Study on Useful Bacon Node Selection in Range Free Localization Algorithm in WSN

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Declaration

Me, hereby declare that this thesis is based on study of algorithm to select useful bacon nodes by myself. Materials of work found by other researcher are mentioned in reference. This thesis, neither in whole or in part, has been previously submitted for any degree.

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Abstract

Localization is important analysis subject in the area of wireless sensor network (WSN), which gives the required information about different occasion in a region. This paper is a study of localization techniques that proposes an idea to get more accurate distance between sensor nodes and bacon nodes. Wireless sensor network is structured with a huge number of small, less costly sensors which can communicate with each other via exchanging information with neighbors. In our proposed idea I can get more accuracy in determining the position of sensor nodes depending on the hop count information. The accuracy of the localization algorithm has a huge impact on the achievement of protocols that depends on location and other applications like routing. If the transmission path among bacon nodes and sensor nodes is curved, then the distance estimated by hop distance is always not close to Euclidean distance between a pair of sensor nodes. In this study I will offer to avoid those respected bacon nodes whose hop count distance to other bacon nodes is not proportional to the known distance between them.

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Chapter-1

Introduction

1.1 Motivation

In many exercises, like targets tracking, governing of unreachable areas, inquiring on natural deposit and so many, this wireless sensor network (WSN) can be very handy and helpful. This localization techniques such low cost and can be used in such area where it is hard to approach. There are many papers exist on localization techniques of wireless sensor networks (WSNs). They propose different techniques and algorithms to get more accurate result on different kind of situations. The importance of this low cost technique for localization, gives the motivation for this study paper.

1.2 Literature Review

The future of communications networks, position-based technologies and real-time localization are needed to be exact, less costly, energy conservative and dependable [1,2]. Sensor nodes location information are required for these applications. As well as for geographical routing protocols and clustering this location information is irreplaceable [3,4]. Because of these applications localization algorithm is turned out a significant subject in WSN researches. So, in WSNs the exactness of position of sensors are necessary. Since some past years, there have been many researches on localization in WSNs, and in most of these researches depend on the estate that there are small amount of sensors whose have knowledge about their exact location using GPS devices are called bacon nodes. [5–7]. The location of sensor nodes are estimated by the hop count distance from bacon nodes and different algorithms to calculate positions, so different algorithms on different situations can provide more accurate result. These study work on getting more accuracy to get position of sensor nodes using different mathematical technique. If there is any obstacle between sensor node and bacon node and the hop counted in a carved way then the distance counted from that bacon node to the sensor node is less accurate. In this kind of situation, we identify the good bacon nodes for each sensor nodes. We will call them useful node [7]. Then we will find out the average hop distance using information from our useful nodes.

1.3 Thesis Orientation

The remaining of this thesis paper is arranged as follows-

- Chapter 2, consists of related work
- Chapter 3, consists of proposed methodology
- Chapter 4, consists of simulation results
- Chapter 5, consists of conclusion

Chapter-2

Related work

2.1 Background

For various applications of WSNs it is necessary for the sensor nodes to have knowledge of their position correlative to the sensor network. The information like atmospheric pressure, temperature and humidity collected via sensor nodes have to be imposed to the correlative position from where it was gathered. So, the positions of sensor node has to be close to exact. That's why this problem of position or location estimating is known as localization. Before this localization term was used in robotics where any remote robot use to determine location or position in any coordinate system. Under certain situations, the sensor nodes also has to know the direction correlative to the network [8].

In WSNs, the nodes are classified-

Dumb Node:

This node has no idea about its position or location at all and after the execution of localization algorithm they would gather the knowledge about their location at the end.

Settled Node:

This node does not know its position at the beginning, which means initially it is a dumb node but it using the localization algorithm, they find their location.

Beacon Node:

These are the nodes whose have idea about their location from the beginning and even without executing the localization they know their position. They have other appointments to know their location but just the algorithm of localization. Such as, they may has a GPS system or they are settled at any known coordinates. The beacon node is known as bacon node as well as reference node.

These sensor nodes can be symmetric or asymmetric communication links. For example, p and q are symmetric then p can reach to q as well as q can reach to p. But if asymmetric then either p can reach to q or q can reach to p.

2.2 Process of Localization

Getting the position of the dumb sensor nodes is the key issue. Localization scheme estimates the dumb sensor nodes position depending on the result of localization algorithm. The basic inputs in localization technique are the bacon nodes positions, if in the network, there is availability of any bacon node, then other inputs are depend upon the technique of measuring. In figure (1) the flow chart of localization technique is shown.

