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MOBILE AIDED IMPROVED TRILATERAL LOCALIZATION BY ADOPTING RANDOM WAY POINT PATTERN

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ABSTRACT

Localization plays a prominent in WSNs. It is essential because if one node contains information collected from physical entity to transfer and the location of other node which is meant to receive is not known then the information gathered becomes useless. The basic idea in localization involves placing GPS in each and every node in the network to know its location. It results in increase of cost. Moreover the efficiency of GPS is not Satisfactory in monitoring indoor applications. In localization, the distance between nodes is essential which will be calculated by using RSSI method. RSSI is adopted in many of the localization algorithms because of its low cost and simplicity. In ranging, Classical Trilateral algorithm is considered but it results distance errors due to instability in equations.The proposed mobile aided Trilateral method results in increasing the network lifetime, reducing the time of estimation, improving the signal strength besides minimizing the energy consumption of nodes. In this method the mobile node moving in random manner gathers the information of neighbouring nodes which will be further useful in Trilateral minimum condition method to localize the unknown nodes position.In this method the distance calculations are performed by mobile node resulting in the minimization of energy usage and distance error associated with neighbouring nodes. As a result the proposed mobile aided method produces the best results in case of signal strength and life time of network when compared to previous Classical Trilateral methods.

Keywords: anchor nodes, localization, mobile node, WSNs.

INTRODUCTION

Wireless sensor network (WSN) has achieved a lot of attention in various areas. It comprises of several modules which are efficient to measure parameters like temperature, humidity etc. It gained importance because of its low cost and scalable nature. WSN has led to the development of various advanced applications like Traffic controlling, Target tracking. It is made possible due to utilization of static and mobile nodes. Use of mobile nodes reduces the iterations the number of nodes required to compute position and cost. Localization is essential concept in WSNs.Limitations like Accuracy, power consumption; cost must be taken into account in WSN Localization

Localization is the prior concept involved in Location Based services. Because the position of device or element must be essential in the LBS systems .Localization has increased its scope in different fields like Traffic controlling, Defence, Emergency services, Indoor positioning etc. Node Localization is very essential. Consider if a node gathered information from environment and the location of target node is not known then the information collected becomes inept. If a building caught fire and the people cannot know the way out, then it leads to a major damage. If they are able to track the position of themselves in 3d then they can be saved.

Several techniques were involved in Localization. One of the simple techniques is to equip sensor node with GPS. It is suitable for outdoor localization but imports poor performance for indoor positioning .Further reckon up of

GPS increases cost which is not an appreciative factor [1]. Anchor nodes also said to be beacon nodes which know the position of themselves. Unknown nodes are the nodes those are to be localized by using various algorithms. These unknown depend on anchor nodes for localization. Some anchor nodes are GPS based and some are manually aware of their position. Some anchor nodes are static and some are dynamic in nature. Mobile nodes are nodes which can move throughout the entire location to transfer information to unknown nodes. Mobile nodes are the nodes which are capable of moving in the entire network and avail the distance information. It is effectively utilized in the real time environment where mobility plays a vital role rather than static parameter. It is a prominent approach where limited mobile anchor nodes are employed instead of several static beacon nodes. Thus the use of mobile nodes in the network plays a major role in enhancing its importance in various applications.One of the Mobility availed techniques is Random Way point mechanism. It is a technique incorporated in Mobile Adhoc networks. In this, the mobile node moves throughout the region and becomes responsible for localization of unknown nodes. It also utilizes the reference anchor nodes if needed. It states at the initial location and choses random destination at certain speed and it pause for fraction of interval and again choses the target location and performs the same process. Thus the unknown nodes are aware of their positions. The path selected by mobile node may mostly comprise of Zigzag, Circle, and Hyperbola etc. But to invade efficient effectiveness path planning is also essential.

Basically Localization is classified in to two sections namely Range based and Range free. Range free technique is simple as it does not require any hardware. It assume the network to be isotropic and consider the hop

count between the nodes to determine distance values .But the accuracy is not high when compared to range based method. It does not require any distance or angle measurements. CPE (convex positioning Estimation), DV Hop (distance vector hoping, centroid algorithm falls under this category. Range based Technique considers the inter node distance measured by special ranging hardware parameter. It contributes high accuracy when compared to range free technique. In order to localize unknown nodes using Range based technique. It involves mainly two sections

a) Distance /Angle calculation

b) Position estimation

A. Angle/distance calculation: It includes TOA (Time of Arrival), TDOA (Time Difference of Arrival), RSSI (Received Signal Strength Indication), AOA (Angle of Arrival).Among them some are more efficient but inordinate. But RSSI (Received Signal Strength Indication) is more prevalent because it is simple and economical to calculate the distance between the nodes. Further that distance information is considered for position determination. But RSSI is sensitive to abnormal conditions and involves gross errors which are to be further eliminated by various approaches.

