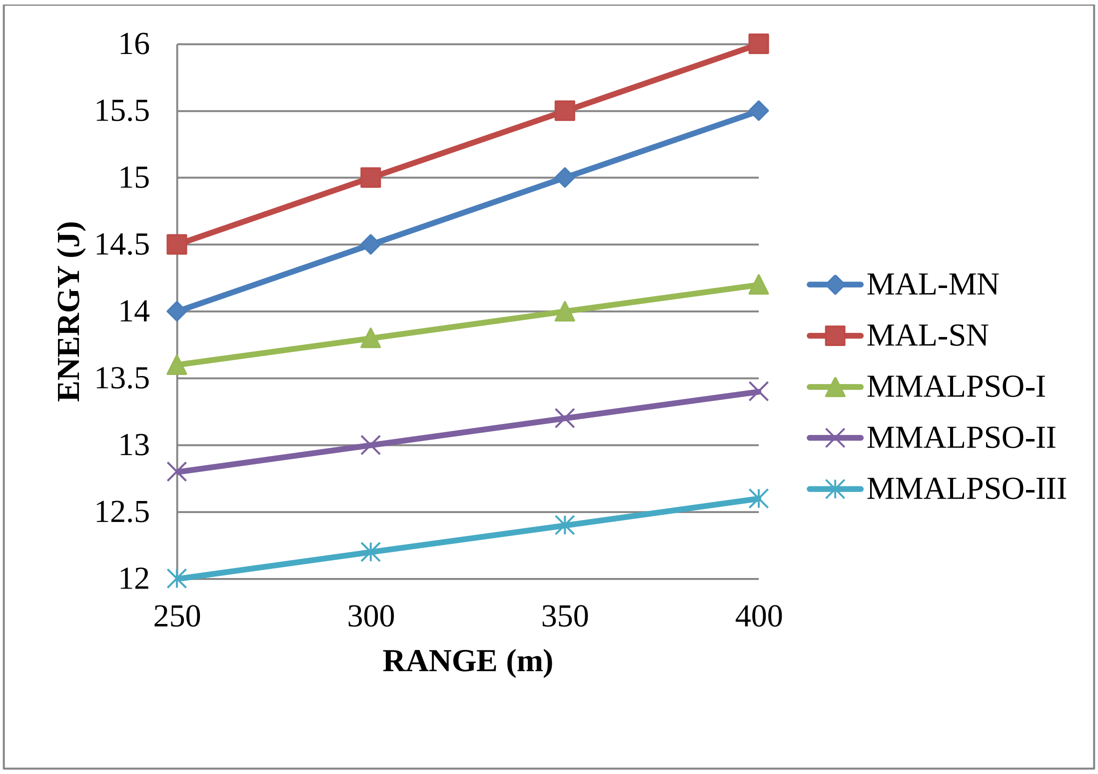


Figure 3.13 Range Vs Energy

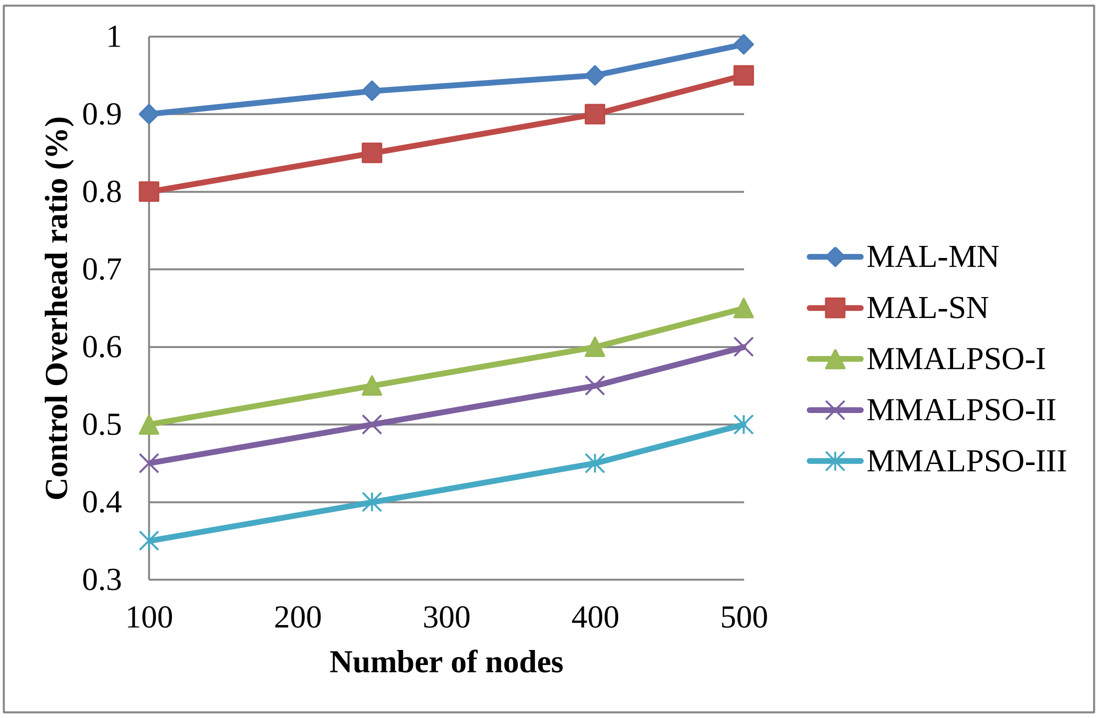


Figure 3.14 Control Overhead Analysis

Figure 3.14 shows the control overhead analysis and it is defined as the ratio of number of control messages to the number of data messages. The proposed Multiple Mobile Anchor based Localization using PSO has lesser control overhead at each iteration level. When the iteration level increases, the control overhead will reduce. Determining the location of sensor node it requires more number of control messages. In first iteration, location of all the sensor nodes are identified. But in second iteration and third iteration only the moved nodes in the network are need to be known. So the proposed MMALPSO-I has high control overhead compared to the other MMALPSO-II and MMALPSO-III. The existing MAL (Mobile Anchor assisted node Localization) approach has high control overhead in both stable and mobile condition. Table 3.2 shows the comparison of QoS parameters such as delivery rate, delay and energy based on transmission range, simulation time and network size. Compared to the existing technique, proposed method achieves high network performance.

Table 3.2 Comparison of QoS Parameters

	NETWORK SIZE	MAL-MN	MAL-SN	MMAL PSO-I	MMAL PSO-II	MMAL PSO-III
DELIVERY RATE (%)	100	0.65	0.75	0.9	0.92	0.95
	250	0.6	0.65	0.85	0.9	0.92
	400	0.52	0.55	0.82	0.84	0.9
	500	0.5	0.52	0.75	0.8	0.87
DELAY (S)	100	0.15	0.35	0.09	0.07	0.05
	250	0.2	0.4	0.1	0.075	0.055
	400	0.25	0.45	0.15	0.08	0.06
	500	0.3	0.5	0.12	0.085	0.065
ENERGY (J)	100	18	17.5	17	16	15
	250	17.5	17	16.5	15.5	14.5
	400	17	16.5	16	15	14
	500	16.5	16	15.5	14.5	13.5
DELIVERY RATE (%)	**SIMULATION TIME**	**MAL-MN**	**MAL-SN**	**MMAL PSO-I**	**MMAL PSO-II**	**MMAL PSO-III**
	50	0.4	0.43	0.7	0.75	0.83
	100	0.42	0.45	0.8	0.82	0.89
	150	0.45	0.5	0.83	0.85	0.92
	200	0.5	0.6	0.9	0.93	0.95
DELAY (S)	50	0.2	0.4	0.25	0.2	0.15
	100	0.3	0.5	0.3	0.25	0.2
	150	0.4	0.6	0.35	0.3	0.25
	200	0.5	0.7	0.4	0.35	0.3
ENERGY (J)	50	13	15	10	10.5	11
	100	14	16	10.5	11	11.5
	150	15	17	11	11.5	12
	200	16	18	11.5	12	12.5
DELIVERY RATE (%)	**TRANSMISSION RANGE**	**MAL-MN**	**MAL-SN**	**MMAL PSO-I**	**MMAL PSO-II**	**MMAL PSO-III**
	250	0.4	0.5	0.8	0.82	0.86
	300	0.5	0.6	0.82	0.84	0.88
	350	0.6	0.7	0.84	0.86	0.9
	400	0.7	0.75	0.86	0.9	0.95
DELAY (S)	250	0.2	0.4	0.5	0.15	0.06
	300	0.25	0.5	0.6	0.18	0.08
	350	0.3	0.6	0.7	0.2	0.1
	400	0.4	0.7	0.8	0.25	0.15
ENERGY (J)	250	14	14.5	13.6	12.8	12
	300	14.5	15	13.8	13	12.2
	350	15	15.5	14	13.2	12.4
	400	15.5	16	14.2	13.4	12.6

3.6 SUMMARY

In this algorithm, a Multiple Mobile Anchor Based Localization technique using Particle Swarm Optimization (PSO) technique is used. PSO is used to determine the trajectory of the mobile anchor nodes which is based upon the node density and the distance between the nodes in the network. Considering three anchor nodes for localization, the mobile anchor node broadcasts packets according to the PSO visiting schedule. It contains id and location of the visited sensor nodes. The unknown nodes having less received low signal strength (RSS) value than the mobile anchor nodes, on receiving the packet calculates the estimated distance between each of the mobile anchors to the unknown node. Each unknown node maintains anchor list consisting of anchor coordinates and estimated distance. After that, localization of the node is done using trilateration method. The unknown node will get two anchors from the list and localize them using trilateration method with the reference node which is the mobile anchor node having least distance to the unknown node. The simulation results have shown that the localization delay is reduced since multiple mobile anchor nodes are used and hence the visiting schedule of the mobile anchors enables it to traverse through the dense and sparse network with minimum of delay.

CHAPTER 4

LOCALIZATION BASED ON BOUNDARY RECOGNITION

4.1 OVERVIEW

Sensor network are extensively used to sense the environmental changes around the world. The major concern in Wireless Sensor Network is localization. Localization is nothing but finding the location of sensors/anchors in the network. To overcome the difficulties in localization a new technique called Localization based on Boundary Recognition (LBR) is proposed. The existing method uses the hop count to find the location of the sensor nodes. Using hop count approach is difficult when the density of the network increases. Another approach to increase the performance is Flooding Mechanism in Localization (FML) which increases the performance. To overcome these issues, here proposed technique that helps to decrease the complexity and increase the performance and also to easily find the location of the sensor node using boundary recognition.

Sensor network is commonly used in many military applications. This network is used to sense around the network and give that information to the sink. The major issues in sensor network are consumption of more energy and it is difficult to find the location of the sensor node. In this technique, to sense around the network, node should be movable. If it is in mobility state, it is very difficult to find the location. All the nodes are in mobile state. During node mobility condition, finding the location is a major concern.

4.2 PROBLEM STATEMENT

The existing techniques are HOP algorithm and FML algorithm. Existing method uses the hop count method for the localization of the sensor nodes. The major problem in localization is wrongly determining the location of the node. Topology maintenance is also difficult. Without knowing the location of node it is not possible to maintain the topology. The accurate location of sensor node is also not possible to be found. This method produces more localization error as the network size increases. The delay will be higher because calculating the hop count will take more time. The control overhead will also be higher as it uses more number of control messages to calculate the hop count. The traffic will be higher due to the high control overhead. If the control overhead increases, the routing overhead decreases. The proposed technique determines the location of sensor node by boundary condition using radio signal strength indicator. By using this radio signal strength indicator the calculation of signal strength of each node is made simpler. Also the node having lower strength will be dedicated as boundary node.

4.2.1 HOP Method

Hop method is used for calculating the hop counts between the anchor nodes. Initially it broadcasts a beacon node with initial number as 1. After passing every unknown node, the hop count will be added to the digit 1. After receiving information, based on the hop count value, hop method is used to calculate the location of sensor node. This method is not that efficient to calculate the location of sensor node. Consider two sink nodes sink x and sink y; Neighboring nodes calculate the sink x hop count value. Likewise it follows for sink y. Then sink x and sink y hop count values are generated as the x and y co-ordinates. Based on the hop count value, the location of sensor node is defined. The average hop size is estimated using the formula, given in equation 4.1

$$Havg = \frac{\sqrt{\{(xj - xi)^2 - (yj - yi)^2\}}}{Hij} A = \pi r^2 \tag{4.1}$$

Where, i and j are the co-ordinates of sink x and sink y and the H_{ij} is the hop count value between the sink x and sink y. When the average hop size of the network varies, the topology varies. The hop size value increases, when a new node enters the network and it decreases as a old node leaves the network. The major issue is that hop count calculation alone is not sufficient for finding the location of node. If any intruder enters the network, the overall mechanism may collapse based on the hop count alone. If the location is defined, the control signal takes different path and it counts the same node again and again, thereby it generates the wrong location of sensor node.

4.2.2 FML Method

In Flooding Mechanism Localization (FML), the minimum hop counts are computed based on the zone region. Network will be split into different zone regions for every zone region the above process will be repeated. The hop count method is followed here with different zone regions. Flood mechanism will continuously send the beacon signals to all the other sensor nodes in the region to count the number of hops between different regions. In flood mechanism the beacon signal cannot be controlled. It will be continuously sent by the base station. Also it cannot be stopped even after getting the hop counts. This is a major drawback in flood mechanism method. Another drawback is that it will send the beacon signal to reachable nodes which may disturb the nodes that are not able to monitor the environment. Continuously transmitting beacon signals may disturb the sensor nodes at their work as the sensor nodes should acknowledge the beacon signals. So it consumes more power and energy for acknowledging the beacon signals. To overcome these issues a new approach is proposed as localization based on boundary, a node which does not depend on hop count.

4.3 PROPOSED METHOD

To overcome the existing issues a new approach LBR method is proposed. Localization based on Boundary Recognition technique will create a network with four regions. Each region has a centralized base station. Base station coverage range is 250m. The localization of boundary nodes can be calculated using the transmission range value. If the location of boundary node co-ordinates are found, then it's the neighboring nodes can also be found. Using the formula given in equation 4.2 the location of boundary nodes can be calculated.

$$B(i,j) = 2\sqrt{\frac{R}{\pi}} \tag{4.2}$$

$$\text{Where, } R = \frac{Tr}{2} \tag{4.3}$$

Equation 4.2 gives calculation formula for the localization of boundary nodes. Where Tr represents the transmission range of the base station. Any node under the coverage range of the base station can calculate the boundary node location. Base station generates the beacon signal within the coverage range of nodes with RSSI indicator. The node with lower transmission range is defined as boundary nodes. The transmission range is known already based on which calculation of the radius between the boundary node and base station is done. From this approach it is possible to calculate the localization of boundary nodes.

4.3.1 Localization based on Boundary Recognition (LBR) approach

Figure 4.1 shows the LBR approach in which each region has one base station that can be selected by the origin of vertex. In this region transmission range of that base station is selectable. It will vary according to the application. Each base station will generate beacon signals with RSSI (Radio Signal Strength Indicator). Using this, the signal strength of the each node is determined. The node having lower strength level will be assigned as boundary node. Thus the transmission range between boundary node and the base station radio can then be calculated.

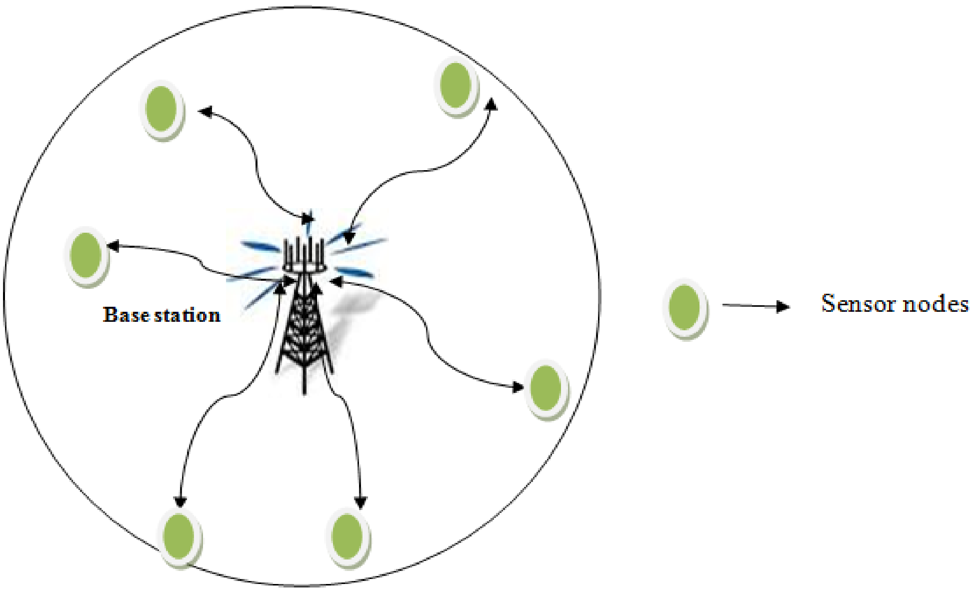
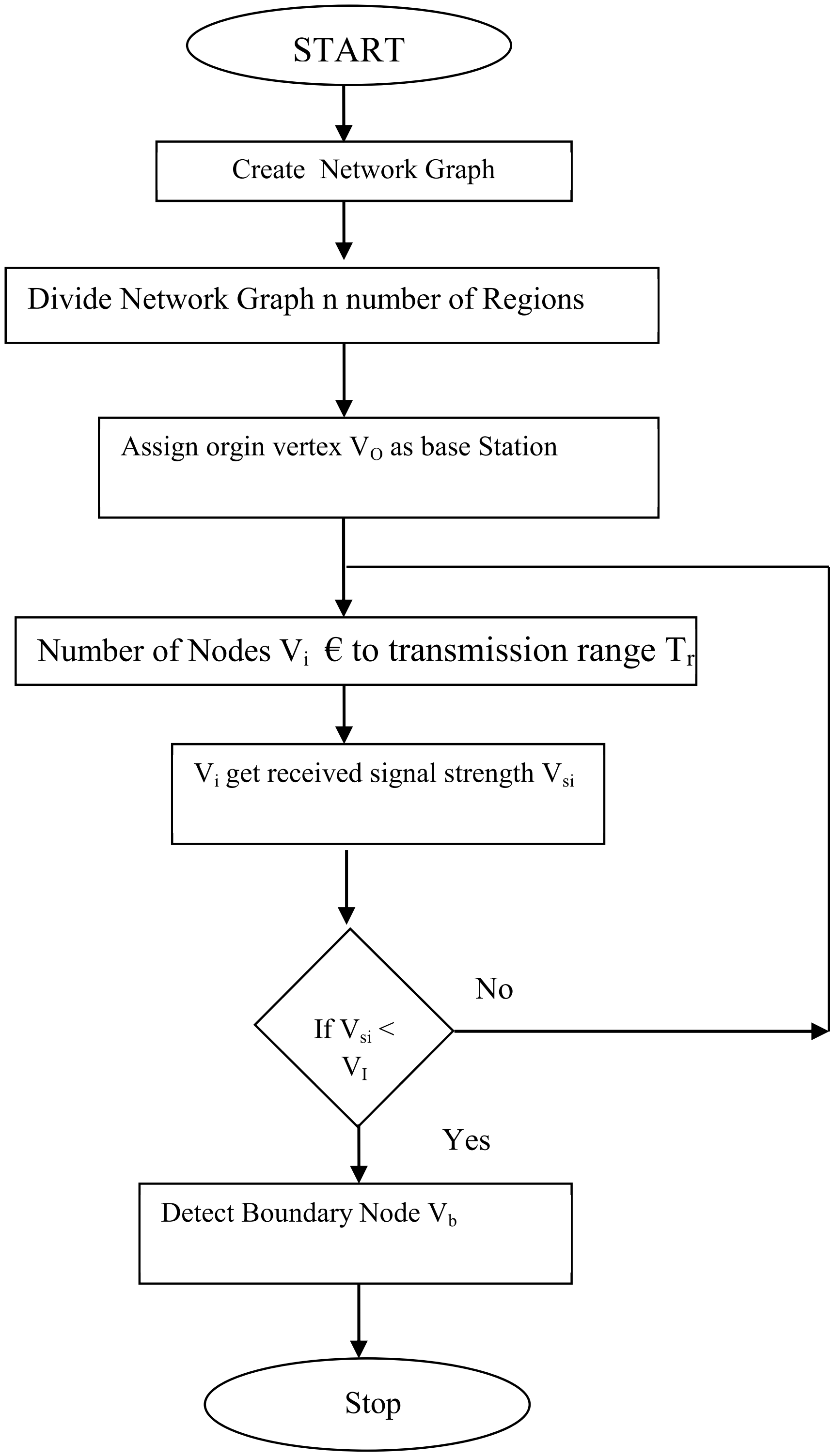


Figure 4.1 Localization based on Boundary Recognition (LBR) Approach

The LBR approach follows the theorem to create a connected graph with internally disjoint paths. It creates a network with condition as stated below; in which ‘n’ represents the number of edges in the network, ‘v’ represents the vertices of network.


