Journal of Advances in Computer Research
Quarterly pISSN: 2345-606x eISSN: 2345-6078
Sari Branch, Islamic Azad University, Sari, I.R.Iran
(Vol. 9, No. 4, November 2018), Pages: 37-57
www.jacr.iausari.ac.ir

Improve Range-Free Localization Accuracy in Wireless Sensor Network Using DV-Hop and Zoning

Fahimeh Doagoey✉
Department of Computer Engineering, Kerman Branch ,Islamic Azad University, Kerman, Iran
fahim.d1990@gmail.com; fahim.d1990@yahoo.com

Received: 2018/02/10; Accepted: 2018/09/08

Abstract

In recent years, wireless sensor networks have drawn great attention. This type of network is composed of a large number of sensor nodes which are able to sense, process and communicate. Besides, they are used in various fields such as emergency relief in disasters, monitoring the environment, military affairs and etc. Sensor nodes collect environmental data by using their sensors and send them to the base station. Energy resource is limited in this type of network and it is usually impossible to recharge or replace dead nodes. Therefore, energy management is an important issue in these networks. Localization in the sensor nodes is an important operation of wireless sensor networks. Thus, data generated by the sensor nodes should also show the position of the node. Hence, a reliable localization algorithm is always necessary. Regarding the localization methods, range-based methods are fairly accurate to estimate the nodes and they estimate the node location. To ensure the accuracy of the obtained range, a range-free method namely distance vector routing has been investigated in this study. Some nodes which benefit from conscious coordinates and help other nodes to estimate their coordinates are called anchor nodes. The present study have used zoning and estimated coordinates of the nodes in each zone to improve localization and it tried to upgrade the accuracy of vector routing localization. The proposed method decreases the energy consumption and increases the localization accuracy.

Keywords: *Wireless Sensor Networks, Localization, Distance Vector Routing, Accuracy*

1. Introduction

Wireless sensor network is composed of hundreds or thousands of small devices called sensor nodes. These nodes are interconnected and they work to perform a specific task or tasks. Currently, wireless sensor network has been considered as one of the most important technologies of this century. Wireless sensor network has been used in many monitoring and controlling applications [1]. Localization is one of the basic operations of the self-organized and stimulants networks such as sensor networks and mobile ad-hoc networks (MANETs). There are different approaches to solve the localization problems in assumptions related to the capabilities of networks and communication tools. These differences include assumptions about the device hardware, signal dispersion model, the required time and energy, network structure (homogeneous or heterogeneous), nature of the environment (indoor or outdoor), dense anchor, synchronization of the devices, communication costs, fault conditions and mobility of device [2]. Selecting localization methods depends on their applications, so high accuracy and sometimes low costs are needed in some situations. Since dense methods are not scalable and they are not suitable for the great networks, the present study focused on distribution methods which are suitable for the sensor networks [3]. Regarding hardware capabilities of sensor network devices and mechanisms that are used to estimate the distance between the nodes, the existing localization algorithms are categorized in two general groups including distance-based and distance independent.

In distance-based algorithms, localization of sensor nodes is done through additional tools such as timer, signal receptor and localization antenna. This type of localization is based on point to point access or angle data. The distance / angle are measured by using time of arrival (TOA), time difference of arrival (TDOA), received signal strength indicator (RSSI) and angel of arrival (AOA) and methods [4].

Distance-based localization may provide fine resolution but it highly needs accurate signal measuring and time synchronization. No additional hardware is needed in distance independent localization, although it benefits from wireless sensor network features and so algorithms is selected to access the localization data. This kind of localization does not need to measure the distance or the angle between the nodes. This method can be divided into two categories; local techniques and step-count techniques. In local technique; a node with unknown coordinates collects spatial data of neighboring anchors with known coordinates in order to estimate its own coordinates. The weakness of range-free methods is their low accuracy which has been tried to be improved in this study.

The remainder of this paper is structured as follows: In Section 2 we provide a short discussion of related work. In Section 3, the proposed approach consists of novel localization method in order to improve estimation accuracy is proposed. Section 4, explores the performance evaluation of the proposed schemes followed by simulation scenario demonstration. At last the study is concluded in section 5.

2. Related Works

Basically, the existing localization techniques are categorized into two categories: range-based and range-free techniques. Range-based techniques [8] first exactly measure the range data (including the angle and distance) between the related equipment, and then it reaches to the desired position based on triangulation and trilateration methods. Range-based techniques use RSSI [4], TOA [6], TDOA [7], and AOA [8].

Wu. et.al [5] improved the accuracy of calculating the Euclidean range between two neighboring nodes by providing a new proximity criterion called RND. RND localization algorithm acts in a way that first an RND-based correction factor is calculated. Then, the range between the unknown node s and the anchor i is obtained regarding the product of the minimum distance RND (i, s) and the RND-based correction factor. When knot s obtains the estimated range to more than three anchor nodes, it is calculated by using the Trilateration method. The DV-RND method can be used in distributed or centralized networks, although this algorithm improves the accuracy of localization through solving average hop length ambiguity and it eliminates the assumption of the uniform distribution of the entire network nodes. However, it produces low additional computational cost equal to O (K log (k)), so that k generates the whole number of neighboring nodes of the anchor i and j .

Global positioning system (GPS) [3] is the most well-known range-based method by using TOA or TDOA. However, GPS devices not only consume a lot of energy, but they also have the ability to operate in indoor environments. Alternatively, Global System Mobile Communication (GSM) works with AOA and RSSI methods. Note that GPS and GSM support localization by using expensive and complex systems. Another technology is Ultra Wide Band (UWB) which is used to measure the time of flight with high accuracy [9].Range-based methods suffer from two major drawbacks, first that range data is easily influenced by multipath fading, noise and environmental changes.

Second, some additional devices are required and these devices usually use more energy and increase the total costs. Thus, while distance-based method uses the distance or the angle between the nodes, the range-free method uses the connection between the nodes. In this method the nodes which are aware of their position are called anchor nodes, while other nodes are called typical nodes. Anchor nodes are stable but typical nodes are mobile. A typical node first collects the connection data and also anchor's position and then it calculates its own position or location. Range-free methods can be implemented on low-cost wireless sensor networks because they do not require range data. Another advantage of independent range method is its strength and robustness. Thus, connection data between nodes is not easily influenced by the environment. As a result, this paper focused on independent range method.

Among independent range algorithms Centroid [10] Convex Position Estimation (CPE) [11] and DV-hop [12] can be named. Centroid and CPE are simple and not too complex, but a typical node requires at least three anchor nodes in its neighborhood. Regarding the interesting advantage of DV-hop algorithm, this paper investigated hop DV-based localization algorithms, as recently a large number of DV-hop-based algorithms have been proposed [14-15].

In [13] a Differential DV-hop (DDV-hop) algorithm has been proposed which used an average distance per step to determine the location of mobile nodes. Unlike the original DV-hop algorithm, the average distance in each step is calculated based on distance differential error at each step of anchor node.

In [15] a strong DV-hop algorithm was presented in which each node measures an average weighted step based on its own topology connection with both anchor nodes. However, these algorithms are not sufficiently accurate.

J. Liu et al in [16] proposed the APIT method, which divides the environment into triangular regions between beacon nodes. Each sensor determines its relative position with the triangles, and estimates its own location as the center of gravity of the intersection of all the triangles that the node may reside in. However, APIT requires long-range beacon stations, which requires expensive high-power transmitters.

Chen et.al proposed ZBLM algorithm in [17] in this algorithm, only two anchor nodes are used for localization of unknown nodes distributed uniformly across the network. Assuming that the network has a square-shaped topology, first, X sink knot is considered in the bottom and left edge and Y sink knot in the bottom and right edge. ZBLM algorithm consists of three main steps: (1) calculating the minimum hops count, (2) segmenting the communication area, (3) determining the coordinates of the sensors located in each section. Then, EZBLM algorithm is used to estimate the location of unknown nodes in each section by using the ZBLM coordinates of nodes and the nodes located in neighboring sectors.

In [18] an optimization algorithm was presented for a Connected Dominating Set (CDS) based on anchor nodes. It should be noted that this algorithm applies the random motion on both anchor nodes and unknown nodes. The optimization process uses genetic algorithm through elitism strategy, so that appropriate solutions can be applied to a rapid convergence as a general solutions. Finally, standard least squares can estimate the location of unknown nodes.

In [19] we analyze the impacts of wormhole attack on the DV-Hop localization scheme, based on which we propose a label-based DV-Hop secure localization scheme to defend against the wormhole attack. We further theoretically prove the correctness of the proposed scheme. Simulation results illustrate the effectiveness of the proposed label-based DV-Hop secure localization scheme.

In this manuscript [20] we suggest a fast adaptive distributed method for maximum likelihood approximation (MLA) in multiple view object localization problem. For this purpose, we use "up to scale" property of projective geometry and by defining coefficients for convergence criterion, we increase the convergence speed of the consensus algorithm. We try to present a mathematical model for the problem. We use two types of error function. The proposed method uses maximum likelihood for obtaining its best parameters. Our approach utilizes "up to scale" property in projective geometry to reach the consensus quickly. The difference between nodes' values and meanwhile consensus values are evaluated by two error functions. To estimate consensus value in the second error function, we used local weighted average of each node.