B. Position estimation: The Trilateral algorithm is a ranging algorithm utilized to obtain the position of unknown node using three anchor nodes. It is based on distance values derived from the RSSI mechanism. The distance between the three anchor nodes and unknown node are determined from RSSI. Finally the cross way of three circles generates the unknown node position information. But it follows the distance values from RSSI mechanism which involves errors due to fading effects. It is sensitive to adverse environmental conditions.Maximum Likelihood Estimation is the further extension of the trilateral algorithm because when more than three anchor nodes are available, then it determines the target (Unknown) node position. Expanding of anchor nodes enhances exactness however builds cost.

RELATED WORK

Localization is gaining much attention these days. Its usage is seen in Monitoring and Tracking applications. Localization is simply termed as identifying target or unknown node for performing communication. The simplest way to achieve localization is usage of GPS in sensor node. It results high accuracy for indoor applications and cannot be appreciated for indoor positioning due to poor impact of GPS in the area of indoor systems. Further adding GPS to all nodes increases the cost of entire network which is not desirable. Ultra wide Band technologies are effectively used in indoor positioning applications. One of the techniques involves UWB coding said to be U-BOTH especially useful in coalmines. It is like an ALOHA based access to obtain location information by exchanging protocols and utilizing MLE(Maximum Likelihood Estimation) method to reduce bit error rate and estimate the moving objects in coal mines. But they are not economical and involve large set up which is not a desired factor [2].

Later several localization algorithms came in to picture to derive the position information. Among them Range free and Range based algorithms are more prevalent. Range Based algorithms depend on distance/angle calculations. Those algorithms have high accuracy and require little hardware setup. Different technologies are involved in measuring distances between the nodes. Synchronization of time is essential factor in many of WSNs which involve periodic sampling to measure a parameter. Ultrasonic TOF is used to derive the position estimation. But it makes the node to be active all the time which results in increase of power consumption and high network traffic conditions [3].

Straight forward method: In this method the time difference between transmitted signal from source and received by the target provides the distance estimation. Time of Arrival method is the simplest method where the time taken by signal to travel from one to another gives the distance value. But it requires precise synchronization which is not possible all times. In TDOA two signals are evolved from single node and are received by the target (unknown node). The time difference between these two signals contributes the distance value. It offers high accuracy but requires additional hardware which results in cost and complexity. Round trip method explains the time taken by signal to move from source to unknown node and return to its initial position considered to determine the required value. If synchronization is varied between two nodes then error occurs which is not an acceptable feature. Moreover the internal delay also restricts its usage in position estimation [4].

The RSSI (Received Signal Strength Indication) mechanism is considered to calculate between the nodes based on signal strength received by other node .distance values. It is simple and economical. RSSI measures the signal strength received by the target node from the transmitted anchor node. It converts the signal strength in to distance which is further used for position estimation. If the distance increases then the signal strength decreases resulting distance inversely proportional to signal strength [5]. But it involves distance errors error as RSSI suffers shadowing and other adverse conditions. If this distance values are used for position estimation then error also propagates throughout the process resulting error in position.so the distance error must be eliminated before it is made available for further processing. Distance error is further prorated as gross, systematic and random errors. Systematic error is said to be exist when a process does not change at certain condition and repeats continuously. It occurs due to aging of device and environmental changes. Random errors are the errors which do not follow any pattern. They occur randomly due to changes in surroundings. Outlier is an abnormality situation which varies from desired value which is not acceptable to acquire. In case of error analysis outlier is measurement value of gross error. It is said to be occur if it experience a lot of inaccuracies. Thus gross error must be eliminated to acquire efficient localization. Dixton proposed a

mechanism to remove gross error before using distance value for position estimation at the data processing stage itself [6]. The Hampel Filter (HF) and Kernel Density Estimator (KDE) are utilized to detect gross errors at the pre-processing stage. It is because gross error is nothing but an outlier which must be removed to improve localization. So Hampel filter also known as Hampel identifier is considered to replace the old mean and standard deviation methods with median technique .but it also processes some drawbacks which were later corrected by Kernel Density Identifier [7]. Thus the distance values derived from RSSI mechanism will be further utilized by various positioning techniques to achieve the information of target location.