START
Create Network Graph
Divide Network Graph n number of Regions
Assign orgin vertex V_O as base Station
Number of Nodes V_i € to transmission range T_r
V_i get received signal strength V_{si}
If V_{si} < V_I
No
Yes
Detect Boundary Node V_b
Stop

Algorithm-I

1. Create G (V, E) by Theorem-1

2. Divide G(V,E) into G_1(V,E); G_2(V,E)……..Gn(V,E) \\ n→ number of regions

3. Assign V_o as BS € G_1(V,E) \\V_o→ origin of vertex BS→ base station

4. V_o € Tr, \\Tr→ transmission range

5. Initiate V_o→"Cm" V_i; i€1, 2, 3, 4…n; \\n represents number of nodes

6. From Cm get V_{si} ; \\using RSSI

**Detect V_{b**} \\ V_b Boundary node

7. If Si < £; assign V_{si}as V_b; \\ assigning boundary node

8. D (V_o to $V_{b)\,=}$B (i,j) \\ finding location using equation (2) and (3)

9. Else assign V_{si}as V_n \\ V_n neighbor node

10. Assign V_o as BS € G_2 (V, E),

11. Repeat step 4

12. Until Gn (V,E)

13. Using step 8 find D (V_o to V_b) €G_1(V,E); G_2(V,E)……..Gn(V,E)

14. From D (V_o to V_b) calculate D (V_b to V_n) \\ using equations (4.4) and (4.5).

15. Continue till; find all the location of V.

Algorithm I explains the localization based on boundary approach. A network is created based on LBR method. The network is then divided into 'n' number of regions. In each region, assign the origin vertex as base station. Base station starts to emit the beacon signal to the reachable nodes which are the nodes in the coverage range of the base station. Each beacon signal consists of radio signal strength indicator. From the received signal, the signal strength of the each node can be detected. By analyzing the signal strength the boundary node is identified.

Based on the signal strength level, the node that has lesser signal strength will be assigned as boundary node. If the signal strength level is lesser than the £, which is a particular threshold level, that lesser signal strength node will be taken as boundary node. The transmission range is known from the origin node to the boundary node. Using that transmission range, first the distance between the boundary node and origin node is determined using equations 4.2 and 4.3 and the process is repeated for each region. From each boundary node the distance to the neighboring node can be found out. If the B (i,j) coordinates are known then using the distance formula the N (i,j) co-ordinates using equations 4.4 and 4.5 can be calculated.

$$N(i) = Bi^2 + 2Bj - 1 \quad \text{¥ i co-ordinates} \tag{4.4}$$

$$N(j) = Bj^2 + 2Bi - 1 \quad \text{¥ j co-ordinates} \tag{4.5}$$

Where, N (i) is neighbor node x co-ordinates

N (j) is neighbor node y co-ordinates

B(i) is boundary node x co-ordinates

B(j) is boundary node y co-ordinates

From the above equation the distance between the boundary nodes and the neighboring nodes can be determined. Using the x and y co-ordinates we can easily specify the location of the sensor node. Adopting this approach it is possible to reduce the location error, distance error and delay. This method increases the throughput, delivery rate and routing overhead. The results and discussions will prove that this method of localization based on boundary recognition approach increases the network performance and overcomes the difficulties that occur in existing techniques such as Hop Count Method and Flood Mechanism Method.

Theorem-1

A graph G (V, E) with V ≥ n is n-1 connected if and only if any two vertices of G are connected by at least two internally disjoint paths.

Proof:

Consider 4 connected vertices G be a graph. The distance between the two vertices has internally disjoint paths. In Figure4.2 dark circle represent the major 4 vertices. All these vertices are internally connected. But the leaf nodes of each vertex are not connected. The 4 vertices in the graph G are represented as edges. These edges are not a cut edge because it is contained in a cyclic representation. The 4 edges have at least two internally disjoint paths which is shown in Figure 4.2.Let the each dark circle be a, b, c and d. The distance between the d(a,b) =1, it shows that a and b are connected by internally disjoint paths. Likewise, for b and c, c and d, and a and d. Figure 4.2 explains the network architecture of the LBR approach

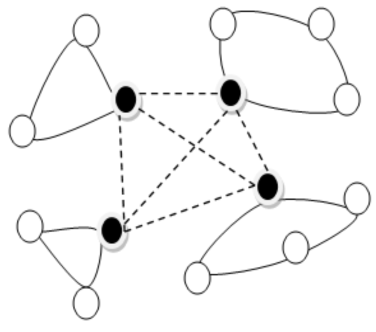


Figure 4.2 Network Architecture

Assuming that this theorem holds for any two vertices at distance less than k and let d (a, b) = k ≥ 2. Without loss of generality, the path d (a, b) will follow the path between the internally disjoint paths of each vertex.

4.4 RESULTS AND DISCUSSION

Simulation results of the overall performance of the network are compared with the existing technique and the proposed technique. The existing technique is used to find the location of sensor node by hop count method and mlood Mechanism method. It decreases the overall performance, energy consumption, delivery rate and throughput. This was proven by using trial done in Network Simulator software.

Table 4.1 Network Parameters used for Simulation

NETWORK PARAMETER	HOP METHOD	FML METHOD	LBR APPROACH
Total Number of Packets	1000	1200	1500
Transmission Mode	Single Path	Multipath	Multipath
Coverage Type	Omni directional Antenna	Omni directional Antenna	Omni directional Antenna
Transmission range	250m	250m	500m to 1000m
Routing protocol	AODV	AODV	AODV
Control Messages	High	High	Medium
Collision	High	Medium	Low
Routing	Unicast	Multicast	Broadcast

Table 4.1 shows the comparison of network parameters such as total number of packets transmitted, transmission mode, coverage type, transmission range, routing protocol, control messages, collision and routing. From this analysis, it can be inferred that LBR approach achieves high performance compared to the existing methods such as HOP method and FML method. The numbers of nodes assigned are from 100 to 500 nodes. Each node is assigned with 20 joule energy. Physical medium is wireless, IEEE 802.11, data link layer used is MAC and queuing type in Link Layer. The connection is given by radio. For proposed method, each node is assigned the transmission range as 500m to 1000m. Routing protocol used is Ad Hoc on demand routing vector protocol the bandwidth allocated for each link is 2 Mbps. This simulation result analyzes the quality of service parameters such as throughput, delivery rate, drop rate and delay. To analyze the network performance, localization error and distance error are calculated.

Figure 4.3 shows that the throughput analyses of LBR approach with different transmission ranges. The number of nodes varies from 100 to 500 nodes in x axis. Throughput achieved is more in the localization based on boundary recognition approach compared to existing, Hop method and FML method. Existing methods use control messages more due to which data packets will get stranded. In the proposed technique, it is overcome by generating beacon signals once for every network change. Based on the received power, the calculation is done. From this approach it achieves the throughput of 1.2 Mbps to 1.4 Mbps for the band limited to 2 Mbps.

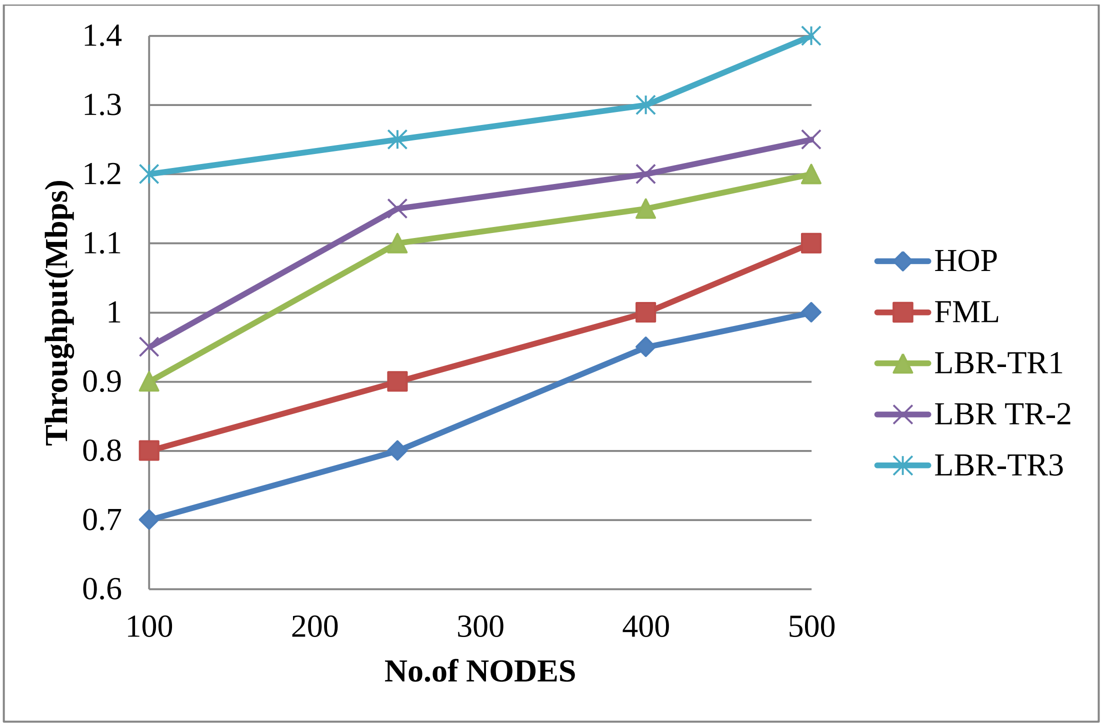


Figure 4.3 Throughput Analysis

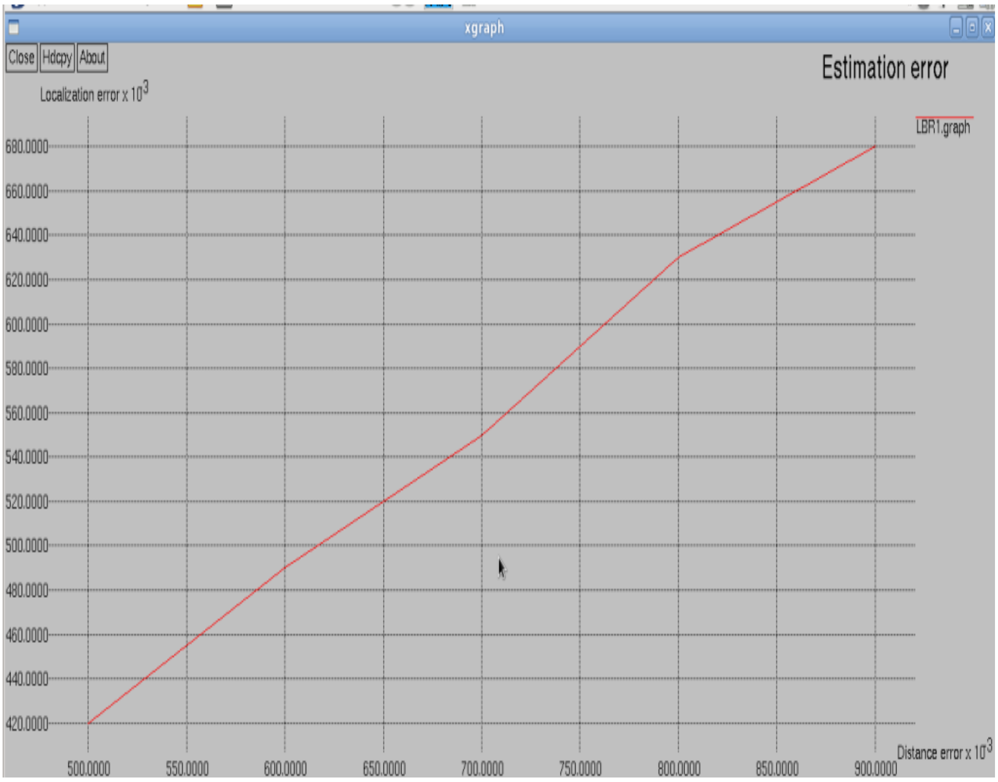


Figure 4.4 Estimation error analysis

Figure 4.4 shows the estimation error analysis. It is derived from the trace file and has plot the graph with the help of xgraph. Figure 4.5 shows the delivery rates of LBR approach. Delivery rate is defined as the ratio of number of packets transmitted to the difference between the number of packets sent and received. When the number of nodes increases the delivery rate decreases due to high collision. Compared to existing method, proposed method achieves higher delivery rate. Transmission range represented as TR varies from first level as 500m, second level as 750m and third level as 1000 m.Figure 4.6 shows the drop rate in existing and proposed method. In LBR approach transmission ranges vary from 500 m to 1000 m. Here TR1 represents the transmission range of 500 m, TR2 the transmission range is 750 m and TR3 is having the transmission range of 1000 m. In LBR approach, the base station transmission range will vary. Under this technique, the increase in transmission range gives better results compared to the existing Hop and FML method.

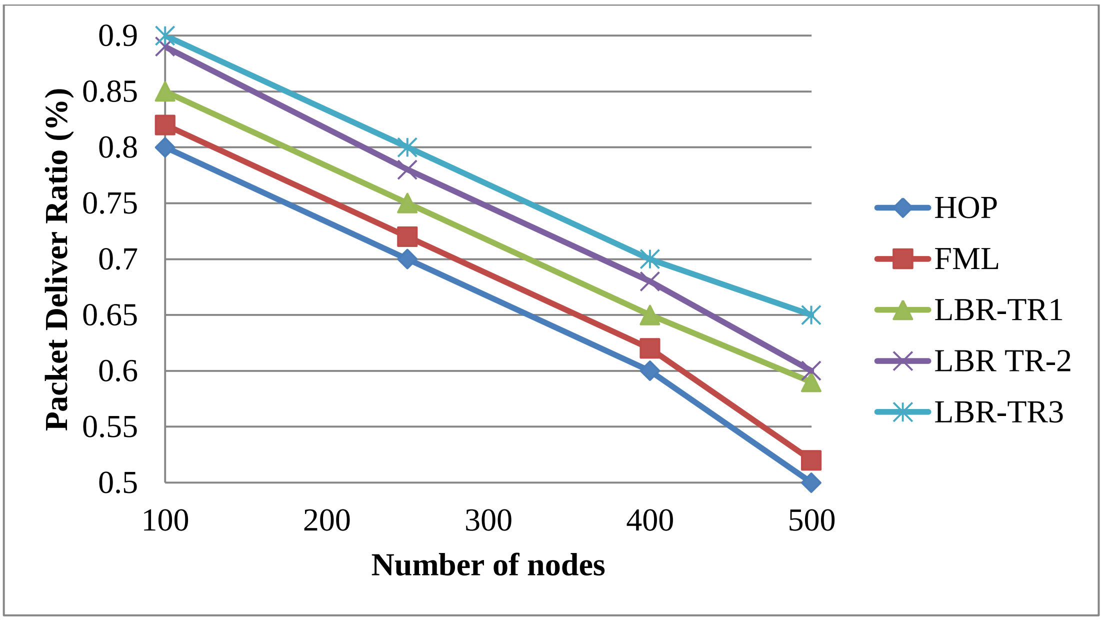


Figure 4.5 Packet Delivery Analysis

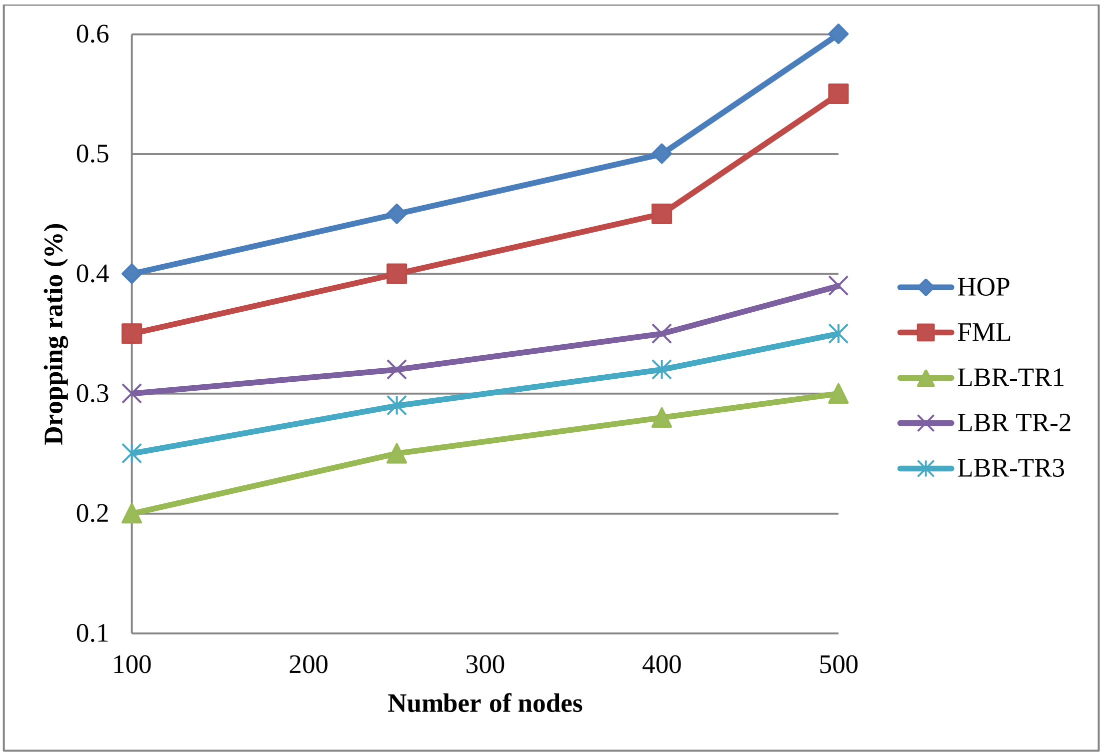


Figure 4.6 Drop Rate Vs Network Size

Figure4.7 shows the estimation error calculated using location error and distance error. The distance error in turn leads to location error. When the distance value changes, it will affect the location. Distance error is directly proportional to the location error. In existing, schemes such as to Hop method, FML there is more estimation error. In the proposed method, estimation error will automatically decrease due to the LBR (Localization Based on Boundary Recognition) approach. From this analysis, it is assured that LBR will give the correct location of sensor nodes.

