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A Study on Performance Analysis of Distance Estimation RSSI in Wireless Sensor Networks

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Abstract

Research has shown that the awareness of positions of wireless sensor nodes is a desirable feature for many applications in Wireless Sensor Networks (WSN). The performance of analysis distance estimation in WSNs is the association bordered by the Received Signal Strength Indication (RSSI) values and distance. The RSSI of nets make available a practical way of estimating the distance between nodes because the use of it does not require any additional hardware but simply a radio transceiver compared to other range based models. In this paper, Performance analysis of the RSSI model that estimates the distance between sensor nodes in WSNs is presented. It is shown that the results of this evaluation can contribute towards obtaining accurate locations of the wireless sensor.

Keywords: wireless sensor network, RSSI model, distance estimation, node.

INTRODUCTION

In sensor networks, 802.15.4 WPAN the most common technique used to calculate the distance between two nodes is the RSSI (Received Signal Strength Indicator) technique because it has the advantage of not requiring additional hardware and synchronization on nodes. Some studies shows that the RSSI index is fairly unreliable and often produces significant errors about the location of the nodes in the network. In this paper, an approach to the problem of nodes localization in an outdoor environment is proposed. In order to obtain more accurate distance estimation, a scenario dependent ranging technique has been adopted. The goodness of the ranging model is estimated through a comparison with the classic model based on the path-loss long-distance; then two localization techniques such as Triangulation and Roc RSSI are used in order to test the improvement obtained for the estimated positions of nodes within the network.

Network evolution has experienced continuous and rapid technological development in recent years. The concept of networking as a simple connection between terminals has evolved, becoming increasingly sophisticated and detailed. Wireless Sensor Networks can observe and extract information relating to the environment in which they are placed. Many studies about energy optimization, routing information, data representation and more, be situated of current interest, and the location is a particularly interesting argument today. Attention to this issue is justified by the increasing demand for more applications dealing with information on the coordinates of a target placed on the network; in fact, the fields of application are huge. Positioning devices are now part of the daily life of the population.

LOCALIZATION IN WIRELESS SENSOR NETWORKS

Performance Metrics.

Multiple metrics can be used to measure the performance of a localization technique. It is not enough to observe accuracy only. Referring to the literature and considering the results of our research we provide the following performance measures: accuracy, coverage, complexity, scalability, robustness, and cost. They are mainly connected with economical or technical constraints such as hardware cost, low battery power, and limited computation capabilities.

Localization Accuracy.

Accuracy is the most important requirement of location systems. Usually, the mean error between the estimated and the true location of the co-anchor nodes in the network is adopted as the performance metric. It is defined as follows:

$$\text{LA} = \frac{1}{N}\sum_{i,j=1}^{N}\frac{\left\|R_{x_i}-R_{x_j}\right\|^2}{R_i^2}\ 100\%$$

Where N denotes the number of nodes in a network whose location is estimated, LA denotes a localization error, R_{x_j} the true position of the node i in the network, R_{x_j} is the estimated location of the node i (solution of the location system) and R_i is the radio transmission range of the node i. The localization error LE is expressed as a percentage error. It is normalized with respect to the radio range to allow comparison of results obtained for different sizes and ranges of networks. Usually, centralized location systems give more accurate position estimates than distributed ones. The Distributed implementation may involve a loss of information due to an incomplete network map and parallel computations.

It is obvious that the higher accuracy, the better the system. However, there is often a trade-off between position estimation accuracy and other characteristics. Therefore a compromise between the required accuracy and other characteristics is needed.

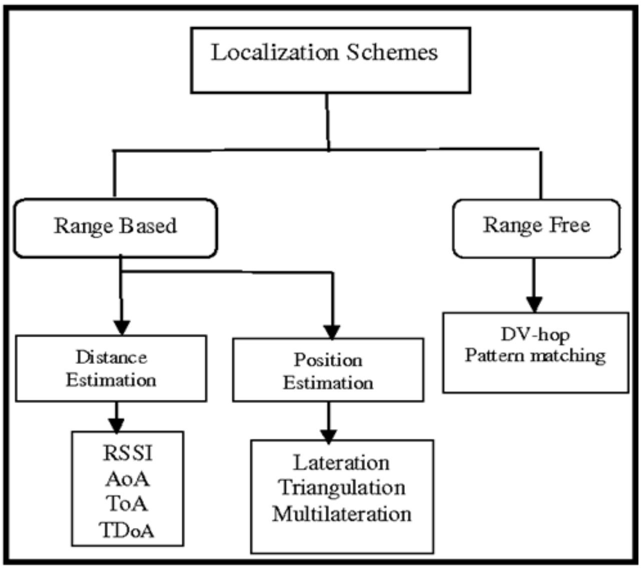

Figure 1. Localization scheme

Coverage.

