

Localization by Decreasing the impact of obstacles in Wireless Sensor Networks

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by

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dedicated to my parents and friends...



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May 2014

Certificate

This is to certify that the work in the thesis entitled "*Localization by Decreasing the Impact of obstacles in WSN*" by *Manish Kumar*, bearing roll number **212CS1093**, is a record of work carried out by him under my supervision and guidance in partial fulfillment of the requirements for the award of the degree of *Master of Technology in Computer Science and Engineering*.

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Manish Kumar

Abstract

In sensor networks, Localization techniques makes use of small number of reference nodes, whose locations are known in prior, and other nodes estimate their coordinate position from the messages they receive from the anchor nodes. Localization protocol can be divided into two categories: (i) range-based and (ii) range-free protocols. Range-based protocols depend on knowing the distance between the nodes. Where as, range-free protocols consider the contents of message sent from the anchor node to all other sensor node.

Previous range-free based localization methods requires at least three anchor nodes, whose positions already known, in order to find the position of unknown sensor node and these methods might not guarantee for complete solution and an infeasible case could occur. The convex position estimation method takes the advantage of solving the above problem. Here different approach to solve the localization problem is described. In which it considers a single moving anchor node and each node will have a set of mobile anchor node co-ordinates. Later this algorithm checks for the connectivity between the nodes to formulate the radical constraints and finds the unknown sensor node location. The nodes position obtained using convex position estimation method will have less location error.

However, Network with obstacles is most common. Localizing these networks, some nodes may have higher location error. The new method is described to decrease the impact of obstacle, in which nodes near or within the obstacle that fail to get minimum of three anchor node position values get the anchor position set from its neighbor nodes, applies the convex position estimation method and gets localized with better position accuracy. The Convex position estimation method is range-free that solves localization problem when infeasible case occurs and results in better location accuracy.

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Chapter 1

Introduction

1.1 Overview of Wireless sensor networks

The recent technological improvement in the fields of wireless communication has made possible the development of low cost ,low power, and multi-functional sensors that are small in size and communication over short distances. A wireless sensor network is comprised of different sensor nodes , small in size , battery powered devices that can communicate and compute signals with other nodes. Nowadays, a smart sensor network are deployed in large numbers to provide opportunity for monitoring and controlling homes, cities and the surroundings. In addition, they have a wide range of applications in providing new technology for surveillance,defense field. Sensors incorporated into machinery,structures and the environments are joined with the effective transmission of sensed data that can offer enormous benefits to guild.

A sensor network is an infrastructure consist of sensing , computing, and communication elements that gives an administrator the capability to instrument, observe, and react to events and phenomena in a specified environment.A wireless sensor network (WSN) contains a number of gateway (or “base station”) that can pass information with a number of sensors nodes via a wireless connection. Information gathered by the node is compressed and sent to the base station directly or if required, it uses other nodes to transfer information to the base station. The information which is transferred , then utilized by base station connection.

The features of a WSN include: Dynamic network topology, heterogeneity of nodes, large scale of node deployment, nodes ability to resist harsh environmental conditions, nodes should run under very strict energy constraints and should

perform sensing and data processing functionalities. The communication scheme is many-to-one (data gathered up at a base station) rather than peer-to-peer.

1.2 Organisation of the thesis

The remainder of this thesis is organized into 5 chapters:

- Chapter 2 Introduces localization in wireless sensor network and related works done in that field.
- Chapter3 Focuses on convex position estimation method and method to decrease the impact of the obstacle.
- Chapter 4 Discusses the performance evaluation and presents simulation results.
- Chapter 5 Summarize the thesis work with concluding remarks and future works

1.3 Summary

In Wireless sensor network conataining large amount of sensor nodes have the capability of sensing computing and communicate with each other . Sensor node has Some limitation regarding nodes energy , which is consumed very fast ,so it has to be utilized with great care when developing applications.

Chapter 2

Localization in Wireless Sensor Networks

Research in the field of localization of sensor nodes in wireless sensor networks has become active since last few years and much research has already been done for various application in this area. This chapter will give a clear idea about importance of localization ,different techniques that are already existing to find to position of sensor nodes .

2.1 Importance Of Localization

Location of sensor node is very crucial in a sensor network since many application such as monitoring forests and/or fields ,where a large amount of sensor nodes are placed. An efficient localization algorithm can determine the accurate position coordinates of devices or nodes using the information available from sensor nodes. In addition ,location based routing protocol can save and utilize significant amount of energy by removing the need for route finding and improve the location for application.

In wireless sensor networks , the problem of determining the location of unlocalized sensor nodes is referred to as localization.

There are different cases where limitation assumes a basic part is at reconnaissance throughout assaults , military provisions to spot targets ,activity checking and a lot of people more provision .On envisioning about the scenes after every calamity where houses are harmed and individuals are harmed or murdered or got stuck

some place in the ruin, the need of figuring out the influenced individuals and spots must be carried out at any expense. To attain the objective of placing the individuals or items, there are numerous strategies extending from physically spotting the individuals by the emergency treatment men to utilizing present day innovations. From late fiascos, we can understand that in the event that we had high innovative gadgets, then exploited people might have been safeguarded instantly. In this sort of situation, if all individuals and valuable articles are outfitted with wearable gadgets like Zigbee 802.15 and comparable gadgets from the medical aid men or halfway controlled gadgets, then they may structure a remote impromptu system as demonstrated in Fig.2.1.

Later, every sensor center point can apply a position estimation figuring so that all devices can know their and others region. Around then, the crisis medicine men will viably run across the zone of the people or thing to secure. Also that, the people need help similarly contemplate the zones around them and help overseeing them to escape from the danger.

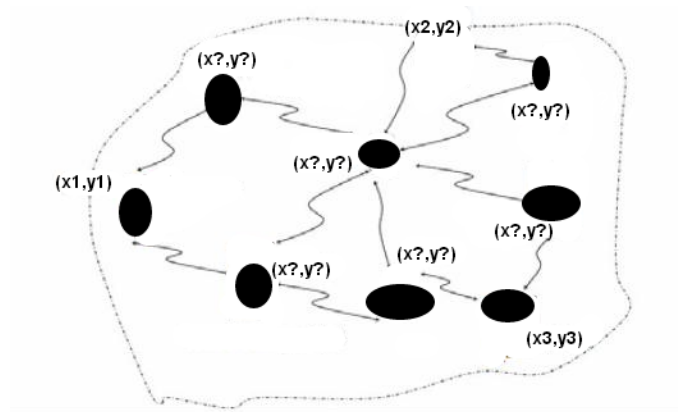


FIGURE 2.1: localization requirement

The Localization problem offers ascent to two vital issues. First and foremost, the issue of characterizing a direction framework. Second, which is the all the more in fact testing, is the issue of ascertaining the separation between sensors (the ranging problem). Solution to these issues could be accomplished utilizing any of the systems below depicted.

This section describes the importance of localization in many applications, where a large number of sensor nodes are placed. Localization is used to find the position of these nodes.