Figure 4.8 shows the delay comparison between existing and proposed algorithms. Delay will be higher, when the numbers of nodes are increased. Due to high collision rate because of increasing nodes, delay will also increase. The existing methods used the control messages to know about the location of sensor nodes. After getting the location of sensor nodes only, it will transmit the packets. So when counting the hops between sink x and sink y, it takes more time to transmit the data packets. In the proposed algorithm, it generates beacon signals; from the received reflecting power it will analyze the location of sensor node. It takes very lesser time to transmit the packets.

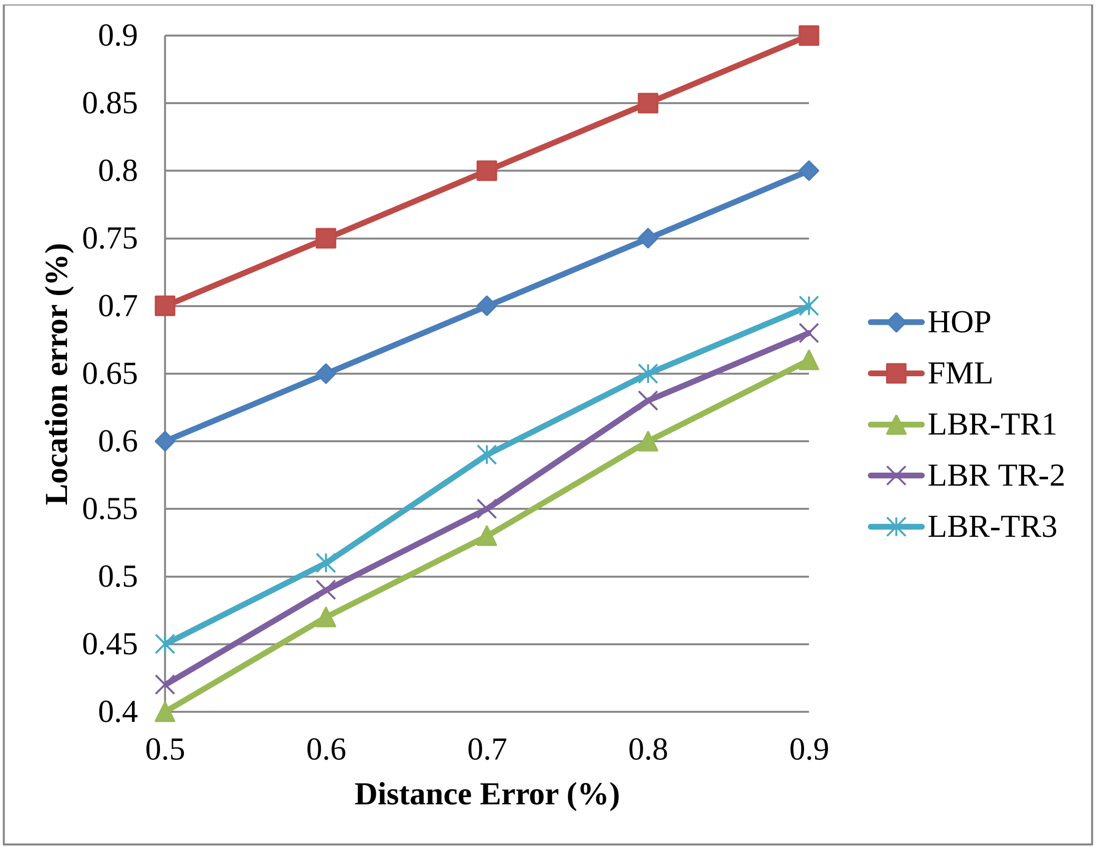


Figure 4.7 Estimation Error Analysis

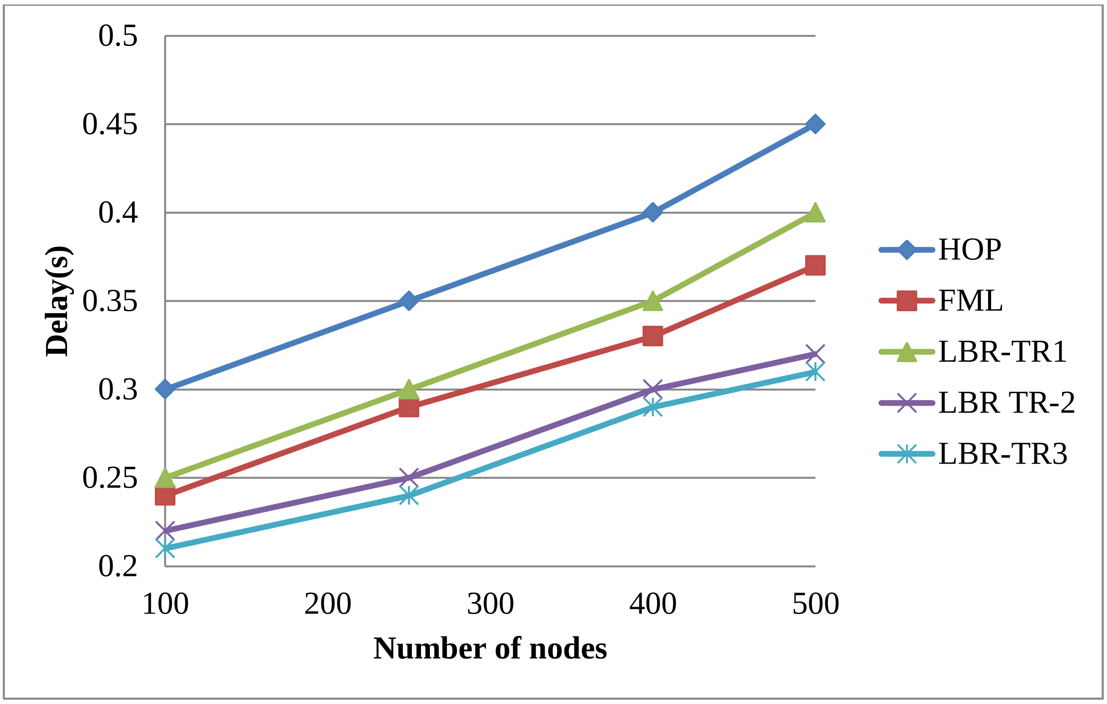


Figure 4.8 Number of Nodes Vs Delay

Figure 4.9 shows the time taken for localization by various methods. Localization is done once the topology gets changed from original. In Hop method, it takes 10 to 13 seconds for the localization of sensor node. FML method takes 8 to 11 seconds. The proposed Localization Based on Boundary Recognition algorithm reduces the time taken for localization to around only 2 to 6 seconds. Compared to the existing approach, proposed localization based on boundary recognition algorithm has taken a lesser time for relocalization.

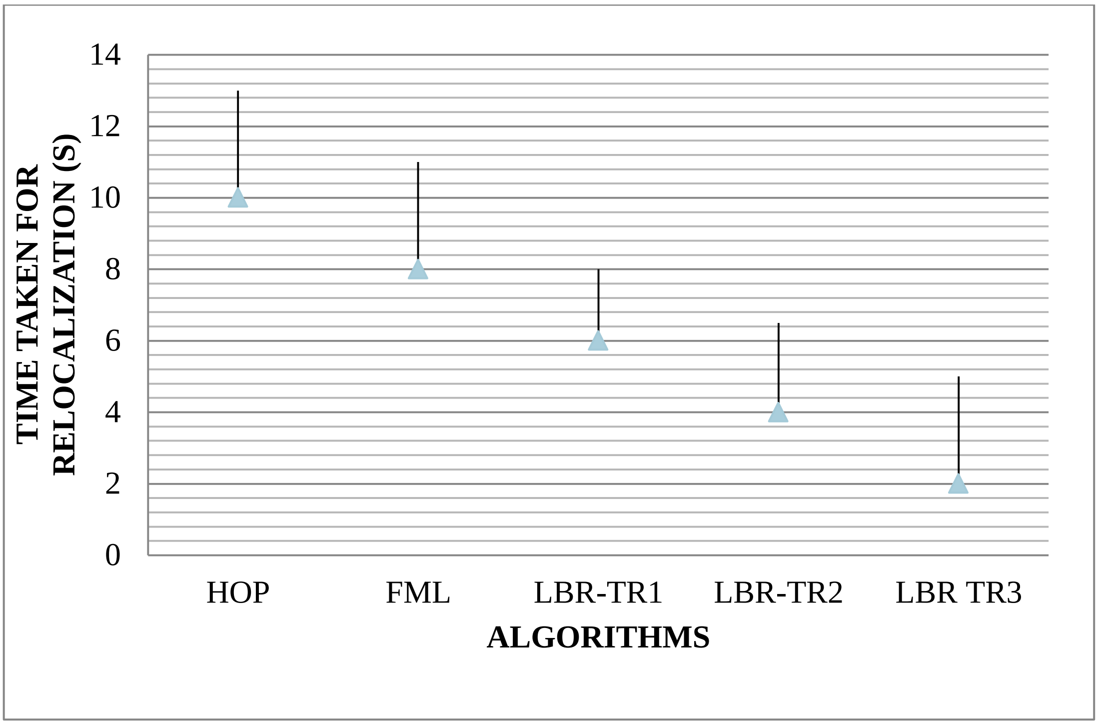


Figure 4.9 Time Taken for Localization

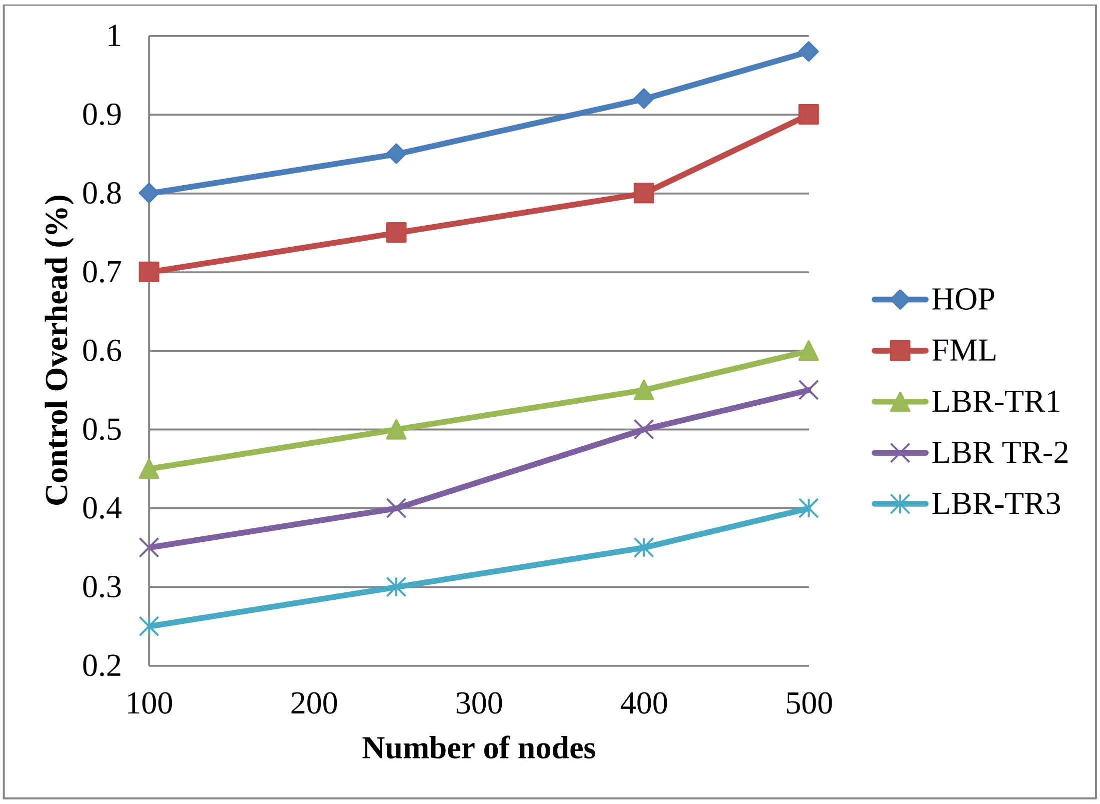


Figure 4.10 Control Overhead Analysis

Figure 4.10 show the control overhead analysis and it is defined as the ratio of number of control messages received to the number of data messages received. Compared to the existing FML (Flood Mechanism In Localization) and HOP method, proposed LBR (Localization Based on Boundary Recognition) reduces the control overhead by reducing the usage of control messages. The proposed LBR (Localization based on Boundary Recognition) approach is analyzed in three different stages based on the transmission range. All these stages have reduced control overhead with the use of proposed LBR approach.

Table 4.2 Comparison of QoS Parameters

Parameters	Hop	FMR	LBR-TR1	LBR-TR2	LBR-TR3
Delivery Rate	50%	55%	65%	75%	85%
Delay (s)	0.45	0.37	0.4	0.32	0.31
Drop Rate	95%	85%	65%	55%	45%
Time Taken for Localization	10-13 sec	8-11 sec	6-8 sec	4-6 sec	2- 5 sec
Throughput (Mbps)	1	1.1	1.2	1.25	1.4
Routing Overhead	0.5	0.7	0.8	0.9	0.92
Localization Error	0.8	0.9	0.5	0.6	0.65
Distance Error	0.9	0.8	0.5	0.5	0.6

Table 4.2 shows the comparison of Quality of Service parameters including the delivery rate, delay, drop rate, throughput, localization error, distance error, routing overhead and time taken for localization. As shown in comparison table, LBR achieves high network performance compared to the hop method and FML method. Here TR1 represents the transmission range as 500m, TR2 represents the transmission range as 750m and TR3 represents the transmission range as 1000m. The above discussion, clearly presents that the proposed algorithm, localization based on boundary recognition approach which gives better performance compared to the existing algorithms.

4.5 SUMMARY

The proposed algorithm, localization based on boundary recognition, achieves high network performance when compared to the existing algorithm such as Hop method and Flood mechanism in localization method. This was substantiated by the simulation results using Quality of Service parameters such as throughput, delivery rate, and drop rate, delay and estimation error. In the localization based on boundary recognition approach, throughput achieved is 1.4 Mbps for the band limited channel of 2 Mbps link. Compared to existing algorithms, proposed algorithm has higher delivery rate. The localization based on boundary recognition has secured 85% of delivery rate after transmitting the packets. Drop rate has been reduced to 45% in proposed algorithm. Delay is also lesser at the rate of 0.3 seconds in proposed algorithm. Estimation error has also been reduced in the LBR approach, as compared to the existing algorithms such as hop method and flood mechanism in localization method. From the analysis it is proven that the proposed algorithm, localization based on boundary recognition approach gives high network performance due to the lesser complexity to find the location of sensor nodes.

CHAPTER 5

NEIGHBOR AWARE LOCALIZATION APPROACH

5.1 OVERVIEW

Localization is crucial for many services in wireless sensor network. Global Positioning System (GPS) could be used to find the location of the nodes, but it fails in indoor environments and wild forested area. So to overcome these issues, two localization algorithms is proposed as Range-based algorithm and Range-free algorithm. Range based algorithm is used to find the location using Euclidean distance. A Range-free approach uses the neighboring nodes to calculate the location of sensor nodes. In the proposed algorithm range free approach is used to find the location of sensor nodes. The existing techniques are virtual hop localization and Dv-hop localization. Dv hop localization is used to get the location of sensor node by hop counts. Drawback in the Dv hop localization is location error will be high. To overcome that, another existing method virtual hops localization is adopted. Virtual hop localization contains virtual number of hop counts which can be filtered using local filtration. The drawback in virtual hop localization is that it consumes more power and has high estimation error. These problems can be overcome by using neighbor aware approach in localization of sensor nodes.