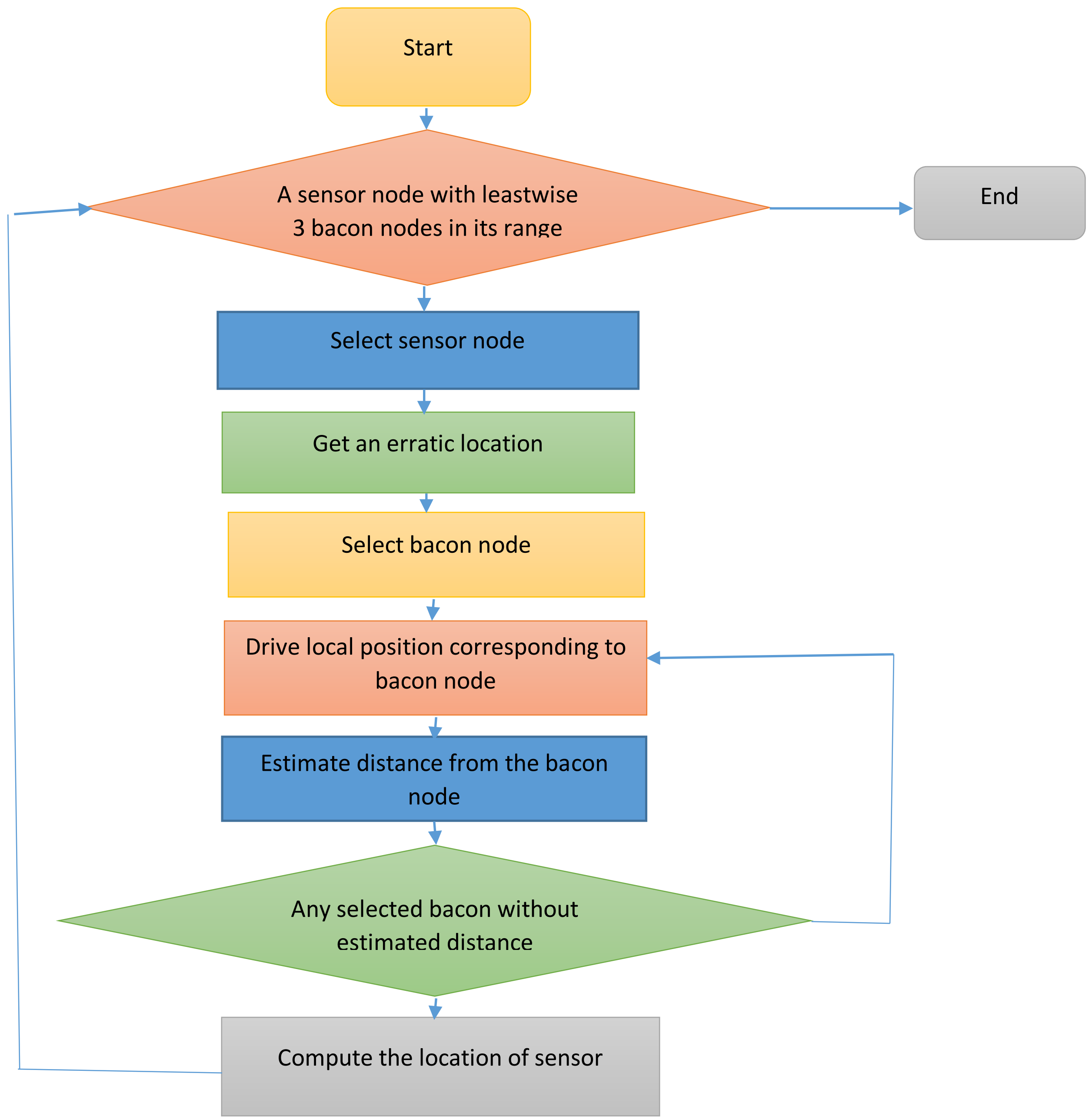

Figure 1: Flowchart of technique of localization

2.3 Primary Techniques of measurement for Localization

There are different measurement schemes in different algorithm of localization. The exactness of different algorithms of localization can manipulated by different factors, thus, for different application the selection of algorithm for localization is a very important concern. For instance, to think of an algorithm of localization for a specific region, shape of the region, architecture of the network, consistency of sensor nodes in a section, bacon nodes range, time synchronization of sensor nodes are basic issues that should be considered. The exactness of an algorithm of localization can be ordained by the type of measurement and its translating accuracy. Localization in WSN can be widely categorized into three types based on the scheme of measurement [9]. Angle of Arrival (AOA) measurements, distance related measurements as well as the Radio Signal Strength (RSS) dependent schemes. The classifications are shown in figure (2). Then we briefly criticize these 3 techniques.

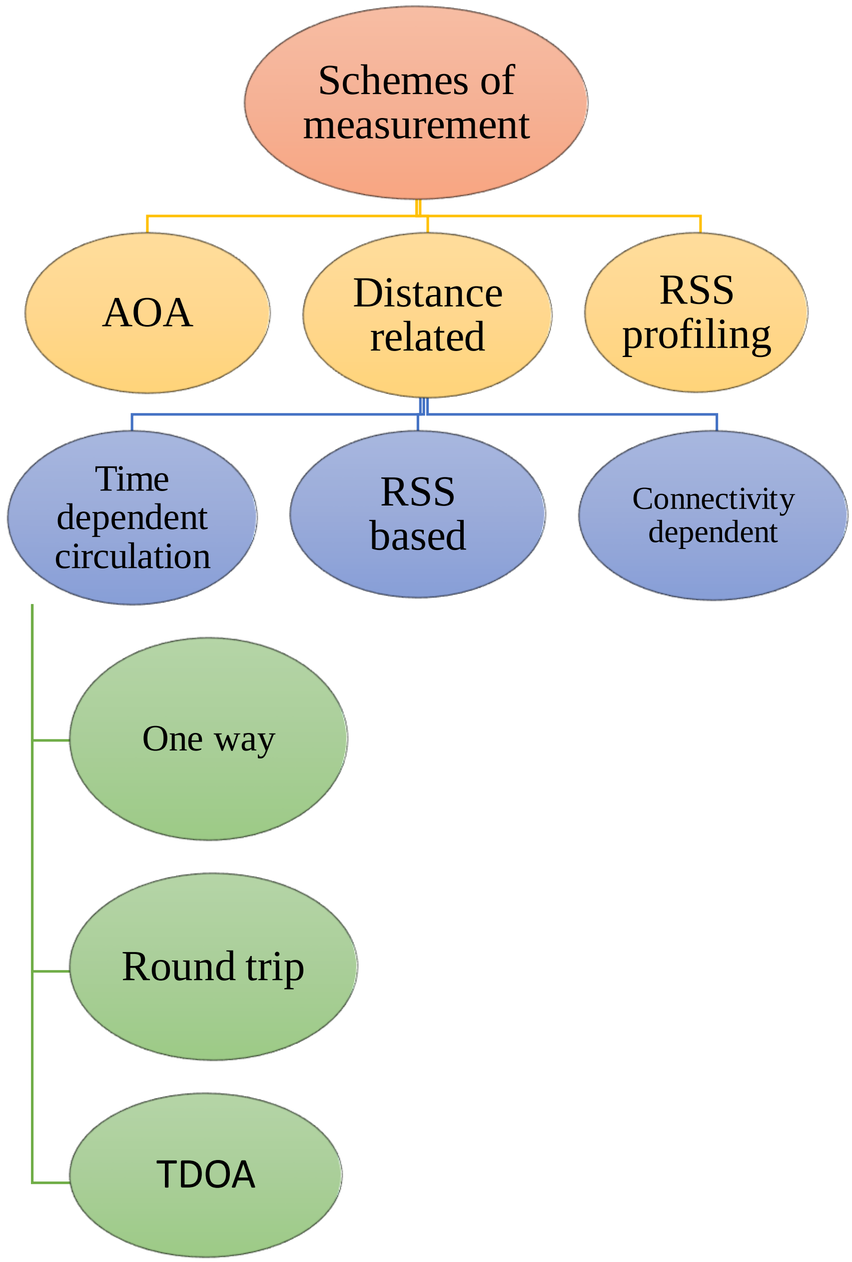

Figure 2. Category of localization algorithm based on measurement scheme.

2.3.1 Measurements of Angle of Arrival (AOA)

The bearing measurements as well as the measurements of direction of arrival are the synonym name of the AOA scheme of measurements. Two types of schemes can be used to gain the measurements of AOA:

First scheme is using response of the amplitude of receiver antenna and second one is using the phase response of receiver antenna. The angle of the signal that is received from the bacon node to the dumb sensors is measured in this scheme. Then, the location of each dumb node finds the specific angle from the bacon node. To measure the location leastwise two bacon nodes are required. Even though, there is little error in mapping the angle, the error of localization can be huge. The direction of transmitting and receiving antenna decides the exactness and the measurement environments effect of multipath and shadowing make it more complicated to measure. The direction of a received signal can be totally wrong, who is a multipath element of the transmitted signal and as a result, there can occur a huge measurement error [10]. So, without using a large array of antenna, this AOA scheme is not worth in localization [10]. So, the scheme of AOA is not convenient to energy, when WSN uses small sensor nodes.

2.3.2 Distance Related Measurement

Distance related measurements is categorized as measurements of circulation time (one way, round trip and time difference of arrival (TDOA)), RSS dependent and connectivity dependent measurements.

2.3.2.1 Measurements of Circulation Time

Measuring the time distinction of signal transmitting from the transmitting end to the receiving end is the principle way in this scheme. This distinction of time of transmitting signal is use to find the distance from the transmitter to receiver as well as the speed of circulation of the signal in that network. The measurement of delaying of time is comparatively a higher leveled work area. The synchronization of the local time at the transmitting end and at the receiving end is highly demanded for the implementation of the one way measurement of circulation time and this is the main drawback in this scheme. Even there is a small distinction of local times between the transmitter end and the receiver end, it will result a huge error in estimation of distance. Subsequently, there will be a huge error in location estimating. At the speed of light, a very little distinction in local times of 1ns at transmitting end and receiving end can cause a 0.3m error of measurement of distance [9]. This scheme is costly because it required exact synchronization between both ends, it requires a highly accurate clock or a complex synchronization algorithm. This scheme becomes less striking because of this complexity of synchronization.