Environmental Adaptive RSSI Based Indoor Localization is used for positioning indoor applications. It involves stationary and slowly moving objects. It is based on Received signal strength rather than TOA. It is simple and economical. It has ability to adopt changes in environment thus it is named as Environmental adaptive RSSI based indoor localization. It updates the changes to opt the real time positioning. It utilizes stationary anchor nodes for positioning. For tracking slow moving objects mobile anchor node is considered which is used to track the target. The presence of mobile node besides reference nodes improves accuracy. The presence of RF signals between reference nodes and mobile nodes disturbed by surroundings especially metallic devices. RSSI is susceptible to environmental changes which lead to errors during tracking [8]. Or estimating position techniques like Triangulation, Trilateration, and Bounding Box. Triangulation. Trangulation are considered. In Triangulation method the unknown node estimates its angles by its reference nodes and by the angle information estimates its own position. It considers AOA values for obtaining angle measurements. The trilateral algorithm is taken to localize the unknown node utilizing three anchor nodes. The anchor nodes are aware of their position. The intersection of three circles is useful in determining the unknown location. The distance values are derived from RSSI mechanism. Bounding Box method is similar to the trilateral method. It uses boxes instead of circles to localize the unknown node. Its error rate is high when compared to trilateral method. Among all the stated methods Trilateral Algorithm method is more prevalent when compared to remaining methods because of its simplicity. But it also suffers from wide error where environment, temperature, electro magnetism are considered to be interference factors. The trilateral algorithm also suffers from instability in equations involved in algorithm itself. Though the distance error is neglected the localization error must be taken into consideration to achieve accurate position of unknown node [9].

SOFTWARE PLATFORM

In this paper MATLAB is elected as the software platform. It is widely utilized in various fields like Educational Institutions, Offices etc. MATLAB stands for Matrix Laboratory. It has powerful graphical tools which deliver perfect images in 2D and 3D. MATLAB is the easiest programming language for writing programs related to Mathematics. It is case sensitive in nature which indicates it has knowledge about lower case and upper case letters. It also has special tool boxes which made its implementation in areas like Image Processing, Signal Processing etc. Localization is utilized to know the position of unknown node. MATLAB plays a prominent role in Localization [10] as the visualization effect of MATLAB is very effective. The distance values are calculated from RSSI method used in Trilateral Algorithm to localize an unknown node. Interpolation is a MATLAB function meant to obtain position information continuously

METHODOLOGY

In this section we propose an effective method which curtails the localization error and upgrades the network lifetime. Anchor nodes are the nodes which are aware of their position, neighbouring nodes are nearby nodes, unknown nodes are the nodes which are unaware of their position and are to be localized. Localization mainly involves two sections. First includes calculating the distance between the nodes. The distance between the nodes will be obtained by RSSI method .It is simple and economical method when compared to TOA, TDOA [11]. The distance will be determined by the following formula

$$RSSI=10n \log10d +A \quad (1)$$

Where,

RSSI - Received Signal Strength Indicator
n - Path loss exponent
d - Distance from transmitter
A - Reference value RSSI at 1m away

The RSSI values are taken by simple localization algorithm namely trilateral algorithm. The trilateral algorithm uses the MLE (Maximum Likelihood Estimation) to localize the unknown node. Minimum condition number procedure utilizes four anchor nodes. Among them three with minimum distance are utilized to localize an unknown node. Let us consider three anchor nodes and Unknown node. The distance between unknown node and the anchor nodes are given as

$$\begin{aligned}(x-x_1)^2+(y-y_1)^2&=d_1^2\\(x-x_2)^2+(y-y_2)^2&=d_2^2\\(x-x_3)^2+(y-y_3)^2&=d_3^2\end{aligned} \quad (2)$$

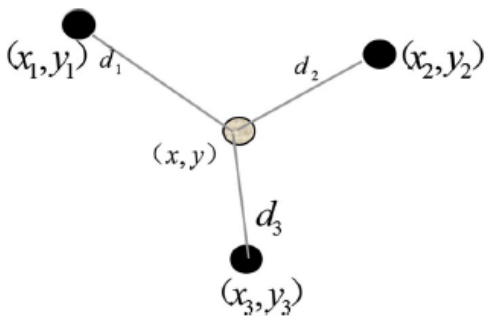

Figure-1. Example of trilateral algorithm.

