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Comparative Study of Localization Algorithms Performance in Wireless Sensor Networks

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Abstract

In wireless sensor networks, localization is an important problem for applications. In fact, most of applications in the wireless sensor networks require knowledge of the location of all nodes with high accuracy, because these nodes are randomly deployed and autonomously operated. In recent years, several techniques have been proposed to efficiently locate nodes. These techniques can be classified as range-free or range-based. The methods using the technique of the range-based are mainly based on the exact calculation of the distance or angle between two nodes in the network. Thus, the position can be obtained simply by triangulation or trilateration. However, methods using the range-free technique use only the network connectivity information between nodes. Nodes use the positions of the anchors; no measure of distance or angle is used. Therefore, these methods can only provide estimated positions of nodes. In this paper we focus mainly on the comparison of performance of three localization methods that are DV-Hop and Centroid (range-free), and RSSI (range-based). Extensive simulations are conducted and results are reported to shed first more light on their performance according to different parameters, such as density.

Keywords: *Wireless Sensor Networks, Localization techniques, Anchors, Simulations, performance evaluation, Accuracy*

1. Introduction

In the recent years, the use of wireless sensors networks (WSN) is growing in security and surveillance domains. The domains of wireless communication, industries and the technologies "MEMS" (Micro-electro mechanical systems) propose wireless sensors that can inform the user about several data. Indeed, the fault tolerance, the reduced cost, and the fast deployment of sensors networks are characteristics which make them a considerable tool in several fields of application.

The sensors data are shared between the nodes of the network. These sensors can be also bound together to form a wireless network basing itself on protocols and proposing programs and embarked networks.

Similar to many technological developments, wireless sensor networks have emerged from military needs and found its way into civil applications. These applications as the forest fire surveillance, the vehicle follow-up … etc, need to have a geographical information to work effectively. For these applications, an event detected by a sensor is useful only if information relative to its geographical location is supplied. Thus, it is necessary to determine the position for each sensors.

The use of the GPS (Global Positioning System)[1] allows to avoid the problem of the outdoor localization. However, its cost (economic and energy) is a limitation to use it in all network nodes. Some techniques by-pass the problem and propose to use anchors: only some nodes know their precise position and allow other nodes of the network, by triangulation [2] or multilateration [2] to know theirs.

The localization in the wireless sensors networks is one of main problems in this type of networks and numerous are the solutions which were proposed. Among the existing algorithms which were widely used in numerous domains, we find RSSI, DV-HOP and CENTROID.

In this article, we propose a comparison study of localization algorithms performance. These algorithms are: Centroid and DV-Hop of range-free category, and RSSI (Received Signal Strenght Indication) of range-based category.

The rest of this paper is organized as follows. In Section2, related work is presented. Section 3 describes methods considered in this work together with different required parameters. In Section 4, simulation environment and results are presented to show the effectiveness of methods using a variety of working scenarios. Conclusions and future work are given in section 5.

2. Related Work

Several technologies leaning on anchors allow a sensor to measure the distance which separates it from a nearby sensor. Most of the localization techniques proposed for wireless sensors networks can be generally classified in two categories: the methods free measure called (Range-Free) and those based measure (Range-Based) (Figure 1).

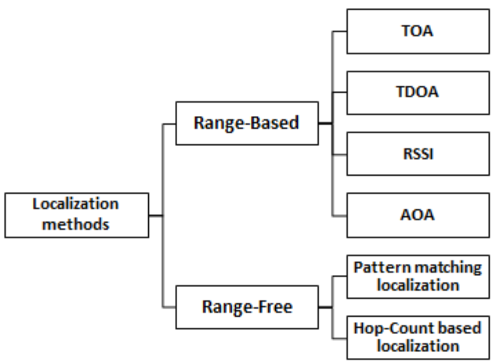

Figure 1 : Localization methods Classification

The principle of the localization algorithms of category "range-based " is to measure the distances or the angles between two nearby sensors (transmitter-receiver).under conditions. Thanks to this capacity of measure, the sensors can obtain their exact positions. Either, an estimated position will be attributed.

The technologies of "range based" category more used are:

Time of Arrival (TOA) supposes that the network nodes are synchronous. The distance which separates two sensors deducts of the speed of propagation of the signal and the difference between the dates of issue and reception of the message. This technology is the one used by the GPS system [3].

