# Performance Improvement for Wireless Sensor Networks

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**Abstract**
In this paper, we prove that our proposed localization algorithm named Improved Accuracy Distribution localization for wireless sensor networks (IADLoc) [1] is the best when it is compared with the other localization algorithms by introducing many cases of studies. The IADLoc is used to minimize the error rate of localization without any additional cost and minimum energy consumption and also decentralized implementation. The IADLoc is a range free and also range based localization algorithm that uses both type of antenna (directional and omni-directional) it allows sensors to determine their location based on the region of intersection (ROI) when the beacon nodes send the information to the sink node and the latter sends this information to the sensors by relying on the antenna. It performance was compared with previous algorithms HiRLoc, PTA and RAL in terms of the number of sensors, average localization error and execution time

**Keywords**: ocalization algorithms, IADLoc, PTA and RAI, antenna, wireless sensor network, beacon nodes

# تحسين الأداء في شبكات الاستشعار اللاسلكية

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**الخلاصة**
في هذه البحث برهنا أن خوارزمية التوطين المقترحة والمسماة تحسين توطين دقة التوزيع لشبكات الاستشعار اللاسلكية (IADLoc) [1] هي الأفضل عند مقارنتها مع خوارزميات التوطين الآخرى من خلال إدخال العديد من حالات الدراسة. يتم استخدام IADLoc لتقليل نسبة الخطأ دون أي تكلفة إضافية واستهلاك الطاقة ضمن الحد الأدنى، وكذلك تنفيذ اللامركزية. خوارزمية IADLoc نستخدم نوعي الهوائي اتجاهي ومتعددة الاتجاهات كما أنها تسمح أجهزة الاستشعار لتحديد مواقعها استنادا إلى منطقة التقاطع (ROI) عندما ترسل العقد منارة المعلومات إلى عقدة وهذا الأخير يرسل هذه المعلومات إلى أجهزة الاستشعار من خلال الاعتماد على الهوائي مقارنة الأداء تم نسبة الى الخوارزميات السابقة RAL، PTA و HiRLoc نسبة الى عدد أجهزة الاستشعار، ومتوسط الخطأ التقريب ووقت التنفيذ.

## Introduction:

A wireless sensor networks localization simulator v1.1 (WSN), [2], which is a network, composed of a large number of sensor nodes that are deployed in the monitoring field. Localization is one of technologies in WSNs used as estimating the position or coordinates of sensor nodes and sink nodes which also called (locator or anchor) and beacon nodes [3]. Localization system is for not only use to

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estimating wireless sensor, but also is used as the basis for routing, density control, and tracking [4]. Localization (Loc) in WSNs is the operation that is used to determine the physical coordinates for a set of sensor nodes in WSNs. There are two types of localization algorithm: range based algorithm that requires hardware, so it is expensive, and the rang free algorithm, which is used to reduce hardware cost.

According to nodes, they can be classified to sink nodes, beacon nodes and sensor nodes. Sink nodes are used to receipt information from beacon and send to sensors, beacon sends information to sink nodes, while and sensor nodes is used to monitor and record the information about a target in the monitoring area. This paper discusses the IADLoc algorithm used in the deployment of sensors with high accuracy in simulation and low error and used both types of (direction and omni-directional) and execution time to be compared with other localization algorithms: applied high-resolution robust localization (HiRLoc), power tuning anchors (PTA) and restricted area-based localization algorithm (RAL).

**Background:**

The high-resolution robust localization is range free localization algorithm depends on region of intersection ($ROI$) there are two version of this algorithm: 1st version is HiRLoc-1, it is used to compute the intersection of all sector areas; the 2nd version is HiRLoc-2 , it is used to compute the sector intersection at each transmission round depended on region of intersection ($ROI$)[5].

The function of Power Tuning Anchors (PTA) algorithm for mobile WSNs with omni-directional antenna, depends on all intersection antenna signals and increases the power level of anchors (sinks) until the mobile sensor localizes its position with minimum received power levels transmitted by the neighbouring anchors (sinks)[6].

