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Performance Analysis of Different Localization Schemes in Wireless Sensor Networks

Sanju Choudhary[1], Deepak Sethi[2] and P. P. Bhattacharya[3]

[1]Department of ECE, College of Engineering and Technology
Mody University, Lakshmangarh, India
choudhary.sanju12@gmail.com
[2]Department of CSE, College of Engineering and Technology
Mody University, Lakshmangarh, India
deepaksethi@live.in
[3]Department of ECE, College of Engineering and Technology
Mody University, Lakshmangarh, India
hereispartha@gmail.com

Abstract: *Wireless Sensor Networks have attracted worldwide researchers because of their applications such as hospital surveillance, smart home, environmental monitoring etc. For such applications awareness of location is a very critical issue which deals with estimating the location of each and every node in a sensor network. It is highly desirable to design scalable, low-cost and efficient localization mechanisms for WSNs. In this paper, various range based and range free localization algorithms have been studied. Performance evaluation on the basis of error estimation is done for both range based and range free algorithms.*
Keywords: *Anchor Nodes, Base Station, Global Positioning System, Range based techniques, Range free techniques, Sensor.*

1. INTRODUCTION

A wireless sensor network (WSN) comprises of hundreds or thousands of nodes. The nodes can sense the environment, perform computation and can communicate with other nodes in the same environment. Nodes are deployed by scattering them into some area of interest and are capable of communicating wirelessly [1]. These networks are implemented for performing a number of applications such as environmental monitoring, forest monitoring, industrial monitoring, agriculture monitoring, disaster prevention etc [2]. The network has source node to transmit their data to the destination node through intermediate or relay nodes. The destination node is connected to a central sink, also known as the Base Station (BS), which provides connection to the wired world [3].

The collected data becomes valueless until we don't know the position of the sensor node. Therefore, it becomes necessary to know the exact position of the nodes. Localization is the method to identify location or position of sensor nodes in the particular geographical area. Localization can be used to identify the location of the node from where information or sensor readings originate and for communication with other sensor nodes to route data. One of the easy ways to identify the location is the manual configuration but this is not practically possible in large networks or when sensors are deployed in inaccessible or unapproachable areas such as volcanoes and underwater.

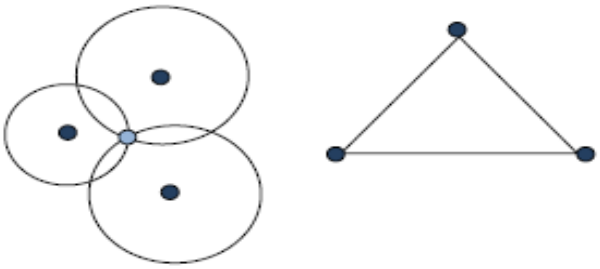
Another way is to add Global Positioning System (GPS) to each and every sensor. But, GPS is affected by buildings and heavy trees because it requires Line-of-Sight (LOS) between the receiver and satellites. The poor signal reception may decrease the accuracy. Moreover, using GPS in large scale area is not cost efficient. Therefore, many localization schemes have been proposed to estimate the location of nodes in WSNs. These localization schemes are used to estimate the location of various sensor nodes in the network with the knowledge of location of some specific nodes called Beacon Nodes or Anchor Nodes, which can obtain their location using global positioning system (GPS), or by placing anchor nodes at points with known coordinates. With regard to the mechanisms used for estimating location, these localization algorithms are classified as two categories: *range-based methods* and *range-free methods* [4, 5].

2. LOCALIZATION IN WIRELESS SENSOR NETWORKS

It becomes very important to know the location of each sensor node in the environment for many applications [6]. Users usually try to know not only what happened but they also try to know where the target is and where the interested event happened. Localization is estimated through communication between localized node (node whose location is known) also known as anchor node and un-localized node (node whose location is not known) for determining their position or geometrical placement. It can be determined by means of distance and angle between various nodes. There are various concepts used in localization such as the following [7].

- *Lateration:*-In this mechanism, distance between nodes is measured to estimate the location.
- *Angulation:*-As the name suggests, angle between nodes is measured to estimate the location.
- *Tri-Lateration*:-In this concept, location of a node is estimated through distance measurement between three nodes. Here, there is an intersection of three circles which

gives a single point which will be the position of an un-localized node, as shown in figure 1(a).