The main aim is to localize the sensor nodes in wild area with reduced location errors and also to increase the Quality of Service parameters such as throughput, packet delivery ratio, drop rate, energy efficiency, lifetime and also to minimize the traffic intensity, delay, overhead and estimation error. Wireless Sensor Network consists of a very large variety of sensor nodes and it consumes power. Each sensor node will monitor its surrounding field and gather the information about the sensor field. It has a distributed architecture consisting of distributed sensor nodes. Finding the location of sensor node is most important for many applications of sensor networks. This will be used to identify the location at which sensor node reading originates. Previous approaches have high estimation error and location error. This can overcome by the proposed method, Neighbor Aware Localization.

5.2 PROBLEM STATEMENT

Localization is a major and important issue in wireless sensor network. In case sensor nodes are deployed in the dense area or forest area, it is difficult to find the location using Global Positioning System (GPS). GPS system is not suitable for indoor environment, where the obstacles make it difficult to achieve the localization. This draw back can be overcome by suitable localization algorithm. The major problem in localization algorithm is that it may produce wrong location of sensor node or estimation of sensor node may introduce some errors. The major issues in localization are high location error, high estimation error, high delay and more power consumption. These are overcome by proposed localization algorithm, which has improvement in throughput, high delivery rate, less drop rate, less delay and less power consumption.

5.3 DV-HOP LOCALIZATION

Two mechanisms are widely used in localization. They are: 1. Dv-hop localization and 2.Virtual hop localization. In these two approaches the location of sensor node is based on the hop counts. In each case of Wireless Sensor Network, beacon signals generate the control messages to get the hop count information in the network. Dv-hop localization is a method similar to Distance Vector Routing. Initially the beacon signal is passed all over the network. Based on the beacon signal reflection information, the routing table with hop count is created. Using that hop count, the location of sensor node in Wireless Sensor Network is determined. If a node wants to transmit the packet to B, path between the A and B may be high. Consider all the paths with distance and hop count. For example,

$$H = \frac{\sum D(A,B)}{\sum H(A,B)} \tag{5.1}$$

From equation 5.1 the hop size formula, D (A, B) is the distance between the A and B. H (A, B) is the Hop counts between the A and B. Suppose there are two paths between the A and B. One path is having 100m distance and another path is having 60 m distance. Likewise, first path is having 6 hop counts between the A and B, second path is having 2 hop counts between the A and B, now using the equation 5.1 the hop size is calculated.

$$H = \frac{100+60}{6+2} = \frac{160}{8} = 20\ m \tag{5.2}$$

Equation 5.2 shows the calculation for localization of sensor node. The drawback in this technique is that it may produce localization error due to the localization estimate.

5.3.1 Virtual Hop Localization

Another existing technique is Virtual hop Localization. In this technique, it is similar to Dv-Hop localization. In Virtual Hop Localization Method, it will consider the virtual hops between the node A and B. Based on the known distance the hop size can be found very easily. Here the distance will be known for every virtual node. Those virtual nodes are referred as reference nodes. Calculation is simpler in virtual hop localization. It uses the alteration method to filter the bad nodes in the sensor network. Using this virtual hop between the two nodes, it creates more disturbances in the wireless sensor network. These difficulties can be overcome by using proposed algorithm.

5.4 PROPOSED WORK

To overcome the issues in the existing approaches, a new algorithm has been proposed as Neighbor Aware Localization (NAL) approach. In this approach the neighboring nodes are used for the localization of sensor node in wireless sensor network. The major steps in the proposed algorithm are using the beacon signal with which the routing table will be generated. It will get the hop count information based on the routing table contents. From the hop count calculation, it will get the number of neighboring nodes list. After getting the neighboring node list, the location of sensor nodes in the Wireless Sensor Network is calculated.

5.4.1 NAL approach

Neighbor Aware Localization approach is illustrated in Figure 5.1. Initially using the beacon signals the hop count information in the

Wireless Sensor Network is obtained. It is range free approach. Without using the distance and angle, it will get the location of sensor nodes.

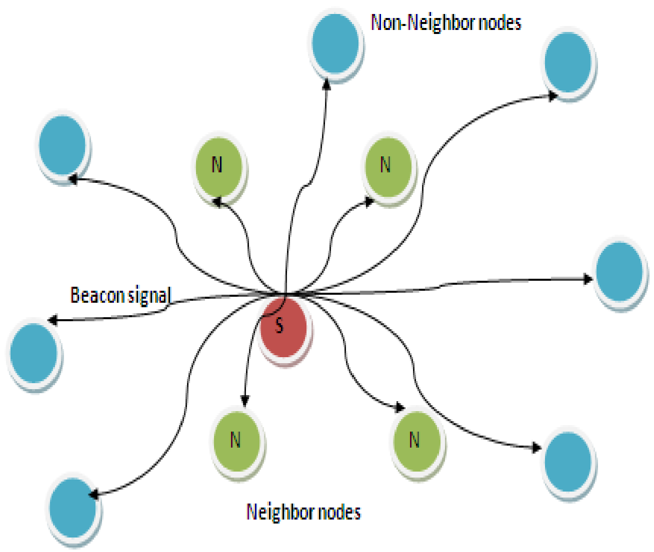


Figure 5.1 Neighbor Aware Localization (NAL) approach

The steps involved in the neighbor aware localization approach are that it will generate the beacon signal to all of the nodes in the network. Based on that, it will get the hop count information. Then the equation 5.3 is used to count the number of neighboring nodes.

$$Nn = \sum_{i=0}^{n} Hi \,, if\ Hi < 1 \qquad (5.3)$$

$$if\ Hi > 1, Nno \qquad (5.4)$$

$$Ls = \{\sum_{i=0}^{Nn} \left[\frac{Ni}{Nn}\right], \sum_{j=0}^{Nn} \left[\frac{Nj}{Nn}\right]\} \qquad (5.5)$$

Equation 5.4 is used to find out the non-neighbor nodes. Equation 5.5 is used for the localization of sensor nodes. Variables used in the equations are discussed below.

- Nn represents number of neighbor nodes
- Hi represents hop counts between the sensor nodes
- n represents the number of nodes in sensor network
- Ls represents the localization of sensor nodes
- i and j are the co-ordinates of sensor nodes
- N represents the Neighbor node

From the equations 5.3 and 5.4 the neighboring nodes among the sensor node is obtained. After getting the number of neighbor nodes, using the centroid theorem the location of sensor node is determined. The network created is in single layered architecture. This Neighbor Aware Localization approach is used to increase the performance of sensor network. This NAL approach follows theorem 1 to generate the network by distributed architecture. Generally sensor network consumes lot of battery power. That can be reduced by using the Neighbor Aware Localization approach; also the complexity can been reduced compared to the existing technique. If the hop count is lesser than one, it will be considered as neighbor nodes If the hop count is greater than one then it will be considered as non-neighbor nodes. Using the number of neighbor nodes, localization of sensor node can be achieved using centroid theorem.

A. Algorithm-I

1. Create G (V,E) ¥ distributed architecture
2. Vi → Beacon signals
3. Calculate Hc
4. If Hc< 1
5. V considered as Ng
6. Else
7. V considered as NNg

Algorithm-I is used to create the network with the distributed architecture. Each node consists of sensor node with sink node. Beacon signals are transmitted to all the nodes in the network is then used to get the hop count values of the node. If the hop counts value is lesser than one that node or vertex will be considered as neighbor node (Ng) else that vector will be considered as non- neighbor node (NNg).

B. Algorithm-II

1. Count Ng of Vn, n=1
2. Find L(Vn) by equation (5)
3. Next Vn+1, n = 1, 2, 3, 4……n.
4. Repeat Step-2 Algorithm-I
5. Until Vn+n, n→ number of nodes
6. Calculate L(Vn+n)

Algorithm-II is used to find the location of every node or vertex in a sensor network. V_n represents the node in sensor network. To start with, the number of nodes attached with the node under consideration is obtained, using the equation 5.5. The location of this node is computed. Then by increasing the number of nodes attached to the node under consideration, the localization process is again done. This process is repeated until the locations of all the sensor nodes in the network are obtained. Figure 5.2 shows the flow diagram of proposed neighbor aware localization approach. To generate beacon signals for the first node and then the hop count is calculated. Using the hop count, find the neighboring node. Then count the neighboring nodes and finds the location of the first node. Then move on to the second node and follow the step starting from beacon signals.

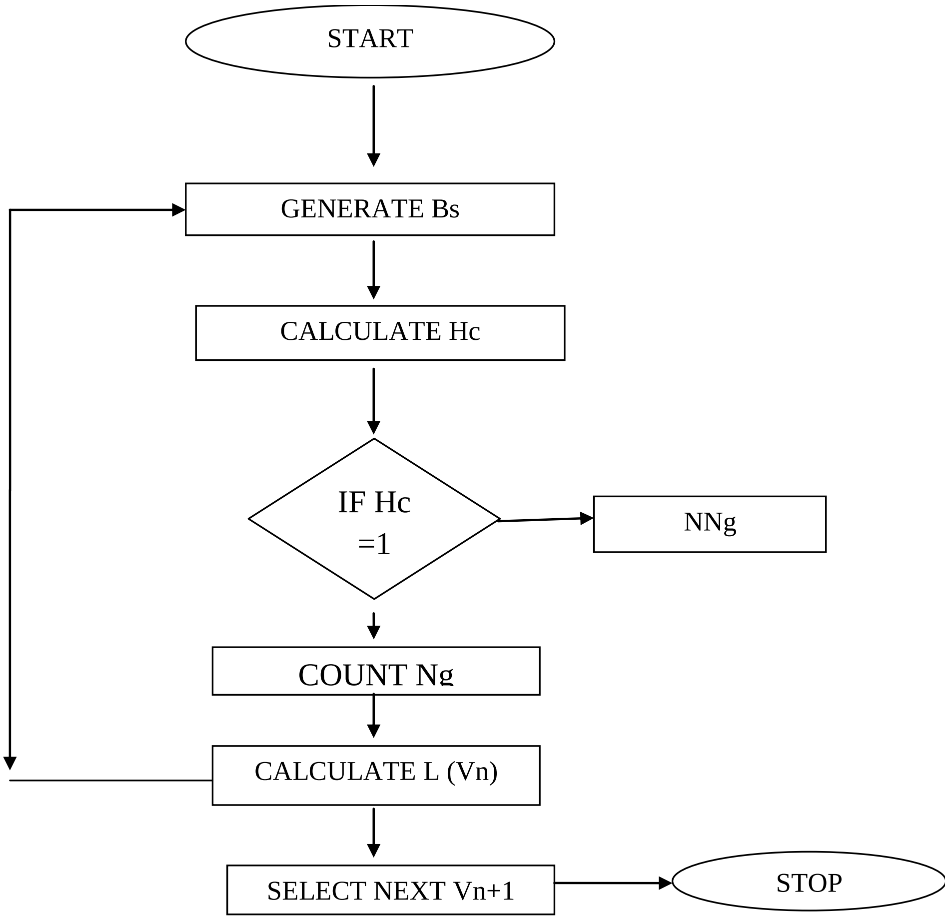


Figure 5.2 Flow diagram of Algorithm

Theorem-1. A distributed node connects 2 neighboring nodes in one hop

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Proof 1. Let n1, n2, n3…nk be the number of distributed nodes in the distributed network, the non-distributed nodes will be s1,s2, s3….sk. It follows one hop connection between the nodes. The maximum number of distributed node connectivity of the ith system is given by Vi ≥ N/Δ (i+1) for i= 1, 2, 3. Where N is the number of nodes, Δ is the degree of each node in the network. Connectivity of the network is defined as the probability of the number of distributed node connecting at least to two unconnected neighbor nodes.

Theorem-2. A distributed node is formed from any two neighbor nodes in graph G if and only if its edges create the random structure.

Proof -2. Let N be the number of distributed nodes and E be the edges of the node. Distributed network contains vertices and edges. Each node is connected to at least two neighbor nodes. The edges it create a random structure in distributed network.

5.4.2 Complexity

The computational complexity of the existing algorithm is high compared to the proposed algorithm. Dv-hop algorithm has the complexity of O (nlogn). The virtual hop algorithm has O (n^2logn), where n represents the number of nodes in the graph; virtual hop contains two architectures, so the complexity is increased. The proposed algorithm has single distributed architecture with that for each single node the location is calculated. So the complexity is lesser O (n), compared to existing techniques.

5.5 RESULTS AND DISCUSSION

From the simulation results, the entire performance of the network is evaluated with Quality of Service parameters such as throughput, energy consumption, power simulated, delay, localization error and estimation error is calculated. In this, proposed technique is using omni directional antenna, with MAC 2.1 with channel bandwidth of 2Mbps. It uses Adhoc On Demand Routing Protocol for maintaining the route. The simulation time taken to analyze the performance at specific intervals from is 20 to 100 seconds. It achieves high throughput, low estimation error, localization error, low energy consumption and low delay.

Table 5.1 Comparison of Network Parameters

NETWORK PARAMETER	DV-HOP	VIRTUAL HOP	NAL APPROACH
Total Number of Packets	1000	1200	1500
Transmission Mode	Single Path	Multipath	Multipath
Coverage Type	Omni directional Antenna	Omni directional Antenna	Omni directional Antenna
Transmission range	250m	250m	250m
Routing protocol	DSDV	DSDV	AODV`
Control Messages	High	High	Medium
Collision	High	Medium	Low
Routing	Unicast	Multicast	Broadcast
Neighbor nodes	Minimum	Maximum	Vary

Table 5.1 shows the comparison of network parameters such as total number of packets, transmission mode, coverage type, transmission range, routing protocol, control messages, collision, routing and neighbor nodes. Neighbor Aware Localization approach is tried with three different numbers of neighbor nodes. First stage is Neighbor Aware Localization approach NAL-I. The number of neighboring nodes for each sensor node is 10 nodes. In second stage, Neighbor Aware Localization approach NAL-II, the number of neighboring nodes for each sensor node is 20 nodes. In third stage, Neighbor Aware Localization NAL-III has 30 neighbor nodes for each sensor node.

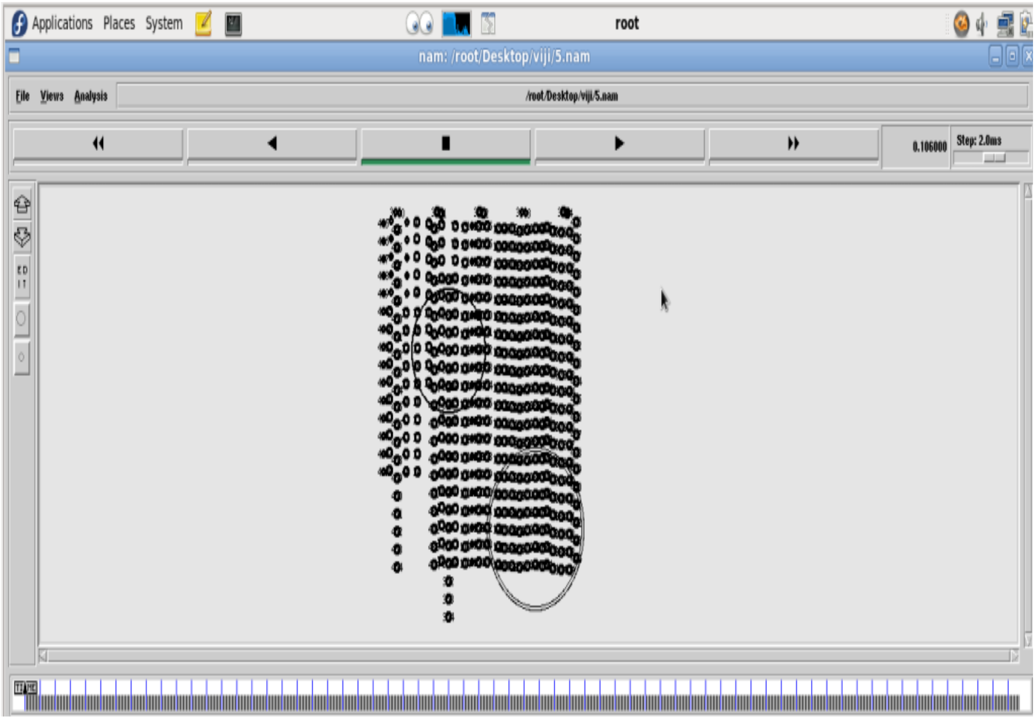

Figure 5.3 Network creation

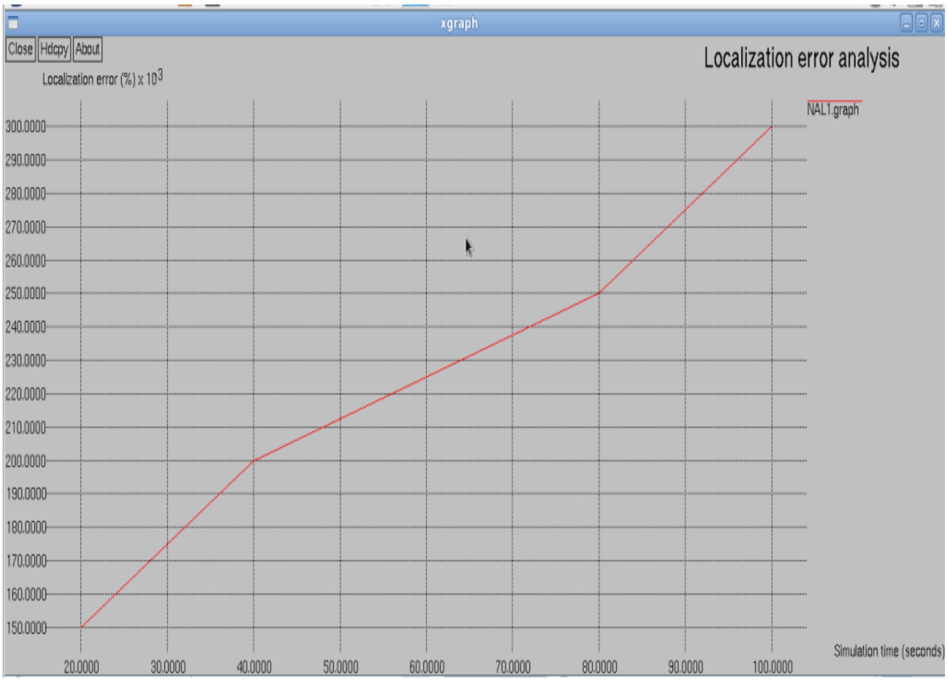

Figure 5.4 Localization error

Figure 5.3 shows the creation of nodes using Network Simulator. Figure 5.4 shows the Localization Error analysis. Localization error analysis has estimated the localization error with respect to the simulation time in seconds. Simulation results on Quality of Service parameters has been compared with the existing techniques such as Dv-hop, virtual hop and the three different stages of neighbor aware localization NAL-I,NAL-II and NAL-III. Figure 5.5 shows that the throughput analysis of Neighbor Aware Localization approaches with different transmission range along with other two methods. Throughput is defined as the ratio of number of packets successfully received to the simulation time. The number of nodes used varies from 100 to 500. Throughput achieved is more in the Neighbor Aware Localization approach compared to DV-HOP and V-HOP. The proposed approach NAL (Neighbor Aware Localization) achieves the throughput from 1.1Mbps to 1.4Mbps.