Time Difference of Arrival (TDOA) based on the difference of the arrival dates of one or several signals and also supposes that the speed of propagation of the signals is known.

Received Signal Strength Indicator (RSSI) considers the loss of power of a signal between its emission and its reception. This loss varies according to the distance between both sensors.

Angle of Arrival (AOA) calculates the angle between two sensors. Every sensor is endowed with antennas directed so as to deduct the angle which it forms with a neighbor when the latter sends it a signal.

The based methods measures are the most wide-spread. For example, the methods described in [4][5][6][7] use the measures of distances between two nearby sensors and the methods proposed in [8][9][10][11] lean on the angles measures.

In the principle of the "range-free" category, the sensors trying to determine their positions lean only on the positions of anchors by, either, exploiting the information of radio connectivity between the nearby nodes, or by using the capacities of detection which every sensor possesses. No measure of distance or angle is used. Thus, these solutions cannot supply that positions estimated at the sensors.

The methods [12] [13] are examples of methods free of measure. The algorithms of category "Range-Free " have some advantages with regard to those of "Range-Based" category such as the moderate cost, the low energy consumption, the simple and strong material in the noise and the small traffic of communication, and can supply an acceptable precision for the localization. Centroid and DV-HOP are solutions of "Range-free" category.

- **RSSI, DV-hop, and Centroid: An overview**

2.1 RSSI

The RSSI is a technique of localization of "Range-based" category which allows determining the distance between a transmitter and a receiver. This distance is proportional at the loss of power between the sensors (transmitter and receiver).

The power received from a signal can be used as a distance valuer, because all the electromagnetic waves have inverse relation of the square between the received power and the distance [14], as indicated in the expression (0).

The idea behind the received signal (RSS) is that the transmitted power (Pt) configured in the issuing device affects directly the received power (Pr) at reception device.

According to the Friis transmission equation at its simplest form in the free space [15], the power of the detected signal decreases in the square of the distance to the sender.

$$P_r = \frac{P_t G_t G_r \lambda^2}{(4\pi d\ )^2} \qquad (0)$$

Where:

- Pr(d): power available at the input of the receiver
- Pt: output power to the transmitter
- Gt: gain of transmitter
- Gr:gain of receiver
- λ = wavelength
- d: distance between transmitter and receiver

In this model, anchors broadcast a signal to all sensors which can estimate the distance between them and anchors by the power of the received signals.

In the ideal circumstances, the mitigation signal power is proportional at d^2, where d indicates the distance between the transmitter and the receiver.

It is possible to estimate the distance between two nodes by measuring the power of the signal. The radio propagation model collectively accepted is the path loss model [16]:

$$RSSI(d) = RSSI_{ref} - 10n\log\left(\frac{d}{d_{ref}}\right) \qquad (1)$$

Where

- d: distance between transmitter and receiver
- $RSSI_{ref}$: received power at the reference distance d_{ref}
- n: is the path loss exponent. A constant value depending on the transmission medium. N=2 in free space environment, but its value increases if the environment is more complex such as walls, big metallic objects. In environments with many obstacles, an approximation of n is between 3 and 6 [17]

According to equation (1), the method used for camputing the distance "d" is given by equation (2), with RSSIref measured at dref =1m.

$$d = 10^{\frac{RSSI_{ref} - RSSI}{10n}} \qquad (2)$$

The unknown positions of nodes can be considered by trilateration.

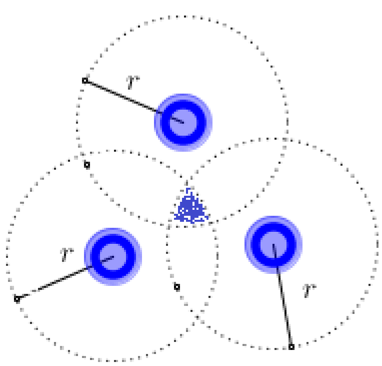

Figure 2 : Signal power

The use of RSSI as a distance valuer leads precision errors because of the fluctuations inherent to the radio channel (interferences, multi-routes, etc.).
Let A_i an anchor situated in (x_i, y_i) and the node M situated in (x, y).
Let us suppose that M reads a distance $\bar{d}i$, whereas the real distance compared with A_i is d_i. We define the error "relative error " concerning A_i as follows:

$$Error_i = \frac{\bar{d_i}}{d_i} - 1$$

2.2 DV-hop

The algorithm of localization DV-hop was proposed by Niculescu and Badri Nath [18]. It is about a solution suited for normal nodes presenting some nearby anchors.