2.2 Classification of Localization

Localization can be achieved using any of these methods:

- Anchor-free v/s Anchor based
- Centralized v/s distributed
- Range-free v/s Range based

2.2.1 Anchor Free v/s Anchor Based

Anchor Nodes (also regularly called Beacon nodes/seed) are essential to localize a system in a global coordinate system. Anchor nodes are essentially normal sensor nodes that have their global position coordinates in priori and different nodes estimates their location from the messages they receive from them. This information could be hard coded, or gained through some extra equipment like a Global Positioning System(gps) recipient. Then again anchor -free nodes are the one without GPS[2]. Here nodes discover their positions in the system utilizing extent estimations between them. Every sensor in the network fabricates its own particular neighborhood coordinate system by expecting itself as the origin of this coordinate system and selecting two non-collinear one-jump neighbors to structure axes. At that point the positions of one-jump neighbors are processed as needs be. Finally, can work on network co-ordinate system to get the node's position in order to define a global coordinate system. At least three non-collinear signal hubs are obliged to limit the hubs in two measurements. If three dimensional directions are obliged, then no less than four non-coplanar beacons must be available.

Advantages of using GPS

Simplifies the problem of finding the coordinates of ordinary nodes.

Practical limitation of using GPS

- (a) GPS can't work in inside or in the vicinity of thick vegetation.
- (b) The high power prerequisites of GPS part consumes the battery of a sensor node really quick.

2.2.2 Centralized v/s Distributed

Most importantly it is important to figure out whether any obliged calculations ought to be performed generally, by the participants, on the premise of some

mainly accessible estimations or all estimations ought to be accounted for to a central station that finds the location of nodes in the network and appropriates them again to the participants. There are two principle issues that ought to be viewed as: scaling and efficiency.

Centralized Algorithms are intended to run on a central machine. Every sensor node collects the estimations of separations all the neighbors and sends the information to the central station where the sensor node coordinates are computed. Centralized algorithms defeat the issues of nodes computational confinements by tolerating the correspondence expense of moving information once again to the focal station. This trade off gets less feasible as the framework creates greater, in light of the way that it unduly concentrates on centers near the base station. Plus, the information transmitted to the central station includes time postpones, so the centralized procedures can not be satisfactory in numerous requisitions (e.g., mobile nodes).

Conversely, distributed algorithms are intended to run in the system where processing takes place at every sensor node. Every node is responsible for finding its position utilizing data about neighbors. It offers a critical diminishment in calculation necessities on the grounds that the amount of neighbors is generally not huge (between ten and twenty), so the amount of connections is typically a couple of requests orders of magnitude less. The utilization of a distributed computation model is also tolerant to failure of nodes and appropriates the correspondence cost equitably over the sensor hubs. On the other side, distributed algorithms implementation is often concerned with the information loss and in view of that the results which could be gotten are generally less correct. Distributed localization can be classified as

- Range-based
- Range-free.

2.2.3 Range Based Localization

Range-based localization techniques are distance-estimation and angle-estimation-based. Some of the most important techniques that are used in range based localization are received signal strength indication (RSSI), angle of arrival(AOA), time difference of arrival (TDOA), and time of arrival(TOA).

RSSI Another range based method is *Received Signal Strength Indicator (RSSI)* technology [3] that has been proposed for hardware-constrained systems. The strength of signal received by the node is used to measure its distance from signal source in RSSI. The main disadvantage is in actual environment the signal gets interrupted by noise, clutters and antenna type, causing high inaccuracy in localization. The strength of signal received by the node is used to measure its distance from signal source. Greater the distance, lower the strength of signal when it arrives to node. The strength of signal weakens as the inverse of square distance, theoretically.

AoA Angle of Arrival (AoA) means the angle at which the receiver received the signal from the transmitter. The angle at which signals are received is estimated in AoA and it uses simple geometric calculations to estimate the relative positions of transmitter and receiver. AoA measurement is an attractive method due to the easiness of calculations (triangulation). The major drawback of this technique is that, multi-path reflections causes an error in estimating the directions.

2.2.4 Range Free Localization

In range-free localization algorithms, there is no assumption about the availability of absolute point-to-point distance estimates between sensor nodes. Therefore, the location of sensor nodes is estimated by exploiting the radio connectivity information or the sensing capabilities of each sensor. These algorithms may require some reference nodes. Range-free methods are distance vector (DV) hop, hop terrain, centroid system, APIT, and gradient algorithm. Range-free methods use radio connectivity to communicate between sensor nodes to deliver their location information. Solution to the Range-free localization depends only on the data information of received messages that are being sent from the reference nodes to all other sensor nodes, Range-Free localization can be achieved using any of these methods:

Centroid Techniques: Here, each sensor node calculates its coordinate position by calculating the center of the locations of all beacon messages it receives. If anchors are well deployed, location error can be minimized, but this is not possible in ad-hoc deployments. Centroid techniques [4] rely on a high density of seeds so that every node can hear several seeds. In order to improve the algorithm, weighted algorithm is used to improve the location accuracy.

DV Hop: Hop counting technique is used to localize the networks where the anchor density is low. Hop-counting techniques [5] broadcast location information throughout the network. DV hop [14] estimates range between nodes using hop count. In DV hop, Atleast three reference nodes broadcast their coordinates information with hop count throughout the network. The information is flooded throughout the network from neighbor to neighbor nodes. When such messages are received by the neighboring node, containing information about the reference nodes and increments the hop count by one . In this way, unknown node can find the number of hops away from anchor node . All anchor nodes and unknown nodes calculates shortest path from each other. Average hop distance formula can be calculated as: distance between two nodes/number of hops . Triangulation method is used to estimate the position of unknown nodes from three or more anchor nodes using hop count to measure shortest distance.

APIT method In Approximate Point in Triangulation (APIT) [6] scheme, anchor nodes gets location information from GPS or transmitters. Unknown nodes, whose location information is not available, gets their location information from overlapping triangles. In APIT , Unknown nodes maintain a table containing information of anchor nodes , that is , anchor ID, signal strength and location of anchor node , this information is received by the unknown nodes in form of beacons messages from anchor nodes . The area is divided into overlapping circles , After selecting three anchor nodes , the unknown nodes check whether the three anchor nodes are in triangle form. This test is called Point-in-Triangulation(PIT) test. This test is done until the accuracy of unknown node location is found. In the end , an unknown node is placed at the intersection of all the triangles , that point is calculated to find the estimated position of an unknown node.

In this section , Different localization techniques are discussed. Location based routing protocol can save and utilize significant amount of energy by removing the need for route finding and improve the location for application.

2.3 Challenges faced during Localization

i. Because of the arbitrary deployment of sensor nodes , a uniform distribution of nodes can't generally be achieved, which may create a situation where few areas could not have any sensor node.

- ii. Uneven power usage among sensor nodes results in some regions without usefulness of sensing and communication.
- iii. Wireless sensor networks are liable to be arbitrarily deployed in out of reach terrains and environments such as war zone and clash zone , as well as inhabitable regions etc .Physical deterrents , for example ,mountains or buildings will naturally exist in numerous networks.
- iv. Sensor networks are typically quite resource-starved. Sensor nodes are normally battery controlled. Communication, processing and sensing movements will diminish the lifespan of the node. So, they must work to reduce the power cost,equipment expense and deployment cost.