This paper [21] aimed to present a novel and smart algorithm using more criteria to optimize the energy consumed by sensor nodes and also to decrease optimum data and the number of RNs, which communicate to sink. The first advantage of the proposed algorithm is that, in high density of sensor nodes, the performance of division algorithm depends on distance and not on the number of nodes, which leads to a significant increase in the number of RNs. The second advantage is that the proposed algorithm provides high level of fault tolerance, as sensor nodes are covered by RN, also in case of any problem for each of the nodes, no problem will be occurred in the nodes' communications. The proposed algorithm can decrease the number of RNs and increase fault tolerance in WSN, without any decreasing in the coverage area.

One existing problem [22] of routing in wireless sensor networks is finding the best path. By the best path, we mean the path where all nodes have highest energy level and shortest distance from base station so that data transfer consumes the least amount of energy. Routing can be considerably optimized using proposed greedy method. In this paper a greedy method is applied which choose the optimum neighbor among large number of neighbors considering energy and distance. This selected node will be utilized for data transfer in next step. Simulation results revealed that proposed method leads to significant improvement in reducing end-to-end delay and energy consumption.

3. Proposed Approach

In this section a method is introduced to increase accuracy in independent range localization based on distance vector routing. This method aims to increase the accuracy of localization with minimal energy consumption in wireless sensor networks as limited resources, especially power supply in wireless sensor network have been always challengeable. The proposed method is shown in Figure 1.

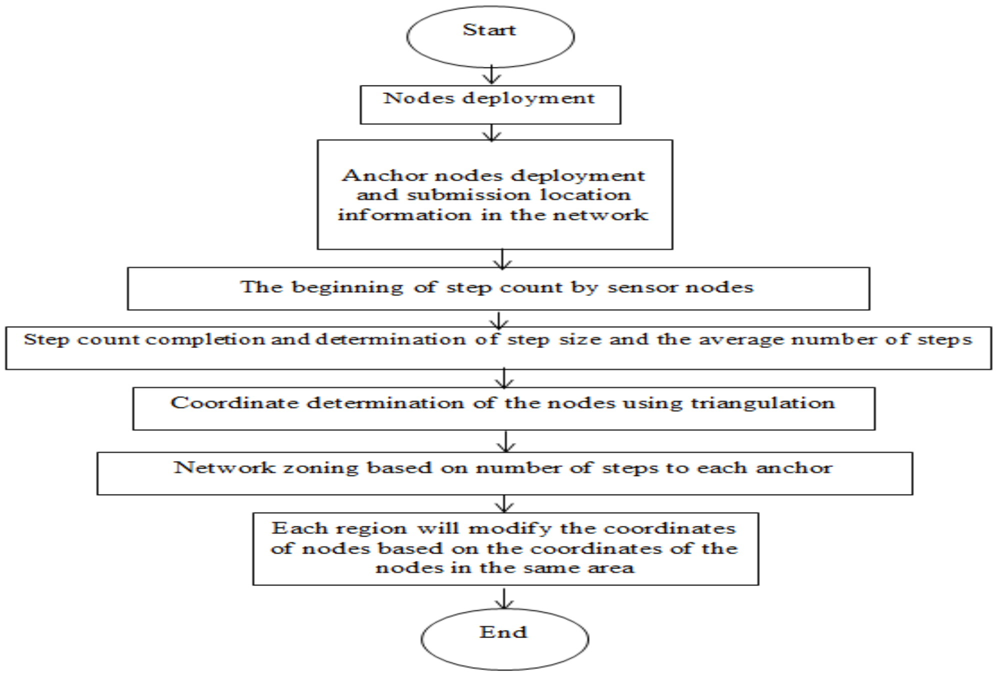


figure1. The flowchart diagram of the proposed method.

3.1 Network model

In the proposed method the wireless sensor network contains two types of nodes namely anchor nodes and sensor nodes. Sensor nodes whose coordinates should be determined measure their locations through calculating the distance to neighboring anchor nodes by using distance vector routing. Therefore, the proposed method is a range-free method based on the anchor. All nodes are randomly distributed in a two-dimensional environment Figure 2.

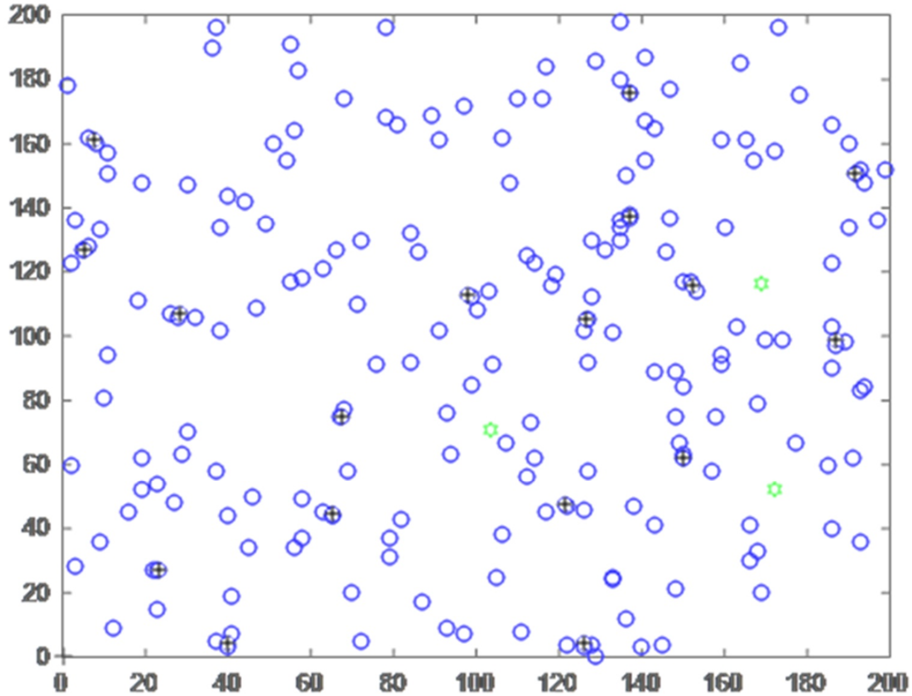


Figure 2. Deployment of nodes

In Figure 2 the distribution of 200 nodes in an environment with 200 * 200 meter coordinates has been randomly shown. Blue circles indicate wireless sensor nodes and the symbol "+" indicates the sink. In addition to the sensor nodes and sink, anchor nodes are also available in the network. Anchor nodes have been shown with a green star symbol. Thus, there are three anchor nodes in total.

The transmission range with radius of each node is considered as Rc. The transmission range is a circular area in which the sensor node is the center of the circle with a radius of transmission range. This range reflects the fact that the sensor node can only be linked to this area with other nodes. The nodes available in this area are called single step or immediate neighbors of the desired node.

3.2 Localization Method

3.2.1 Step Count

In this method, first anchor nodes start sending messages with Rc distance. The message structure has been shown in figure 3. Sensor nodes whose distance to the anchor node is less than Rc , receive this message. By receiving this message, sensor node regards one step to anchor node and stores it. Then, it adds one unit to count step and the message of Rc radius plays again on the network.

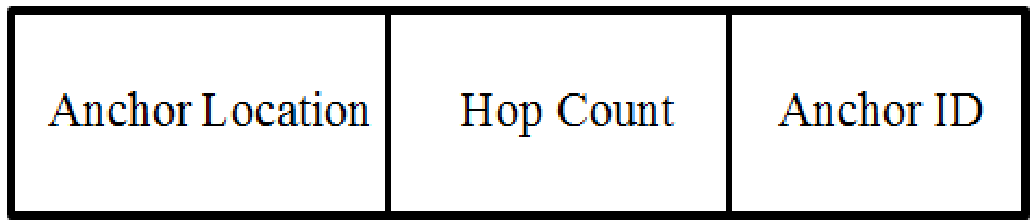


Figure 3. Message structure

When each node receives the message, it measures the step count and as step count increases, it is distributed in the network. If the step count message is received several times by one node, the least step count is considered for the node. Figure 4 shows the nodes with the number of steps 1 and 2 relative to the anchor node.