2.3.2.2 Connectivity Based

We have already viewed several schemes so far but the easiest scheme of all of these is connectivity based. In this scheme, each sensor has a radio transmission range, if a sensor is in this radio transmission range of another, they connect to each other. Such measurement technique is considered as the binary measurement. It is binary 1, if a sensor is in the range of another and connected to each other and binary 0, if they are not in the range of each other and not connected. Hop count is used to represent the distance between two sensor nodes then the average hop distance correctly as possible is computed using different algorithms [15]. The well-known name is range free localization of this class of WSNs localization algorithm.

2.3.3 RSS dependent Measurement

The RSS dependent measurement calculates the distance from one sensor node to another as we discussed previously. Using this distance between sensor nodes this algorithm of localization determine the location of the sensor nodes. However, there are two major challenges to implement this kind of algorithm.

First difficultly to use this RSS scheme in wireless environments is the odd distribution of objects in the measuring region of indoor wireless conditions as well as outdoor wireless conditions. Then the second ticklish task is model parameter selection. To improve the exactness of measuring the position of sensors without these described difficulties, this measurement scheme calculate the positions of sensors using the map of RSS measurements [11-14]. Using the signal strength of bacon nodes of different position of the region of measurement, this technique primarily format a map form. Spreading out sniffing devices at some known positions which is the online way or using priori measurement which is offline way, anyone of these can be used to get the form of map [12]. This scheme is mainly used in WLAN, but they may occur to be striking for WSN too [16].

2.4 Range Free Localization Technique

Range free localization scheme is very much inexpensive scheme than other range bases schemes. It uses the contentment of received packets [16]. And in this paper this technique is our main subject of concern. DV-Hop [17] and Centroid [18] are two most popular algorithms of localization to determine the position of sensor nodes for range free localization scheme. Centroid is considered for sensor nodes whose have leastwise three nearby bacon nodes. Let that *S* is a sensor node who has 3 nearby bacon nodes *A*, *B*, *C*, whose coordinates are given as (x_1,y_1), (x_2,y_2) and (x_3,y_3), and all of them have same range of communication. Centroid scheme follows the principle to determine the location of sensor node to calculate the central point of *S* centroid of bacon nodes. The location of *S* centroid, denoted as (x_c, y_c) is computed as-

$$(x_c, y_c) = \left(\frac{(x_1+x_2+x_2)}{3}\right), \left(\frac{(y_1+y_2+y_2)}{3}\right)$$

When the distribution of bacon nodes is regular, with very less computational and communication cost, comparatively a good accuracy can be get using Centroid scheme. But if the formation of bacon nodes be irregular, the estimated location of sensor nodes will not be accurate using the Centroid scheme.

Again, DV-Hop is hop count base method, only small number of bacon node are required for this method. In various localization method, DV-Hop plays an important key to estimate the primary distance between sensor nodes to bacon nodes. The hop count which represent the estimated transmission distance among bacon nodes is circulated throughout the network. Then bacon nodes can calculate the average size of hop, using this estimation result each sensor node computes their estimated distances to bacon nodes.

Chapter-3

Proposed Methodology

3.1 Motivating Scenario

We consider a simple scenario which is shown in Figure (3) [8]. There are seven sensor nodes *S1* to *S7* and five bacon nodes *A1* to *A5*. All the connectivity among sensor nodes and bacon nodes are given there. In the figure, we can see the actual distance from *A1*, *A2* and *A3* to *S1* according to hop count is almost equal to the Euclidean distance respectively. But since there is an obstacle, the transmission path is carved rather than straight from sensor node *S1* to *A4* and *A5*. Thus, we need to count hops in a carved way, as a result, the hop count distance from *S1* to *A4* is 8 and to *A5* is 9. But the Euclidean distance from *S1* to *A4* and *A5* hardly 3 or 4. As the transmission path is curved, an inaccurate distance is computed by the sensor nodes to those bacon nodes whose transmit packets in a bendy path. If the sensor node, *S1* computes its position using this faulty information, then there will be a major error in determining the exact location of sensor *S1*. By eliminating the bacon nodes *A4* and *A5* for location computation this problem can be solved, i.e., *S1* should compute the location of itself by taking into account the distance from all bacon nodes except *A4* and *A5*. However, *S1* does not have any information about its position, so it does not have any idea which bacon nodes are useful to use for determining its location. To resolve this problem we can use each bacon node to determine which bacon nodes are useful to estimate location corresponding to that bacon node. The bacon nodes are able to determine such things, Since bacon nodes has knowledge about their location and the Euclidean distance and hop distance among bacon nodes can be computed by bacon nodes. So they can compute how curved is one from other. Realizing which bacon nodes are curved in hop count path and which bacon nodes are kind of straight,