In this section , challenges which are faced during localization of sensor nodes are discussed.

2.4 Design issues

The design issues that need to be considered while working on wireless sensor network are described below.

Sensing Coverage

There is a contrast between sensing and radio coverage, which implies that in the radio communication, the coverage is essentially more extensive than the sensing coverage. In this manner, the sensing coverage is a vital part from the application perspective. The coverage of a network is classified in three different methods as sparse,that just parts of the zone of investment are secured, dense if the complete framework is covered and redundant coverage when different sensor nodes accept the same information in the same region.

Mobility

If there are some nodes which can move , they could rearrange themselves after deployment to increase wireless connectivity , forming a robust network that can respond dynamically to changing environmental conditions . WSNs can be categorized as partly or fully mobile depending on the ratios of nodes which are moving. These two differ in terms of, partly is only a subset of nodes moving, however,all the nodes will moving in fully mobile. It can be moving objects by the impact of nature such as wind, earthquake, and landslide. Indeed, the mobility in nodes can

be active or passive which depends on the node's mobility.

Computation Power

The main source is the processor for consuming battery life. Energy consumption in processing of data is very less if compared to communication of data between the nodes. Hence, a location discovery algorithm should utilize neighborhood information in order to minimize communication power.

This section describes the various design issues in wireless sensor network , which needs to be considered , when working on localization of sensor nodes.

2.5 Measurement Techniques

Once an algorithm finds the distances to all other nodes in neighbor, it tries to estimate node position of nodes using the estimated distances. The very known measurement techniques used are:

Trilateration Trilateration is simply a technique that uses distances between one unknown sensor node and three anchor sensors to estimate the unknown sensor node location. An unlocalized sensor location is unique, when at least three anchor nodes are connected with it in a 2-D space. The coordinate location of the unlocalized sensor is identified by finding the point where three circles intersect each other, as shown in Figure 2.2(A). If it contains error, the point where three circles intersect may not be a single point.

Triangulation Triangulation is simply a technique that is used when the angle of the sender node is estimated instead of distance and it uses the AoA to determine the position of sensors nodes. With the angle of each anchor node, with respect to the unlocalized sensor node in some reference frame, the unlocalized sensor node's positions are calculated by using the trigonometry laws . In this case, as shown in Figure 2.2(B) , at least two distances are required.

Multilateration An unlocalized sensor node location may also be calculated with multilateration with its separation to more than three anchor sensor node. The estimated sensor node location by the multilateration localization technique is the one that minimizes the sum of squared distances between a hypothesized sensor location to all the anchor locations [13]. For example, in Figure 2.2(C), to compute the location (x, y) of node S, following function can be used[10].

$$\min \sum (D_{s,i} - \hat{D}_{s,i})^2$$

Where $D_{s,i} = \sqrt{(x - x_i)^2 + (y - y_i)^2}$ is the estimated distance.

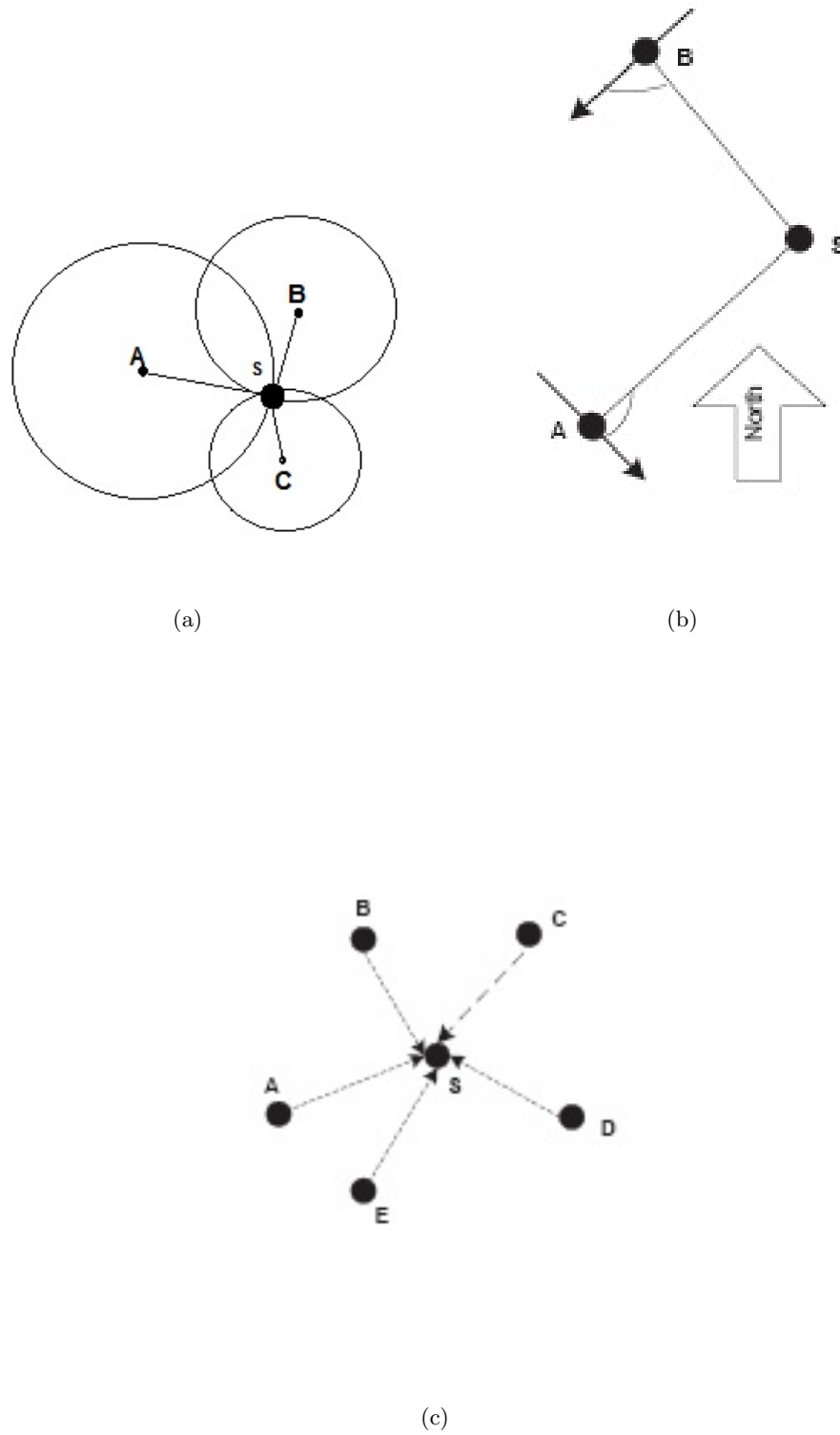


FIGURE 2.2: Measurement techniques: (A) Trilateration (B) Triangulation (C) Multilateration

2.6 Related works in range free based fields

There are many existing techniques and algorithm's which are trying to solve the problem of finding the accurate position of unlocalized nodes in wireless sensor network. Range free localization techniques deploy information related to topology of network as well as connectivity information for calculation location. The approaches used to solve this node localization problem gets changed with the assumptions that they make about their device capabilities and network. Solution to the Range-free localization depends only on the data information of received messages that are being sent from the reference nodes to all other sensor nodes. The protocols discussed include:

- Centroid Localization
- DV-Hop Localization
- APIT Localization

2.6.1 Centroid Localization

Centroid localization [4] is a range-free, proximity-based, coarse-grained localization algorithm, that uses beacon node having location information (X_i, Y_i) to find the node location. After receiving the information from these anchors, a node estimates its position by using the following formula:

$$(X_{est}, Y_{est}) = \left(\frac{X_1 + X_2 + X_3 + \dots + X_N}{N}, \frac{Y_1 + Y_2 + Y_3 + \dots + Y_N}{N} \right) \quad (2.1)$$

The main advantage of this scheme is its simplicity and ease of implementation. However centroid techniques depends on a high density of anchor nodes so that every node can hear several anchors.