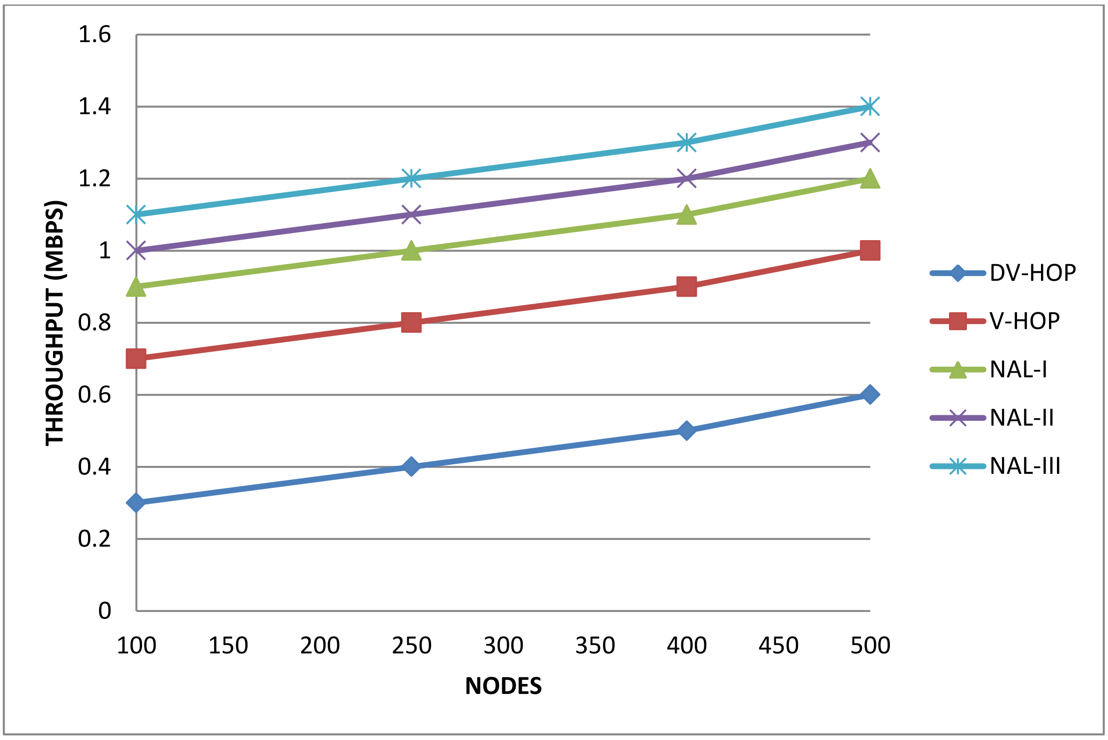

Figure 5.5 Network size Vs Throughput

Figure 5.6 shows the localization error in the NAL (Neighbor Aware Localization) techniques, localization error automatically decreases in the neighbor aware localization approach. From this analysis, it is assured that neighbor aware localization method will give the correct localization of sensor nodes. But the existing DV-hop and virtual hop method has high localization error compared to the proposed neighbor aware localization approach. This neighbor aware localization approach uses neighboring nodes to find the location of the sensor node so it produces the accurate result when compared to other techniques.

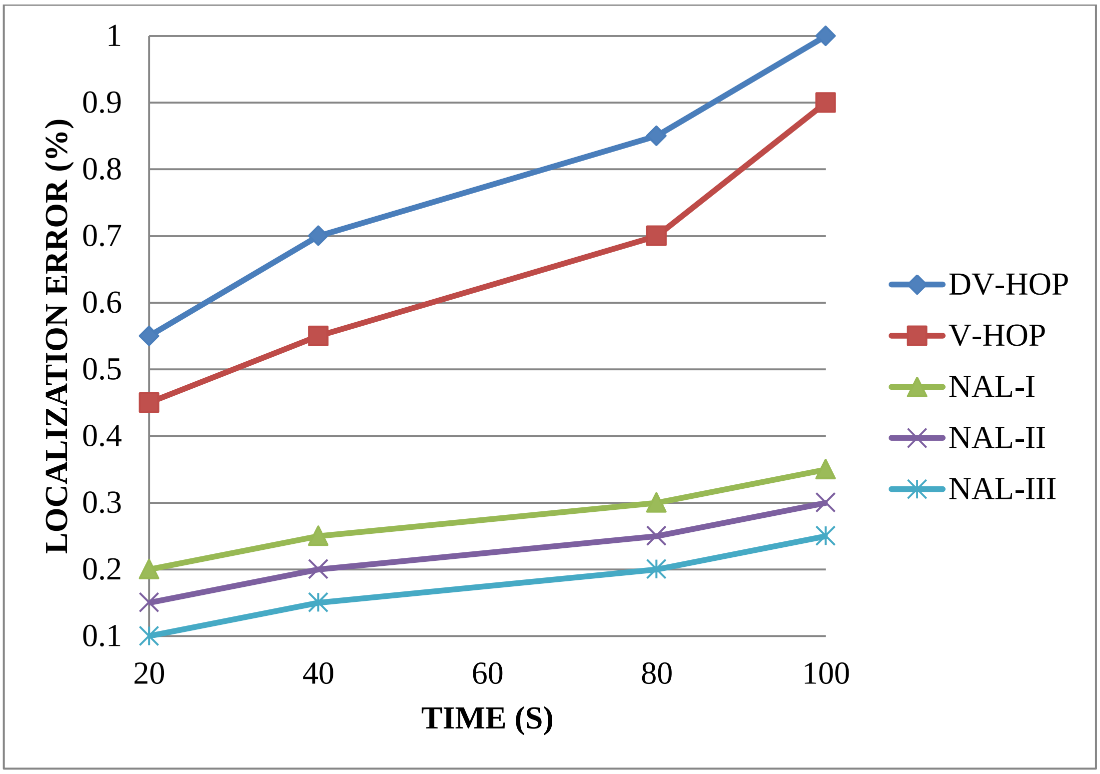

Figure 5.6 Localization Error Analysis

Figure 5.7 shows the estimation error determined by using location error and distance error. The estimation error in Neighbor Aware Localization technique is comparatively lesser than the DV-HOP and V-HOP method. The estimation error of the NAL (Neighbor Aware Localization) technique ranges from 0.12 to 0.27. The estimation of the location is determined using the different algorithms such as DV-HOP, virtual hop and proposed NAL (Neighbor Aware Localization) technique. The estimation is checked whether it is correct or not by the calculations based on the estimation error. NAL (Neighbor Aware Localization) technique has the estimation error of 12% to 27%.

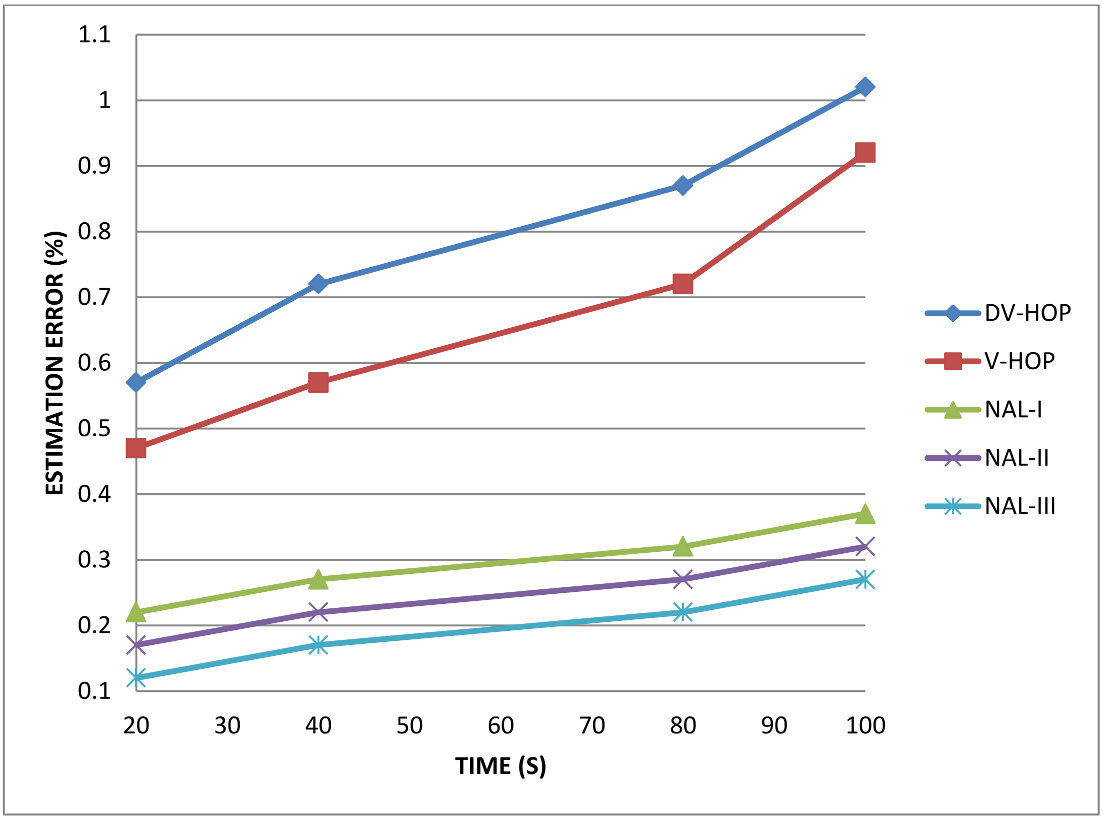

Figure 5.7 Simulation Time Vs Estimation Error

Figure 5.8 shows the comparison chart of energy consumptions. The energy consumption is more in the existing Dv-HOP and V-HOP method. The energy consumption is an essential parameter which makes the technique more attractive. The Neighbor Aware Localization method results in better performance on energy consumption. The energy consumption ranges from 8 to 9.5 joules of proposed Neighbor Aware Localization approach in three different conditions. Compared to the existing method, proposed Neighbor Aware Localization approach has reduced energy consumption.

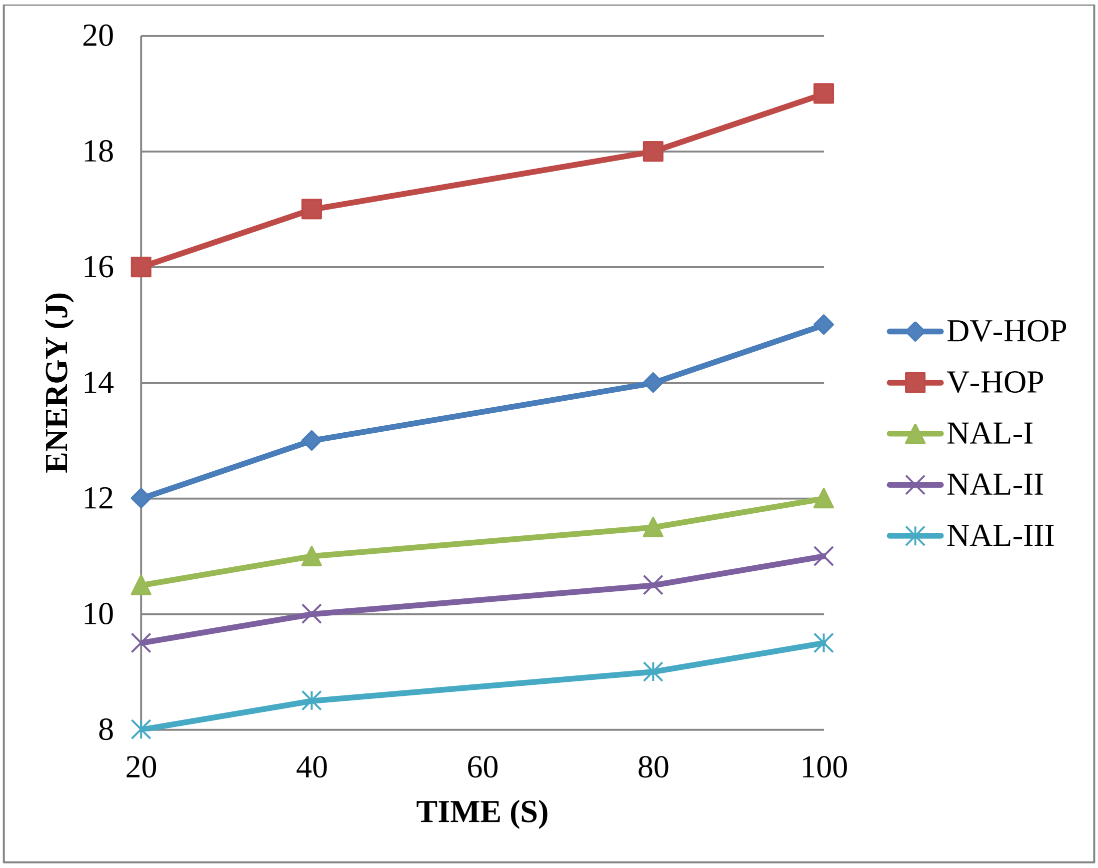

Figure 5.8 Energy Consumption Analysis

Figure 5.9 shows the delay response which is reduced in the Neighbor Aware Localization Approach. The traditional techniques like Dv-hop and V-hop are having very poor delay response. The delay response of the Neighbor Aware Localization varies from 0.35 to 0.55 seconds respectively. Delay is defined as the time taken to transmit the data from one end to another end. One end will be acting as source and another end will be acting as destination. The existing techniques Dv-hop and virtual hop has high delay due to the more number of hop counts used between the source and destination. The proposed Neighbor Aware Localization approach reduces the delay as lesser number of hop counts are used between the source and destination.

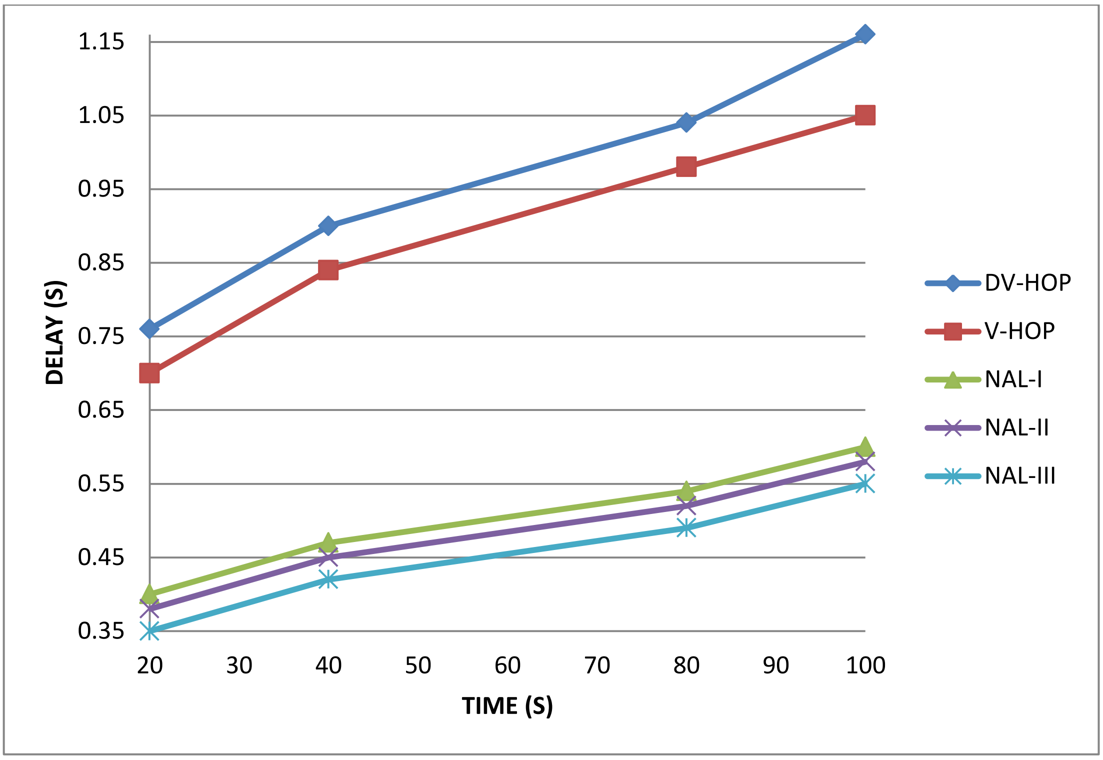

Figure 5.9 Simulation Time Vs Delay

Figure 5.10 shows the power efficiency of proposed and existing algorithms. Neighbor Aware Localization achieves higher power efficiency compared to the existing techniques such as DV-hop and virtual hop. Power efficiency is analyzed based on the energy level of the each node in the network. Energy is inversely proportional to the power efficiency. The proposed algorithm is using lesser amount of energy and that in turn reduces the energy consumption. So the proposed Neighbor Aware Localization approach increases the power efficiency.