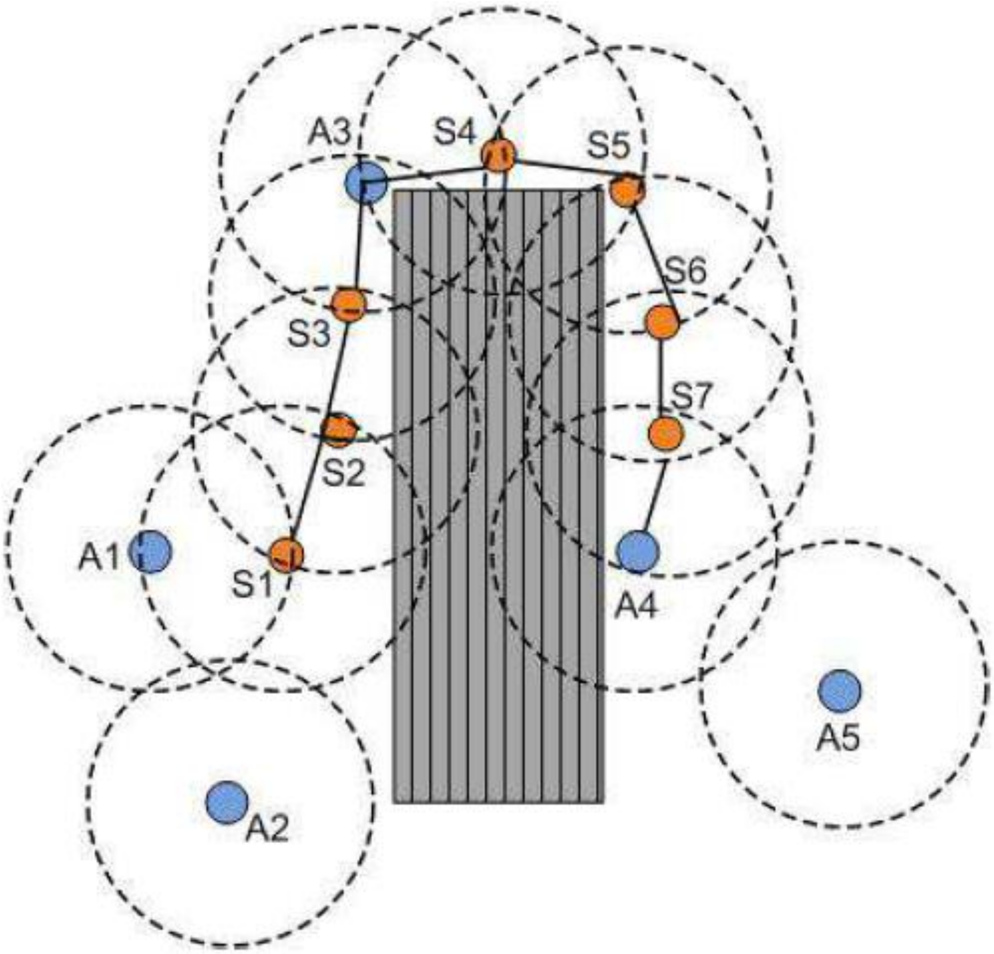

Figure 3. Motivating scenario

they can select the best bacon nodes for localization and all the nearby neighbor sensors are informed by each bacon nodes. Then, this set of useful bacon nodes are exploited by their nearby sensor nodes for localization. For different bacon, the set of useful bacon will be different. So, the set of useful bacon nodes for different sensor nodes will not be the same. As an instance, in Figure. 3, for the sensor nodes nearby bacon nodes *A4* and *A5*, the bacon nodes on the opposite side of the obstacle *A1* and *A2* are not useful to estimate the position of sensors, as opposed to, for bacon nodes *A1* and *A2'*s neighbor sensors *A4* and *A5* are not useful. Now the challenge is to determine the set of useful bacon nodes for each sensors and eliminate the unuseful bacon sets for estimating the accurate location. The method to cope with the challenge is described in following section.

3.2 Proposed Method

Our proposed method is determining useful bacon set for different senor using the information containing by each bacon node and average hop size.

3.2.1 Determining Average Hop Size

Bacon nodes has the information of its position, using classical distance vector exchange, all nodes in the network can get distance.

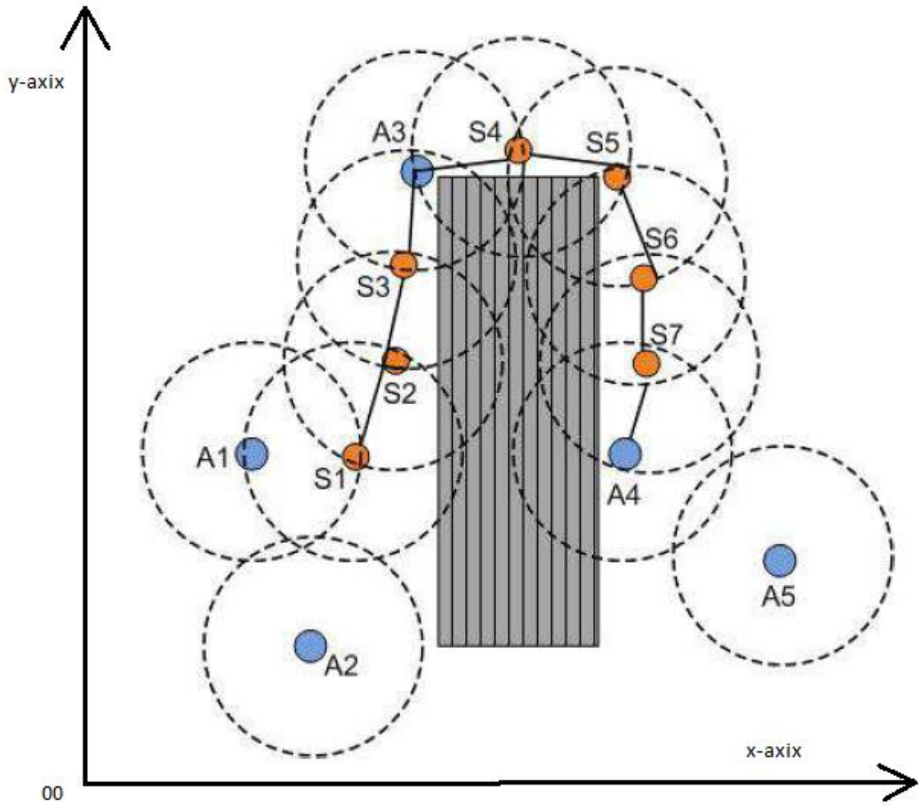

Figure 4. Sample scenario in coordinate system

There we can get distance from a bacon to its neighbor unknown node is-

$$d_{ub} = \sqrt{(x_u - x_b)^2 + (y_u - y_b)^2}$$

They keep up a table $\{Xi,\ Yi,\ h_{ij}\}$ and only interchange updates with their neighbors[19]. In the second stage, after it accumulates distances to other nodes, it estimates a size for one hop. Then the total transmission distance can be calculated as,

$$T_d = \sum \sqrt{(x_i - x_j)^2 + (y_i - y_j)^2}$$

After first estimation each node exchange its information with its neighbor nodes. By doing so, the network will know the total number of transmission hop in the network. Let, the total number of hop in this network is h_{ij}. Then, it can calculate average hop size for this network as,

$$H = \frac{\sum \sqrt{(x_i - x_j)^2 + (y_i - y_j)^2}}{h_{ij}}$$

3.2.2 Strategy to Select Set of Useful Bacon Nodes

In real life scenarios, the transmission route between two bacon nodes is not always straight. Here in this strategy we will find out if the transmission path between two bacon nodes very curve or not and if there better bacon nodes are available for estimation the position of nodes.

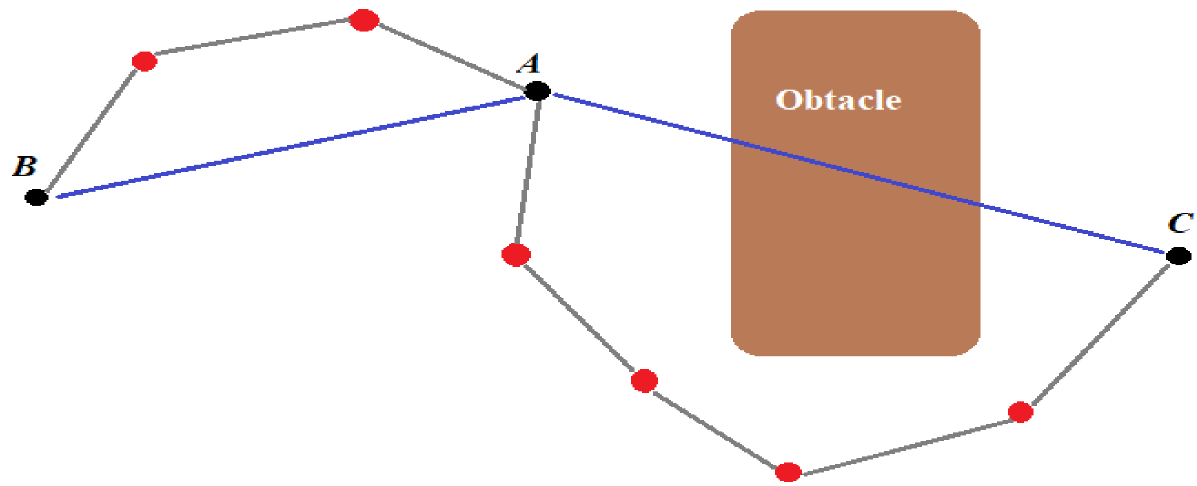

Figure 5. Sample scenario of difference between the Euclidean and transmission distance

Here, in figure (5), *A*, *B* and *C* there are three bacon nodes. Since they have information about their position, they can calculate their Euclidean distance from *A* to *B* and *A* to *C* are *e1* and *e2* respectively. . Let the average hop size of this network is *H*. We can assume a scenario, where there is no obstacle between *A* and *B*. From the figure the hop count from *A* to *B* is 3. By exchanging information with neighbors each bacon can get the information what is the hop that distance between them $q1=3$. So now it is possible to count the transmission distance from A to B. Let us consider that, transmission distance $r1=q1 \times H$, which is almost equal to $e1$. Since, the transmission path is almost straight. Here, the difference of the Euclidean distance and transmission distance is, $u1=r1-e1$.