2.6.2 DV Hop Localization

Hop counting technique is used to localize the networks where the anchor density is less. Hop-counting techniques [5] broadcast location information throughout the network. DV hop [14] estimates range between nodes using hop count. In the DV-Hop localization [5] uses a mechanism which is similar to classical distance vector routing. In this scheme, one beacon node, which consist of anchor positions with

hop count parameter initialized with one broadcasts a beacon signal throughout the network containing the anchor's location . Each node which receives the information , keeps the minimum value per anchor, and then ignores the other beacons with higher hop count values. In DV hop, atleast three reference nodes broadcast their coordinates information with hop count throughout the network. The information is flooded throughout the network from neighbor to neighbor nodes. When such messages are received by the neighboring node, containing information about the reference nodes and increments the hop count by one . In this way, unknown node can find the number of hops away from anchor node . All anchor nodes and unknown nodes calculates shortest path from each other.

The average single-hop distance is then calculated by anchor i using the following formula:

$$HopSize_i = \frac{\sum \sqrt{(x_i - x_j)^2 + (y_i - y_j)^2}}{\sum h_j} \quad (2.2)$$

In this formula, (X_j, Y_j) is the coordinate of anchor node j and h_j is the distance, in terms of hops, from anchor j to anchor i . Once calculation is done , anchors broadcast the estimated HopSize to all neighboring nodes. Triangulation method is used to calculate location , when a node can determine the estimated distance to more than 3 anchors. Theoretically, if there is some error existing in the distance estimation, location accuracy will be lost and is subjected to error.

2.6.3 APIT Localization

In Approximate Point in Triangulation (APIT) [6] scheme, anchor nodes gets location information from GPS or transmitters. Unknown nodes, whose location is not available, gets their location information from overlapping triangles. In APIT , Unknown nodes maintain a table containing information of anchor nodes , that is , anchor ID, signal strength and location of anchor node , this information is received by the unknown nodes in form of beacons messages from anchor nodes . The area is divided into overlapping circles , After selecting three anchor nodes , the unknown nodes check whether the three anchor nodes are in triangle form. This test is called Point-in-Triangulation(PIT)test. This test is done until the accuracy of unknown node location is finally acheived. In the end , an unknown node is placed at the intersection of all the triangles , that point is calculated to find the estimated position of an unknown node. However they do suffer from same disadvantages like DV-Hop techniques.

2.7 Summary

Computing the node's position or node's co-ordinates in WSN is termed as localization. Different methods are available for localization which has its own advantages and disadvantages. However, selection of the method depends on application context and data that are available while localizing.

Chapter 3

Localization Using Convex Position estimation method

This chapter mainly focuses on the convex position estimation method, whose implementation has been done using a mobile anchor node. The discussion begins with the network model considered for localization, containing unknown nodes and brief note on mobile anchor nodes. Later detail discussion done on how node can be localized using the convex position estimation method and how the impact of the obstacle on wireless sensor network can be reduced.

3.1 Network Model

The network area of 100m*100m is considered where 'N' nodes are deployed randomly and mobile anchor node having the transmission radii of 'r' & 'R' traverse across the network in defined path. The network model is represented in the form of graph, G with N nodes as the vertices, i.e $V(G) = ((x_1, y_1), (x_2, y_2), \dots, (x_n, y_n))$ and bidirectional communication constraints as the edges, $E(G)$. We add the ordered pair $(x, y) \in E(G)$ if $d_{ij} \leq R$, and this holds for all the pair of vertices lying in the vertex set $V(G)$ of G. The edge between anchor node i and node j is weighted by the distance between i and j. Fig 3.1 shows network model scenario

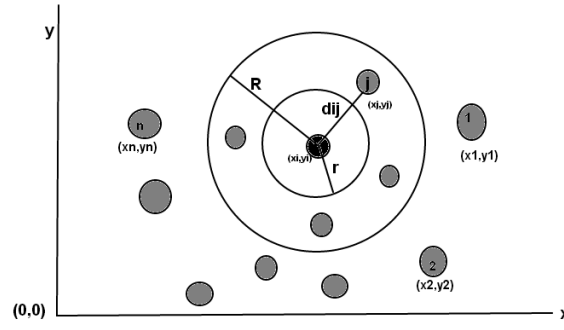


FIGURE 3.1: Example of network model considered for localization.

3.2 Mobile Anchor nodes

A small set of nodes that are mobile and are aware of their own position called mobile anchor nodes. These mobile anchor nodes will distribute their coordinate values to other unknown nodes in the network helping them to discover their coordinates. Mobile anchor with ‘m’ level of transmission power and transmission radii of r & R (lower & upper bound respectively) are considered and they are assumed to have GPS. They are being used in sensor network by other nodes as reference nodes to provide coordinates in the absolute reference system. Thus, at time t , each node inside radio range of a mobile anchor will hear an area declaration from them. In realistic deployment, it is very important to manage network impacts and record for missed messages. Figure 3.2 shows a situation, the location accuracy of sensor nodes is seriously impacted by the route that a mobile anchor traverses. Different movement patterns of the anchor can be straight-line movement pattern [7] and random movement patterns. In the straight-line movement patterns, the entire area has been virtually divided into grids. In the grid (cell), every square has an edge length of r , which is the radio transmission range of the anchor [7]. The anchor travel in pre-defined straight line and turns at right angles.

In the random movement pattern, however, the anchor will randomly change its direction, after a certain distance.

3.3 Empty Feasibility set & Non-empty Feasibility set:

Triangulation is one of the measurement techniques available to compute node location. To apply this method we need to know minimum of 3 anchor node position and distance from unknown sensor node to these 3 anchor nodes. Having

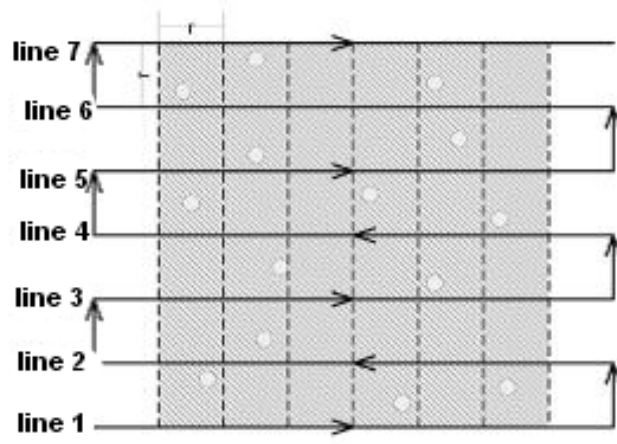


FIGURE 3.2: Traverse route of the anchor in straight-line movement pattern.