Restricted-area-based localization algorithm (RAL) is used to provide a lower estimation error and is used with Omni-directional antenna. Each sinks in RAL can transmit beacon signals at different power levels of antenna. The RAL is divided into two ways the first is restricted-area-based I that is used for intersection of circle of all sinks heard by unknown node (sensors unknown location). The second is restricted-area-based II is used for using all vertical bisectors of the line which connects each pair of sinks nodes to restricted-area-based I. Both are used to calculate the intersection points and average of estimation error of unknown nodes (sensors with unknown location) [7].

**Improved accuracy distribution localization (IADLoc) algorithm**

This algorithm - which was described in details in [1]-is the integration of the three other algorithms; at first restricted area-based localization algorithm [7], which is free range and omni-directional antenna, the function of this algorithm utilizes all the perpendicular bisectors of the line, which connects each pair of sink nodes and give the coordinates for sensor nodes. The second algorithm is power-tuning anchors [6] for mobile sensor is free range and omni-directional antenna; the function of this algorithm localizes the position of sensors on the received power levels transmitted by the neighboring sink nodes. That all the sinks can be able to their transmission power and transmit beacon signals at different power levels starting from maximum to minimum received by sensors. The third algorithm high-resolution robust localization [5] that is free range and directional antenna, the function of this algorithm sensor determines their location based on the intersection of the areas covered by the beacons transmitted by reference points.

The IADLoc algorithm depends on $ROI$, where the intersections between the signals of sink nodes and depended at the same sensor and same communication that's where $SN_1, SN_2$ are sink nodes both send their own signal by using antenna in the same area where there are sensors $s$ and the receipt of information for tracking and monitoring the target in the $ROI$. In IADLoc each sensor in the area determines their location (sensors do not interact to determine their location) based at the beacon information transmitted by sink nodes with high accuracy. Each sink transmits beacon information by using an antenna and beacon containing the sink coordinates and angle of the antenna boundary line with respect to a common global axis. An example is shown in figure 1 where $SN_1$ is intersected with $SN_2$ through the same sensors $s$, where the beacon node send the information to the sink nodes after that the sensors $s$ received and send the information to the $SN_1, SN_2$ while the $R$ is region communication for the sink nodes.

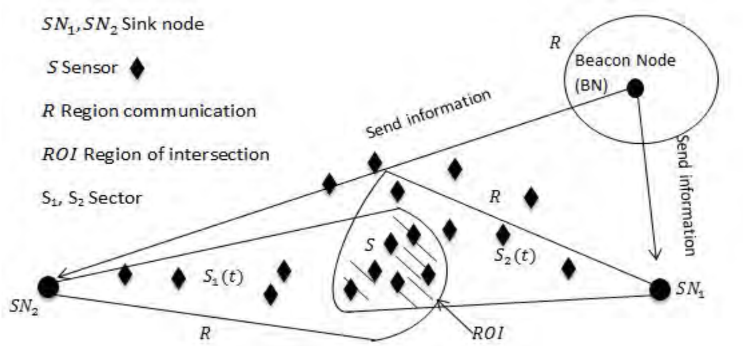



**Figure 1-** Sink1 intersections with sink2 at same sensor and communication using directional antennas

In network deployment, we have aset of sensors $S$ without knowning location and randomly distributed with density $P_S$ in the area $A$. Also assume nodes know the location and orientation called sinks randomly distributed with density$P_{SN}$,$P_S \gg P_{SN}$. To distributed random of sink nodes with density $P_{SN} = \frac{|SN|}{A}$ can be modeled as a spatial homogeneous Poisson point process. Sensors $S$ distributed random can be as modeled as random sampling of the area with density$P_S = \frac{|S|}{A}$. The $SNH_s$ denoted to the sink node heard by sensors $S$ with range $R$ and distributed sensors $S$ hears exactly $SN$ sinks to given by the Poisson distribution by equation (1)

$$P(|SNH_s| = SN) = \frac{(P_{SN}\pi R^2)^2}{SN!} e^-(P_{SN}\pi R^2)^2 \quad (1)$$