Now, again, from the figure (5), for A to C, the hop distance is q2=5, like
the previous calculation it can get transmission distance $r2=q2\times H$. Here, $u2=r2-e2$.

Now, we if there are n number of bacon nodes in the network. So, the differences between the Euclidean distance and transmission distance for every pair of bacon nodes can be considered as- $\boldsymbol{u= u1,u2,u3 \ldots\ldots\ldots\ldots\ldots\ldots. un}$. Now, first we sort the array $\boldsymbol{u}$ in ascending order and eliminate last 1/2 of the array and keep first 1/2 in array $\boldsymbol{u}$, then using an algorithm we can determine the median value of $\boldsymbol{u}$**.** Let the median value of $\boldsymbol{u}$ is $\boldsymbol{u_m}$. Now in our proposed method, useful bacon node for each bacon is when $\boldsymbol{u} < \boldsymbol{u_m}$ and if for any pair $\boldsymbol{u} >= \boldsymbol{u_m}$,then the bacon node will be ruled out for estimating position of the others neighbor sensors.

Algorithm for selecting useful bacon nodes:

Require: *k: Bacon ID;*

V_A*: The bacon set* $\{(x_i, y_i); h_{ij}\}$

Where,

$1 \le i \le |V_A|$ *and* $i \ne j$ *: received position of bacon I and corresponding hop count to bacon j*

Ensure: *Useful Bacon Position* (x_m, y_m)

$m \in Friendly_j$

while $i \in V_A$ *and* $i \ne j$

do

$$d_{ij} = \sqrt{\left(x_j - x_i\right)^2 + (y_j - y_i)^2}$$

$$H = \frac{\sum \sqrt{d_{ij}}}{h_{ij}}$$

end while

while $i \in V_A$ *and* $i \ne j$

do

$r_{ji} = q_{ji} \times H$

$u_{ji} = r_{ji} - e_{ji}$

end while

u = sort(u)

u = [0 : (u/2)]

U=round (median (u))

while $i \in V_A$ *and* $i \neq j$

do

if $u_{ji} < U$

$Friendly_j = V_{ji}$

end if

end while

Broadcast useful bacon nodes position (x_m, y_m).

Chapter-4

Simulation Results and Performance Evaluation

The proposed method in this paper is still a theory, due to the shortage of time we still have not implement this method to simulating result and performance evaluation. Here, we mainly focus on investigating the localization errors in different approaches such as DV-Hop [17], pattern-driven [19], RAL [20] and FASS[8].

Network Parameter	Value of Parameter
Area	10×10m
Number of sensors	200
Number of bacon	20
Ratio Rang	2m

Table 1. Network Parameters for Simulation.

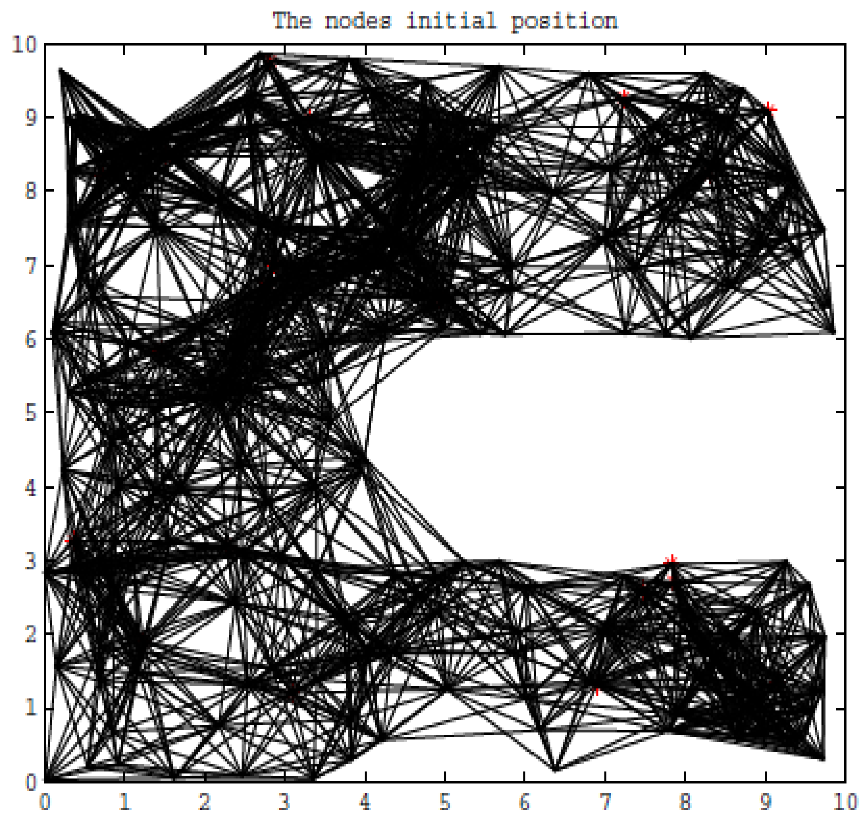

Figure 6. C-Shape Topology in Anisotropic Network

We simulated in C-shape and S-shape anisotropic network as shown in Figure (6) and Figure (7) respectively. Table (2) shows the initial network parameters for simulations. Eventually, we increase the number of sensor and bacon nodes. In our simulations, sensor nodes are open to use random models. The sensor nodes are irregularly spread throughout the region, within a view to an ad hoc arrangement of netwok, e.g., spreading sensors using a robot. This kind of model does not contain evenly in the network topology. The plotted data pictorial in result figures represent the average result of 100 trials in randomly generated network topologies. The definition of average localization error is that the ratio of the differences between the estimated location (x'_i, y'_i) and the real location (x_i, y_i) to the communication range of sensor nodes. *r* is the radio range, which use to find the average error of localization. The average localization error △ of the sensor network which is composed of $|V_s|$ sensor nodes is expressed as follows-

$$\Delta = \frac{1}{|V_s|} \sum_{i=1}^{V_s} \left(\sqrt{(x'_i - x_i)^2 + (y'_i - y_i)^2} \right)$$