DV-Hop is of category " Range-free ". It is a localization algorithm that estimates the distance by using the information of hop and calculates then the location. This algorithm is simple, practicable and offers a quality of high coverage.

The algorithm consists of following three stages:

Stage # 1: Obtain Minimum Hop Count

At first, every anchor A_i broadcast through the network a message containing its position and a field of hops count initialized by 0. The format of the anchor message is {id, xi, yi, the hop count}. This hop count value will increase with augment of hop during the message broadcast.
Every node M (anchor or normal node) records the position of A_i, and initializes $hop_{i,M}$ as hop count value in the message. $hop_{i,M}$ is the minimum hop count between M and A_i. If the same message is received again, M maintains $hop_{i,M}$. If the received message contains a hop count value wich is lower than $hop_{i,M}$, M will update hop_i with this value and relieve the message. Otherwise, M will ignore the message. Thanks to this mechanism, all the network nodes can obtain the minimum hop count to each anchor.

Stage # 2:

As every anchor received, in the stage n°1, the positions of the other anchors as well as its minimum hop count to other anchors, A_i can calculate its average distance by hop, noted d_{phi}. Once d_{phi} is calculated, it will be broadcasted through the network by A_i.

The Figure 3 presents an example to calculate d_{ph1}, which is the average distance by hop of A_1. After the stage n°1, the anchor A_1 can obtain the positions of A_2 and A_3 indicated by (x_2, y_2) and (x_3, y_3), as well as its minimum hop count of A_2 and A_3 noted $hop_{1,2}$ and $hop_{1,3}$. Then, in the stage n°2, A_1 calculates its distance to A_2 and A_3, noted d_1, d_2 respectively:

$$\sqrt{(x_1 - x_2)^2 + (y_1 - y_2)^2} = d_1$$
$$\sqrt{(x_1 - x_3)^2 + (y_1 - y_3)^2} = d_2$$

The average distance by hop of A_i (d_{ph1}) can be calculated as follows :

$$d_{ph1} = \frac{d_1 + d_2}{hop1,2 + hop1,3}$$

Stage # 3: Calculate the coordinates

The unknown nodes calculate their own coordinates by the distance estimated in the stage n°2. During the reception d_{phi}, the normal node M multiply $hop_{i,M}$ (its hop count to A_i) by d_{phi}, so that M obtains its rough distance of every anchor A_i, noted d_i. $i \in \{1,2, m\}$ if we suppose that there is m anchors. So, the following equation can be diverted, where (x, y) is the estimated position of M:

$$\begin{cases} (x-x_1)^2+(y-y_1)^2=d_1^2 \\ (x-x_2)^2+(y-y_2)^2=d_2^2 \\ \cdots\cdots\cdots \\ (x-x_m)^2+(y-y_m)^2=d_m^2 \end{cases}$$

The equation below has m quadratic equations.

For simplification in calculation, we can transform m equations in linear equations.

The equation can be transformed as:

$$\begin{cases} 2(x_m-x_1)x + 2(y_m-y_1)y = d_1^2 - d_m^2 - x_1^2 + x_m^2 - y_1^2 + y_m^2 \\ 2(x_m-x_2)x + 2(y_m-y_2)y = d_2^2 - d_m^2 - x_2^2 + x_m^2 - y_2^2 + y_m^2 \\ 2(x_{m-1}-x_2)x + 2(y_{m-1}-y_2)y = d_{m-2}^2 - d_m^2 - x_{m-1}^2 + x_m^2 - y_{m-1}^2 + y_m^2 \end{cases}$$

To solve the equation above according to lesser approximations squared, the normal node M can obtain its position considered $M_{DV\text{-}hop}$:

$$M_{DV\text{-}hop}: \begin{bmatrix} x \\ y \end{bmatrix} = (A^T A)^{-1} A^T B \qquad (3)$$

where $A = -2 \times \begin{bmatrix} x_1 - x_m & y_1 - y_m \\ x_2 - x_m & y_2 - y_m \\ \cdots & \cdots \\ x_{m-1} - x_m & y_{m-1} - y_m \end{bmatrix}$

$$B = \begin{bmatrix} d_1^2 - d_m^2 - x_1^2 + x_m^2 - y_1^2 + y_m^2 \\ d_2^2 - d_m^2 - x_2^2 + x_m^2 - y_2^2 + y_m^2 \\ \cdots \\ d_{m-1}^2 - d_m^2 - x_{m-1}^2 + x_m^2 - y_{m-1}^2 + y_m^2 \end{bmatrix}$$

A^T is the transposed of the matrix A, and A^{-1} is its opposite. Anchors cannot be on the same line. Otherwise the equation, A^TA will be singular, thus ($A^TA)^{-1}$ does not exist.