From using equation (1), used to compute the probability for every sensor $S$ hears at least $SN$ sinks. The random distributed sensor node in the number of sink nodes heard after received the information from beacon nodes by each sensor:

$$P(|SNH_s| \geq SN, \forall_s \in N) = P(|SNH_s| \geq SN)^{|N|} \quad (2)$$

$$P(|SNH_s| \geq SN, \forall_s \in N) = (1 - P(|SNH_s| \geq SN)^{|N|} \quad (3)$$

$$P(|SNH_s| \geq SN, \forall_s \in N) = (1 - \sum_{i=0}^{K-1} \frac{(P_{SN}\pi R^2)^2}{SN!} e^-(P_{SN}\pi R^2)^{|N|} \quad (4)$$

The sensors $s$ collects information coming from the sinks with it coordinates $(x_s, y_s)$ and the coordinates for all sinks $(X_i, Y_i)$ with radius $R_i$ centered at $(x_s, y_s)$.

$SNH_s = \{SN_i: \|s - SN_i\| \leq R_i(1)\}$

Where

$$i = 1 \ldots |SN| \quad (5)$$

The sensors $s$ deployment randomly in the area and search its place by finding sinks heard coordinates where $X_{min}, Y_{min}$ it is minimum coordinates and $X_{max}, Y_{max}$ it is maximum coordinates. To distribute sensor nodes (static or mobile) in boundary the area where $X_{max} - R_i$ is the sensors distributed right vertical boundary, $X_{min} + R_i$ is the sensors distributed left vertical boundary, $Y_{max} - R_i$ and $Y_{min} + R_i$ is the sensors distributed left horizontal boundary. To deploy beacon nodes (BN) randomly and send information by victor $\rightarrow$ to sink

$$BN = BN' + \sum_{i=1}^{m} \overrightarrow{AiBi} \quad (6)$$

Where$BN'$' the initial estimate location of the sensor node $S$ and $\overrightarrow{AiBi}$ is a vector.

**Performance evaluation:**

In the WSNs localization simulator v1.1, the sink nodes are deploy with coordinates and antennas and are fixed place. The strategy for sink node deployment is four axes, first the grid is randomly deployed, second the grid is with 8 sinks, third the grid is with 6 sinks, fourth the grid is with 5 sink and the number of sink nodes are intersected from 2 to 8 sinks with type of antenna (directional or omni-directional) and it's radio rage is with 250 m and beam width 45°. Table 1 shows the summarized WSNs localization simulator's parameters.

**Table 1-** Parameters of WSNs localization simulator v1.1

| ***Parameter*** | ***Value*** |
|---|---|
| **Sensor filed** | 500m x 500m |
| **Number of sink node** | 8 or 6 or 5 |
| **Sink radio range** | 250 m |
| **Sink beam width** | 45° |
| **Number of beacon nodes** | 50 |
| **beacon radio range** | 40 m |
| **Sensors node** | 200 |

After implementation of the IADLoc algorithm, a comparison between other algorithm occured, i.e HiRLoc algorithm and PTA algorithm and RAL algorithm. Four cases of studies are explored for the comparison; first case of study represented impact of sink radius on the localization error, second case of study investigated the effect of changing the number of the used beacons on the localization error, third case of study deployed the number of sensors and fourth case of study focused on the execution time.

Figure 2 shows the resultant of the comparison between IADLoc algorithm with directional antenna and HiRLoc algorithm uses static motion of sensors.