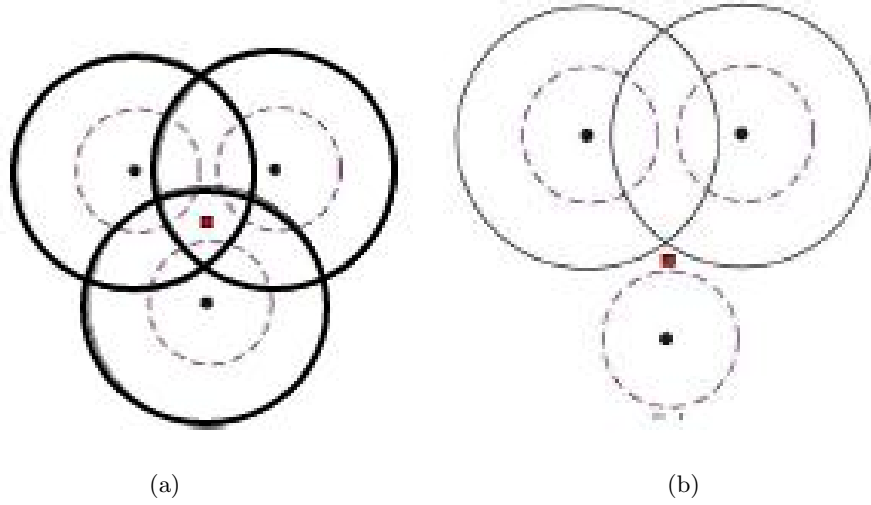


FIGURE 3.3: Two localization scenario (a) when feasibility set is non-empty (b) when feasibility set is empty.

this information in hand, node position can be decided by finding the intersection of the circles centered at the anchor node co-ordinates. In many cases, three circles usually do not intersect and fail to obtain node position. Hence localization problem need to be changed into mathematical problem of solving the set of quadratic equations, where some equation may have solution which is termed as feasibility set is non-empty and some equation may not have solution which is termed feasibility set is empty. Fig3.3 shows these two scenarios.

3.4 Convex Position estimation algorithm

Some location algorithms are based on the solution obtained on solving the set of quadratic equations & assume they must have solution (feasible case), which is sometimes not possible (infeasible case). Hence need for the novel localization algorithm arises that address both the feasible and infeasible cases. A co-operative convex position estimation algorithm[10] can be used that consider the existence of obstacle in mobility assisted WSN. Convex position algorithm [8] [9] belongs to the class of range-free anchor-based localization algorithms. If one node can communicate with another and if a radical constraint exists between them, then it can be represented as linear matrix or in form of vector or set and can be solved using convex position estimation. In this scheme, mobile anchor co-operate with the static sensor nodes that need to be localized. As for the concept of localization in WSN, minimum of 3 static anchor nodes are required. However the same can be achieved using single mobile anchor node[11] and each sensor node will have a set of mobile anchor node positions. During the initial stage of localization, mobile anchor sends the information to all sensor nodes while moving. Where message include mobile anchor node id, its current position, its transmission radius, transmission power. After receiving the signal, sensor nodes determine its position.

As shown in fig 3.4, If unknown-position sensor node is present at some β (indicated by green square), that receive the signal sent by the mobile anchor node whose current position is α (indicated by black dot) & has transmission radii r & R , then can conclude that distance between nodes satisfies the condition .

$$r \leq \| \beta - \alpha \| \leq R \quad (3.1)$$

Otherwise

$$\| \beta - \alpha \| > R \quad (3.2)$$

If the distance falls within the transmission radii and two nodes have connectivity between them, then can say it satisfies the radical constraint because sometimes there might be a situation when two nodes cannot communicate even if the relative distance between them is under ideal transmission radius. In similar manner, the communication between two sensor nodes can take place although their relative

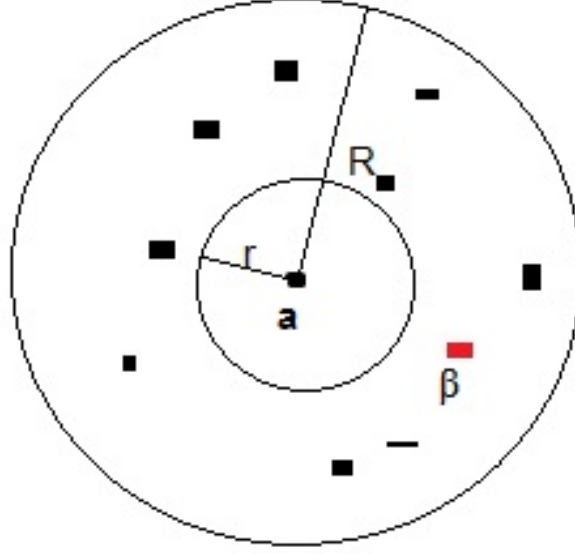


FIGURE 3.4: Radical Constraint case.

distance is larger than their transmission radius due to the effects of obstacles and radio irregularity. Hence once radical constraint is satisfied, unlocalized node position can be calculated by following the steps described in convex position estimation algorithm.

Algorithm: Convex Position Estimation Method

Purpose find sensor nodes location in both feasible and infeasible case. To provide better location accuracy by emphasizing on optimization.

Input: The network with sensor nodes deploy randomly and mobile anchor nodes with defined transmission radii r & R .

Output: Estimated coordinates of the sensor nodes.

step 1: Obtain the anchor node coordinates (x,y) and store in a set.

step 2: Find the distance between the anchor nodes (by considering all the anchor nodes coordinate (x,y) present in the set) by varying the anchor node values in a discrete step size.

step 3: solve the equation and check at which anchor node value along with discrete step size, we get minimum summation.

$$\sum[(|D| - r)^2 + (|D| - R)^2]$$

Finally the value obtained in step 3 is considered as the estimated position of unknown sensor node. Where $|D|$ Euclidean distance between the anchor node co-ordinates. Hence when the convex position estimation method is used to find nodes location it results in providing better accuracy as the method emphasis on optimization and it finds the nodes location in both feasible and infeasible case. This method takes the advantages of range-free and the mobility of the anchor node.

This section describes the convex based position estimation algorithm, which belongs to the class of range-free anchor-based localization algorithms. In this scheme, mobile anchor co-operate with the static sensor nodes that need to be localized.

3.5 Algorithm to decrease the impact of the obstacles

A position estimation algorithm requires a enough number of pair wise node range to be able to determine position of node locations correctly. However, due to several reasons like presence of obstacle, sparse node deployment; it is difficult to meet the above requirement in practice. The lack of connectivity between the sensor nodes may prevent the nodes from getting direct node-to-node distances. When obstacle is introduced within the network, location error will be high for the nodes that are near the obstacle. So there is need to reduce the impact of obstacle during localization in WSN. This can be done by considering single mobile anchor that moves across the network with obstacle. Sometimes, sensor node many have their mobile anchor node set values to be less than 3, in which case if we try to localize the network, these nodes will have high location error. It is these special nodes referred as boundary nodes [12] that are near or within the obstacle needs to be localized by reducing the impact of obstacle on them which shown in fig 3.6.