The linear equations will be simplified as shown as below

$$A = \begin{bmatrix} 2(x_1 - x_3) & 2(y_1 - y_3) \\ 2(x_2 - x_3) & 2(y_2 - y_3) \end{bmatrix} \quad (3)$$

$$B = \begin{bmatrix} x_1^2 - x_3^2 + y_1^2 - y_3^2 + d_3^2 - d_1^2 \\ x_2^2 - x_3^2 + y_2^2 - y_3^2 + d_3^2 - d_2^2 \end{bmatrix} \quad (4)$$

$$X = \begin{bmatrix} x \\ y \end{bmatrix} \quad (5)$$

The unknown node will be determined as

$$\hat{X} = (A^T A)^{-1} A^T B \quad (6)$$

But the classical trilateral contains distance errors and instability of equations. For this purpose minimum condition number is considered.In this method four anchor nodes are taken. Among them three are selected based on minimum condition number [12].

The Trilateral Mincd method Condition of matrix A is given below:

$$\|A\| \|A^{-1}\| = cond(A) \quad (7)$$

But the error rate is still present. It will be further reduced and the signal strength will be improved with the addition of Mobile Anchor node. The mobile anchor node moves throughout the network area. It moves in Random manner in the area acquiring Random Way Point Mobility method.

Mobile aided trilateral method

In this method, the mobile node moves randomly by collecting the information of all neighbouring nodes present in the network. The information includes distance between mobile node and corresponding unknown nodes. Then distance information is further processed by Trilateral Algorithm with Minimum condition number (Mincd) to localize the unknown nodes. The importance of adopting mobile node in the proposed system is that the neighbouring anchor nodes are not involved in the calculation unlike classical trilateral algorithm. The energy of neighbouring nodes will be saved. In general the random manner is selected because the mobile node moves randomly selecting the target suddenly. After reaching the target it pause for some time and selects another destination abruptly. The time of estimation will be reduced. The distance error associated with anchor nodes will also be reduced as the neighbouring anchor nodes are not involved in estimation. The signal strength will also be improved because adopting of mobile node provides the information of neighbouring nodes with minimum condition number and minimum distance for position estimation using trilateral algorithm. If the distance is low then error rate will be low. The signal strength will be high when distance will be low. The Random Way point Considers the pause time between the changes in direction and speed. It mainly follow the below steps

a) Select a random target

b) To move within the defined range [Vmin, Vmax] where Vmin and Vmax minimum and maximum speeds

c) Reach the Target

d) Pause for some time at the Target

e) Select new Target and repeat the process

Maximum speed and Pause time are key prameters involved.

Let us consider node randomly selects speed Vi for movemdent from Pi-1 to pi with pause time Tpi at waypoint Pi. The complete movement of mobile node in Random path is given by

(Pi,Vi,Tp,i)}i
∑N=(P1,V1,Tp,1),(P2,V2,Tp,2),(P3,V3,Tp,3)., (8)

First the mobile node moves throughout the region by collecting information of neighbouring nodes. The information contains distance values using RSSI mechanism between mobile node and corresponding neighbouring nodes using

Distance MN(i,j) = sqrt((MN1x - netXloc(j))^2 + (MN1y - netYloc(j))^2) (9)

in the MATLAB simulator
Where MN indicates Mobile Node

Then distance values are taken for Minimum condition trilateral Algorithm to localize the unknown nodes using Minimum condition formula given above equation (7). Thus the unknown nodes are localized. The proposed mobile aided Improved Trilateral localization by

adopting random way point provides best results in case of error rate and signal strength when compared to the trilateral algorithm based on NT (nearest three anchor nodes) method and Minimum condition number.
The location error formula is shown below:

$$\phi = \frac{1}{NR}\sum_{i}^{N}\Delta d_i \times 100\% = \frac{1}{NR}\sum_{i}^{N}\sqrt{(X_i - x_i)^2 + (Y_i - y_i)^2} \quad (10)$$

RESULTS

In this paper, The Matlab is endorsed as the simulation platform because of its simplicity in computing and visualization. The total devices are taken as 31 where 5 are treated as anchor nodes available in simulation area in along with 10 reference nodes which are hidden , one Mobile Anchor node and 21 unknown nodes. These nodes are distributed randomly over 100m x 100m square area in the simulation platform. The simulation results mainly compare two methods namely trilateral method and Proposed Mobile aided method.

Firstly the blind nodes are randomly generated over the simulation area along with the anchor nodes, mobile node in Figure-2 representing network positioning. The room size is considered to be 100m x 100m.