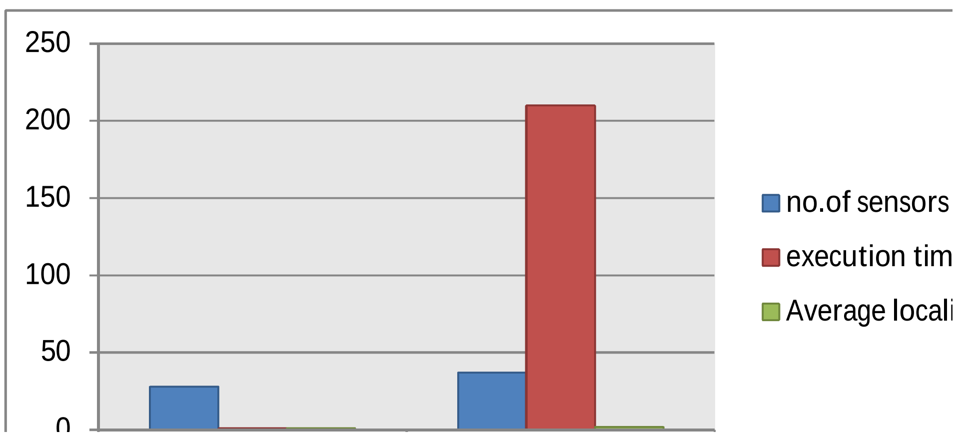



**Figure 2-** Comparisons between IADLoc with directional antenna and HiRLoc algorithm.

Figure 3 shows the result of comparison between IADLoc algorithm with omni-directional antenna for both PTA algorithm and RAL algorithm which use mobile motion sensors.

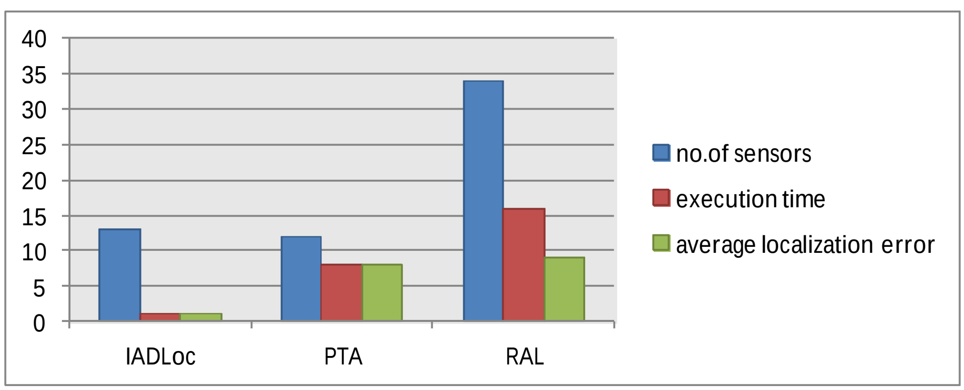



**Figure 3-** Comparisons between IADLoc with omni-directional antenna and both PTA and RAL algorithms.

**1st Case of study: localization error vs. sink radius**

The first case is to study the impact of sink radius on the localization Error. The sink radiuses change from 250 to 500 units the resultant indicates that the results of the IADLoc algorithm according to localization error, it is less than previous algorithms when the sink radius increases this is illustrated in both figure 4 and 5.