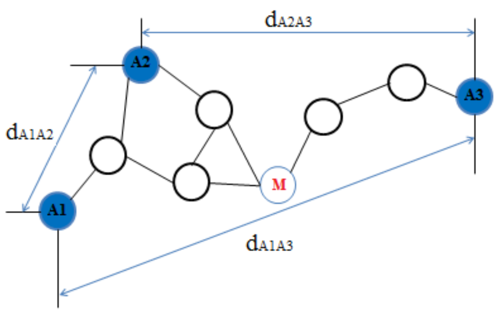

Figure 3 : DV-HOP estimation

$d_{A1A2}=30$
$d_{A1A3}=70$
$d_{A2A3}=40$

In the figure 3, A1, A2, and A3 are anchors. They calculate the average distance of each hop.

A1 : (30+70)/ (2+6)=12,5
A2 : (30+40)/ (2+5)=10
A3 : (40+70)/ (5+6)=11

The node M position can be estimated by calculating distances:

$d_{A1M}=3*10=30m$
$d_{A2M}=2*10=20m$
$d_{A3M}=3*10=30m$

The localization error of each unknown node is meseaured according to the following formulation:

$$Error = \sqrt{(x2 - x1)^2 + (y2 - y1)^2}$$

where (x_1, y_1) are real node M coordinates, and (x_2,y_2) the estimated coordinates

An other precision variable (Accuracy) is used to describe the positioning efficiency.

The precision is gived by : $Accuracy = Error1/R$
where Error1 represents the average error value, and R the communication radius which has to be the same for every node.

2.3 Centroid

Algorithm Centroid is proposed at first by Bulusu [19]. The method Centroid is the most used method in the localization algorithms. It is a question of considering the barycenter point (center of gravity, either center of inertia or center of mass) of the anchor nearby as the estimated position of the normal node.

In [19], a simple radio wave propagation model was chosen, what corresponds to the outside environment.
The scenario is illustrated in the Figure 4. In network, we consider that there are m anchors situated at known positions A_1 (x_1, y_1), A_2 (x_2, y_2)... A_m (x_m, y_m). All these anchors have the same communication radius R. Inside the intersections, is located the normal node M. It means that all these anchors A_i are the nearby anchors of M.

During a fixed time t, the normal node M, which is attuned to the channel, gathers all the sensors signals of different anchor. Although every anchor A_i sent (i, t) signals of M_{sent}, because of the interference of radio waves propagation, the normal node can receive signals $M_{recv}(i,t)$ of A_i (Note that $M_{recv(i,t)} \leq M_{sent(i,t)}$)

To know if a an anchor is inside the radio coverage area of the normal node, the metric connectivity for every anchor A_i, noted CM_i was defined as follows:

$$CM_i = \frac{M_{recv}(i,t)}{M_{sent}(i,t)}$$

We also defined a threshold for CM_i, noted CM_{thresh}

Finally let us suppose that M can have m anchors of which the CM_i is bigger than CM_{thresh}. These m anchors are A_1 (x_1, y_1), A_2 (x_2, y_2)... A_m (x_m, y_m). Then M is located in the center of gravity of these m anchors:

$$\begin{cases} x_{center} = \frac{(x_1+x_2+\cdots+x_m)}{m} \\ y_{center} = \frac{(y_1+y_2+\cdots+y_m)}{m} \end{cases} \quad (4)$$

The procedure of Centroid algorithm is presented as follows:

CENTROID Algorithm:

During the time t, the normal node M obtains the positions of m anchors (A_1, A_2, …, A_m).
The position of A_i is (x_i, y_i).
$x_{center} \leftarrow 0$; $y_{center} \leftarrow 0$;
for i←1 to m do
$x_{center} \leftarrow (x_{center}+x_i)$; $y_{center} \leftarrow (y_{center} + y_i)$
$x_{center} \leftarrow x_{center}/m$; $y_{center} \leftarrow y_{center}/m$
Result : x_{center} and y_{center}

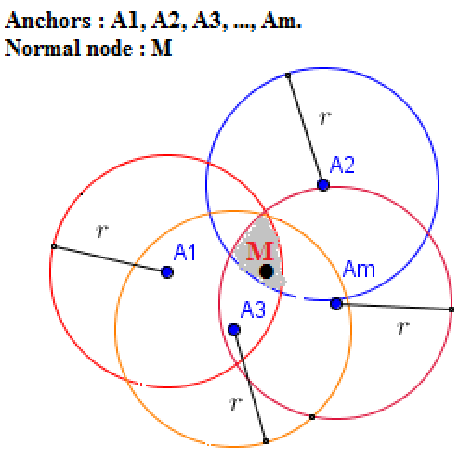

Figure 4 : Example for Centroid localization

3. Evaluation Study

To estimate and compare the concerned localization algorithms performance, we realized simulations by using the mathematical simulation tool: MATLAB. So, the simulations presented in this section have ideal scenarios: radio ideal propagation without path loss and of no nodes mobility , and none datagram collisions. We estimated, then, the algorithms RSSI, Centroid and DV-HOP.

These simulations allow us, for every algorithm, to determine the localization precision, so the nodes average localization error. We opted for scenarios making vary the anchors number and the sensors number.

In this section, several scenarios will be applied to study the algorithms performance. The parameters of all these scenarios are represented in the Table 1 below. Most of the parameters are shared by these scenarios, and other parameters (marked by "*") vary according to each scenario.

In Table 1, the transmission radius R is 40, and the sensors are distributed in an area 100m×100m. During each simulation, nodes are randomly distributed inside the zone. It means that, in a specific scenario, the nodes positions in a simulation will be different from those of another simulation.

Table 1 : Simulation parameters

Scenario Parameters	**Values**
Node Radio Range	40
Simulation Area	100m × 100m
Radio Propagation	Ideal,no pathloss,nointerference
* Number of sonsors “n”	to be decided in specific scenario
* Number of Anchors “m”	to be decided in specific scenario

After, we are going to present every scenario with the simulation results corresponding for the algorithms (RSSI, Centroid, and DV-HOP).

3.1 Scenario 1

The parameters of the first scenario were already represented in Table 1. We give the values of these particular parameters (marked by "*"): The total number of sensors is "n=50", and the anchors number "m" is varied from 10 to 40.

The figure 5 represents a random distribution of nodes for three algorithms DV-HOP, CENTROID, RSSI. In this example, 10 of 50 are anchors and the others are normal nodes.

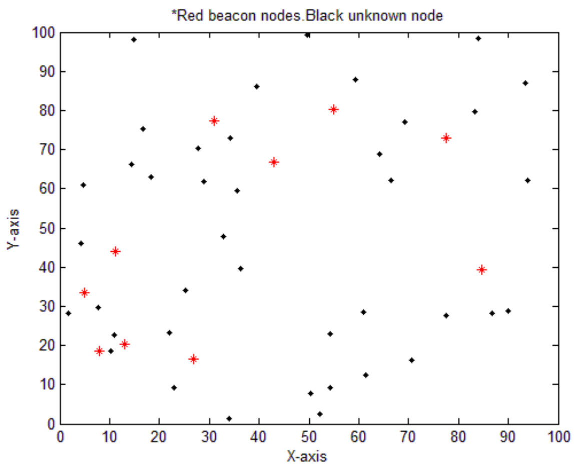

Figure 5 : Random distribution for algorithms (RSSI, CENTROID, DV-HOP) (nb_anchors=10)

Let us suppose that normal nodes communicated with anchors and know their positions. Then, according to the equations (1), (3) and (4), the normal nodes can calculate its positions considered respectively by the algorithms RSSI, DV-HOP, and CENTROID. The precision of these algorithms is quantified by the metric " localization error". The error is the distance between the estimated position and the real position. Always, lower localization error indicates a better precision. The simulation results are presented in figure 6.