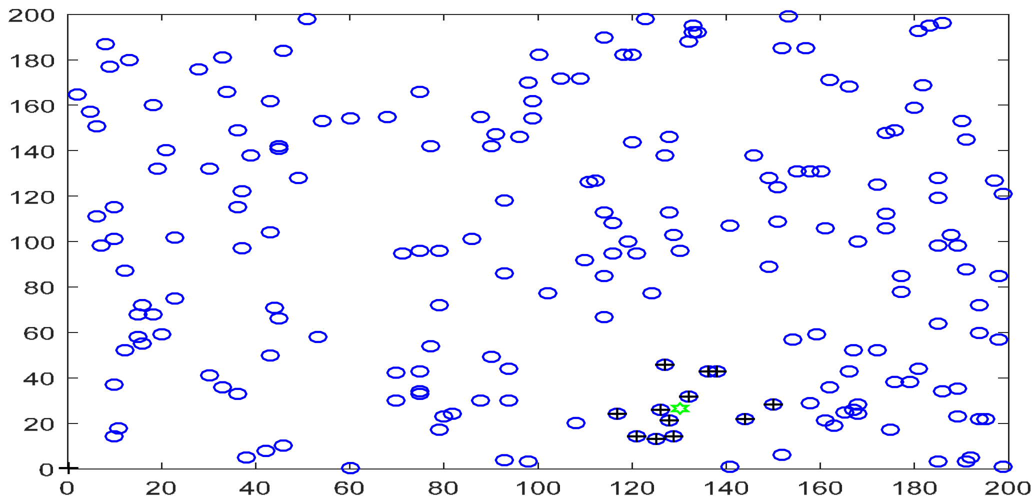


Figure 4.a) Sensor nodes with one distance step

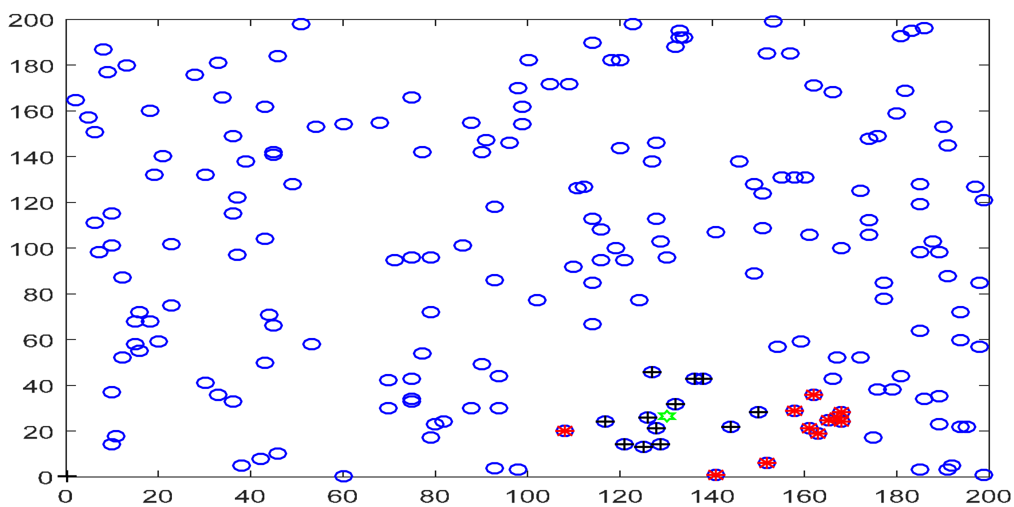


Figure 4. b) Sensor nodes with two-step distance

Figure 4 Nodes with the number of step one and two from the determined anchor nodes after a specified time, all the sensor nodes have a step count regarding all the present anchors on the network. Because the localization is free from the range, it is essential to take a mechanism to determine the location of nodes. Each node, in addition to the anchor nodes coordinates has the least number of steps to anchor nodes. Therefore, in localization process, it is not enough to measure the anchor nodes coordinates, but the distance to anchor nodes should be available as well. Therefore, this is an issue which needs to be considered.

3.2.2 Step Size

The number of steps between the anchors and the sensor and also between the anchors is available regarding the previous section. Regarding this point, the step size between two anchor nodes can be measured. Equation 1 is used for this purpose, it is defined as one in which the Euclidean distance between two anchors; i, j is divided to the number of steps to achieve an average size of each step.

$$\text{Hopsize}_i = \frac{\sum_{j\neq i}\sqrt{(x_i - x_j)^2 + (y_i - y_j)^2}}{\sum_{j\neq i}\text{hopcount}_{ij}} \quad (1)$$

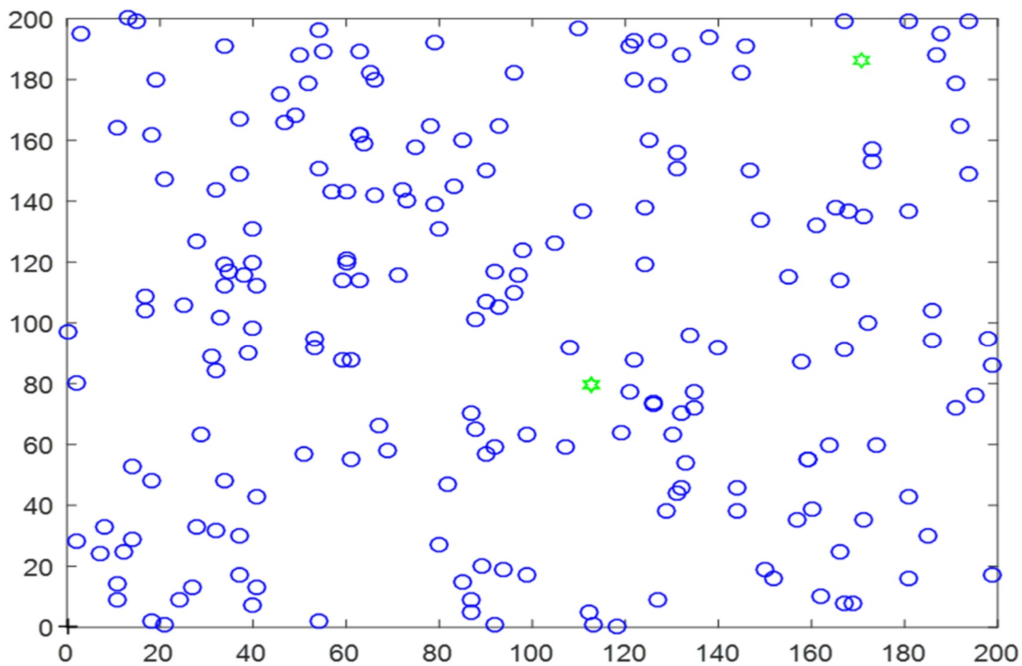


Figure 5. An example of step size

For example, in Figure 5, the distance between two distinct anchors is 121.23 meters and the number of steps between them is 16 steps. As a result, here the size of the step is 10,287 meters. Table 1 shows the number of steps and step size between distinct anchors, and Table 2 shows the average step number and step size. In this example, the average step size of the entire modes is 8.106 meters.

Table 1. Number of steps and distance between anchors

	Anchor				Total Steps		Anchor				Total distances
		1	2	3				1	2	3	
Anchor	1	0	18	6	24	Anchor	1	0	161.6118	61.6697	223.2815
	2	21	0	17	38		2	161.6118	0	121.23	282.8418
	3	7	16	0	23		3	61.6697	121.23	0	182.8997
Total Steps		28	34	23	85	Total distances		223.2815	282.8418	182.8997	689.023

Table 2.step size

	Anchor				Step size
		1	2	3	
	1	0	8.9784333	10.278283	9.3033958
Anchor	2	7.6958	0	7.1311765	7.4432053
	3	8.8099571	7.576875	0	7.9521609
Step size		7.9743393	8.3188765	7.9521609	8.1061529

Step size for each pair of anchor is measured in accordance with Equation 1 and then the average step size is considered as the step size. Given the size of each step and the number of steps between each sensor and the anchor, the distance between the sensor and anchors is easily obtained Equation 2.

$$Distance_{A,\,I} = Hop\ Count_{A,\,I} * Hop\ Size \quad (2)$$

3.3 Categories of Nodes

Considering the distance between the nodes and anchors as Equation 2 causes large errors in the localization. To improve the localization error, the nodes are categorized. To this purpose, the nodes whose step number to the anchors of the network is the same are categorized in one category. Algorithm categories between the network nodes have been presented in the following sections.

```
Function Zoning
   Input: Sensor Nodes (S), nodes
  Output: S
         For I =1:1: anchor
           For j=1:1: anchor
              For k=1:1: anchor
                Zone (I, J, K).member (1) =0;
                       w=0;
                      For s =1:1: nodes
                      IF S(s).hop to anchors= (I, J, K)
                          w=w+1;
                   Zone (I, J, K).member (w) =s;
              End.
            End.
          End.
       End.
End.
```

3.4 Estimating the Coordinates

After zoning, the sensor nodes estimate their coordinates based on the number of steps and the step size and anchor coordinates. Considering the distance between the known nodes and unknown node and the known nodes coordinates, bound-finding method can be used to measure unknown node coordinates. The process of triangulation method is as follows. The intersection of three circles with the center of anchor nodes and the distance radius to the sensor node determine the sensor node coordinate.