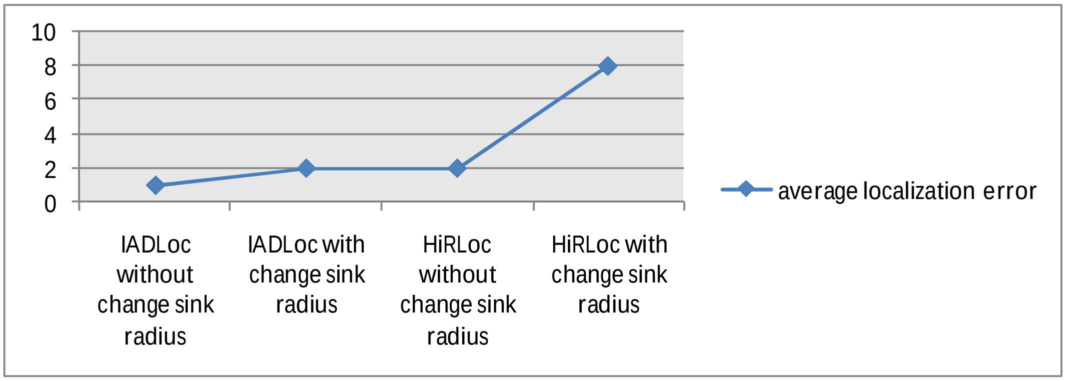



**Figure 4-** Average localization errors: IADLoc vs. HiRLoc

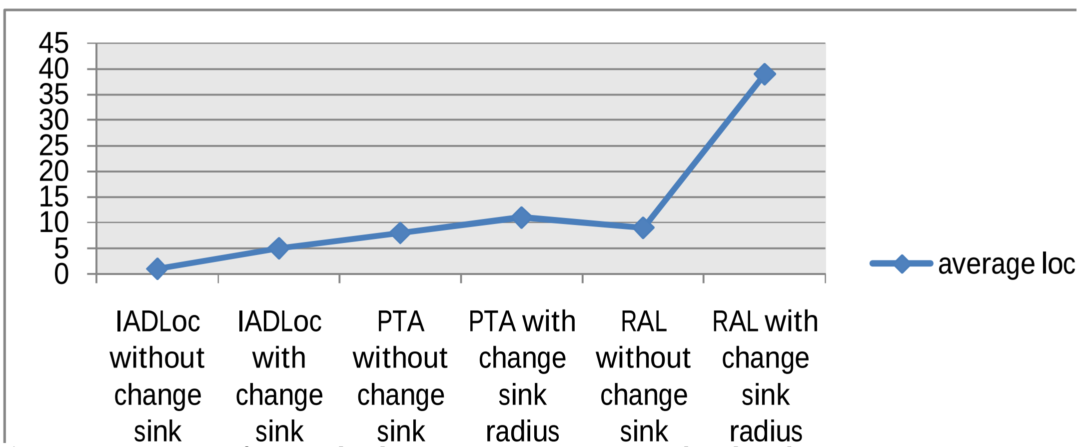



**Figure 5-** Comparison of average localization errors: IADLoc vs. Other algorithms

**2nd Case of study: localization error vs. number of beacons**

The second case of study is the impact of number of beacons on the localization error, two tests illustrate to determine the accuracy of the IACLoc algorithm, and this is represented in figure 6.