However finding the presence of obstacle play a vital role, this can be detected by checking the connectivity between the boundary nodes and the neighbor nodes. Neighbor nodes are one that falls within the transmission radius of boundary nodes. If checking for the connectivity results in intersection then obstacle exists in the network. Localizing the boundary nodes that fall near or within the obstacle can be done by considering the mobile anchor node co-ordinate set values of the neighboring nodes, where neighboring nodes relay their mobile anchor node co-ordinate set values to these boundary nodes, that can used as an input to the convex position estimation method in order to find the location of these boundary

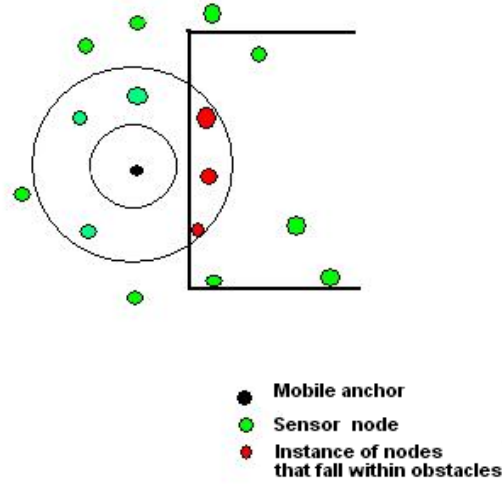


FIGURE 3.5: A sensor network with an obstacle.

nodes and can obtain better position accuracy by decreasing the impact of the obstacle.

Algorithm: *method to decrease the impact of obstacle*

Purpose *To decrease the impact of the obstacle on the node's location and localize the nodes which has less than 3 anchor values.*

Input: *The network with obstacle where sensor nodes deploy randomly and mobile anchor nodes defined transmission radii r & R is considered.*

Output: *Estimated coordinates of the sensor nodes.*

step 1: *find the presence of obstacle by checking the connectivity between the nodes near obstacle and the neighboring nodes.*

step 2: *If connection result in intersection ,obstacle exist for each node near the obstacle.*
 1. *Obtain the anchor node values from the neighbor nodes.*
 2. *Apply the convex position estimation method.*

This section describes the algorithm used for decreasing the impact of obstacle in wireless sensor network. When an obstacle is introduced within the network, location error will be high for the nodes that are near the obstacle. So there is need to reduce the impact of obstacle during localization in WSN.

3.6 Summary

Convex position estimation method belongs to range-free anchor-based localization algorithms. This method uses radical constraint, finds the nodes position and results in obtaining better location accuracy as method emphasis on optimization. Presence of obstacle in network results in some nodes with high location error and some nodes failing to get localized. Method to decrease the impact of obstacle addresses this issue by considering the neighbor nodes into consideration and solves the location problem using convex position estimation method their by reducing the impact of the obstacle and resulting in better location accuracy.

Chapter 4

Simulation Results

4.1 Performance Evaluation

It is often the case that a number of solutions exist for solving the same localization problem. Evaluating the performance of localization algorithms is important for both researchers and practitioners, either when validating a new algorithm against the previous state of the art, or when choosing existing algorithms which best fit the requirements of a given WSN application. However, there is currently no agreement in the research and engineering community on the criteria and performance metrics that should be used for the evaluation and comparison of localization algorithms. Neither there exist a standard methodology which takes an algorithm through modeling, simulation and emulation stages, and into real deployment. Part of the problem lies in the large number of factors that may cause some affect to the performance of a localization algorithm, including but not limited to: the type of measurements being used and measurement errors, the distributions of anchor and non-anchor nodes, the density of network nodes which is usually measured by the average node degree, the geometric shape of the network area, whether or not there is any prior knowledge of the network, the wireless environment in which the localization technique is being deployed. Quite often a localization algorithm performing well in one scenario, e.g., in regular networks, does not deliver a good performance in another scenario, e.g., in irregular networks. A localization algorithm delivering an excellent performance in simulation environment may also not perform satisfactorily in real deployment. All these phenomena highlight the importance of building a scientific methodology for the evaluation of localization algorithms.

The performance evaluation for convex estimation method focuses on the accuracy of location estimation. We are considering a 2-dimensional region with a 100 m x 100 m size. We assume the mobile anchor node has two level transmission power with the transmission radii r and $R = 2r$, respectively [10]. The average localization error is used to determine the performance of localization algorithm. Localization error can be defined as

$$error = \frac{1}{N} \sum_{i=1}^N \|x_i - \hat{x}_i\| \times \frac{1}{r} \quad (4.1)$$

Where x_i is actual position for node i and \hat{x}_i is estimated position for node i .

4.1.1 Performance in the Ideal Environment

This section discusses the results of the implemented algorithm in the ideal situation, when the sensing area has no obstacles .Fig.4.2 showing results in the ideal situation, in which the unlocalized nodes are shown by circles, their estimated positions are shown by asterisks and the edges that link the unlocalized nodes and the estimates represent the error in estimation.

4.1.2 Performance in the Non-ideal Environment

Here, the simulation results of the implemented algorithm in the non-ideal situation, the sensing area containing obstacles, is discussed. Fig.4.5 shows the results implemented in non-ideal situation, where the nodes that are within the obstacle are denoted by rectangle, red rectangle are nodes that fail to get localized when the algorithm is executed. The location estimation of the nodes after reducing the impact of the obstacle that are shown by the circle and the edges that link the unlocalized nodes and the estimates nodes represent the errors in estimation. Fig 4.6 & Fig 4.7 shows the percentage of error when network parameters like the number of sensor nodes & transmission radius of anchor nodes are varied.

4.2 An example demonstrating the algorithm

For demonstrating how node location is calculated we can consider the instance of the scenario where node has the anchor node coordinates set values as $(60,0), (75,0), (90,0)$.

A set may have more than 3 anchor node co-ordinates, for simplification purpose we consider a set with minimum of 3 anchor node coordinates.

Anchor node transmission radii r & R is set to 15 and 30 respectively. Later following the steps described in the algorithm estimated position of the node will be at (80,20) which is plotted in graph shown in Fig.4.1.