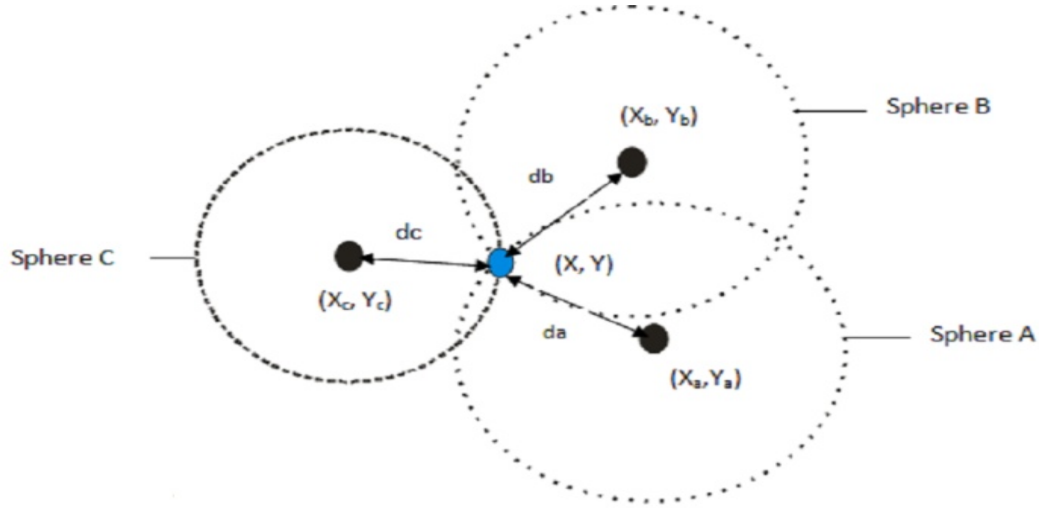


Figure 6. Triangulation localization method

$$\begin{aligned} d_a^2 &= (x - x_a)^2 + (y - y_a)^2 \\ d_b^2 &= (x - x_b)^2 + (y - y_b)^2 \\ d_c^2 &= (x - x_c)^2 + (y - y_c)^2 \end{aligned} \tag{3}$$

$$\begin{aligned} d_a^2 &= x^2 - 2x \cdot x_a + x_a^2 + y^2 - 2y \cdot y_a + y_a^2 \\ d_b^2 &= x^2 - 2x \cdot x_b + x_b^2 + y^2 - 2y \cdot y_b + y_b^2 \\ d_c^2 &= x^2 - 2x \cdot x_c + x_c^2 + y^2 - 2y \cdot y_c + y_c^2 \end{aligned} \tag{4}$$

$$\begin{aligned} d_b^2 - d_c^2 &= 2x \cdot (x_c - x_b) + x_b^2 - x_c^2 + 2y \cdot (y_c - y_b) + y_b^2 - y_c^2 \\ d_b^2 - d_a^2 &= 2x \cdot (x_a - x_b) + x_b^2 - x_a^2 + 2y \cdot (y_a - y_b) + y_b^2 - y_a^2 \end{aligned} \tag{5}$$

$$\begin{aligned} v_a &= \frac{\left(d_b^2 - d_c^2\right) - \left(x_b^2 - x_c^2\right) - \left(y_b^2 - y_c^2\right)}{2} \\ v_b &= \frac{\left(d_b^2 - d_a^2\right) - \left(x_b^2 - x_a^2\right) - \left(y_b^2 - y_a^2\right)}{2} \end{aligned} \tag{6}$$

$$y = \frac{v_b \cdot (x_c - x_b) - v_a \cdot (x_a - x_b)}{(y_a - y_b) \cdot (x_c - x_b) - (y_c - y_b) \cdot (x_a - x_b)}$$
$$x = \frac{v_a - y \cdot (y_c - y_b)}{(x_c - x_b)} \quad (7)$$

X $_a$, x $_b$, x $_c$; x value in each anchor node
Y $_a$, y $_b$, y c; y value in each anchor node
X, Y; non-guide sensor node coordinate
d_a, d_b, d_c ; distance of each anchor node to unknown distance

3.5 Estimation Improvement

In the proposed algorithm, after obtaining the approximate coordinates of all nodes, the category presented in the previous section was used to improve estimated coordinates. The coordinates of a node is determined on the basis of its belonging to respective category. In other words, coordinates of a category are highly similar. Thus, the node coordinates of a category is obtained by Equation 8:

$$Node_i(x, y) = \begin{cases} x = \dfrac{\sum_{k=1}^{n} x_k}{n} \\ y = \dfrac{\sum_{k=1}^{n} y_k}{n} \end{cases} \quad (8)$$

Where n is number of sensor nodes in the node category of $_I$ and x $_k$ and y $_k$, so k node coordinates are in the same category.
Finally, we simulate the three methods separately and compare their localization Performance, including the location error and range error .the location error and range error are defined as follows.

$$Localization\ Error = \sqrt{(x_{real} - x_{est}) + (y_{real} - y_{est})} \quad (9)$$

Where (x_{real}, x_{est}) and (y_{real}, y_{est}) are real coordinates and estimated coordinates, respectively, of a given unknown sensor.

3.6 Energy Consumption Parameters

Energy consumption in wireless sensor networks occurs in several situations. The energy consumed in the sink is not important as it is connected to the urban power or an infinite source, so it is neglected in most research. The main issue is the calculation of energy consumption in each sensor node which has a limited power supply. The energy of each node is usually consumed in three situations: the time of sending / receiving data, the time sensation and the time of processing information. Among these three situations, the energy consumed for processing is negligible when it is compared to two others. Besides, the energy used to sense it can be also neglected. Most of the energy consumption in wireless sensor nodes is a situation in which data is sent or received and energy consumption can be neglected in other situations due to its small amount.

The data should be converted from digital to a valid signal and it is done in the electronic transmission circuit. This signal is then delivered to a booster circuit. As shown in Figure 1, the energy consumption in the electronics circuit is equal to E_{elec} * k and in the amplifier circuit, E_{amp} * k * d2. Here, k indicates the number of bits to be sent, and d denotes the distance that these bits must pass. The signals transmitted by the receiver circuit are returned from the signal to the digital data. The energy consumed for this task is equivalent to E_{elec} * k.

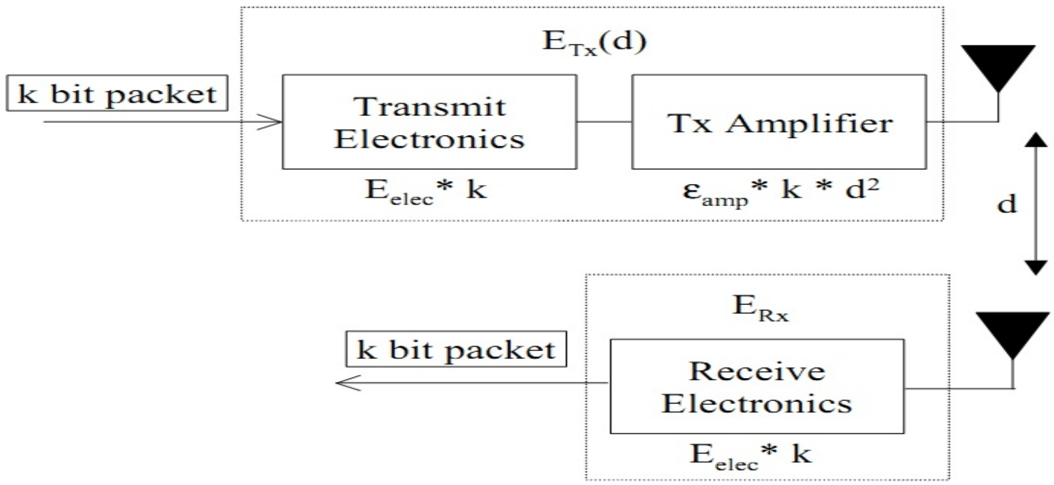


Figure 7. Energy consumption for sending/receiving [18]

In general, the relationship between energy consumption is discussed below. E_{tx} represents energy consumption for k bits up to *d* and E_{rx} is the energy needed to receive *k* bits. If the sent distance exceeds the threshold, more energy is needed to send the data. This threshold is specified by *do*;
here it is do = √ ((E_{fs} / E_{emp})) [18].

$$Etx = \begin{cases} Eelec * k + Emp * k * d^2 & if\ d < do \\ Eelec * k + Efs * k * d^4 & if\ d > do \end{cases} \tag{10}$$

$$Erx = Eelec * k \tag{11}$$

In next section the proposed method is evaluated and compared with EZBLM and DV-hop in different situations.

4. Evaluation

In this section, we examine the proposed method and evaluate the results of simulations. Among the available software, scientific software MATLAB is chosen to debate because the base paper introduced EZBLM method benefits from this software. Therefore, the results obtained will feature more citations. It is necessary to clarify the parameters of the network before the beginning of the simulation. Some of the main parameters among with their values are listed in table 3.

Table3. Simulation parameters

Parameter	Value
Network environment	Flat 2D
Deployment Strategy	Random
Network Length	200 meter
Network Width	200 meter
Number of Sensor Nodes	50
Number of Anchor Nodes	3
Total Number of Nodes	53
Rc	50,60,70 meter

In the next step, the proposed method is examined and it is compared with EZBLM [19] and DV-hop [23] in different situations. Accuracy is very important in localization algorithm to determine the coordinates of the node. Therefore, the localization error in the proposed method must be measured with other methods to determine the accuracy of the proposed method.