(a) (b)

Figure 1: (a) Tri-Lateration & (b) Triangulation

- *Multi-Lateration*:-This is same as tri-lateration, but here we consider more than three nodes for location estimation.
- *Tri-Angulation*:-In this concept, at least two angles of an un-localized node from two localized nodes are measured to estimate the position, as shown in figure 1(b).

3. RANGE BASED AND RANGE FREE LOCALIZATION

Many localization techniques have been proposed to give the location information of any unknown sensor node. In this paper, we classify the localization schemes based on the dependency of the range measurements [8]. These schemes can be categorized as range based and range free localization schemes. A brief description of these schemes is given in detail in the sections below.

3.1 Range- Based Localization

The Range based localization algorithms first precisely measure the distance or angle information between the nodes and then with the help of trilateration or triangulation techniques they estimate the desired position of the node [9].
There are many algorithms for localization and tracking of an unknown node in the network which can categorized into the following groups:
1. Distance based localization algorithms assume that the distances between the nodes of the WSN are measured.
2. Angle based localization algorithms assume that the unknown nodes can measure the angles to the anchor nodes with respect to some origin.
3. Received signal strength based algorithms assume that the unknown node can only measure the signal power from the base stations at its location.

3.2 Range-Free Localization

The Range free localization techniques use connectivity information between the nodes to find their location. In these techniques, there are anchor nodes which already know their locations and normal nodes which are usually mobile. Normal nodes find their locations with reference to the anchor nodes [10, 11]. Range free localization techniques are simple and cost effective in comparison to range based techniques as in these schemes, distance measurement, angle of arrival and special hardware are not used. Range-free methods include the following schemes:-

3.2.1 Distance Vector (DV) Hop

Distance vector routing and GPS localization ideas are used to propose DV Hop algorithm. DV Hop algorithm reduces the complexity and cost by improving the localization accuracy. DV Hop estimates range between nodes using hop count. It is composed by following stages: Firstly, it makes all the nodes in the network to obtain the hop count of anchors. Then, after getting other anchor locations and hop distances, anchors calculate the average single hop distance and give it a survival period, after that it broadcast its correction value. The unknown nodes will record the first received correction value, and forward it to neighbour nodes. This strategy can ensure that most nodes can receive the average single hop distance from latest anchors. Afterward, the unknown nodes can calculate the total distance to anchors according to the recorded hop count [12]. The hop count for a single anchor A, as a reference, is shown in figure 2. Here, a single anchor broadcasts a beacon to be flooded throughout the network containing the anchors location with a hop-count parameter initialized to one. Each receiving node maintains the minimum counter value per anchor of all beacons received by it and ignores those beacons with higher hop-count values. Beacons are flooded outward with hop-count values incremented at every intermediate hop [13].

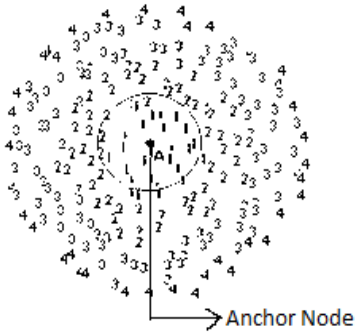


Figure 2: Anchor Beacon Propagation Phase

3.2.2 Centroid Scheme

Centroid algorithm first checks whether the unknown node is in the communication range of anchor node or not. Anchor nodes which are within the communication range of unknown node form a polygon and then calculate the centroid. We assume the centroid of this polygon as unknown node's location.
Implementation of centroid scheme contains the following actions [14]: First, all anchor nodes broadcast their location and identity to all unknown nodes available in their transmission range. The unknown nodes listen the signal for a fixed time T and collect the location information from various anchor nodes. Second, all unknown nodes determine their position as the centroid (*Xest, Yest*) from all positions of

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anchor nodes in their range by using the formula mentioned in Equation (1).

$$(Xest, Yest) = \left(\frac{Xi,+\cdots+,Xn}{N} , \frac{Yi,+\cdots+,Yn}{N} \right) \quad (1)$$

where, *(Xi, Yi) & (Xn, Yn)* are coordinates of anchor nodes, (*Xest, Yest*) represents the estimated position of the unknown node, N is the number of anchor nodes which are in the communication range to the unknown node. Schematic for the centroid algorithm is shown in figure 3. This polygon is formed by all the anchor nodes which are in the communication range of unknown node. Centroid of polygon can be calculated by using above equation 1. The calculated centroid of this polygon is the unknown node's estimated location.