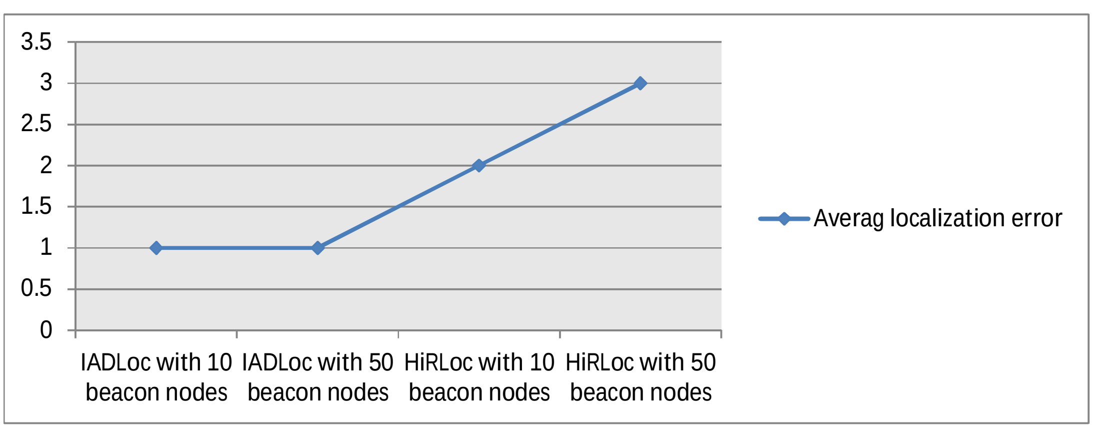



**Figure 6-** Average localization errors vs. number of beacon nodes between IADLoc and HiRLoc

Figure 7 shows the accuracy result for the average localization error of IADLoc versus PTA and RAL. This indicates that the IADLoc gives the location or coordinates of sensors node with low error rate unlike previous algorithms that give the location or coordinates of sensors node with high error rate.

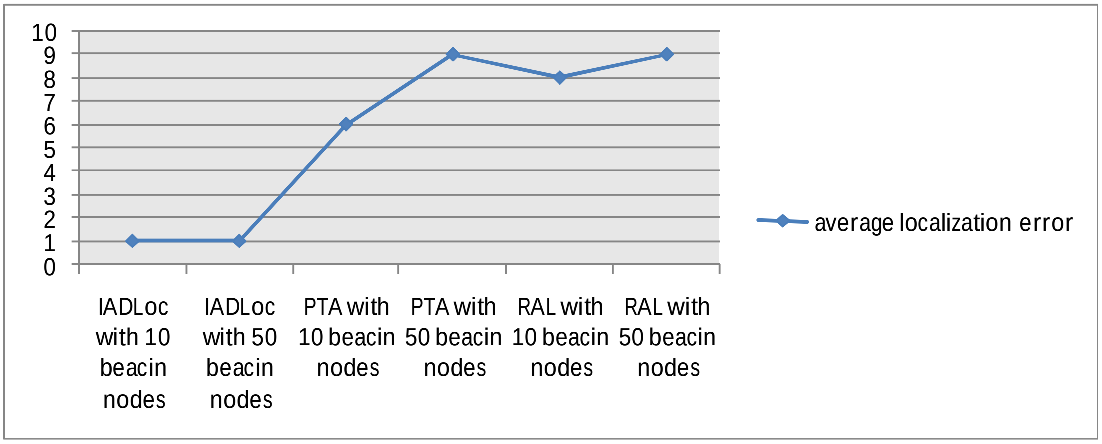



**Figure 7-** Average localization errors vs. number of beacon nodes between IADLoc and PTA and RAL

### 3rd Case of study: number of sensors

The number of sensors in the simulation environment is 200 nodes, figure 8 Shows in terms of the distribution of sensors for all localization algorithms that's where IADLoc algorithms with change antenna or without change it and is less on the distribution of the sensors, but a few are from the rest of the previous algorithm and thus achieved the proposed algorithm to reduce hardware cost and low energy consumption.