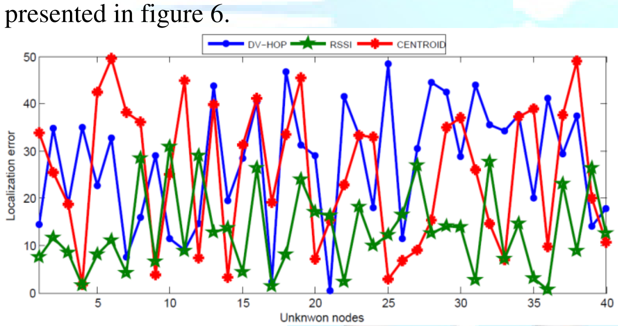

Figure 6 : Localization error per each unknown node (10 anchors)

The simulation results show that the algorithm RSSI has a better precision than DV-HOP and Centroid. After, we are going to increase the number of anchors neighbors. The results below are obtained for a number of anchors varying from 10 to 40. The Table 2 represents, for each scenario, the number of anchors, the average localization error and the precision.

Table 2 : Average location error vs Accuracy

Anchors Nodes	**Algorithms**					
	RSSI		**CENTROID**		**DV-HOP**	
	***Avg. L.E**	****Acc.**	**Avg.L. E**	**Acc.**	**Avg.L. E**	**Acc.**
10	13.358	0.334	25.237	0.630	27.476	0.686
20	11.826	0.295	29.619	0.740	27.928	0.698
30	11.397	0.284	28.958	0.724	30.801	0.770
40	12.084	0.302	27.316	0.682	30.426	0.760

*Average location error
**Accuracy

For the scenario 2, the particular parameters values (marked by "*" in Table 1) are the following ones: the total number of sensors is "n=75", and number anchors nearby "m" is varied from 10 to 70. The figure 7 represents a random distribution of nodes for three algorithms DV-HOP, CENTROID, RSSI. In this example 10 of 75 are anchors and the others are normal nodes.

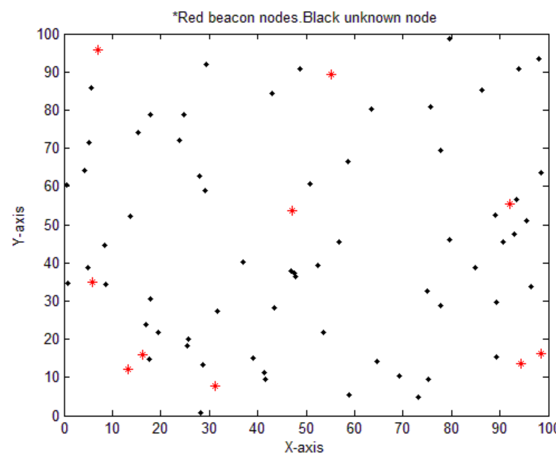

Figure 7 : Random distribution for the algorithms (RSSI, CENTROID, DV-HOP) (nb_anchors=10)

3.2 Scenario 2

The simulation results for scenario 2 are represented in figure 8:

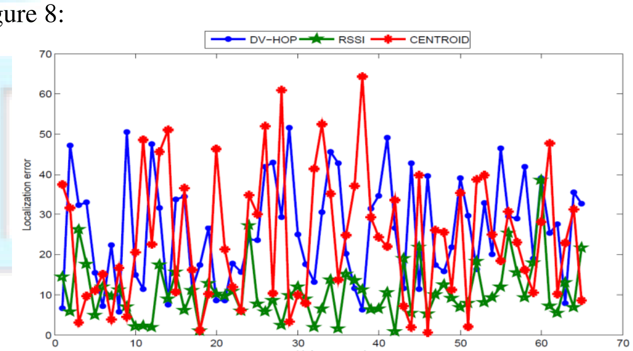

Figure 8 : Localization error per each unknown node (10 anchors)

By comparing the scenarios 1 and 2, we obtain the analysis and the following conclusions:

- The total nodes number has an influence on the localization algorithms performances. The regular distribution of nodes can lead to a better localization precision, even with less anchors.

- Normally, when a node has several nearby anchors, its estimated position can be more precise, so the localization algorithms can have better performances. However, when we compare results in Table 1, and Table 2, we can notice that: although the scenario 2 has several nodes neighbours that the scenario 1, the performance of the algorithms in the scenario 2 is not rather good that that in the scenario 1. The reason results of the anchors distribution.