Figure 8 shows a situation where the location error is visually seen. In this figure, the red- points show the coordinates of sensor node prediction by the proposed algorithm and the blue circles show the actual coordinates of the sensor nodes. Visually efficiency extraction of the proposed method, is a bit difficult. Therefore we evaluate the proposed method according to the chart. What is important in a location algorithm is the accuracy of knot coordinate determination. Therefore, the location error of the proposed method should be evaluated by other methods to determine the accuracy of the proposed method.

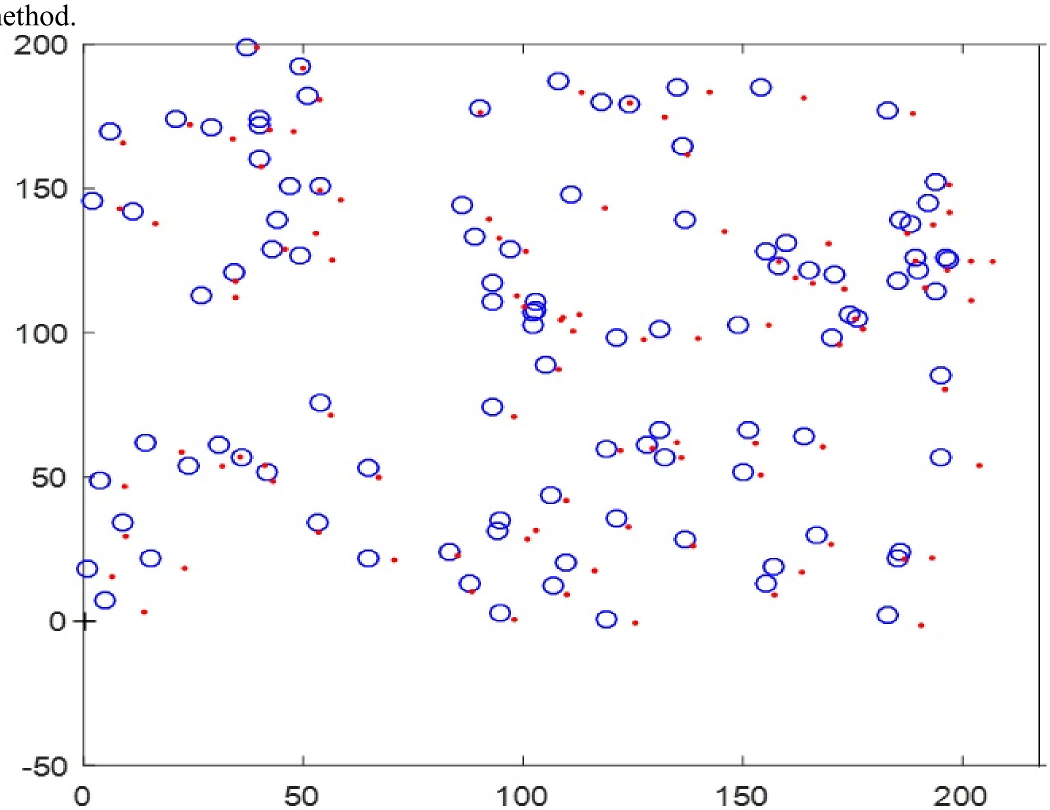
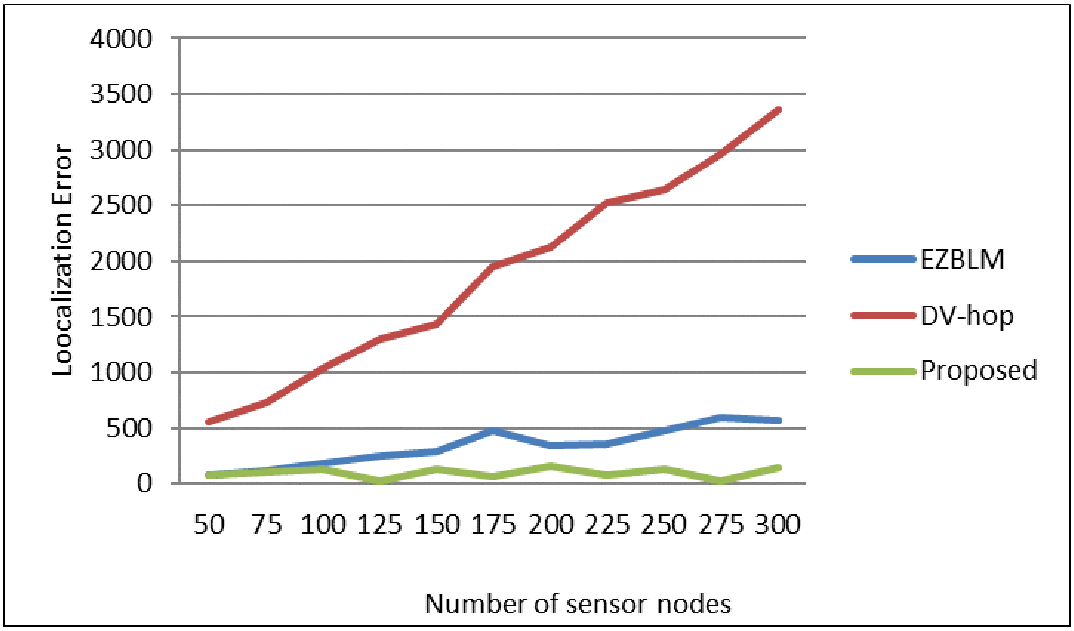


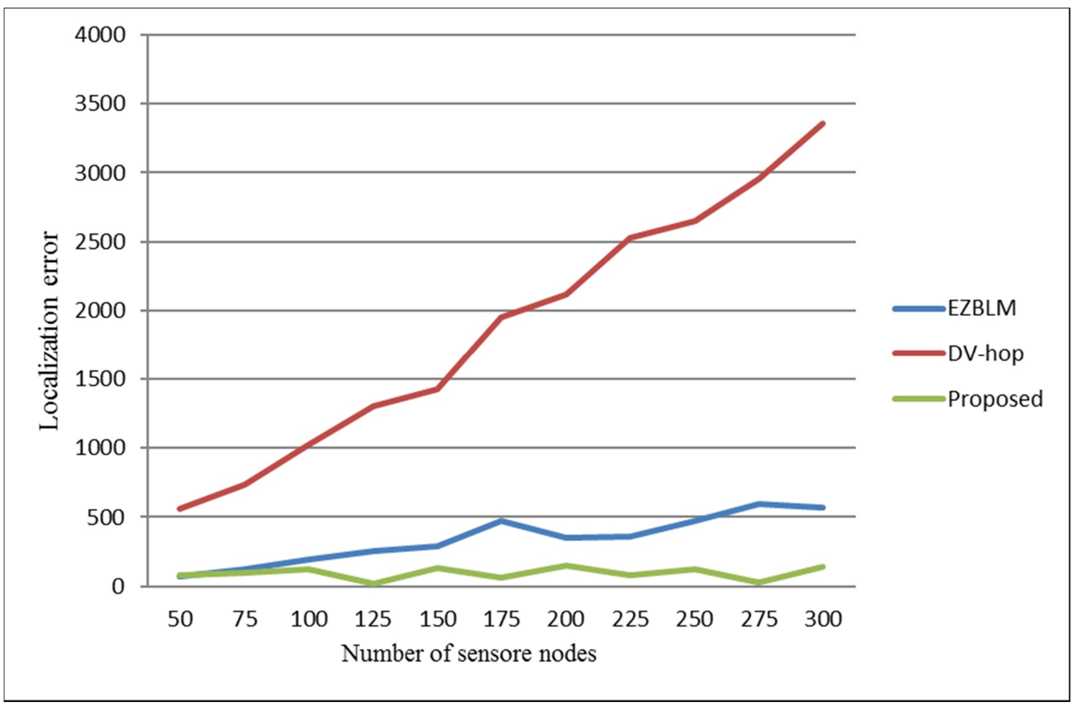
Figure 8. Error locating proposed methods

Figure 9 shows the error rate obtained by EZBLM, DV-Hop methods. The horizontal axis shows the number of different sensor nodes which starts from 50 to 300 respectively. This figure shows three different methods with different nodes and the same arrangement in each distribution. The vertical axis shows the error rate the difference between the actual and estimated coordinates.