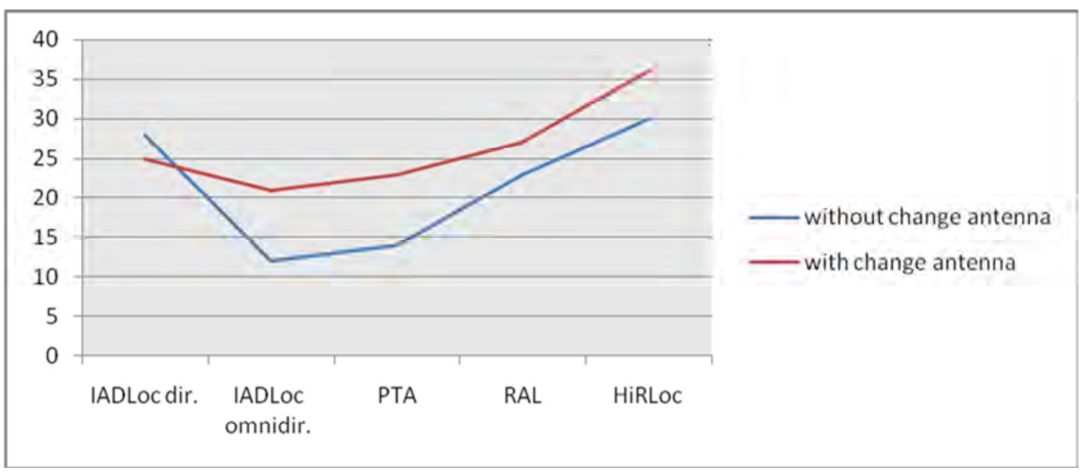



**Figure 8-** Sensors number deploy for all localization algorithm

### 4th Case of study: execution time

Figure 9 shows the execution time for all algorithms needed for sensors distribution and coordinates foundation. It is clear that the IADLoc needs less time to find coordinates or locations of sensors node in both change antenna or without change, where The HiRLoc needs considerable time up to the minutes or more.

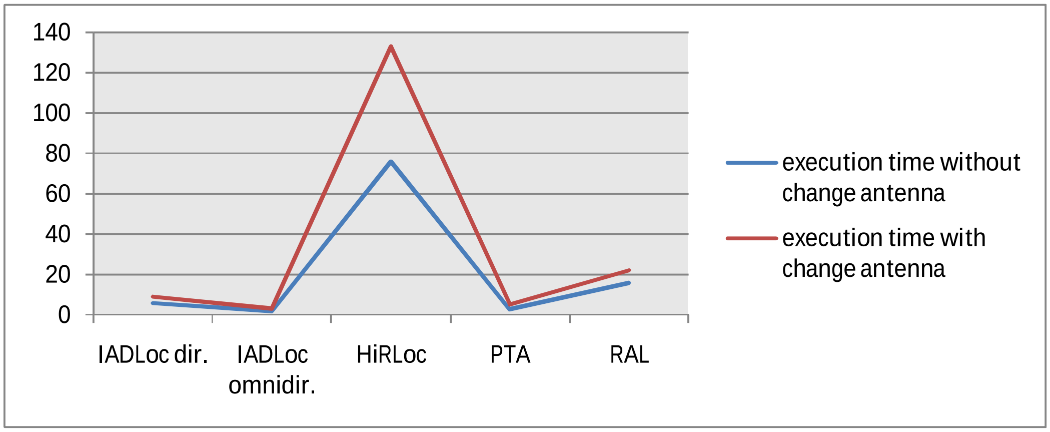
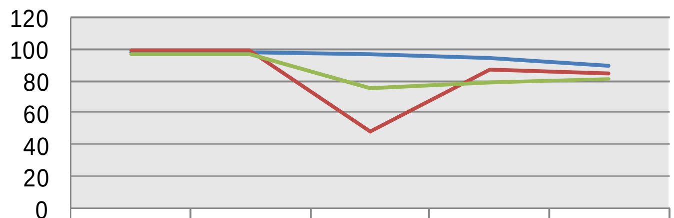



**Figure 9-** Execution time for all localization algorithms

**Conclusions**

The conclusions can be summarized in figure 10. The figure shows the accuracy for localization algorithms in terms of the average localization error, execution time and number of sensors. These were compared with other algorithms, i.e. HiRLoc, PTA and RAL.




| | IADLoc dir. | IADLoc omnidir. | HiRLoc | PTA | RAL |
|---|---|---|---|---|---|
| average localization error | 98.9 | 98.9 | 97.8 | 95.5 | 90.5 |
| execution time | 99.9 | 99.9 | 48.7 | 88.5 | 85.6 |
| no. of sensors | 97 | 97 | 76 | 80 | 82 |

**Figure 10**- Accuracy of IADLoc with respect to other localization algorithms

The main challenges for IADLoc methodology is in designing and planning the operations of wireless sensor networks (WSNs) and distribution of sensor nodes in the sensing area with Identify coordinates.

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