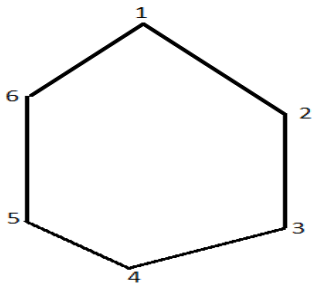

Figure 3: Schematic of Centroid Localization

The technique of location estimation using centroid method is economic and quite simple.

3.2.3 *Approximate Point in Triangulation (APIT)*

APIT is an area-based range-free localization scheme. Unlike centroid algorithm that assumes the node communication range as circle, APIT algorithm doesn't have this ideal assumption [15]. It assumes that a small number of nodes, called anchors, equipped with high-power transmitter, know their location. Using beacon signals from these anchors, APIT performs location estimation by isolating the environment into triangular regions between anchor nodes as shown in figure 4. By utilizing different combinations of anchors, the size of the estimated area in which a node resides can be reduced to provide a good location estimate. In APIT, the following four steps are included [16]:

- Beacon Exchange
- Point in Triangulation (PIT) testing
- Approximate Point in Triangulation (APIT) Aggregation
- Centre of Gravity (COG) calculation

APIT can only evaluate a finite number of neighbours. APIT can also make an incorrect decision. Therefore, there are some chances of error which are known as InToOut error and OutToIn error. In InToOut error, a node mistakenly thinks it is outside of triangle due to edge effect and in OutToIn error, a node mistakenly thinks it is inside of triangle [15].

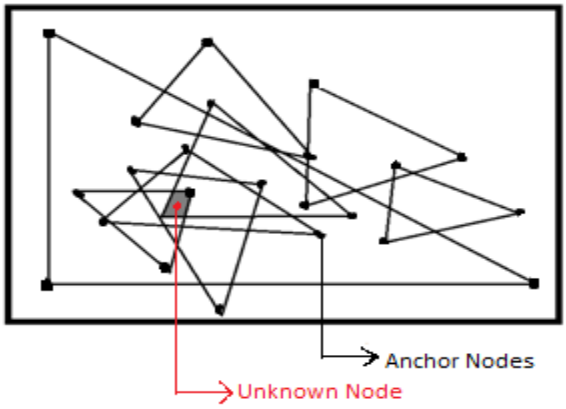

Figure 4: Area Based APIT Algorithm

4. PERFORMANCE ANALYSIS OF RANGE BASED SCHEME

Here, we have considered only the distance based localization of a single target. There are 16 anchor nodes in the system and one mobile unknown node. As it is a distance based scheme, we have first measured distances between the nodes i.e. between each anchor node and unknown node using Euclidean distance formula and we find the location of the unknown node through multi-lateration.

Table 1: Simulation Parameters of Range Based Scheme

Parameters	Values
Number of anchor nodes	16
Number of unknown node	1
Network Area	100*100 m
Communication Range	30 m

As given in table 1, we have simulated the error using the MATLAB software for single unknown mobile nodes with communication range of 30 m.

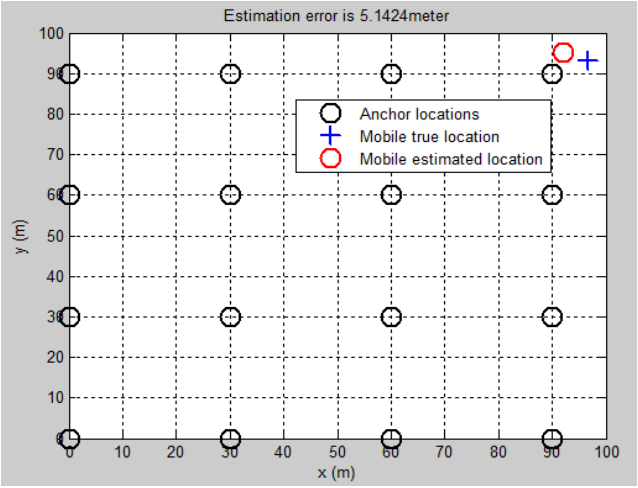

Figure 5: Error estimation for distance based localization

In the above graph we have placed 16 anchor nodes. We first measured the distances between unknown node and each

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anchor node by using Euclidean distance formula and then by multi-lateration technique the estimated position of unknown node has been calculated. After performing distance based localization using multi-lateration technique, we found true location and estimated location of unknown node. By this, estimation error is found to be 5.1424 meters.