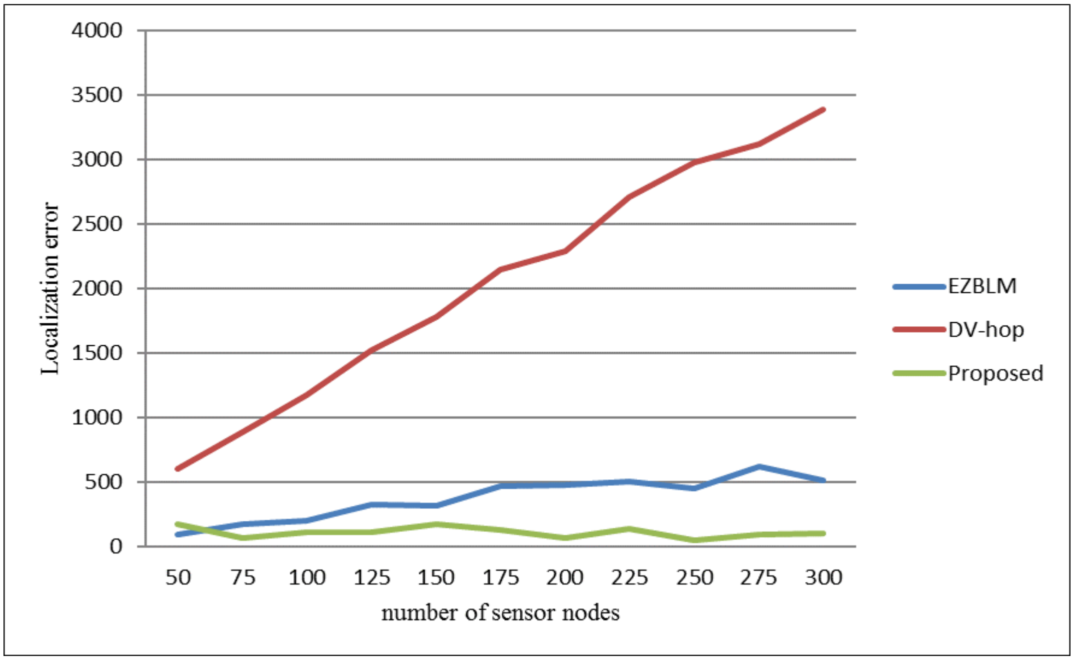
RC=50

Figure 9(a). Error rate in EZBLM, DV-Hop and proposed methods



RC=60

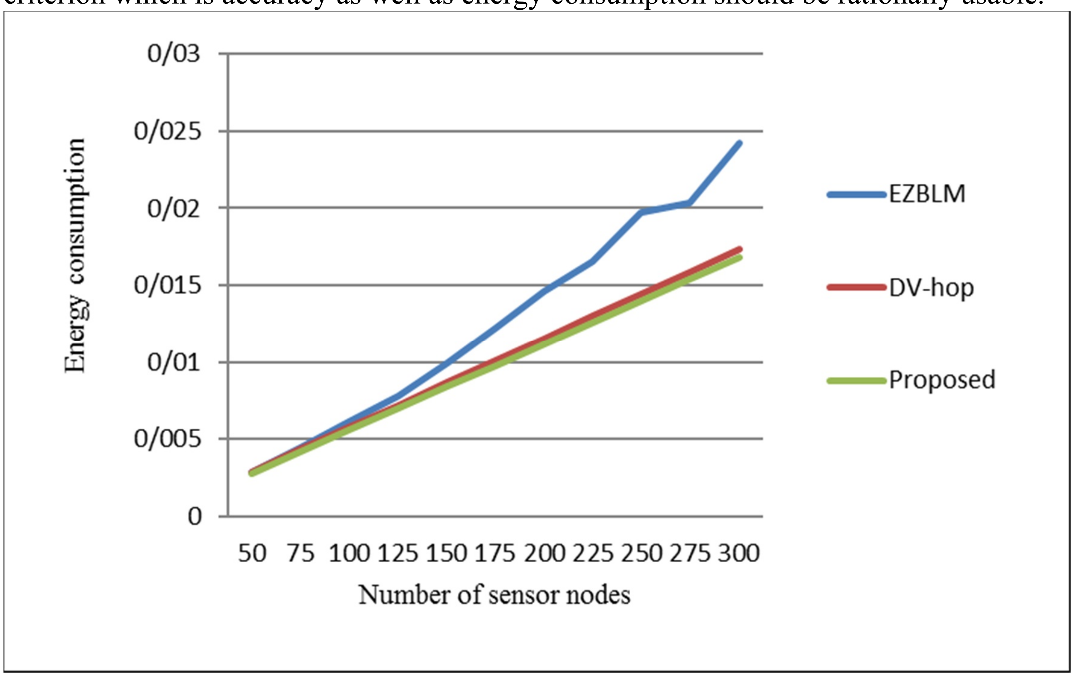
Figure 9(b). Error rate in EZBLM, DV-Hop and proposed methods



RC=70

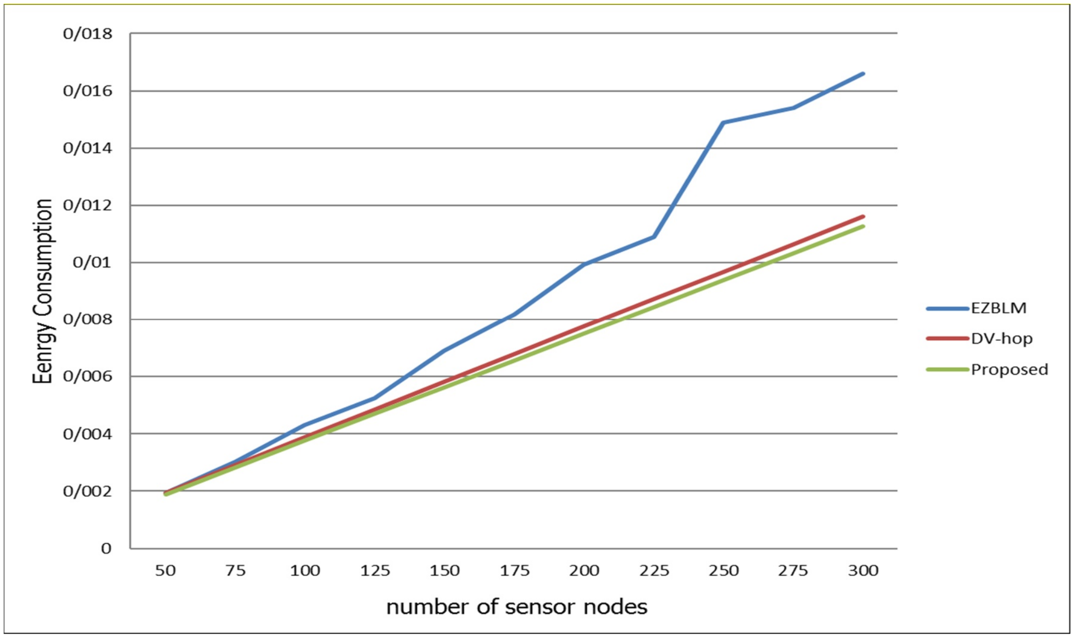
Figure 9(c). Error rate in EZBLM, DV-Hop and proposed methods

As it is shown in Figure 9, the error rate in the proposed method is much lower than that of EZBLM and DV-Hop. As a result, in this method the most important localization criterion which is accuracy as well as energy consumption should be rationally usable.



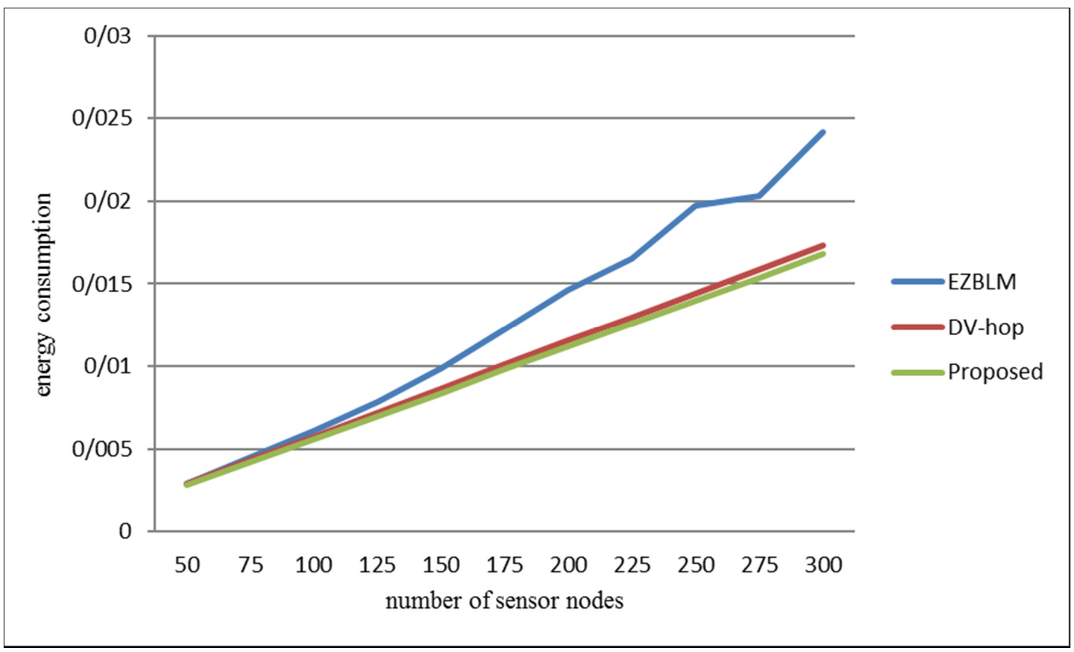
RC=50

Figure 10(a). Energy consumption in EZBLM, DV-Hop and proposed methods



RC=60

Figure 10(b). Energy consumption in EZBLM, DV-Hop and proposed methods



RC=70

Figure 10(c). Energy consumption in EZBLM, DV-Hop and proposed methods

In figure 10 the amount of energy is consumed by Jules for a number of different sensor nodes in proposed, EZBLM and DV-Hop methods. According to figure 10, energy consumption in the proposed method is less than the other two methods. Therefore, in addition to increase in the accuracy, the energy consumption decreased and finally an efficient method is resulted.