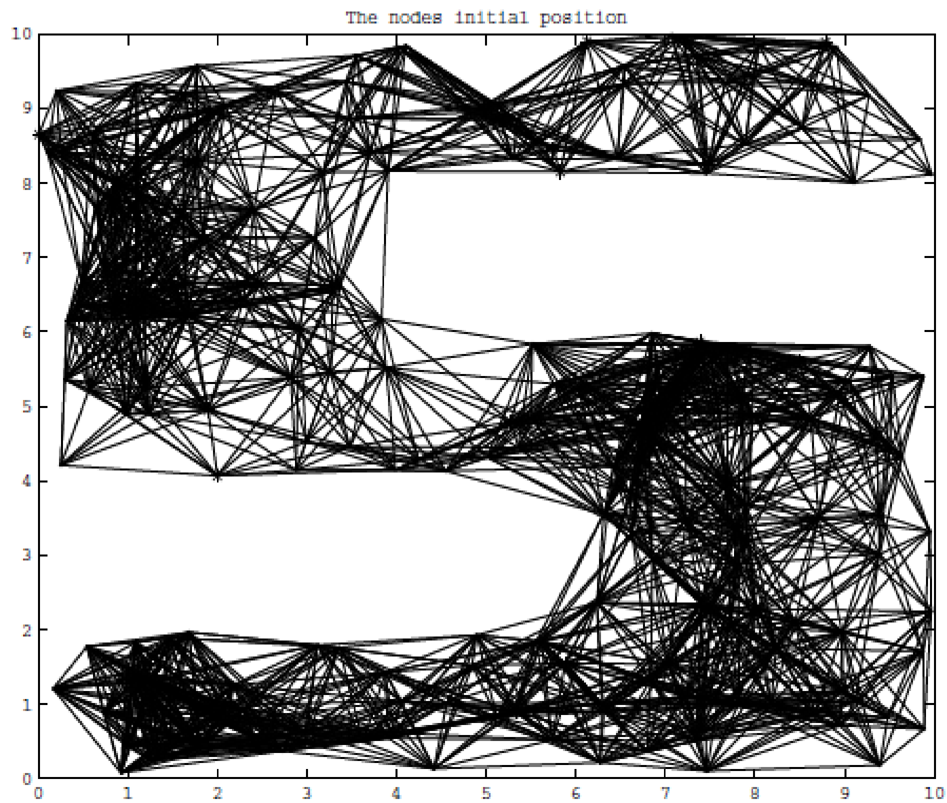

Figure 7. S-Shape Topology in Anisotropic Network

4.1 Impact of Number of Bacon Nodes

In this first simulation, we varied the number of bacon nodes to look on its result on localization exactness. The performance comparing of these different algorithms at an uneven region, i.e., in C-shape topology is shown in figure (8). In DV-Hop scheme, it uses each bacon nodes to estimate the position of sensors, has high localization error, even after the number of bacon nodes are increased, it still has high localization error. Because the newly added bacon nodes do not confirm that the distinction of the Euclidean distance and bended shortest transmission path distance is small, so, the average error of localization fluctuated. As opposed to, with the increase of bacon nodes, the other approaches i.e., pattern driven, RAL and FASS continually prosper the act of estimating position.

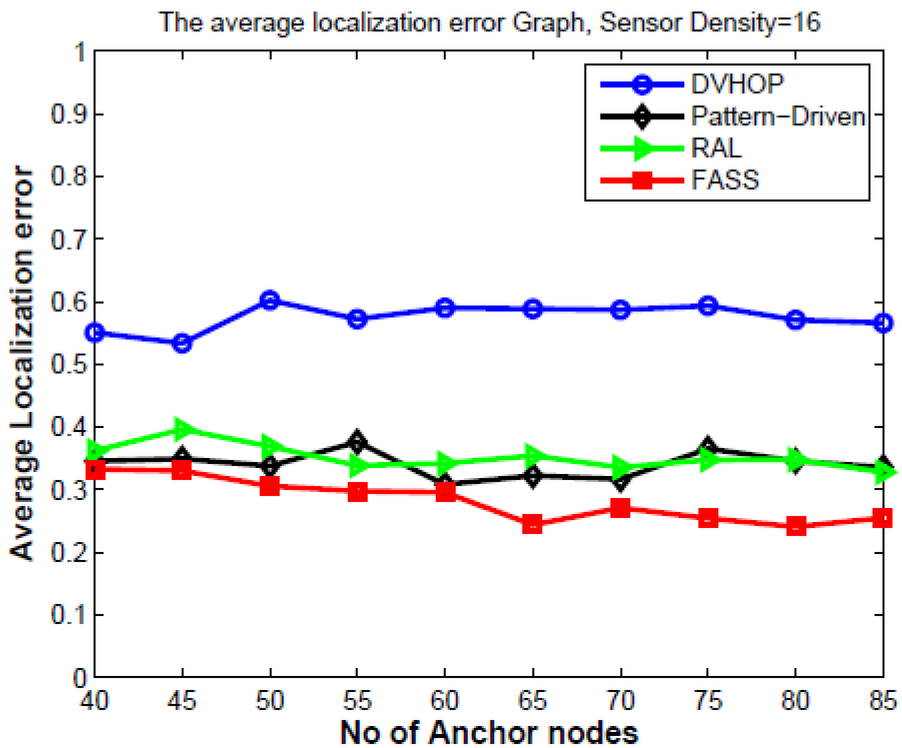

Figure 10. Localization error vs. number of bacon nodes in anisotropic C-shape network.

In S-Shape topology, the transmission path among bacon nodes and sensors are terribly curved. In this case, it will get a horrible wrong information of average distance of hop if it utilizes all the bacon nodes. In DV-Hop approach, every the bacon nodes is used to estimate the position, so in this approach the localization error will be very high. In FASS, if the number of bacon node increases, it will possibly get more useful bacon nodes to estimate the location of sensors. So, the performance of estimating position of sensors get better.

4.2 Impression of Density of Sensors

In our second simulation, we observe the performance of location estimation by varying the sensor density. We can see in figure (11), the performance of FASS is better than other approaches when the sensor density is 6, as the density of sensor increases to 24, the performance of FASS as well as other approaches decreases. The reason is that as the sensor density increases, the numbers of one hop neighbor nodes increases. So the per hop average distance computation error decreases and the calculation error does not propagate to large number of hops. In low sensor density such as 6 or 8, if the hop number is large then there is a high possibility that the transmission path between two bacon nodes is curved. But if there is less number of hop then the transmission path between two bacon nodes is almost straight and the average hop distance calculation is more exact than before. Figure (12), shows the performance different approaches when varying the sensor density in S-Shape network which is severely detoured.

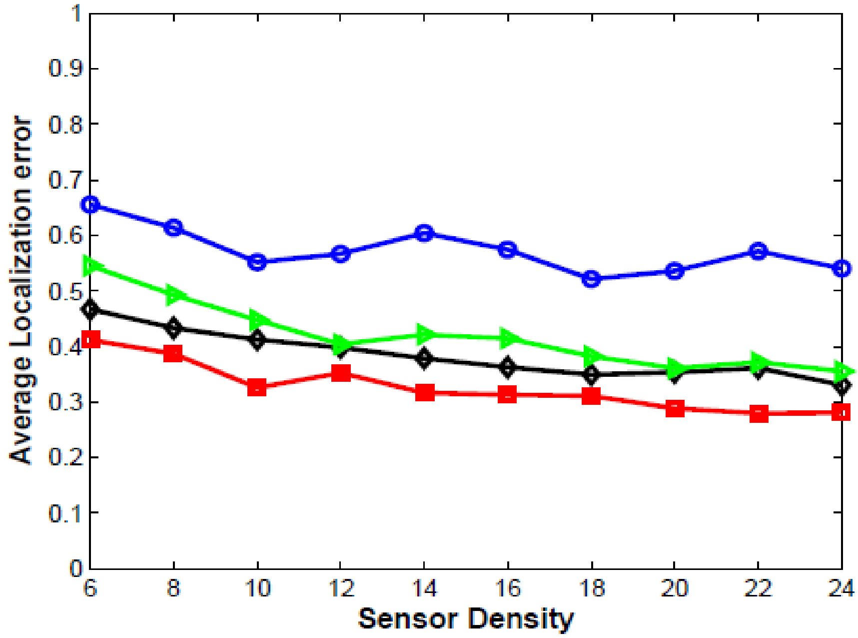

Figure 11. Localization error vs. sensor density in anisotropic C-shape network.