5. PERFORMANCE ANALYSIS OF RANGE FREE SCHEMES

5.1 Centroid Algorithm

We have performed the centroid algorithm using the parameters given in table 2. Error estimation for an unknown node has been done. This algorithm is simulated using MATLAB software. The anchor nodes which are within the communication range of an unknown node first form a polygon. After that a centroid of that polygon is calculated and that centroid point becomes the estimated location of unknown node.

Table 2: Simulation Parameters

Parameters	Values
Number of anchor nodes	16
Number of unknown node	1
Network area	100*100 m
Communication range	30 m

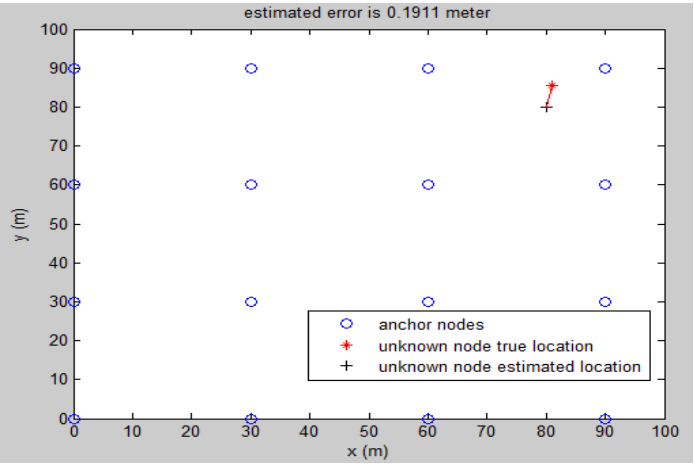

Figure 6: Error estimation for centroid algorithm

After performing centroid algorithm, we have calculated estimated error that is 0.1911 meter.

5.2 APIT Algorithm

The APIT localization scheme was implemented and simulated using the parameters given in table 3.

Table 3: Simulation Parameters

Parameters	Values
Number of anchor nodes	16
Number of neighbour nodes	5
Number of unknown node	1
Network area	100*100 m

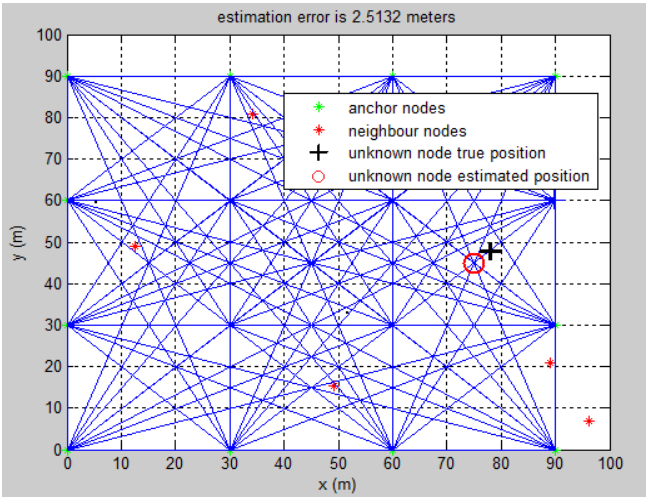

Figure 7: Error estimation for APIT Algorithm

Here, APIT is implemented using 16 anchor nodes. There is a single unknown node whose location is to be estimated. Some neighbors of unknown node are taken which are distributed within the communication range of unknown node. All the possible triangles are formed with the help anchor nodes. By using neighboring nodes, the unknown node decides whether it is inside or outside the triangle. Only if all the neighboring nodes are inside the triangle, the unknown node assumes itself to be inside the triangle. When unknown node is inside the triangle, centroid of the triangle is calculated and stored. After performing APIT test for all the nodes, center of gravity (COG) of all the intersecting triangles is calculated. The resultant location is the estimated location of the unknown node.

After the performance test of APIT Algorithm the estimated error comes out to be 2.5132 meters.