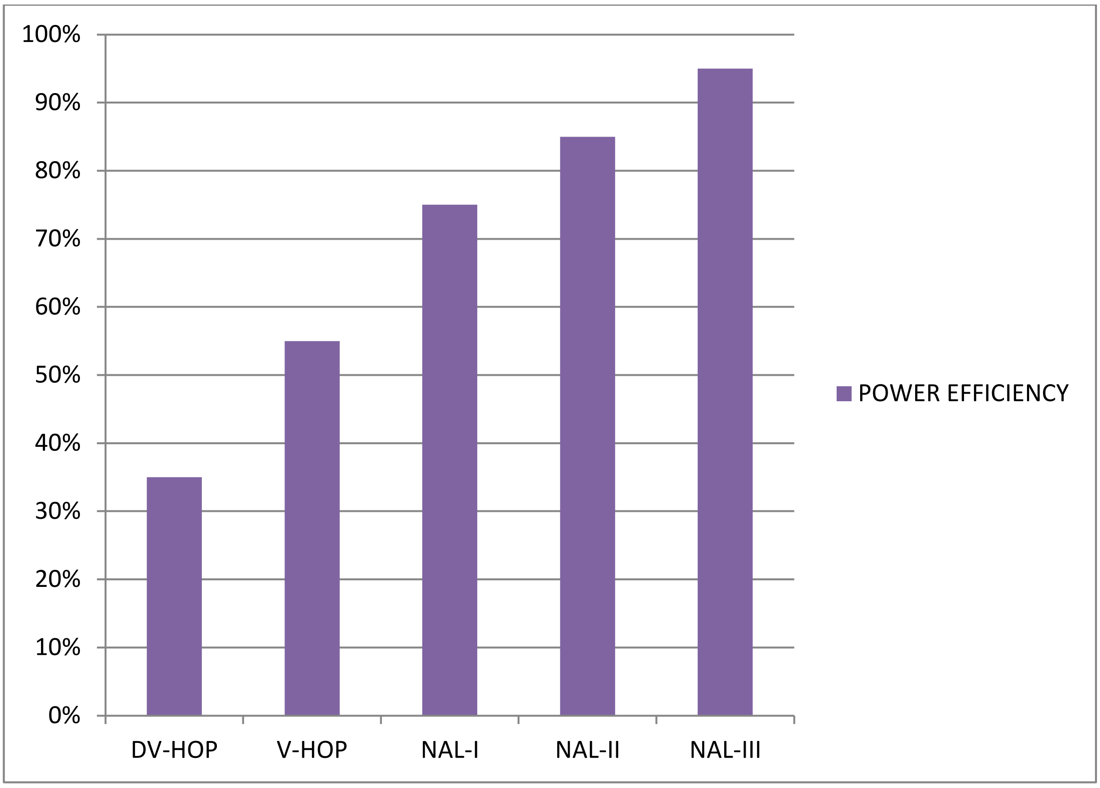

Figure 5.10 Power Efficiency of all the Parameters

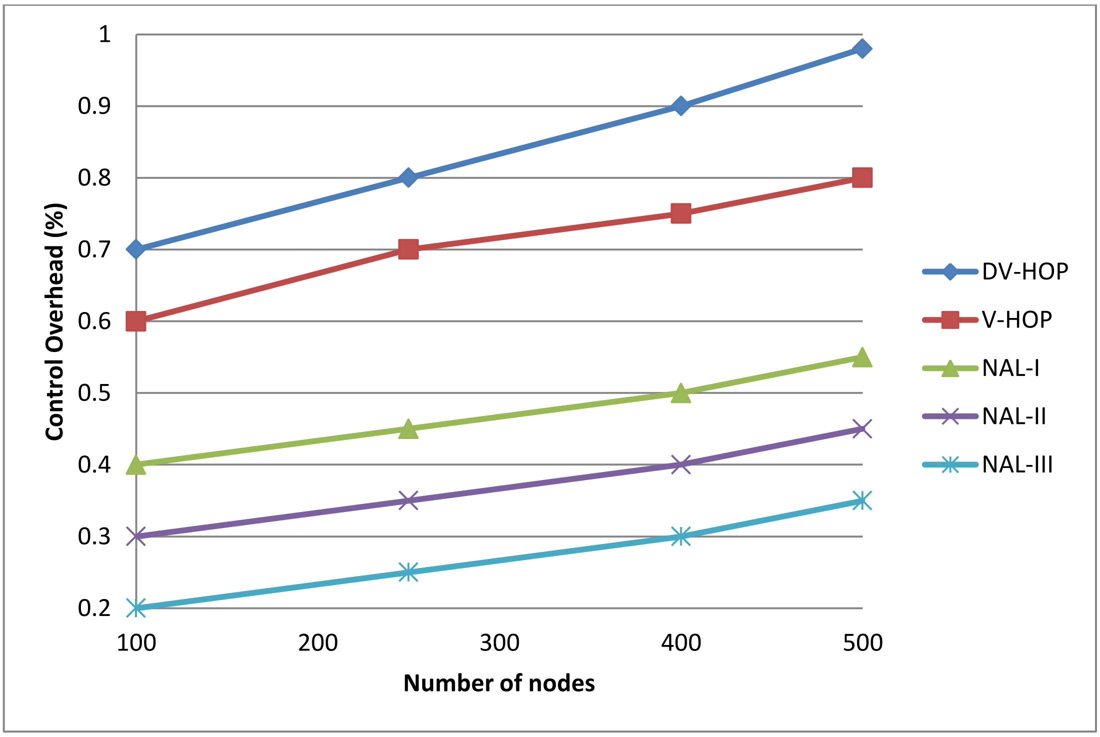

Figure 5.11 Control Overhead Analysis

Figure 5.11 shows the control overhead analysis and it is defined as the ratio of number of control messages received to the number of data messages received. Compared to the existing technique DV-HOP and virtual hop technique, proposed neighbor aware localization technique has reduced control overhead. DV- HOP and virtual hop uses the more number of control messages but the proposed Neighbor Aware Localization approach uses the lesser number of control messages and that reduces the control overhead ratio. Table 5.2 presents the comparison of Quality of Service parameters such as throughput, localization error, estimation error, energy consumption, and delay and power efficiency. In each technique, it varies from different levels with respect to number of nodes and simulation time.

Table 5.2 Comparison of QoS Parameters

Parameters	DV-HOP	V-HOP	NAL-I	NAL-II	NAL-III
Power Efficiency	35%	55%	75%	85%	95%
Delay (s)	1.16	1.05	0.6	0.5	0.4
Energy Consumption (J)	15	19	12	11	9
Time Taken for Localization (s)	15	13	5	4	3
Throughput (Mbps)	0.6	1	1.2	1.3	1.4
Routing Overhead	0.5	0.7	0.8	0.9	0.92
Localization Error	0.9	0.8	0.35	0.3	0.25
Estimation Error	0.95	0.9	0.4	0.35	0.3

5.6 SUMMARY

The simulation results have shown that the proposed Neighbor Aware Localization approach achieves higher network performance compared to the existing algorithm. The existing techniques such as Dv-hop and virtual hop has low throughput, low routing overhead. Also it has high localization error and estimation error. Localization error is directly proportional to the estimation error. If the localization error occurs, it is because of finding wrong location of sensor node. But neighbor aware localization algorithm reduces the error in determining the location of sensor node. The neighbor aware localization has high throughput, low energy consumption high power efficiency and low localization and estimation error. The Neighbor Aware Localization algorithm achieves high network performance compared to the existing technique. A simulation result has been compared with the existing and proposed method with three different stages based on the number of neighbor nodes. Finally the neighbor aware localization approach has satisfied the quality of service requirements compared to the existing techniques as Dv-Hop and Virtual Hop methods.

CHAPTER 6

LOCALIZATION FOR DISTRIBUTED CLUSTERED NETWORK

6.1 OVERVIEW

Wireless Sensor Network is a distributed architecture with random network deployment. The major concern in the Wireless Sensor Network is the localization of sensor node due to random node deployment. Finding the location of sensor node is the most import factor in Wireless Sensor Network. From finding the location of sensor node, one can get the accurate details of sensing information. So finding the location of sensor node in random deployment is a most important task. To find the location of sensor node many techniques such as used like the range based algorithm and range free algorithms are introduced. The existing techniques followed the range free algorithm, which leads to increase in the location error and estimation error. To overcome these issues the proposed technique follows the range based algorithm. The proposed technique has three modes of operation. Initially, it generates the nodes with random deployment, in the second mode the cluster head is created and in the third mode based on the range based algorithm, location of sensor node is identified. These three modes of operation make up the proposed algorithm and is named as Localization for Distributed Clustered Network (LDC) algorithm.

The existing techniques are Multi Hop Localization (MHL) and Virtual Force Localization (VFL). The multi hop algorithm is used to attempt range free algorithm, which has been designed using hop counts. Virtual force algorithm finds the location by attractive and repulsive forces of virtual motion paths between the sensor nodes. The major issue in the existing techniques are having high localization error, estimation error and energy consumption. This can be overcome by using the proposed algorithm of localization for distributed clustered network algorithm. This technique is designed using range based localization algorithm. The range based localization algorithm is used to estimate the location with the help of Euclidean distance and angle, from cluster head to sensor nodes. This will be discussed briefly in proposed technique and results and discussion are presented.

6.2 PROBLEM STATEMENT

The problems infects the Wireless Sensor Network is mainly due to distributed structure. This distributed architecture has distributed nodes with random deployment. Due to the random deployment, finding the location of sensor node is very difficult. Also, all the sensor nodes are movable and in active mode. Due to that energy consumption will be more and also power demand will also be high. Another issue in the sensor network is delay. During the localization, process, finding the location of sensor node takes more time. Due to that, it produces more delay. It uses the control messages to find the location of sensor node. Some of the localization algorithms calculate the shortest path between a pair of nodes using the Euclidian distance. It is valid only if the shortest path is a straight line. This is not valid for network having concave topology as it can give distorted results.

Some nodes give good approximation whereas for others, Euclidean distance differs significantly from the length of the shortest path. The nodes positioned at edges of the WSN area may not deal with localizing the nodes using some localization algorithm. Hence the distance information of each node obtained is of low quality. Most solution uses radio signals to measure the distance between the nodes based on the Received Signal Strength. It may cause less accuracy or less reliable results as these signals are deeply affected by the environment either due to the presence of obstacles or multi-path phenomenon. The heterogeneity of the channel depends on the propagation direction. It cannot be ignored; atmospheric condition like temperature has less effect on the signal whereas rain can affect the signal.

6.3 CLUSTER BASED LOCALIZATION

The techniques such as Multi Hop Localization and Virtual Force algorithm deals with cluster based localization. Multi hop localization is used to find the location by range free localization algorithm and by multi lateration method. Virtual force algorithm also follows the range free algorithm. It estimates the location by virtual forces generated between the sensor nodes. The main drawback of multi hop network is it accumulates more errors. This has been overcome by virtual force algorithm, it produces errors but compared to multi hop localization virtual force algorithm generates lesser error.

6.3.1 Multi hop Localization

Assuming some nodes which should have at least three sensor nodes at any given time to find the location. To make a triangulation formulation, initially select three sensor nodes. To perform the triangulation, each node selects three sensor nodes by assuming the point co-ordinates.

Based on the co-ordinates and performing the triangulation, the distance is estimated. Using the distance it will find out more nodes in multi hop localization. The idea behind this is to compute more node position and spread position knowledge throughout the network. The major problem in the multi hop lateration method is it accumulates more error. The position of the node is probabilistically known and not accurate. This has been overcome by another existing technique.

6.3.2 Virtual Force Algorithm

The Virtual Force Algorithm is using a sensor deployment strategy and it enhances coverage area after deployment of sensor nodes. The number of sensor nodes is deployed in an attempt to maximize the sensor field coverage. The combination of attractive and repulsive forces generated by the virtual motion paths will generate the movement for the randomly placed sensors. From this effective positions of the sensors are identified. It is a range free algorithm; it does not depend on the distance and the angle. It mainly focuses on the virtual motion that was generated by the virtual force algorithm. From the virtual motion, it can find the location of sensor nodes. The effectiveness of the algorithm is that it reduces the errors in the average level.

The existing techniques such as multi hop localization and virtual force algorithms used to assume the distance and virtual motion between the sensor nodes due to which it generates more errors. This leads to low accuracy of localization of sensor node. To overcome all these issues the Localization for Distributed Clustered Network algorithm is proposed.

6.4 PROPOSED TECHNIQUE

The proposed technique is Localization for Distributed Clustered Network algorithm. The proposed technique has three modes of operation. The first mode is creating distributed network. Converting distributed into hierarchical structure and creating cluster head is second mode. The third mode is estimating the location by localization algorithm. It is range based algorithm. It is estimated by the Euclidean distance formula. It will estimate the localization by known point co-ordinates.

6.4.1 Network Architecture

Localization for Distributed Clustered Network algorithm consists of three modes of operation. Initially it generates the cluster by distributed architecture with random deployment of sensor nodes. The node with known co-ordinates is assigned as the cluster head. Based on the cluster head the region will be split. Then using the known co-ordinates of cluster head remaining sensor nodes location will be found. Cluster head will be designed by the known co-ordinates and estimated distance.

Figure 6.1 shows the formation of distributed network with cluster head formation. Each cluster has different cluster head that will be denoted as C. Each cluster head has cluster members that are denoted as M. The cluster members are the sensor nodes. Each cluster head is connected to the respective cluster members. Cluster head selection is based on the known co-ordinates of the network. Initially the network is fully distributed following random deployment. The cluster head is assigned with known co-ordinates and distance from the neighboring nodes. Using the known co-ordinates, the proposed technique will find the location of sensor node. After creating the network and cluster head formation, the localization of sensor nodes in the Wireless Sensor Network is carried out.

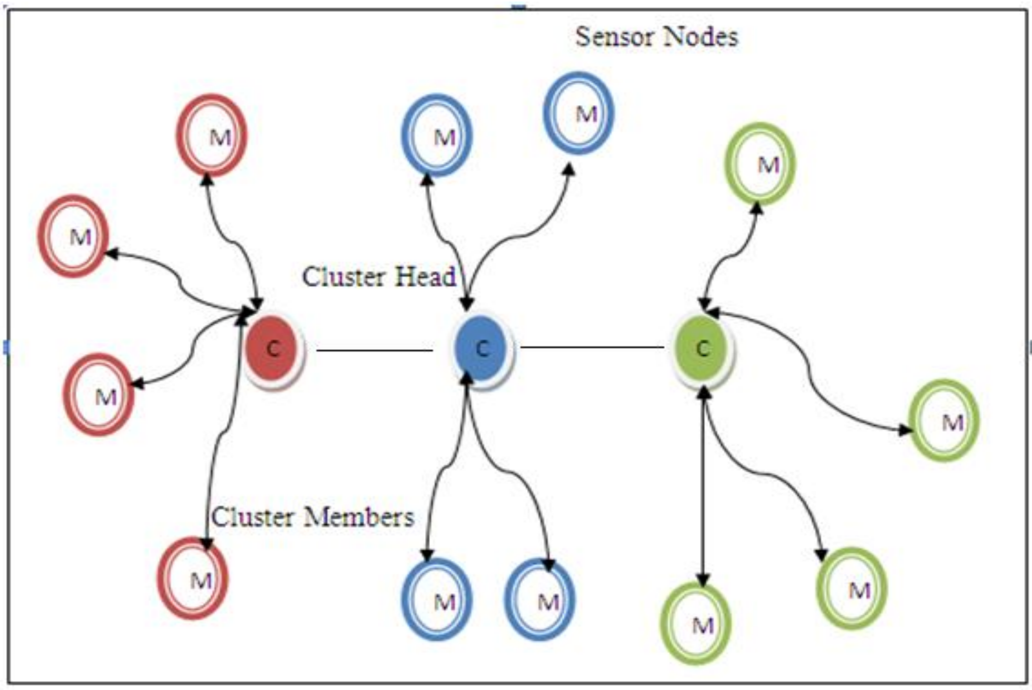

Figure 6.1 Network Architecture

6.4.2 LDC Approach

Figure 6.2 shows the Localization for Distributed Clustered Network approach. In this method cluster head has known co-ordinates which are (x_1,y_1), (x_2,y_2) and (x_3,y_3). The cluster members are having unknown co-ordinates that is denoted as (x_j,y_j). From cluster head 1 to cluster head 2 the distance will be assigned as d_1. Cluster head 2 to cluster head 3 the distance will be assigned as d_2. Cluster head 3 to cluster head 1 the distance is d_3.

From this d1, d2 and d3 are the known distances, which will be assigned and estimated, based on the requirement. This will be used to estimate the location of sensor nodes (cluster members). Cluster head formation is most important factor in this Localization for Distributed Clustered Network algorithm. The known co-ordinate node will be assigned as cluster head.

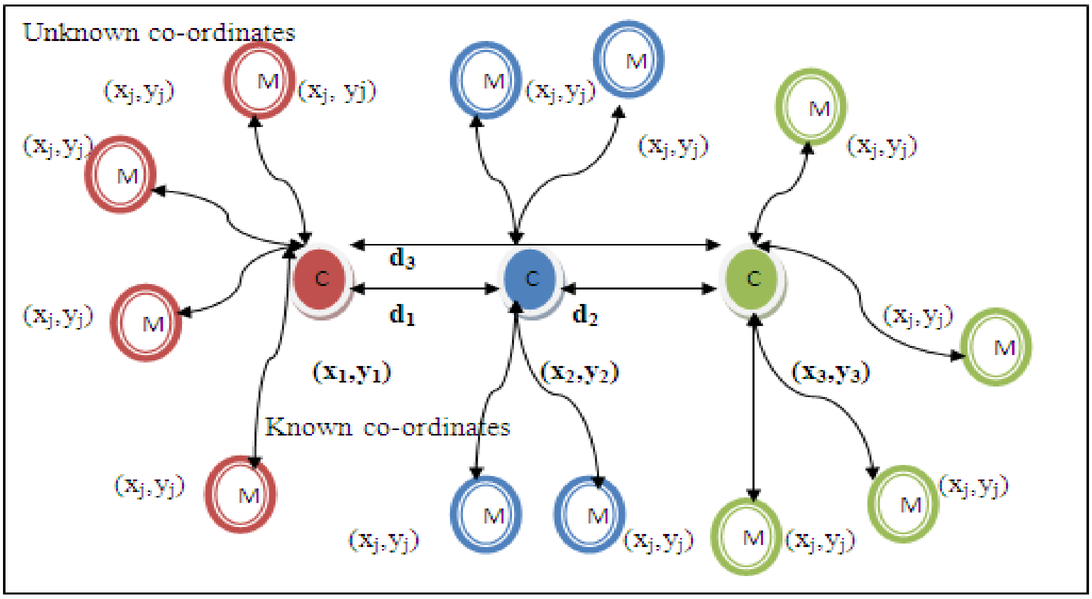

Figure 6.2 Localization Distributed for Clustered Network (LDC) Approach

The Localization for Distributed Clustered Network algorithm has to estimate the location of sensor node by Euclidean distance. The Euclidean distance formula is shown in the equation 6.1

$$(x_i - x_j)^2 + (y_i - y_j)^2 = {d_i}^2 \qquad (6.1)$$

(i,j) are the co-ordinates and by are assigned i= 1, 2, 3 and j= 1, 2, 3. d_1, d_2 and d_3 are the estimated distance. These are constants.