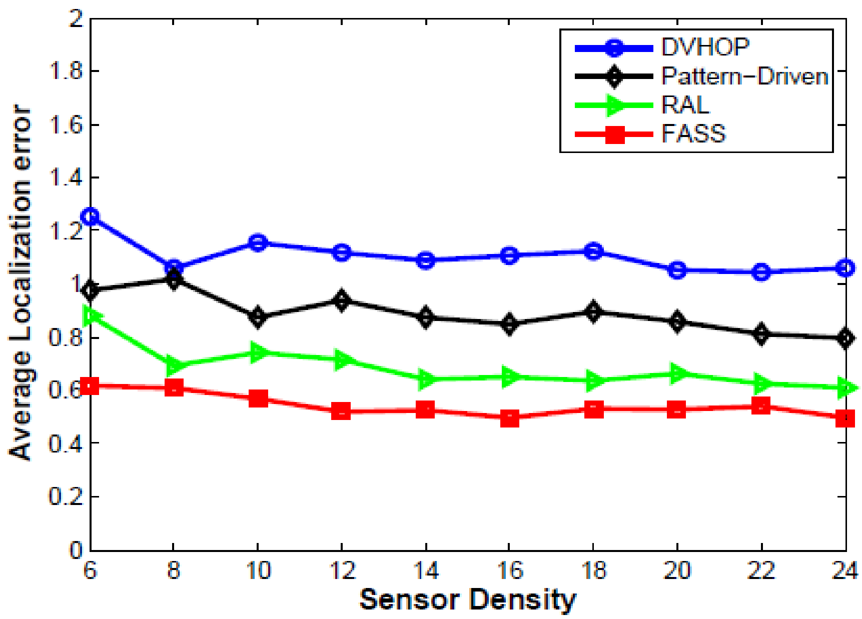

Figure 12. Localization error vs. sensor density in anisotropic S-shape network.

We have varied the sensor density from 6 to 24. When the sensor density falls in the range of 6 to 15, then the effective localization remains a problem in S-shaped networks. Kleinrock and Silvester have proved in [21] that 6 is the optimum sensor density to maintain the network connectivity. In S-shaped network the localization deserves an investigation, since, lower sensor density means smaller possibility of traffic jam, and radio interference and lower deployment cost.

4.3 Impact of Varying Useful Bacon Nodes

In this simulation we compared the performance of FASS approach by varying useful bacons. In S-shape anisotropic network, with 3, 8, 24 and 40 useful bacon nodes the performance of FASS is shown is figure (14). We have varied the number of bacon nodes from 40 to 49 and then by selecting different number of useful bacon nodes evaluate the performance of FASS. From the figure, we can see that, when the total number of bacon nodes is 40, then by selecting all the bacon nodes for localization, i.e., FASS with 40 useful bacons is worse than the others. However, as the number of bacon nodes is increased, the performance of FASS with 40 useful bacons have got better. We can see that, the performance of FASS with 3 useful bacon is not good when compared with FASS with 8 and 24 useful bacons but better than FASS with 40 useful bacons when the total number of bacon nodes is 40. We have selected three bacon nodes among all bacon nodes, but it is not good enough to meet the bad geometry of bacon nodes and that’s why, its performance is not good enough. Since 8 bacon nodes are sufficient to meet the bad geometry of bacon nodes [22], the performance of 8 and

24 bacon nodes are almost same. From this simulation result we can say that, for accurate localization it is very important to select sufficient useful bacon nodes in anisotropic network.

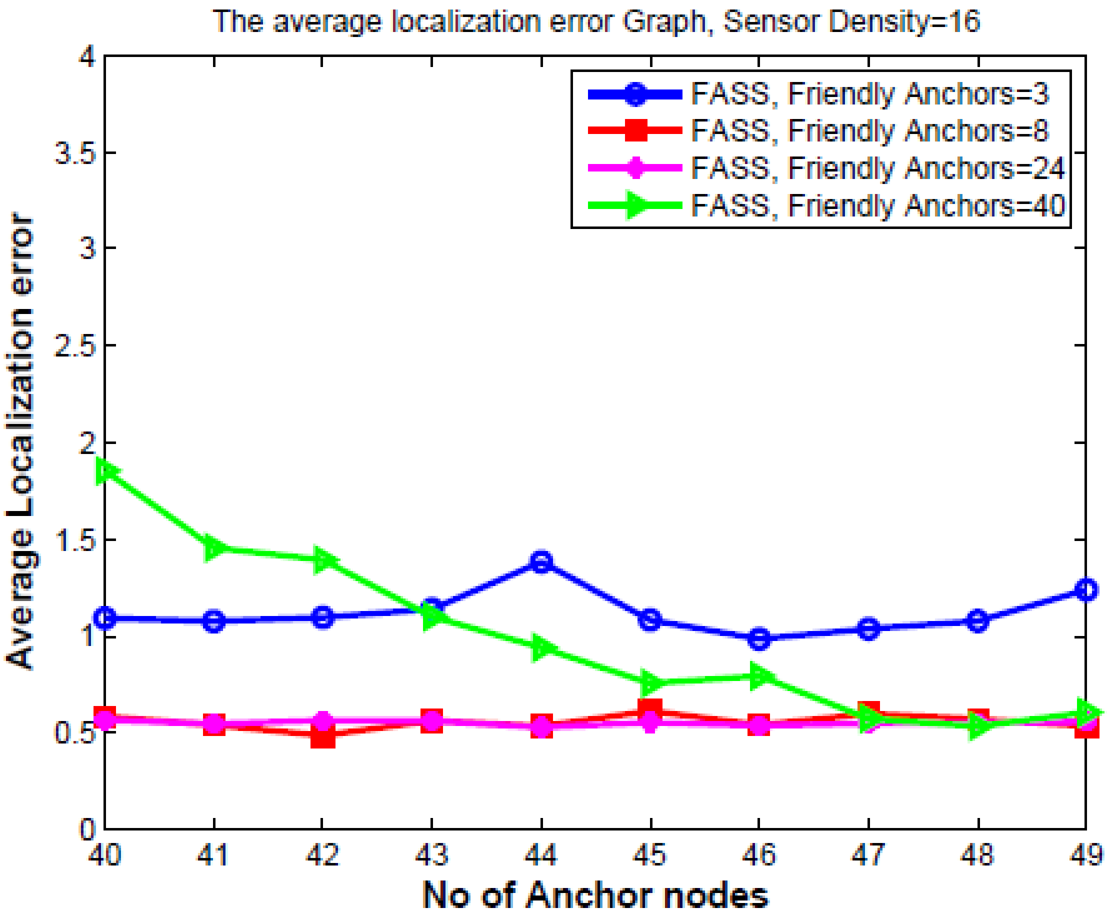

Figure 13. Localization error with different number of useful bacons.