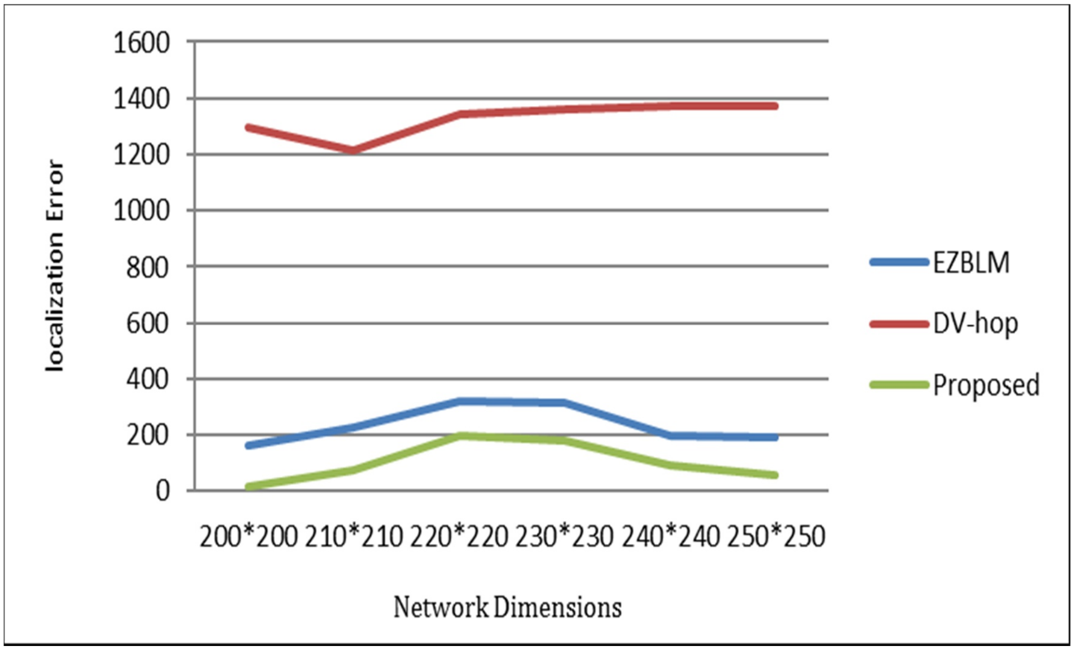


Figure 11. Error rate of localization based on network size

To investigate the effect of network dimensions on efficiency of the proposed method, the transfer domain is measured 60 meters and the network dimensions are regarded 200× 200, 210× 210, 250× 250 meters and the results were examined. Figure 11 shows the error rate obtained by EZBLM, DV-Hop and proposed methods. The horizontal axis shows the network dimensions from 200× 200 to 250× 250 meters. The data of this figure obtained from implementing all three methods with different dimensions of the network with the similar arrangement in each distribution.

As it is shown in figure 11 the error rate in the proposed method is much lower than DV-Hop is EZBLM. As a result, accuracy which is the main criterion in determining the efficiency of localization improved through the proposed method. Regarding the previous scenario, in addition to accuracy, the energy consumption is also evaluated.

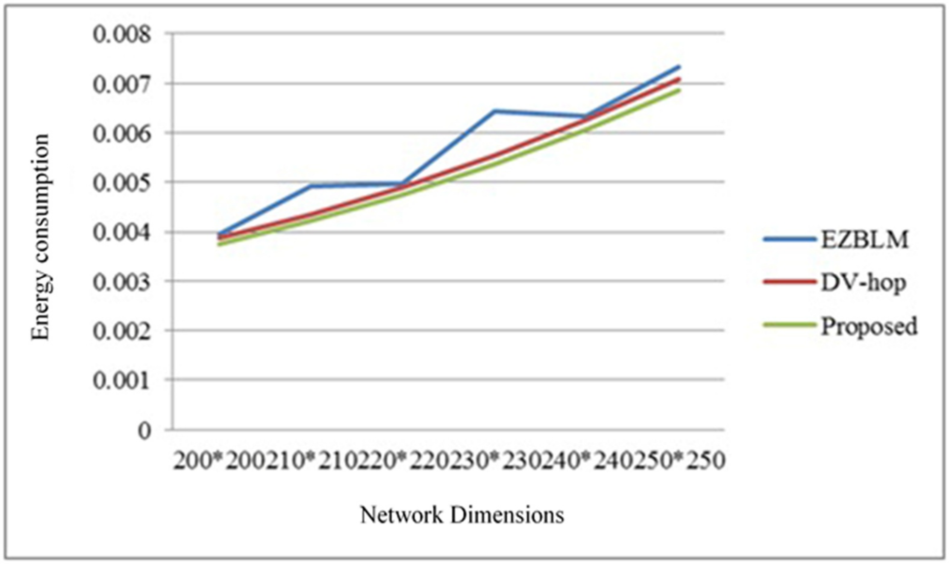


Figure 12. Energy consumption in EZBLM, DV-Hop proposed methods based on network dimensions

In figure 12, the energy consumption is measured by Jules for the number of different sensor nodes in EZBLM and DV-Hop methods. According to figure 12, energy consumption in the proposed method is less than the other two methods. Therefore, in addition to increase in the accuracy, the energy consumption decreased and finally an efficient method is resulted.

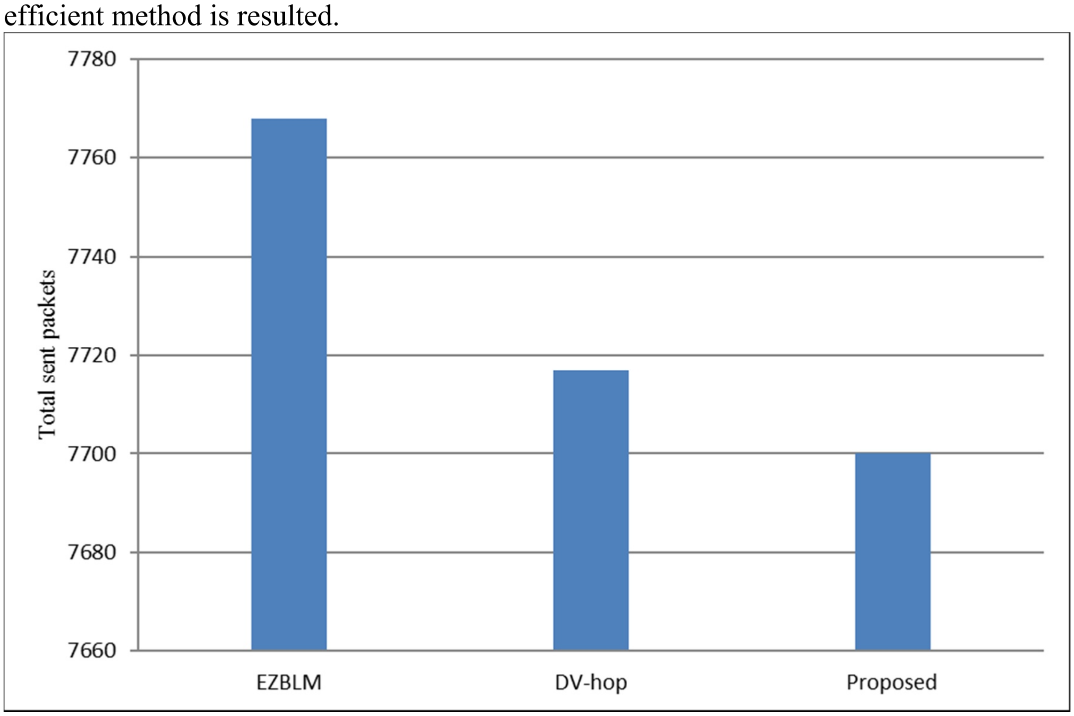


Figure 13. Total sent packets EZBLM, DV-Hop and proposed methods

Energy consumption in the localization process is directly correlated with the number of sent packets to estimate the coordinates of sensor nodes. According to figure 13, total number of sent packets to determine the coordinates of the nodes in the proposed method is less than the other two methods. So it can be said that reducing the number of sent packages improves efficiency of the proposed method. In the end, the amount of energy consumption to send each packet in three EZBLM, DV-hop and the proposed method is measured. To do this purpose, first network parameters are set. The number of sensor nodes is 200, and the network dimension is 200×200 and radius of network at each node is 60 meters. Figure 14 shows the energy consumption to send each packet. The horizontal axis shows the number of sent packages and vertical axis shows energy consumption based on Joule.