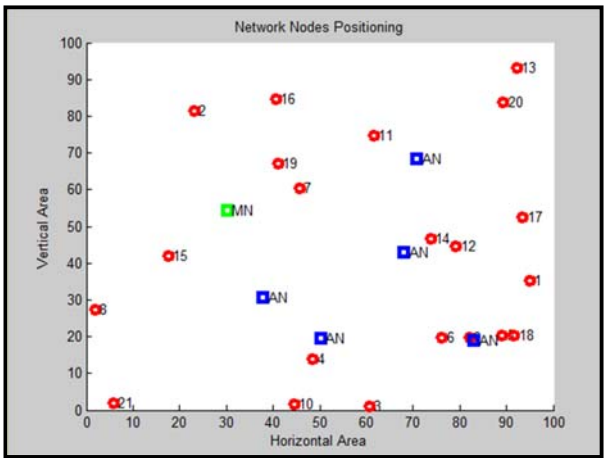

Figure-2. Network positioning of nodes.

The nodes are distributed randomly over the simulation area. The nodes of one network may communicate with nodes of another network by setting up a link. The link between different nodes of different networks is shown in Figure-3.

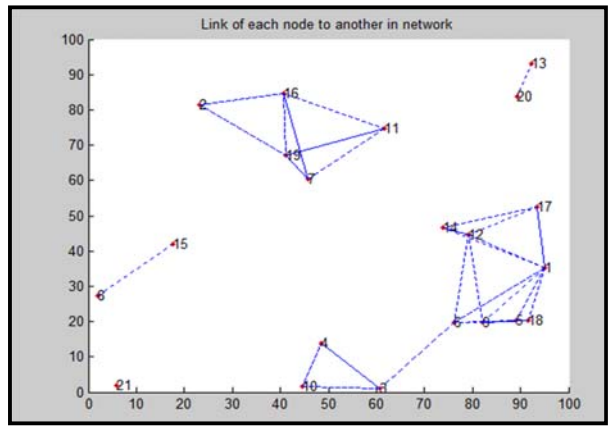

Figure-3. Linking of node of one network to another network node.

The mobile node moves in random way point pattern over the entire filed collecting the information of neighbouring nodes. The mobility of node depends on time and speed. In the simulation the time assigned to mobile node is considered to be 100sec. It is viewed in Figure-4.

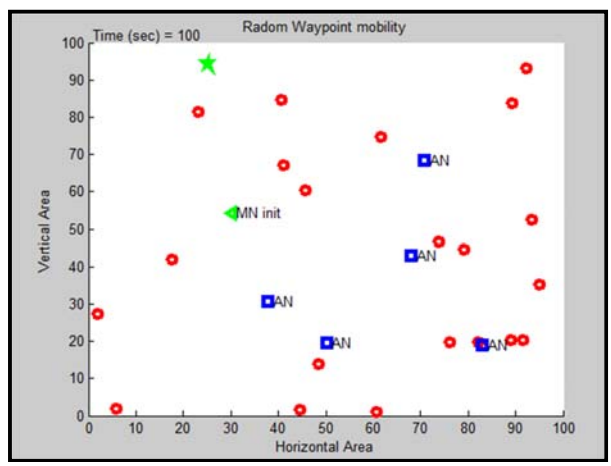

Figure-4. Mobile node moving in random manner throughout the simulation area.

After collecting the information which includes distance values will be send to further calculations. The calculations include trilateral minimum condition method resulting the localization of unknown nodes. The mobile node involves 20 trials to localize unknown nodes. The Figure-5 displays the blind nodes which were localized by proposed mobile aided improved trilateral localization method.

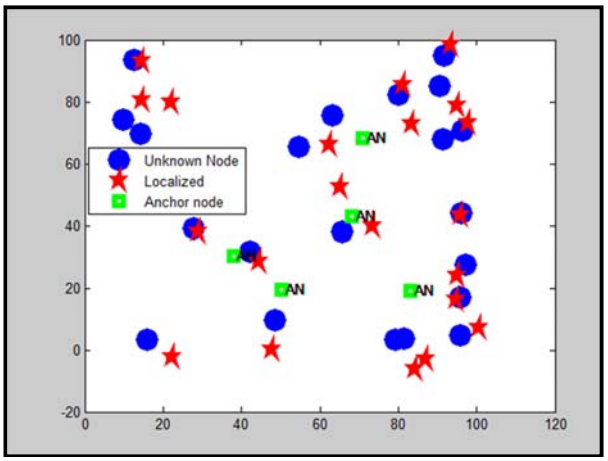

Figure-5. Localization of unknown nodes.