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Chapter-5

Conclusion

5.1 Concluding Remark

In localization evaluation, accuracy is the most important key. Most applications of WSNs required high accuracy. However, a good selection of set of useful bacon nodes can play a very important role to increase accuracy. So, in this paper, we focused on this. We proposed an algorithm which is easy to implement and less costly.

In this thesis paper, we introduce a new a new method to select useful bacon nodes for estimating sensors position in range free localization techniques especially in anisotropic WSNs. This approach, identify the good bacon nodes for each sensor nodes using the information that is already known to the bacon nodes. It utilized information of hop count and the Euclidean distance to compute position of sensors. Thus, we proposed one novel method to identify the useful bacon nodes from all the bacon nodes in anisotropic network. This proposed approach of choosing useful node can be integrated in different range free localization algorithm. We hope that, our designed algorithm for selecting useful bacon nodes will be successful after implementation. Hopefully, this algorithm will make the range free localization technique more efficient for WSNs.

5.2 Future Plan

In the future, our first plan is to implement this algorithm in range free localization techniques. Comparing the simulation of the implementation of this algorithm with other approaches in different situations. In additional, we will work to improve this algorithm in order to get better accuracy with less cost.

References

1. Vossiek, M.; Wiebking, L.; Gulden, P.; Wieghardt, J.; Hoffmann, C.; Heide, P. Wireless local positioning. IEEE Microw. Mag. 2003, 4, 77–86.

2. Flora, C.D.; Ficco, M.; Russo, S.; Vecchio, V. Indoor and outdoor location based services for portable wireless devices. In Proceedings of the 25th IEEE International Conference on Distributed Computing Systems Workshops, Columbus, OH, USA, 6–10 June 2005; pp. 244–250.

3. 3. Paul, A.K.; Sato, T. Effective Data Gathering and Energy Efficient Communication Protocol in Wireless Sensor Network. In Proceedings of the Wireless Personal Multimedia Communication (WPMC'11), Brest, France, 3–7 October 2011; pp. 1–5.

4. Al-Karaki, J.N.; Kamal, A.E. Routing techniques in wireless sensor networks: A survey. IEEE Wirel. Commun. 2004, 11, 6–28.

5. Chowdhury, T.; Elkin, C.; Devabhaktuni, V.; Rawat, D.B.; Oluoch, J. Advances on Localization Techniques forWireless Sensor Networks. Comput. Netw. 2016, 110, 284–305.

6. Halder, S.; Ghosal, A. A survey on mobile bacon assisted localization techniques in wireless sensor networks. Wirel. Netw. 2016, 22, 2317–2336.

7. Paul, A.K.; Sato, T. Detour Path Angular Information Based Range Free Localization in Wireless Sensor Network. J. Sens. Actuator Netw. 2013, 2,3, 25–45.

8. De Oliveira, H. A. B. F., Nakamura, F. E., Loureiro, A. A. & Boukerche, A. (2005, October). Directed Position Estimation: A Recursive Localization Approach for Wireless Sensor Networks. In Proceedings of the 14th International Conference on Computer Communications and Networks, ICCCN ’05, pp. 557–562.

9. Mao, G.; Fidan, B. Localization Algorithms and Strategies for Wireless Sensor Networks; Information Science Reference-Imprint of IGI Publishing: Hershey, PA, USA, 2009.

10. Yassin, A.; Nasser, Y.; Awad, M.; Al-Dubai, A.; Liu, R.; Yuen, C.; Raulefs, R.; Aboutanios, E. Recent Advances in Indoor Localization: A Survey on Theoretical Approaches and Applications. IEEE Commun. Surv. Tutor.2017, 19, 1327–1346.

11. Bahl, P.; Padmanabhan, V.N. RADAR: An in-building RF-based user location and tracking system. In Proceedings of the IEEE INFOCOM 2000 Conference on Computer Communications. Nineteenth Annual Joint Conference of the IEEE Computer and Communications Societies (Cat. No.00CH37064), Tel Aviv, Israel, 26–30 March 2000; Volume 2, pp. 775–784.

12. Krishnan, P.; Krishnakumar, A.S.; Ju,W.H.; Mallows, C.; Gamt, S.N. A system for LEASE: Location estimation assisted by stationary emitters for indoor RF wireless networks. In Proceedings of the Twenty-third AnnualJoint Conference of the IEEE Computer and Communications Societies (IEEE INFOCOM), Hong Kong, China, 7–11 March 2004; Volume 2, pp. 1001–1011.

13. Prasithsangaree, P.; Krishnamurthy, P.; Chrysanthis, P. On indoor position location with wireless LANs. In Proceedings of the 13th IEEE International Symposium on Personal, Indoor and Mobile Radio Communications, Pavilhao Altantico, Lisboa, Portugal, 18 September 2002; Volume 2, pp. 720–724.

14. Ray, S.; Lai, W.; Paschalidis, I.C. Deployment optimization of sensornet-based stochastic location-detection systems. In Proceedings of the IEEE 24th Annual Joint Conference of the IEEE Computer and Communications Societies, Miami, FL, USA, 13–17 March 2005; Volume 4, pp. 2279–2289.

15. Niculescu, D.; Nath, B. Ad hoc positioning system (APS). In Proceedings of the IEEE Global Telecommunications Conference (GLOBECOM ’01), San Antonio, TX, USA, 25–29 November 2001; Volume 5, pp. 2926–2931.

16. R. Stoleru, T. He, and J. A. Stankovic, “Range-free localization, secure localization and time synchronization for wireless sensor and ad hoc networks,” Springer, vol. 30, pp. 3-31, 2007.

17. D. Niculescu and B. Nath, “Dv based positioning in ad hoc networks,” J. Telecommun. Syst., vol. 22, no. 1-4, pp. 267–280, January 2003.

18. N. Bulusu, J. Heidemann, and D. Estrin, “Gps-less low cost outdoor localization for very small devices,” IEEE Pers. Commun. Mag., vol. 7, no. 5, pp. 28–34, Oct. 2003.

19. Q. Xiao, B. Xiao, J. Cao, and J. Wang, “Multihop range-free localization in anisotropic wireless sensor networks: A pattern-driven scheme,” IEEE Transaction on Mobile Computing, vol. 9, no. 11, pp. 1592–1607, November 2010.

20. B. Xiao, L. Chen, Q. Xiao, and L Minglu, “Reliable bacon-based sensor localization in irregular areas,” IEEE Transactions on Mobile Computing, vol. 9, no.1, pp. 60–72, January 2009.

21. L. Kleinrock and J. Silvester, “Optimum transmission raddi for packet radio networks or why six is a magic number,” in Proc. Nat’l Telecomm Conf, 1978, pp. 431–435.

22. T. He, C. Huang, B. M. Blum, J. A. Stankovic, and T. Abdelzaher, “Range-free localization schemes for large scale sensor networks,” in Proc. of the ACM MobiCom 2003, San Diego, 2003, pp. 81–95.