The coverage of localization procedures is related to the deployment area, network density, hardware tools and resources of devices that form a network. Now and then in effect in outsized, distributed sensor networks when nodes do not have enough neighboring nodes, unevenly distributed anchor nodes, or in the case of under the weather equipped devices, problems with localization of the whole linkage may occur. In such a situation the question is how much of the network can be localized. In the case of poor results, the only option is to increase the number of anchor nodes in a network.

Complexity.

The complexity of a location system can be attributed to hardware, software, and operation factors. In general, range-based methods are much complex than range-free techniques and involve hardware complexity. Software complexity depends on the computing complexity of the positioning algorithm. In centralized location systems, a central unit calculates the estimated locations due to its powerful processing capability, and sufficient power supply and memory. If calculations are carried out on the sensor node, the effects of complexity could be evident. The Most procedures that form a sensor network lack strong processing power, memory and power source, so techniques with low complexity are often preferred.

Scalability.

The scalability of a location system ensures suitable estimation of localization when the network or deployment area gets larger. A location system should scale on the network size (number of nodes) and density, the size of a deployment area and dimensional space. In the case of range-based techniques, the location performance degrades when the distance between the transmitter and receiver increases. The dense network, wireless signal channels may become congested and more complex communication infrastructure may be required. The location system can locate the nodes in 2- D or 3-D space; some of them can support both 2-D and 3-D spaces. Consolidated systems usually aggregate all measurements and input data at a central unit to carry out processing. By contrast, distributed implementation of localization improves scalability.

Definition 1

Interval data: For given I_d,$I_R \in R$, and$I_R \geq I_d$, we call the set I = [I_d ,I_R]={u/ $I_d \leq u \leq I_R$}interval data, where $I_d$is the lower bound of the interval data, and$I_R$is the upper bound. If I_d =I_R which means the upper and lower bounds are equal, the interval data becomes exact data.

Definition 2

Midpoint and radius of interval data: For a given interval data I = [I_d ,I_R], let$r_D = [I_d - I_R]$ thus, we have

$$I_D = D_d - R_D, I_D = D_d + R_D$$

We define $D_d$and $r_D(r_D \geq 0)$ as the midpoint and radius, respectively, of interval data I. Therefore, we can also express the interval data as follows:

$$I_D = D_d - R_D, I_D = D_d + R_D$$

Because we estimate RSSI-D according to the exact RSSI values measured in the RSSI-D procedure, we propose our third definition as the distance between the interval data and the exact data.

(3) ***Distance between the interval data and the exact data*:**

For given interval data $I_X = D_X - R_X, D_X + R_X$, y=y, where$R_X, D_X \in R$. The distance relationship between the two data sets is illustrated in Figure 1. When they are separate from each other, as shown in Figure2 (a), the minimum distance is $[D_X - Y]$-$R_X$and the maximum distance is $[D_X - Y]$+$R_X$when they are joined, as shown in Figure 2(b), the minimum distance is 0, and the maximum distance is $[D_X - Y]$-R_X= $2r_x$ when the interval data contains the exact data, as shown in Figure 2(c), the minimum distance is 0, and the maximum distance is $[D_X - Y]$+R_X = $2r_x$. Therefore, we can calculate the maximum distance D_{max}between X and Y, the minimum distance $D_{min}$and the distance d between the interval data and the exact data as follows:

$$D_{min} = \max(0, |[D_X - Y]| - R_X)$$

$$D_{max} = |[D_X - Y]| + R_X$$

$$D = [D_{min} D_{max}]$$

As indicated by Equation, the distance between the interval data and the exact data remains as interval data, which can comprehensively represent different distance values.

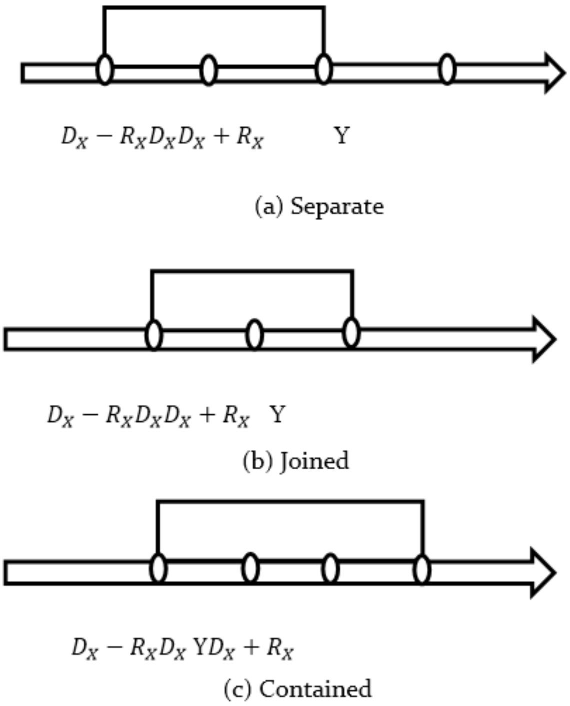

Figure 2. Distance Relation between Interval Data and Exact Data

DISTANCE ESTIMATION IN ONLINE AND OFF-LINE

To improve distance estimation accurateness, we have wished-for a RSSI-D approximation technique using interval data gathering, called Distance Estimation using Indeterminate Data Gathering (DEUDC). As given away in Figure 3, the background of DEUDC is encompassed by an off-line environment measurement component and an online distance estimation module.