-The algorithm RSSI always has the best precision. However, we shall also have to notice that, the algorithm DV-HOP has a better precision

Table 3 : Average location error vs Accuracy

Anchos Nodes	Algorithms					
	RSSI		CENTROID		DV-HOP	
	*Avg.L.E	**Acc.	Avg.L.E	Acc.	Avg.L.E	Acc.
10	10.739	0.268	24.136	0.603	26.247	0.656
20	12.216	0.305	27.715	0.692	28.816	0.720
30	7.562	0.189	26.737	0.668	31.712	0.792
40	7.352	0.183	24.400	0.610	32.7283	0.818
50	8.994	0.224	25.405	0.635	33.9136	0.847
60	5.4825	0.1371	25.517	0.637	33.9423	0.848
70	3.385	0.084	36.439	0.911	28.8852	0.722

*Average location error
**Accuracy

3.3 Scenario 3

In the scenario 3, the total number of sensors is "n=100" , and the nearby anchors number "m" is varied from 10 to 90. The figure 9 represents a random distribution of nodes for three algorithms DV-HOP, CENTROID, RSSI. In this example, 10 of 100 are anchors and the others are normal nodes.

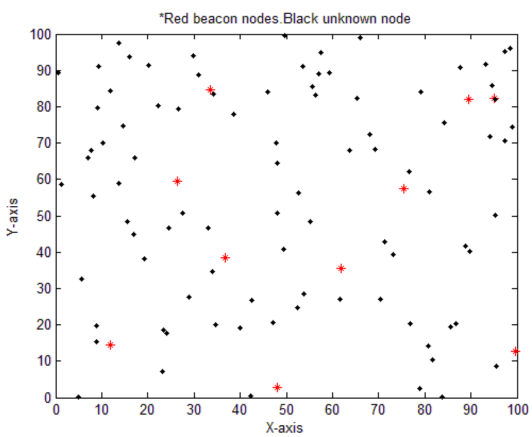

Figure 9 : Random distribution for algorithms (RSSI, CENTROID, DV-HOP) (nb_anchors=10)

The simulation results are presented in figure 10

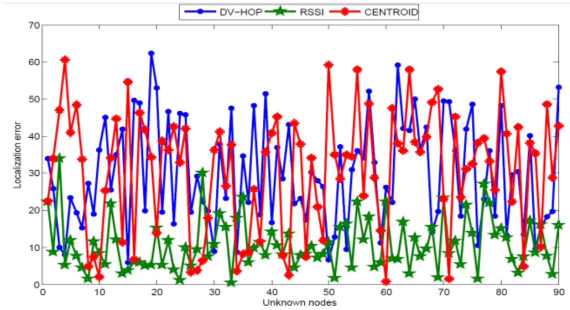

Figure 10 : Localization error per each unknown node (10 anchors)

By comparing results in Table 3 and Table 4, we can notice that: when we change the number of sensors, algorithm with the best precision can also change. In the scenario 3, the best algorithm is RSSI, whereas CENTROID has less precision. Consequently, by a particular case like the three scenarios above, we cannot determine the best algorithm. So, instead of a single simulation, we shall have to produce a large number of random simulations, so that many results can be obtained. We are going to have a global vision on the performance of the algorithms.

Table 4 : Average location error vs Accuracy

Anchors Nodes	Algorithms					
	RSSI		CENTROID		DV-HOP	
	*Avg.L.E	**Acc.	Avg.L.E	Acc.	Avg.L.E	Acc.
10	10.828	0.270	30.573	0.764	29.804	0.745
20	9.462	0.236	27.627	0.690	29.857	0.746
30	8.226	0.205	27.652	0.691	32.588	0.814
40	7.489	0.187	26.416	0.660	33.516	0.837
50	8.462	0.211	22.765	0.569	34.212	0.855
60	4.915	0.122	26.511	0.662	34.255	0.856
70	5.148	0.128	24.009	0.600	33.677	0.841
80	6.525	0.163	24.650	0.616	32.812	0.820
90	4.989	0.124	28.796	0.719	31.306	0.782

*Average location error
**Accuracy

3.4 Scenario 4

For more results, in this scenario, parameters are:

The total nodes number n=125 and the anchors number m is varied from 10 to 120.

The figure 10 presents a random node distribution for three algorithms DV-HOP, CENTROID, RSSI. In this example, 10 of 125 are anchors and the others are normal nodes.