COMPARISON OF ESTIMATED ERROR

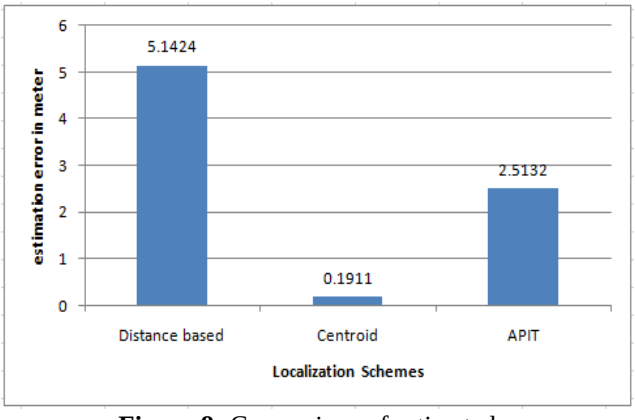

Figure 8: Comparison of estimated error

We have simulated for three different localization schemes and found that centroid algorithm has minimum error which is a range free algorithm as shown in figure 8.

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6. CONCLUSION

In this work, different localization algorithms of range based and range free schemes have been discussed and their performances are evaluated on the basis of error estimation. When error is taken into consideration it is observed that range free localization schemes like Centroid and APIT give better results than range based localization scheme. Therefore, it may be concluded that range free localization schemes are better than range based localization schemes.

REFERENCES

[1] **Ian F. Akyildiz, Weilian Su, Yogesh Sankarasubramaniam, and Erdal Cayirci. "A Survey on Sensor Networks." IEEE Communications Magazine, 2002.**

[2] **Carlos F. García-Hernández, Pablo H. Ibargüengoytia-González, Joaquín García and Hernández, "Wireless Sensor Networks and Applications: a Survey", International Journal of Computer Science and Network Security (IJCSNS), Vol. 7, No. 3 , pp. 208-218, 2007.**

[3] **Hu, Fei, and Xiaojun Cao, " Wireless sensor networks: principles and practice," CRC Press, 2010.**

[4] **Lovepreet Singh and Sukhpreet Kaur, "Techniques of Node Localization in Wireless Sensor Networks: A Review," International Journal of Innovative Research in Computer and Communication Engineering (IJIRCCE), Vol.2, No. 5, 2014.**

[5] **Shweta Singh, "Localization Techniques in Wireless Sensor Networks." International Journal of Computer Science and Information Technologies (IJCSIT), Vol. 6, No.1, pp. 844-850, 2015**

[6] **R. Manzoor, "Energy efficient localization in wireless sensor networks using noisy measurements," M.S. thesis, 2010.**

[7] **Akyildiz, Ian F., et al. "Wireless sensor networks: a survey," Computer networks, Vol.38, No.4, pp. 393-422, 2002**

[8] **Priya, Amita Malik, "A Review on Localization Algorithms in Wireless Sensor Networks," International Journal of Computer Science & Engineering Technology (IJCSET), 2014.**

[9] **Niewiadomska-Szynkiewicz, Ewa, "Localization in wireless sensor networks: Classification and evaluation of techniques," International Journal of Applied Mathematics and Computer Science, Vol. 22, No.2, pp. 281-297, 2012.**

[10] **A.Youssef and M. Youssef, "A taxonomy of localization schemes for wireless sensor networks," International Conference on Wireless Networks (ICWN), pp.444-450, 2007.**

[11] **J. Bachrach and C. Taylor,"Localization in Sensor Networks," Massachusetts Institute of Technology, Cambridge, Mass, USA, 2004.**

[12] **He, Tian, et al. "Range-free localization schemes for large scale sensor networks," International conference on Mobile computing and networking, ACM, 2003.**

[13] **Jiang, Kun, Li Yao, and Juan Feng, "Wireless Sensor Networks Target Localization Based on Least Square Method and DV-Hop Algorithm," Journal of Networks, Vol. 9, No.1, pp. 176-182, 2014.**

[14] **Liu, Yu, Xiao Yi, and You He, "A novel centroid localization for wireless sensor networks." International Journal of Distributed Sensor Networks, 2012.**

[15] **Cheng, WenHua, Jia Li, and Huaizhong Li, "An improved APIT location algorithm for wireless sensor networks," Advances in electrical engineering and automation. Springer Berlin Heidelberg, pp. 113-119, 2012.**

[16] **Zhiyi Fang, Hongyu Sun, Zelin Deng and Fan Yang. "Improved APIT Algorithm and its Application in Core Positioning System," 2nd International Conference on Science and Social Research (ICSSR), Vol. 6, pp.227-283,2013.**