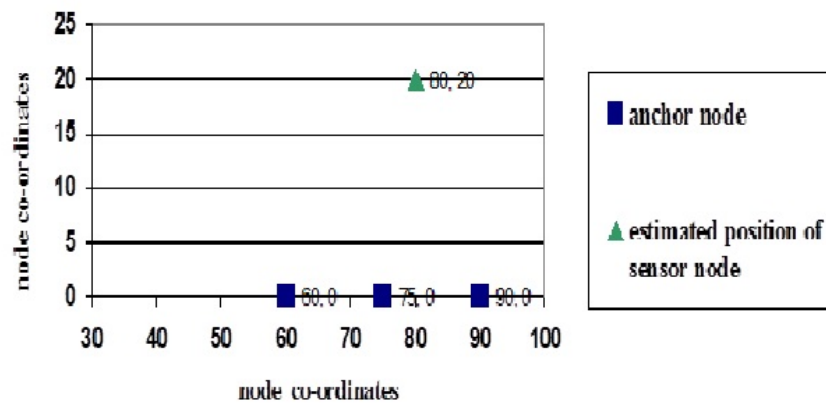


FIGURE 4.1: Location estimation scenario

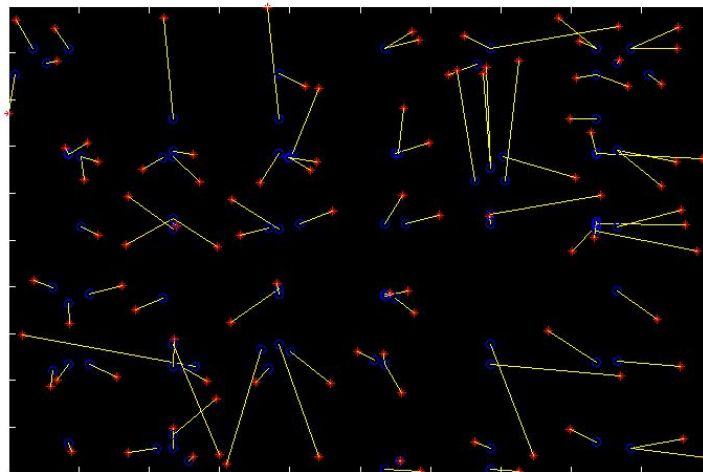


FIGURE 4.2: Localizing the network without obstacle

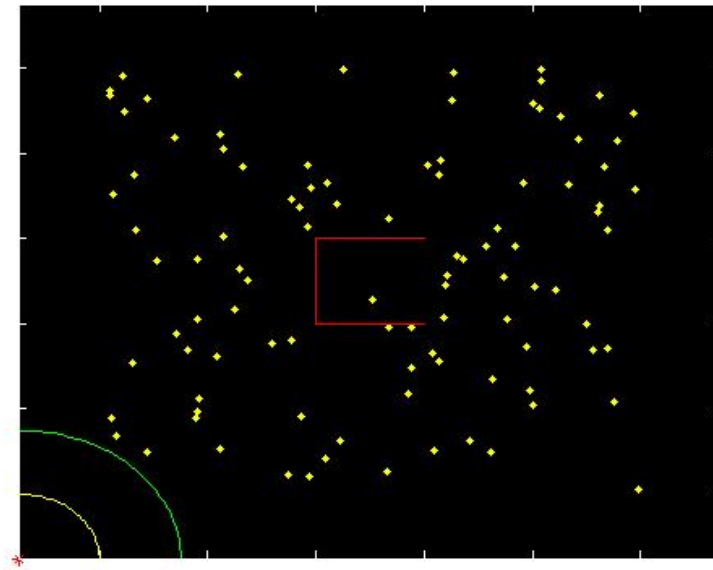


FIGURE 4.3: Wireless sensor network with obstacle.

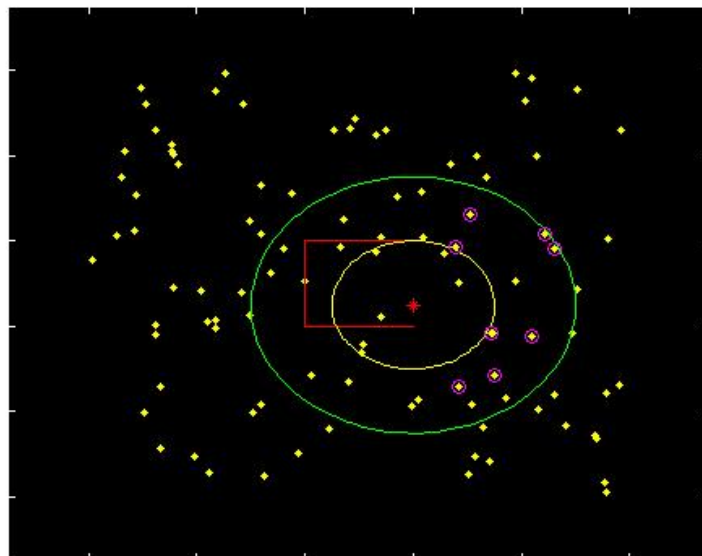


FIGURE 4.4: Mobile anchor node movement in wireless sensor network with obstacle.

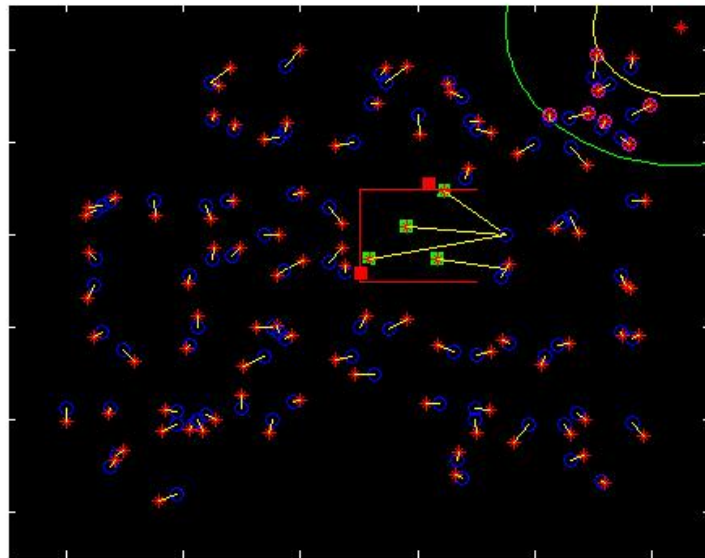


FIGURE 4.5: Localizing the network with obstacle by not considering the impact of the obstacle.

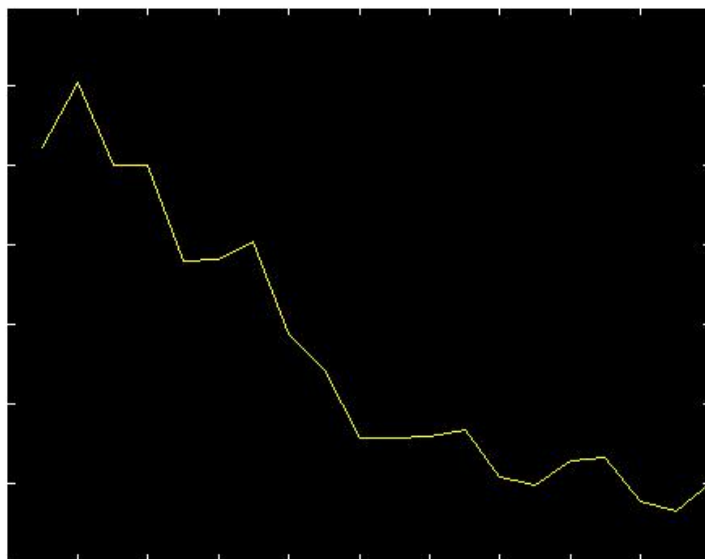


FIGURE 4.6: Graph obtained on changing the number of nodes in WSN. It shows location error is high for sparsely deployed nodes. Graph decreases as the nodes are increased.