Substitute in equation 6.1 and will get, subtract the equations 6.2 and 6.3 equate to first resulting in equations 6.2 and 6.3.

$$(x_1 - x_i)^2 - (x_3 - x_i)^2 + (y_1 - y_j)^2 - (y_3 - y_j)^2 = {d_1}^2 - {d_3}^2 \qquad (6.2)$$

$$(x_2 - x_i)^2 - (x_3 - x_i)^2 + (y_2 - y_j)^2 - (y_3 - y_j)^2 = {d_2}^2 - {d_3}^2 \qquad (6.3)$$

(x_1,y_1), (x_2,y_2) and (x_3,y_3) are known co-ordinates. Rearrange the equations 6.2 and 6.3 this technique will yield the equations 6.4 and 6.5 respectively.

$$2(x_3 - x_1)x_i + 2(y_3 - y_1)y_j = ({d_1}^2 - {d_3}^2) - ({x_1}^2 - {x_3}^2) - ({y_1}^2 - {y_3}^2) \quad (6.4)$$

$$2(x_3 - x_2)x_i + 2(y_3 - y_2)y_j = ({d_3}^2 - {d_2}^2) - ({x_3}^2 - {x_2}^2) - ({y_3}^2 - {y_2}^2) \quad (6.5)$$

Rewriting the equations 6.4 and 6.5 in vector matrix from,

$$2\begin{bmatrix} x_3 - x_1 & y_3 - y_1 \\ x_3 - x_2 & y_3 - y_2 \end{bmatrix}\begin{bmatrix} x_i \\ y_j \end{bmatrix} = \begin{bmatrix} ({d_1}^2 - {d_3}^2) - ({x_1}^2 - {x_3}^2) - ({y_1}^2 - {y_3}^2) \\ ({d_3}^2 - {d_2}^2) - ({x_3}^2 - {x_2}^2) - ({y_3}^2 - {y_2}^2) \end{bmatrix} \quad (6.6)$$

Using equation 6.6 the co-ordinates of x_i, y_j can be calculated along with equations 6.7 and 6. 8

$$x_i = \frac{({d_1}^2 - {d_3}^2) - ({x_1}^2 - {x_3}^2) - ({y_1}^2 - {y_3}^2)}{2\{(x_3 - x_1)(y_3 - y_2)\} - \{(y_3 - y_1)(x_3 - x_2)\}} \quad (6.7)$$

$$y_j = \frac{({d_3}^2 - {d_2}^2) - ({x_3}^2 - {x_2}^2) - ({y_3}^2 - {y_2}^2)}{2\{(x_3 - x_1)(y_3 - y_2)\} - \{(y_3 - y_1)(x_3 - x_2)\}} \quad (6.8)$$

The unknown co-ordinates are calculated by using equations 6.7 and 6.8. Using the known cluster head co-ordinates the unknown co-ordinates of cluster members can be estimated. It will estimate the localization with high accuracy.

A. Algorithm

1. Create G(V,E)
2. Random (V,E) \\ random deployment
3. Assume V_{c1}(x1,y1) \\ cluster head-1
4. Assume V_{c2}(x2,y2) \\ cluster head-2
5. Assume V_{c3}(x3,y3) \\ cluster head-3
6. $D_1 \rightarrow$ create E1 from V_{c1} to V_{c2} \\ distance
7. $D_2 \rightarrow$ create E2 from V_{c2} to V_{c3}
8. $D_3 \rightarrow$ create E3 from V_{c3} to V_{c1}
9. Calculate X_j by equation 7
10. Calculate Y_j by equation 8
11. Using (X_j,Y_j) then move to j+1
12. Until j=1,2,3…n

This algorithm explains the Localization for Distributed Clustered Network algorithm. The first three steps involve the first mode of operation. It is used to create the distributed network architecture. Steps 4 to 8 involve the second mode of operation. These steps are used to create the cluster head with the known co-ordinates and to estimate the distance. Last four steps are used to calculate the unknown co-ordinates of cluster members.

6.5 RESULTS AND DISCUSSIONS

The analysis of simulation results of the proposed algorithm compared with the performance of the existing technique is presented. To prove that the distributed localization for clustered algorithm has high accuracy of localization and low energy consumption, simulation results were discussed. Assume the physical layer as wireless medium. MAC protocol is used as IEEE 802.11 with the data link layer. Transport layer uses the User Datagram Protocol for wireless transmission with constant bit rate of 512 packets per second with delay of 0.01 seconds. Queuing type used in the network architecture is drop tail queue. The coverage parameter is based on the Omni- directional antenna with the coverage range of 250 m. The transmission bandwidth used in the proposed technique is 2Mbps.

Table 6.1 shows the comparison of network parameters for various configurations. The parameters analyzed are the Quality of Service parameters such as packet delivery ratio, routing overhead, control overhead and distance error, delay and energy consumption. The LDC algorithm is tested for varying sizes of the cluster head. Initially LDC –I uses the size of the cluster head as 3, LDC –II used the size of the cluster head as 9 and LDC –III uses the size of the cluster head as 18.

Table 6.1 Comparison of Network Parameters

NETWORK PARAMETER	MHL	VFA	LDC
Total Number of Packets	1000	1200	1500
Transmission Mode	Single Path	Multipath	Multipath
Coverage Type	Omni directional Antenna	Omni directional Antenna	Omni directional Antenna
Transmission range	250m	250m	250m
Routing protocol	AODV	DSR	OLSR
Control Messages	High	Medium	Low
Collision	High	Medium	Low
Routing	Unicast	Multicast	Broadcast
Neighbor nodes	Vary	Vary	Vary
Cluster head	Nil	Nil	Vary

Figure 6.3 shows the packet delivery ratio, it is defined as the ratio of number of packets sent to the number of packets to receive. Only 50% of the packets are delivered to the node in existing technique. In proposed algorithm, it achieves the 85 to 90% of packet delivery ratio. The existing technique multi hop localization and virtual force algorithm has low delivery rate and the proposed LDC – I uses the size of the cluster head as 3, LDC –II used the size of the cluster head as 9 and LDC –III uses the size of the cluster head as 18, has high delivery rate for three different sizes of cluster head.

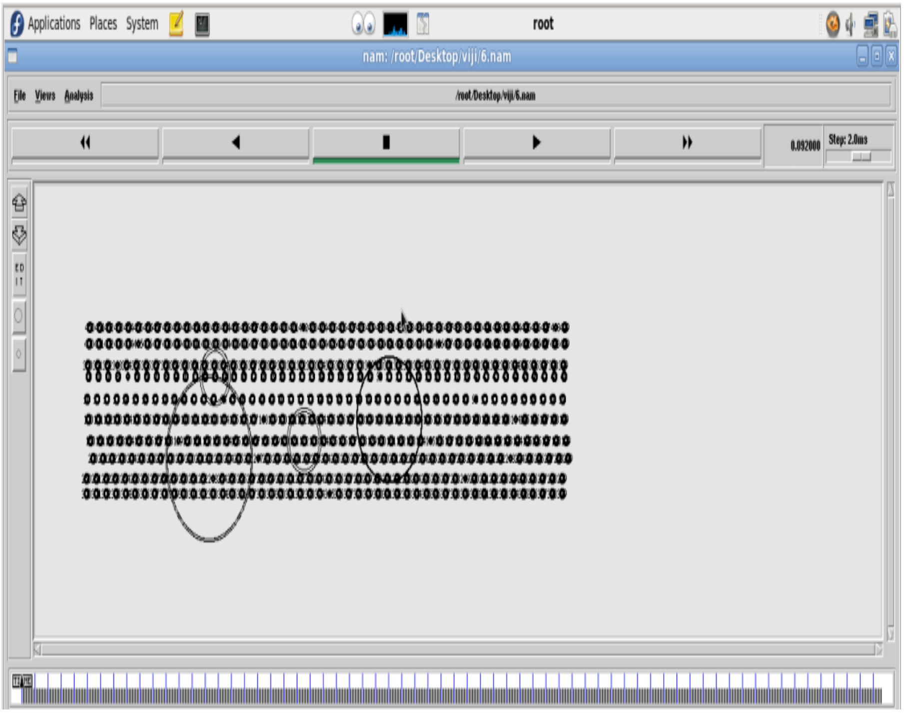

Figure 6.3 Node creation

Figure 6.3 shows the node creation using the Network Simulator using “transcript command” language. Figure 6.4 shows the delivery rate analysis and it is plotted using the xgraph and the values are extracted from the trace file.

Figure 6.4 Delivery rate

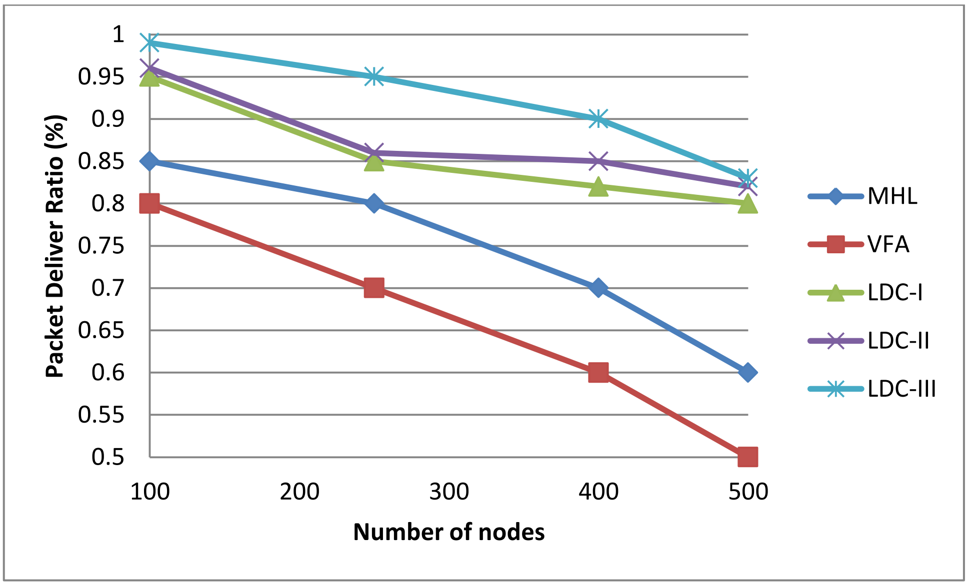

Figure 6.5 Network Vs Packet Delivery Ratio

Figure 6.6 shows the routing overhead. It is defined as the ratio of number of data messages to the number of control messages. Compared to the existing algorithms, proposed methods achieve high routing overhead. It increases the data messages by decreasing the control messages. Localization for Distributed Clustered Network algorithm has high packet delivery rate and high routing overhead compared to the existing techniques such as multi hop localization and virtual force algorithm. The existing Multi Hop Localization (MHL) and Virtual Force Algorithm (VFA) has received the lesser number of data messages that lead to less delivery rate and high drop rate. But the proposed Localization for Distributed Clustered Network algorithm has high routing overhead.

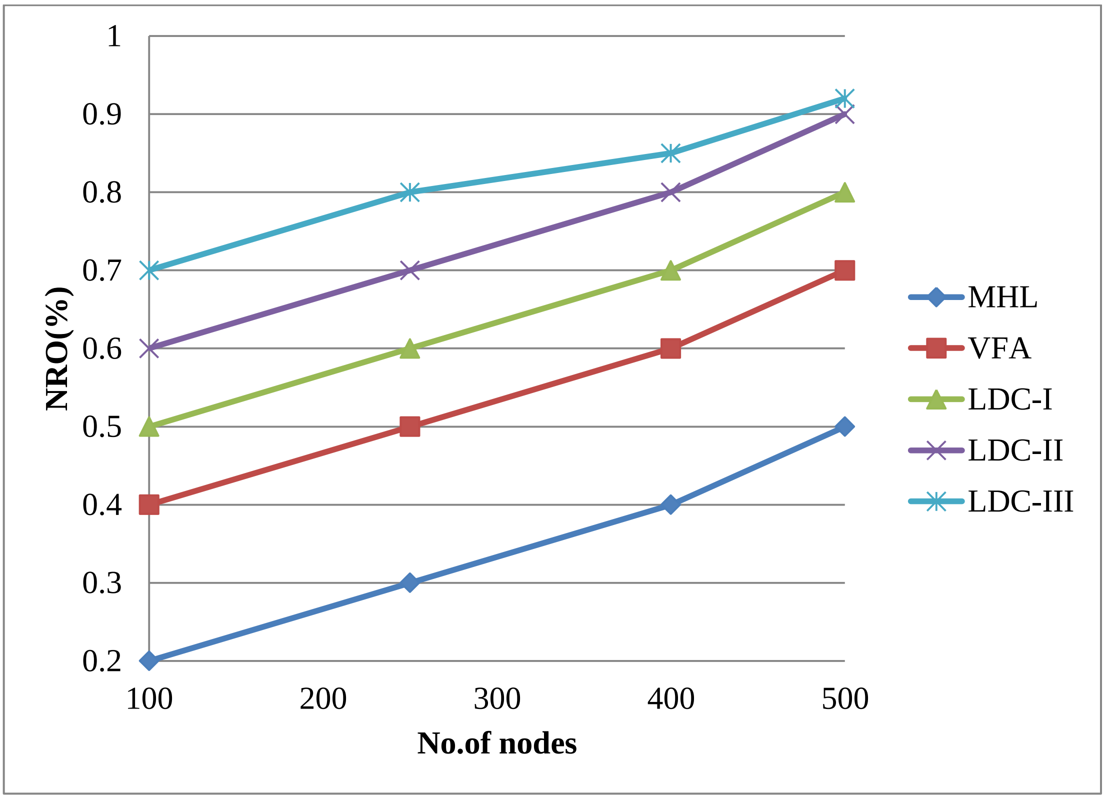

Figure 6.6 Number of Nodes Vs Routing Overhead

Figure 6.7 shows the control overhead, it is defined as the ratio of number of control messages received to the number of data messages received in the nodes. The number of control messages required for the proposed Localization for Distributed Clustered Network algorithm for the same number of nodes is lesser than the traditional algorithm. The simulation results of the proposed technique have utilized lesser number of control messages. The existing multi hop localization and virtual force algorithm have high control overhead.

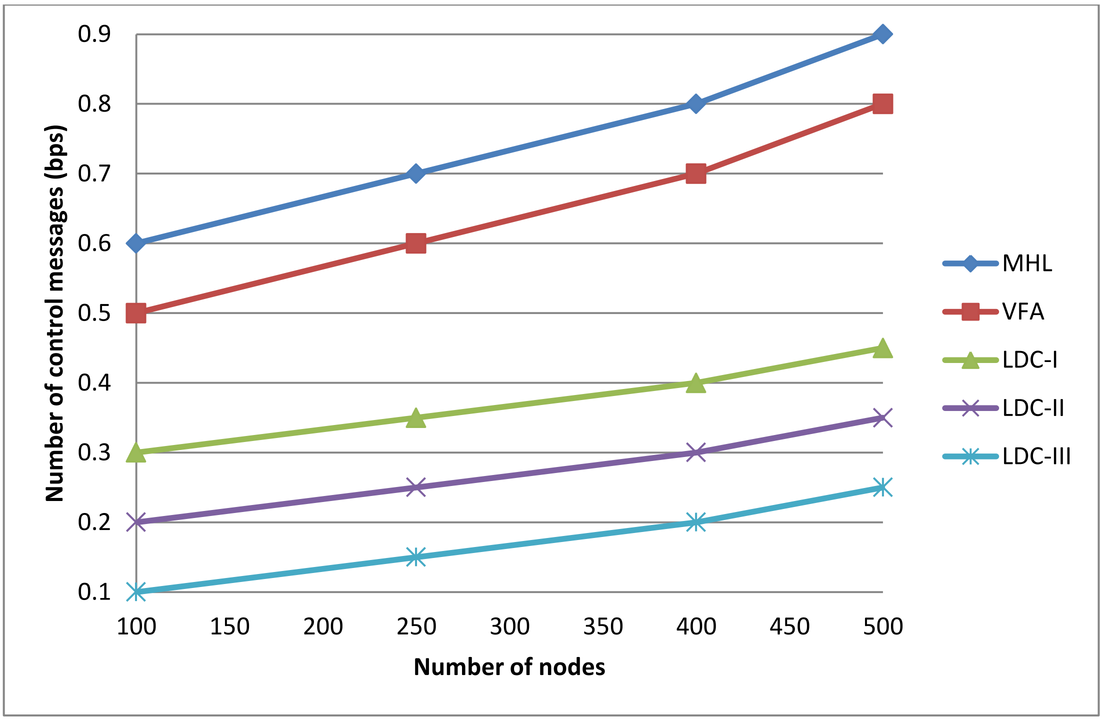

Figure 6.7 Network Size Vs Control Overhead

Figure 6.8 shows the delay response of the proposed technique vs existing technique. The delay is defined as the time taken to transmit the packets from one node to another node. The delay response of the proposed technique varies from 0.2 to 0.31 seconds. It is more than 2 times better than the existing multi hop localization method and VFA method. The existing multi hop localization and virtual force algorithm has high delay due to the more number of hops between the source and destination. But the proposed localization for distributed clustered network algorithm has reduced delay.