The final position of blind nodes which were localized by the proposed mobile aided improved trilateral localization using Random way point mobility is given below Figure-6.

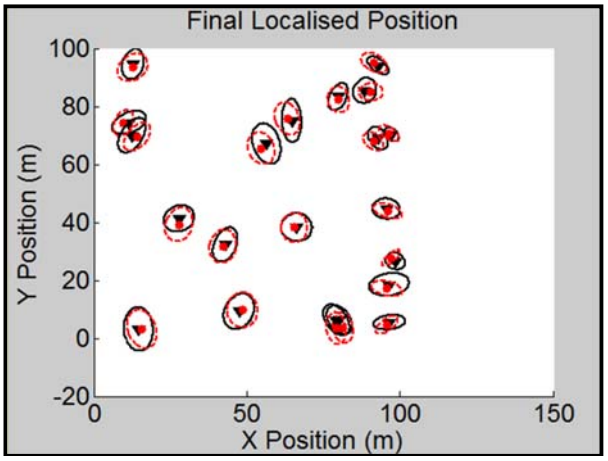

Figure-6. Final localized position of unknown nodes.

The error rates of five methods are taken in to account, where proposed mobile aided method obtains low error rate when compared to remaining methods which is shown in Figure-7.

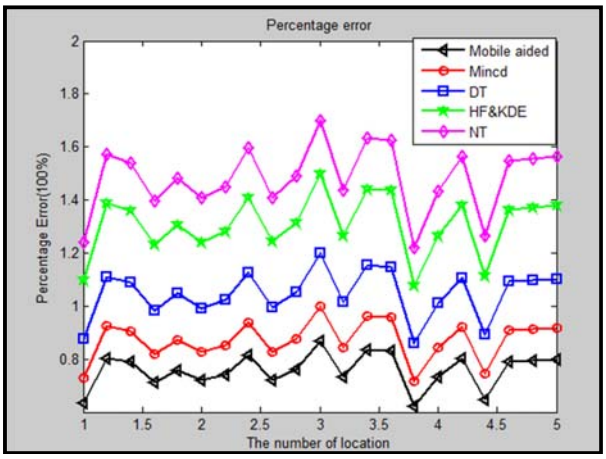

Figure-7. Comparison of percentage errors of five aspects.

NT- Nearest Three Anchor Node Method
HF & KDE-Hampel Filter and Kernel Density Estimator
DT-Dixton Test
Mincd-Minimum condition number method
Mobile Aided -Proposed Method

The Proposed Mobile Aided method improved trilateral method improves Received Signal Strength When compared to previous Minimum Condition Number (Mincd Method) as shown in Figure-8.

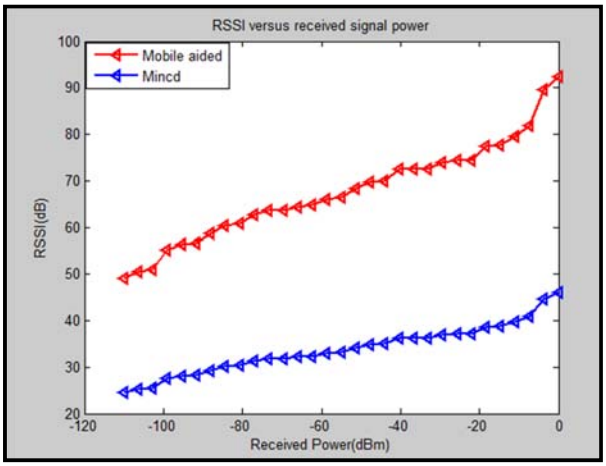

Figure-8. RSSI values of mobile aided and mincd methods.

CONCLUSIONS

In this paper adopting of one mobile anchor node moving in Random manner acquiring the information of neighboring anchor nodes provides best performance over classical Trilateral method. This provides best results because the neighbouring nodes are not involved in the trilateral process as the mobile node gathers information is gathered by mobile anchor node only which results saving the energy of neighbouring considering few anchor nodes for Localization. The distance error rate also reduced because the neighbouring anchor nodes are not involved as

a result the error associated with them also eliminated. The signal strength also improved when compared to Classical Trilateral Algorithm .Thus the proposed Mobile Aided method improves the Time of estimation, Network Life time, reduces the energy consumption and minimizes the error rate when compared to classical Trilateral MinCd Method.

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