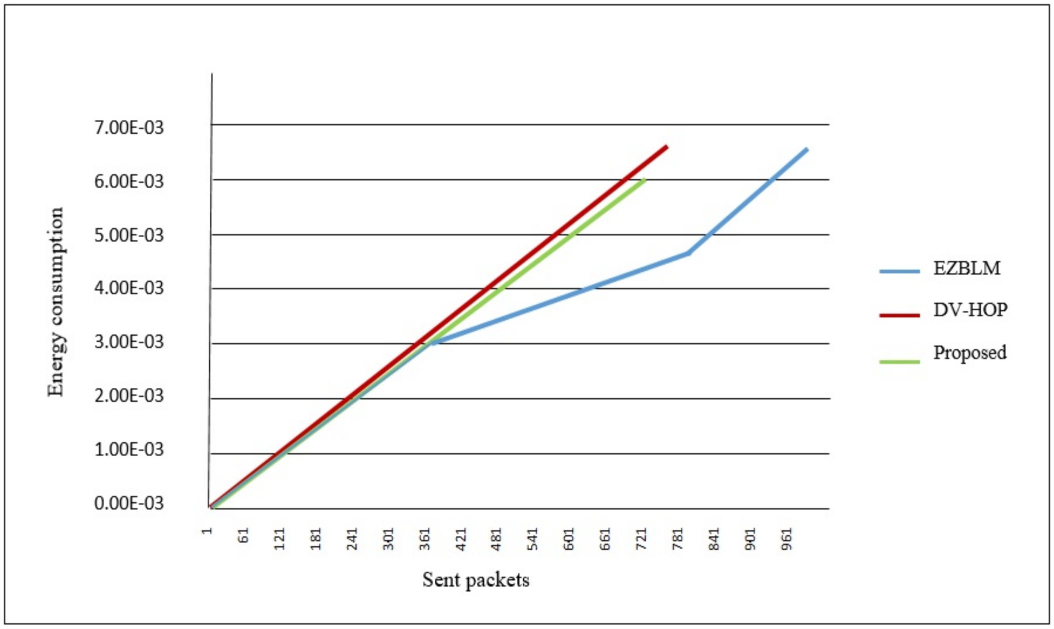


Figure14. Energy consumption for the sent packets

Regarding this figure, the energy consumption in the proposed method is less than the other two methods. EZBLM method sends more packets for the localization which increase energy consumption in sending. Given the difference of Energy consumption in the sent packets of the proposed method and DV-Hop is high due to similar mechanisms in sending packet and step count. But the proposed method consumes less energy when it is compared to DV-Hop.

5. Conclusion

The independent range localization methods have relatively high error rates. The proposed method has been designed to deal with such a problem. In this method, first the anchor nodes send messages in the network and the nodes measure the step count to the anchor node. Then, the sensor nodes with the same step number are placed in one area with the anchor nodes and their coordinates are improved. After examining the simulation results and when they were compared with EZBLM and DV-Hop methods, in terms of efficiency it was determined that this method is significantly better than other two methods. In each scenario, in addition to changing the range of communication, the number of sensor nodes was changed in order to measure effectiveness of the proposed method in different conditions. Another scenario which was mentioned was the network size or dimensions which is effective on localization process and due to its importance a separate scenario was considered for this parameter to be exactly measured. Based on the results it can be concluded that the proposed method showed better results than EZBLM and DV-Hop methods and it localized more accurate. Therefore, if other researchers and scholars tend to follow this project we help them in this section. Clustering structure is a very useful structure in wireless sensor network so it greatly increases network efficiency. In this structure a small percentage of nodes (optimal 5%) were chosen as high cluster and they can interact with the base station. Besides the positive properties of the clustering structure in load balancing, increase in the network lifetime, increase in fault tolerance and etc. can be used to control the localization of the wireless sensor network.

References

[1] S. S. Iyengar, & R. R. Brooks (E.ds). Distributed sensor networks: sensor networking and applications. CRC press. (2016).

[2] J. Zhang, G. Song, G. Qiao, T. Meng, H. Sun, An indoor security system with a jumping robot as the surveillance terminal, IEEE Trans Consume Electron. 57 (4) 1774–1781, November 2011.

[3] R. Ouyang, A. Wong, K. Woo, GPS localization accuracy improvement by fusing terrestrial TOA measurements, in: IEEE International Conference on Communications (ICC), pp. 1–5, May 2010.

[4] P. Kumar, L. Reddy, S. Varma, Distance measurement and error estimation scheme for RSSI based localization in wireless sensor networks, in: Fifth IEEE Conference on Wireless Communication and Sensor Networks (WCSN), Allahabad, India, pp. 1–4, December 2009.

[5] G. Wu, S. Wang, B. Wang, Y. Dong, "Multi-hop distance estimation method based on regulated neighborhood measure", IET Communications, Vol. 6, Issue. 13, PP. 2084-2090, 2012.

[6] P.J. Voltz , D. Hernandez, Maximum likelihood time of arrival estimation for real-time physical location tracking of 802.11a/g mobile stations in indoor environments, in: Position Location and Navigation Symposium (PLANS), California, USA, pp. 585-591, April 2004.

[7] L. Kovavisaruch, K.C. Ho, Alternate source and receiver location estimation using TDOA with receiver position uncertainties, in: IEEE International Conference on Acoustics, Speech, and Signal Processing (ICASSP'05), Pennsylvania, USA, pp. iv/1065–iv/1068, March 2005.

[8] P. Rong, M. Sichitiu, Angle of arrival localization for wireless sensor networks, Ann. IEEE Commune. Soc. Sensor Ad Hoc Commune. Networks374–382, USA (1)(2006).

[9] Z. Li, W. Dehaene, G. Gielen, A 3-tier UWB-based indoor localization system for ultra-low-power sensor networks, IEEE Trans. Wireless Commun.2813–2818. 8 (6) June 2009.

[10] R. Patro, Localization in wireless sensor network with mobile beacons, in: Proceedings of 23rd IEEE Convention of Electrical and Electronics Engineers in Israel, pp. 22–24, September 2004.

[11] L. Doherty, K. Pister, L. Ghaoui, Convex position estimation in wireless sensor networks, in: Proceedings of IEEE INFOCOM '01, Alaska, USA, vol. 3, pp. 1655–1663, April 2001.

[12] D. Niculescu, B. Nath, DV based Positioning in ad hoc networks, J. Telecommun. Syst267–280. 22 (1) (2003).

[13] Yang, X., & Zhang, W. An Improved DV-Hop Localization Algorithm Based on Bat Algorithm. Cybernetics and Information Technologies, 16(1), 89-98 (2016).

[14] Xu, J., & Wang, D. Positioning Study on a Kind Of Improved DV-HOP Algorithm in Wireless Sensor Network. International Journal of Grid and Distributed Computing, 9(8), 87-96 (2016).

[15] J. Lee, W. Chung, E. Kim, I. Hong, Robust DV-hop algorithm for localization in wireless sensor network, in: International Conference on Control Automation and Systems, pp. 2506–2509, (2010).

[16] J. Liu, Z. Wang virtual, "nodes-based range-free APIT localization scheme for WSN, "Springer Science Business Media New York (2015).

[17] Chi-Chang Chen, Chi-Yu Chang, Yan-Nong Li, “A Zone-Based Localization Scheme for Wireless Sensor Networks with Bilateration , " Advances in Intelligent Systems and Applications. SIST, Vol. 20, PP. 511-520, (2013).

[18] Tamandani, Y.K. Bokhari, U. “SEPFL routing protocol based on fuzzy logic control to extend the lifetime and throughput of the wireless sensor network” Wireless Networks, 22(2):647-653(2016).

[19] Kumar, G., & Rai, M. K An energy efficient and optimized load balanced localization method using CDS with one-hop neighborhood and genetic algorithm in WSNs. Journal of Network and Computer Applications, 78, 73-82. (2017).

[20] Mohamad Mohamadi, Hamid Parvin, Es'hagh Faraji, Sajad Parvin," Distributed Agreement Based Ml Approximation" Journal of Advances in Computer Research, (2016).

[21] Hamid Barati, Mohsen Sedighi, Ali Movaghar, Iman Attarzadeh,” Proposing a Novel Algorithm for Fault-Tolerant Relay Node Placement in Wireless Sensor Networks” Journal of Advances in Computer Research , (2013).

[22] Majid Hatamian, Hamid Barati, Ali Movaghar, "A New Greedy Geographical Routing in Wireless Sensor Networks", Journal of Advances in Computer Research, (2014).

[23] Honglong Chena, Wei Louc, Zhi Wang, Junfeng Wu, Zhibo Wang Aihua Xia," Securing DV-Hop localization against wormhole attacks in wireless sensor networks,” Pervasive and Mobile Computing, (2014).