Location error is less if a transmission radius of the anchor node is low because sensor node will get more anchor node co-ordinate values which can be effectively minimized for optimization. However, larger radius will generate the less number of anchor node value set which will impact the location accuracy.

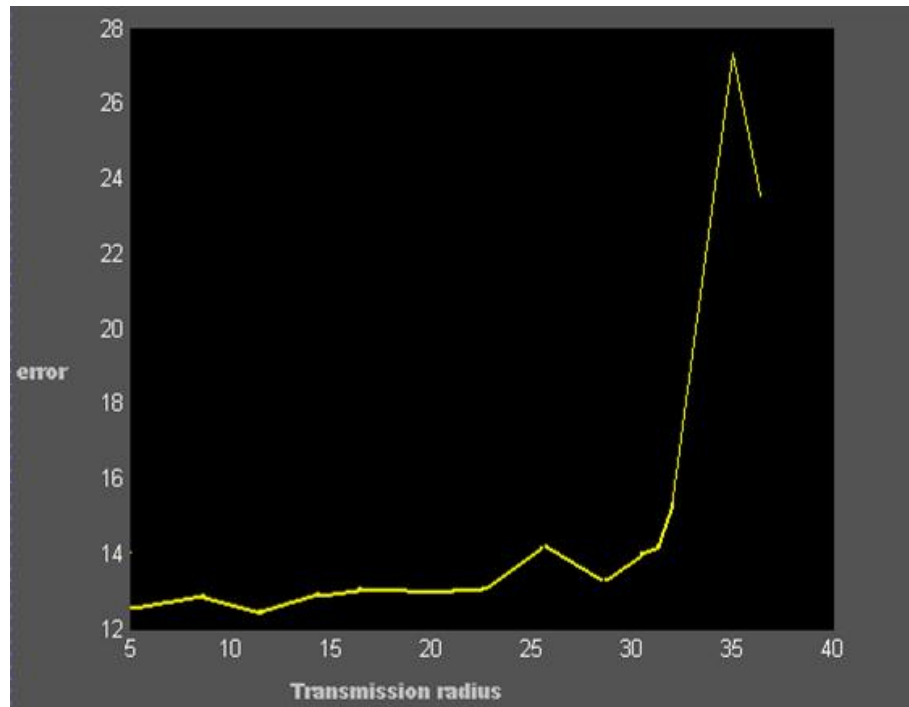


FIGURE 4.7: Graph obtained on changing the transmission radius of anchor nodes

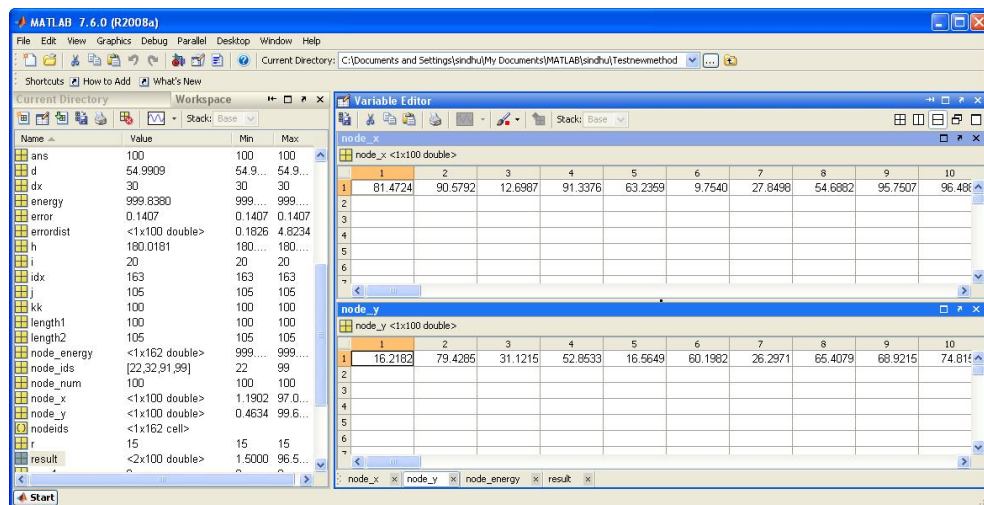


FIGURE 4.8: Actual co-ordinates(x,y) of the sensor nodes

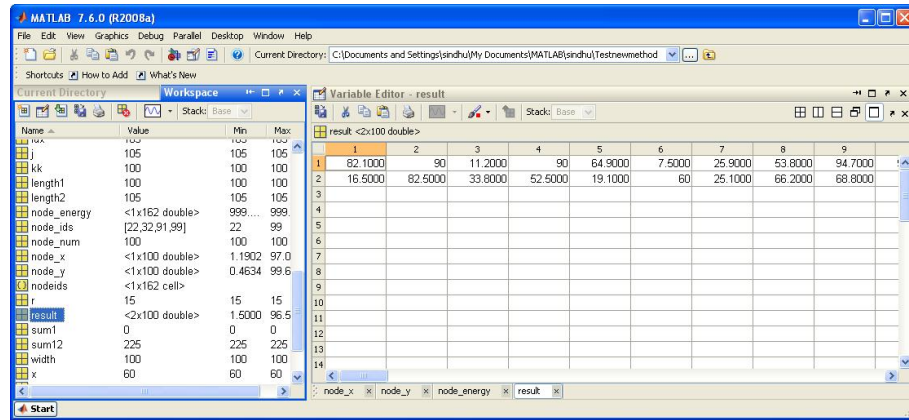


FIGURE 4.9: Estimated co-ordinates(x,y) of sensor nodes obtained on running the convex position estimation method.

4.3 Summary

Any algorithm developed has to be evaluated for the performance metrics. The convex position estimation method has been evaluated considering location error as a performance metric. The performance has been studied under ideal and non-ideal(presence of obstacle) situation and how location error can be reduced in non-ideal situation using the method to decrease the impact of the obstacle. Snapshots of the simulation results help in obtaining the overall view of steps involved in the project.

Chapter 5

Conclusion and Future Enhancement

Localization in sensor networks have become an active research area for the past few years. Knowledge of sensor node's position is an essential requirement for many applications, ranging from military to mobile. In this project, convex position estimation method has been implemented using the tool MATLAB. The simulation results shows that implemented method can efficiently localize the nodes during complex localization scenario namely, to find node's position when feasibility set is empty. The results also demonstrate that energy is utilized efficiently as their no message flooding in the network or requiring large table to store the data. It also depicts that even the impact of the obstacle can be reduced effectively & all the nodes get localized, which fail if we consider triangulation, multilateration. In future work, the implemented method can be verified using real sensors in mobility assisted wireless sensor networks and the security issue can be addressed by trying to prevent worm-hole attack. Performance comparison of the convex position estimation method with other localization methods can be done. With the help of this technique, how on demand relative localization could be achieved for newly deployed nodes without waiting for the mobile anchor node to traverse across the area.

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