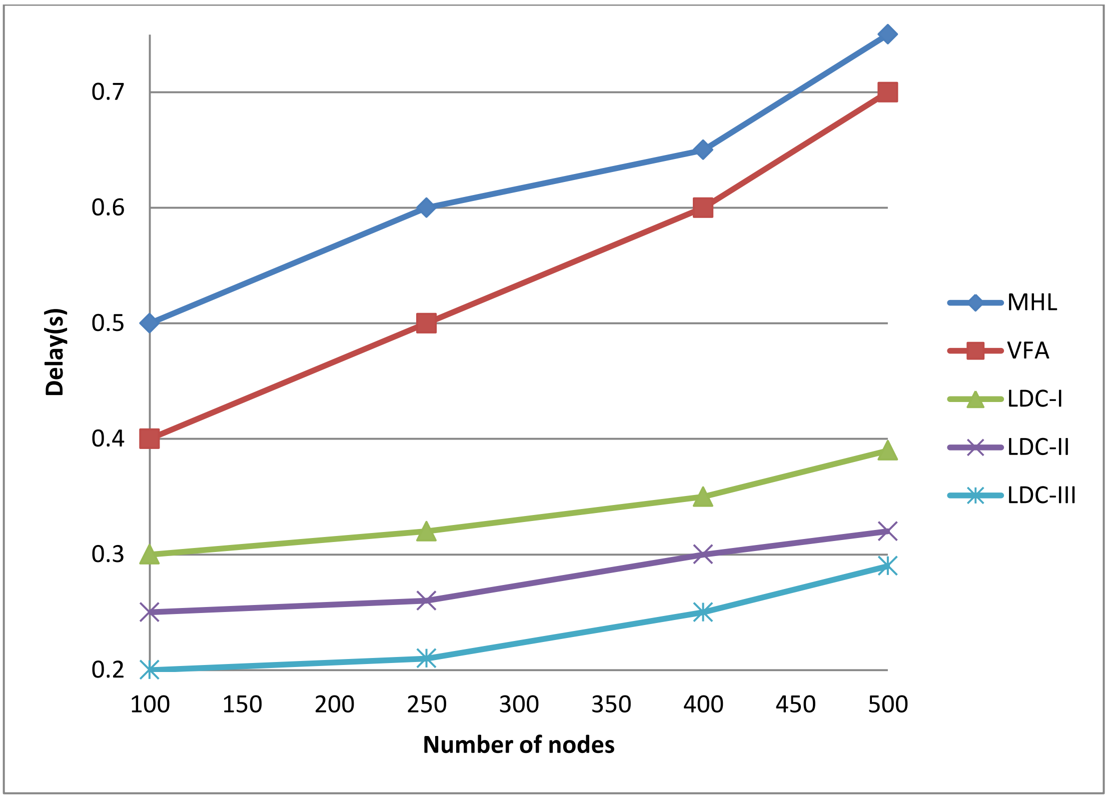

Figure 6.8 Network Size Vs Delay Analysis

Figure 6.9 shows the estimation error. It is based on the estimation of the location of sensor node with accuracy. Existing techniques has low accuracy and high localization error, but proposed algorithm has lesser error compared to the existing techniques. The localization of the sensor node estimated using the proposed Localization for Distributed Clustered Network algorithm which can estimate the location more accurately compared to other existing techniques.

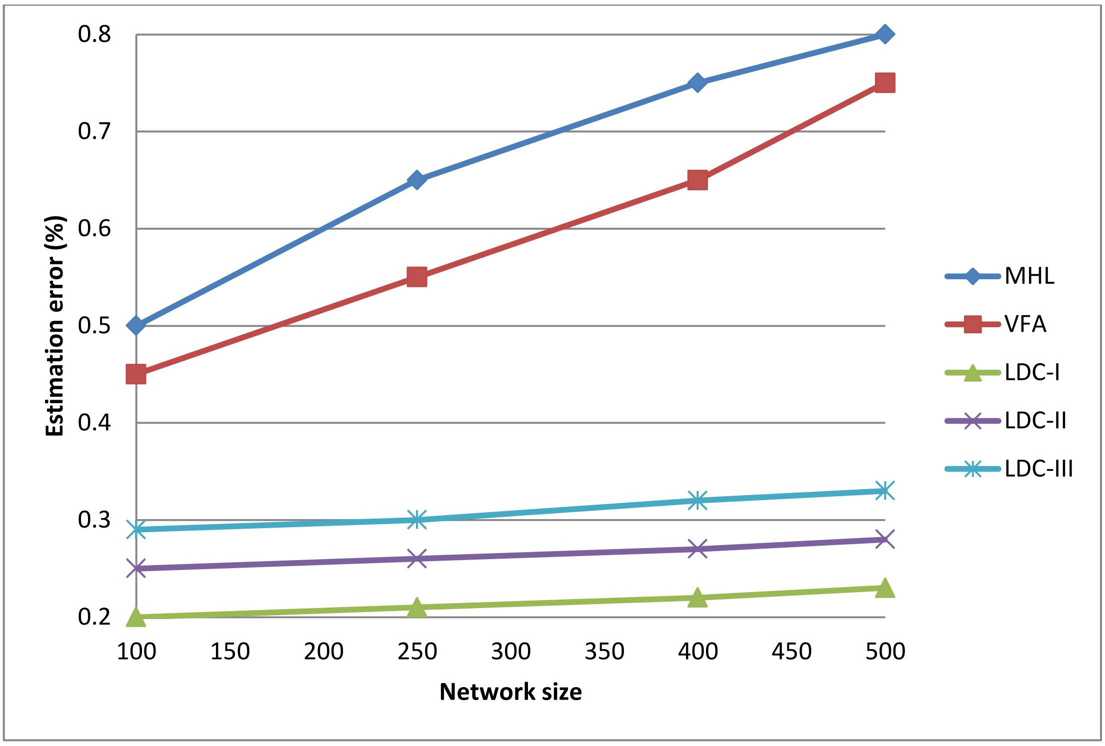

Figure 6.9 Network Size Vs Estimation Error

Figure 6.10 shows the energy consumption. Initially the energy is assigned as 20 joules for all the sensor nodes in the Wireless Sensor Network. The Proposed technique, distributed localization for clustered network consumes less power compared to the existing techniques, multi hop localization and virtual force algorithm. The existing Multi Hop Localization and Virtual Force Algorithm techniques have taken the more time to localize the sensor node, so it consumes more energy. But the proposed localization for distributed clustered network algorithm utilizes less time to localize the sensor node and in turn reduces the energy consumption compared to the existing techniques.

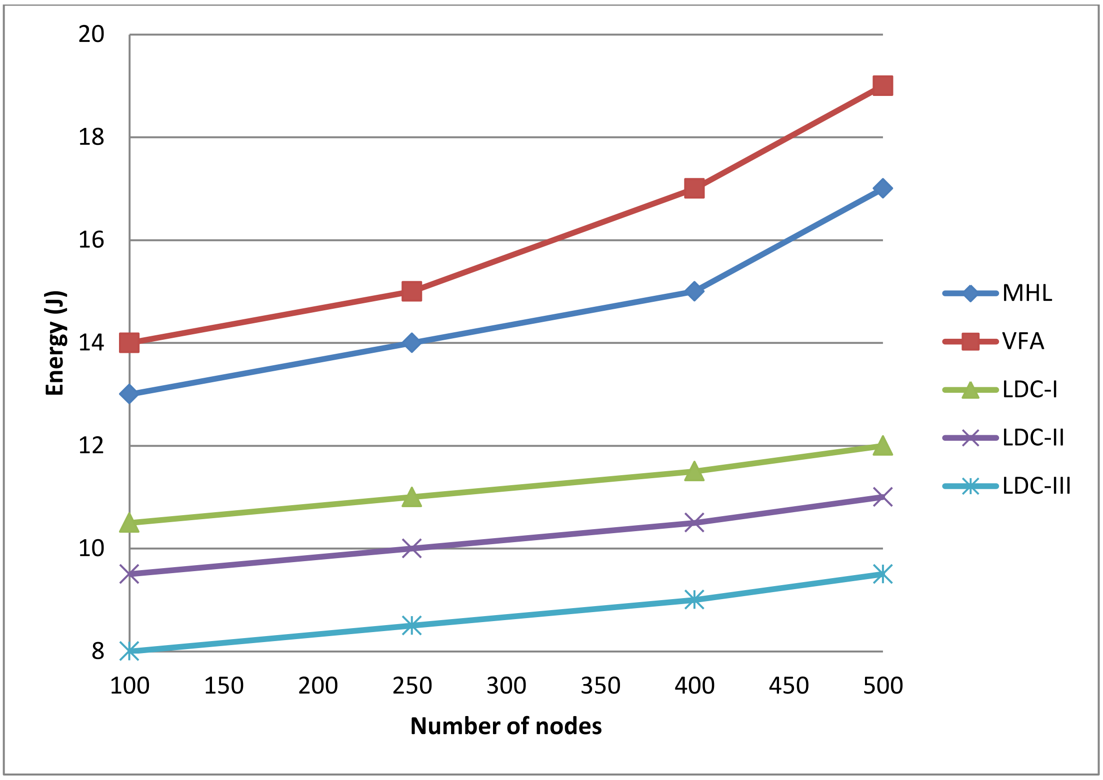

Figure 6.10 Energy Consumption Analysis

Table 6.2 shows the comparison of Quality of Service parameters such as energy consumption, power efficiency, delay, localization error, estimation error, routing overhead, delivery rate and throughput. The proposed technique based on distributed localization for clustered network has high throughput, high delivery rate, high power efficiency and high routing overhead. It has less localization error, less estimation error, less time taken for localization, lesser delay, less energy and power consumption, less control overhead compared to the existing techniques as multi hop localization and virtual force algorithm.

Table 6.2 Comparison of QoS Parameters

Parameters	MHL	VFA	LDC-I	LDC-II	LDC-III
Power Efficiency	45%	58%	88%	92%	98%
Delay (s)	0.7	0.6	0.4	0.35	0.3
Energy Consumption (J)	17	16	11.5	10	8.8
Time taken for localization (s)	13	11	4	3	2
Throughput (Mbps)	0.8	1.1	1.22	1.33	1.4
Routing Overhead (%)	0.5	0.6	0.85	0.92	0.93
Localization error (%)	0.8	0.75	0.23	0.28	0.33
Estimation error (%)	0.9	0.8	0.24	0.3	0.35
Delivery Rate (%)	0.6	0.5	0.8	0.82	0.83
Number of Control Messages (bits)	4000	3500	1050	1300	1450

6.6 SUMMARY

Localization and energy consumption are the major issues which can be overcome by range based localization and range free localization algorithms. Range free localization algorithm used in the existing technique, consumes more energy and has low accuracy. Range based algorithms are used in the proposed technique, Localization for Distributed Clustered Network (LDC) algorithm, has high accuracy and also it consumes less power.

The simulation result clearly illustrates that this algorithm has high delivery rate and high routing overhead. Multi hop localization uses large control messages whereas the range free localization uses beacon signals only to find the location of sensor node. Range based algorithm does not depend on the control messages for the localization. So the proposed algorithm reduces the control overhead compared to the existing techniques. When the load of control messages decreases, collision will also decrease. If the collision decreases, delay will also decrease. Proposed technique like Localization for Distributed Clustered Network algorithm achieves high Quality of Service parameters such as packet delivery rate, routing overhead as high and the localization error, delay, control overhead and energy consumption less. The simulation results prove that the proposed technique has low localization error and low power consumption.

CHAPTER 7

CONCLUSION AND FUTURE SCOPE

7.1 CONCLUSION

In this research work, a Multiple Mobile Anchor Based Localization Technique using Particle Swarm Optimization technique is proposed. The technique is developed to reduce the delay caused by the traditional single mobile anchor node localization. The decrease in energy of the sensor nodes may affect the efficiency of the whole network. PSO determines the trajectory of the mobile anchor nodes based upon the node density and the distance between the nodes in the network. The unknown nodes have lesser Received Signal Strength (RSS) value than the mobile anchor nodes which on receiving the packet estimates the distance between each of the mobile anchors to the unknown node. Localization of the node is done using trilateration method. The unknown node will get two anchors from the list and localize them using trilateration method with the reference node. The reference node is the mobile anchor node having least distance to the unknown node. The simulation results have shown that the localization delay is reduced since multiple mobile anchor nodes are used and the visiting schedule of the mobile anchors enables it to traverse through the dense and sparse network.

The second localization approach is based on boundary recognition, which achieves high network performance compared to the existing algorithm such as Hop method and Flood mechanism in localization method. The simulation results used the Quality of Service parameters such as throughput, delivery rate, and drop rate, delay and estimation error. From the Localization based on Boundary Recognition approach, throughput achieved is 1.4 Mbps for the band limited to the channel of 2Mbps link. LBR Localization Based on Boundary Recognition has secured a 85% delivery rate of the packets. Drop rate has been reduced by 45%. Delay is lesser at the rate of 0.3 seconds. Estimation error is also reduced in the LBR approach. It is lesser when compared to the existing algorithms such as Hop method and Flood mechanism in localization method. Performance analysis proves that, Localization based on Boundary Recognition approach gives high network performance due to lesser complexity in finding the location of sensor node. It also gives high performance on network parameters such as transmission mode, coverage type, transmission range, routing protocol, control messages, collision and routing. The FML method achieves high delivery rate and throughput. The dropping ratio is reduced in the proposed LBR localization with increase in transmission range over the traditional methods. It also reduces the estimation error which results in exact location of sensor nodes over the hop method and FML method. The hop method produces more localization error when there is an increase of network size. This technique generates beacon signals to reduce the delay compared to existing techniques and algorithms. The time taken for localization in the proposed algorithm is 2 to 6 seconds where as in existing hop method and FML method it is between 8 to 13 seconds. The Quality of Service of the proposed technique is better over the other methods.

The simulation results have proved that the proposed mechanism of Neighbor Aware Localization approach achieves higher network performance compared to the existing algorithm. The existing techniques much as Dv-hop and virtual hop has low throughput, low routing overhead. It makes a high localization error and estimation error. Localization error is directly proportional to the estimation error. If the localization error occurs, it is because of finding wrong location of sensor node. The false localizations in finding the location of sensor node are less in the proposed method. The proposed algorithm of Neighbor Aware Localization approach has high throughput, low energy consumption, high power efficiency and low localization and estimation error. The proposed algorithm achieves high network performance when compared to the existing technique. Finally the Neighbor Aware Localization approach has satisfied the Quality of Service requirements compared to the existing techniques of Dv-Hop and Virtual Hop methods. The simulation results has been compared for evaluating the entire performance of the network using Quality of Service parameters such as throughput, energy consumption, power efficiency, delay, localization error and estimation error. It achieves high throughput, low estimation error, localization error, low energy consumption and low delay. The time taken for simulation analysis for the proposed technique is between 20 to 100 seconds. Simulation results analyze the Quality of Service parameters compared with the existing technique as Dv-hop and virtual hop and it is proposed in three different stages as Neighbor Aware Localization NAL-I,NAL-II and NAL-III. In the proposed Neighbor Aware Localization approach it achieves the throughput from 1.1Mbps to 1.4Mbps. Localization error and estimation error will automatically decreased due to the use of Neighbor Aware Localization approach. The estimation error of the proposed technique ranges from 0.12 to 0.27. In existing method, the estimation error varies from 0.57 to 1.02. The NAL results in better performance even on energy consumption. The energy consumption of the suggested technique ranges from 8 to 9.5 joules and the delay response is also reduced in the proposed Neighbor Aware Localization approach. The power efficiency of the proposed NAL approach is 95%, 60% higher than the existing techniques.

Range based algorithms are used in the proposed technique Localization for Distributed Clustered Network algorithm which exhibits high accuracy in finding the location of the sensor nodes consuming less power. The simulation result shows that the proposed algorithm has high delivery rate and high routing overhead. The proposed algorithm reduces the control overhead compared to the existing technique. Proposed technique, achieves good results as seen from Quality of Service parameters such as delivery rate, routing overhead are high and the localization error, delay, control overhead and energy consumption are low. Simulation result proves that the proposed technique, Localization Distributed for Clustered Network algorithm has low localization error and low power consumption.

Localization for Distributed Clustered Network algorithm has high delivery rate and low routing overhead compared to the existing techniques such as Multi Hop Localization and Virtual Force Algorithm. Proposed technique consumes lesser power compared to the existing techniques. Another issue in the sensor network is delay. The proposed algorithm has lesser error compared to the existing techniques. The proposed algorithm has lesser delay of 0.2 to 0.3 seconds. The power efficiency of proposed algorithm is high about 98% compared to other algorithms. The number of control messages required for the proposed Localization Distributed for Clustered Network algorithm for the same number of nodes is lesser than the traditional algorithm. Overall, the proposed research work is well suited for location tracking environments.

7.2 FUTURE SCOPE

In future, these proposed algorithms can be implemented in fast moving mobile sensor network applications. The future scope of the proposed work is given below:

- Secure Transmission: The proposed algorithm can be modified for implementing in the Wireless Sensor Network with secure transmission.
- Environmental monitoring: To monitor the environment this localization algorithm will be more helpful.
- Network Structure: Due to the mobile sensor nodes, network structure may vary. The proposed algorithms generate beacon signal to get the information about the localization after the change in topology. The network structure will be maintained by the proposed algorithms.

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LIST OF PUBLICATIONS

Paper Published:

1. **S.Kavitha &** Dr.J.Kanakaraj 'A Review on Sensor Properties and Characteristics in Node Tracking Systems" Sensor Letters, ISSN1546-198X vol. 13, 1–6, 2015 pp.1-6 (Paper Accepted) **(ANNEXURE –I)**

2. **S.Kavitha,** Dr.J.Kanakaraj & Dr.G.Mary Jansi Rani 2014 'Mobility based Energy Efficient Tracking using Particle Swarm Optimization (PSO) in Wireless Sensor Networks" International Journal of Applied Engineering Research, ISSN 0973-4562 vol. 9. no. 21 (2014) pp.11327-11340. **(ANNEXURE –II)**

3. **S.Kavitha,** Dr.J.Kanakaraj 'Multiple Mobile Anchors based Localization using Particle Swarm Optimization (PSO) for Wireless Sensor Networks' Journal of Theoretical and Applied Information Technology, ISSN 1992-8645 vol. 58, no. 1, December 2013, pp.219-229. **(ANNEXURE –II)**

4. Irin Kurian, **S.Kavitha** "IMLBTR Based Localization of Wireless Sensor Network in the Wild" International Journal of Innovative Research in Science, Engineering and Technology ISSN: 2319-8753 vol.3 no.3 March 2014 pp.10038-10044.

5. Evangeline Asha B , **Kavitha S** 2014 'Implementation of packet classification Algorithm using VHDL" International Journal of Emerging Technologies and Engineering (IJETE) ISSN 2348 – 8050, vol.1, no. 10 November 2014, pp.256-260.

6. **S.Kavitha** 'Packet classification Algorithm using state machine' International Conference on 19 & 20 2015 in Tamizhan College of Engineering and Technology,

7. **S.Kavitha** 'Multiple mobile anchors using PSO in WSN' International Conference on 3 & 4 September 2012 in Kathir College of Engineering, Coimbatore

8. **S.Kavitha** ‘Neighbor Aware Localization Approach’ International Conference on Intelligent and Control Systems 7 & 8 January 2016 in Karpagam College of Engineering, Coimbatore.

9. **S.Kavitha** Localization for Distributed Clustered Network International Conference on International Conference on Inventive Research in Engineering and Technology 16 & 17 April 2016, Pattaya, Thailand (Paper Accepted)