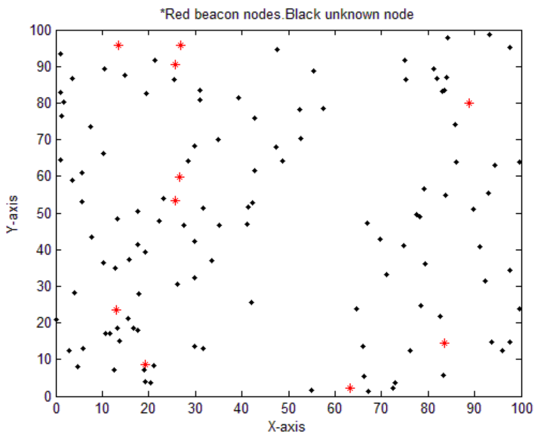

Figure 11 : Random distribution for the algorithms (RSSI, CENTROID, DV-HOP) (nb_anchors=10)

The simulations results are as follows:

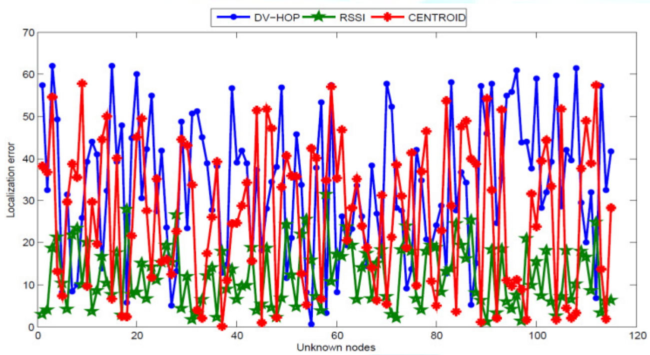

Figure 12 : Localization error per each unknown node (10 anchors)

For these three algorithms, the localization error, the average value of localization errors and the precision can be obtained as the previous three scenarios. The results of simulation are represented in the Table 5.

So that, we can have a clear view on the algorithms performance. According to the results, we can conclude:

- Algorithm RSSI is more precise than DV-HOP and Centroid.

- When the number of sensors is increased, it is obvious that RSSI has an important precision. But, in the case of several anchors, additional information is available for the normal node. Thus the algorithms as DV-HOP and Centroid can supply relatively a good precision.

Table 5 : Average location error vs Accuracy

Anchors Nodes	**Algorithms**					
	RSSI		**CENTROID**		**DV-HOP**	
	***Avg.L .E**	****Acc.**	**Avg.L.E**	**Acc.**	**Avg.L.E**	**Acc.**
10	12.197	0.304	26.747	0.668	33.838	0.846
20	10.039	0.251	28.285	0.707	31.825	0.795
30	11.800	0.295	26.280	0.657	30.964	0.774
40	7.587	0.189	26.974	0.674	31.264	0.781
50	7.272	0.181	27.674	0.691	34.812	0.870
60	7.384	0.184	23.435	0.585	34.640	0.866
70	7.735	0.193	28.864	0.721	32.126	0.803
80	7.226	0.180	24.601	0.615	33.491	0.837
90	6.125	0.153	28.662	0.716	33.152	0.828
100	6.906	0.172	30.014	0.750	33.193	0.829
110	5.851	0.146	26.669	0.666	34.416	0.860
120	4.283	0.107	22.225	0.555	27.889	0.697

*Average location error
**Accuracy

4. Conclusions and Future Work

In this paper, we quantitatively compared and characterized the performance of three localisation methods. Simulations have been conducted to compare main performance metrics such as error, precision. We investigated the effects of anchors density and the total number of sensors. The obtained results show that the number of anchors and the total number of sensors have a direct effect on the performance. In these results, the RSSI outperforms the others, but RSSI is not a good candidate to estimate the distance in sensor networks because RSSI localization in indoor environments presents severe limitations, also the presence of obstacles would further aggravate the situation and energy consumption. The Centroid algorithm is given a better accuracy when the normal node has three points anchors neighbors. The algorithm finds the center of gravity of the nodes and considers this center as the estimated normal node position. However, it is difficult to use the Centroid algorithm in the case where the nodes have less than three neighboring nodes. Therefore, necessarily the normal nodes need to use the DV- hop algorithm for localization.

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