***Off-line environment measurement*:** We first complete RSSI illustration measurements at poles apart to improve distance estimation accurateness, we have wished-for an RSSI-D approximation technique using interval data gathering, called Distance Estimation using Indeterminate Data Gathering (DEUDC). As given away in Figure 3, the background of DEUDC is encompassed by an off-line environment measurement component and an online distance estimation module communiqué points in the wireless communiqué surroundings. We then deference to the RSSI data intended for arithmetical computation and model the RSSI distribution distinguishing in terms of RSSI uncertainties. We can obtain an RSSI-D charting grounded on this technique.

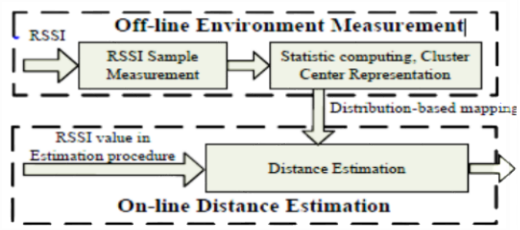

Figure 3. The framework of DEUDC.

***On-line distance estimation*:** During the RSSI-D estimation technique, the RSSI charge is restrained by a WSNs (e.g., DD2530 WSN node), and we can estimation the communiqué detachment using indeterminate data gathering.

In the on-line distance estimation component, considering poles apart stages of improbability in RSSI values, we accept RSSI-D estimation ways and means using both hard and easy-going uncertain data gathering methods to increase the approximation accuracy.

The hand-outs of this manuscript are as follows:

- We propose DEUDC, a RSSI-based communication estimation method, which uses a mapping strategy and an uncertain data clustering method. Unlike sample-based mapping in RADAR and ARIADNE systems, we resort to distribution-based mapping to overcome the uncertainty in RSSI readings.
- To address the uncertainty in RSSI values, we adopt interval data and statistical information to represent the RSSI distribution characteristic of each distance. In comparison to sample-based mapping, by exploiting distribution-based statistics, our approach can potentially obtain greater improvement in estimation accuracy and efficiency.
- We propose an RSSI-D estimation method in which uncertain data soft and hard clustering algorithms are implemented in order to obtain better estimation accuracy with respect to different levels of uncertainty in RSSI.
- We have evaluated DEUDC using real data sets from representative wireless environment. Experimental results show that DEUDC out-performs state-of-art estimation methods.

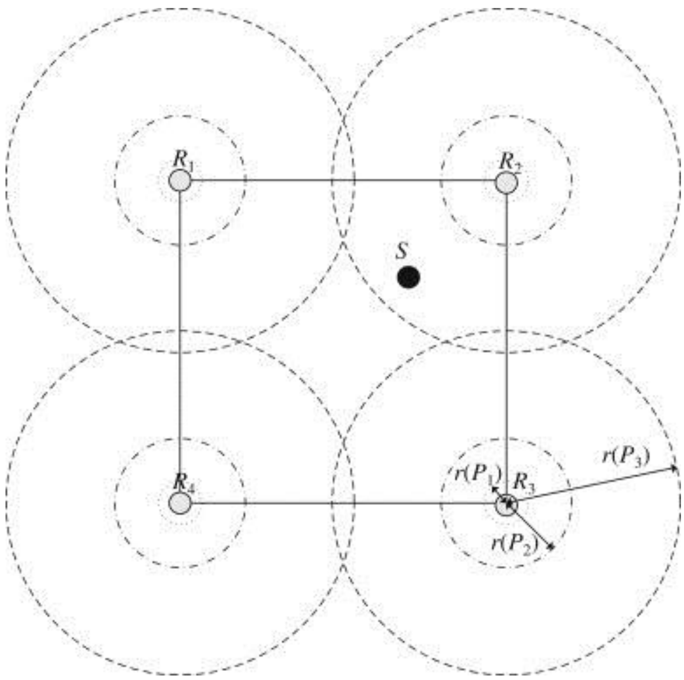

Figure 4 .Impact of Correlation Factor on the RSSI-D Estimation Method

Parameter	**Corridor**	**Hall**	**Air**
Node	**DD2530**	**DD2530**	**DD2530**
Temperature	**22 0^0c**	**22.5 0^0c**	**20 0^0c**
RSSI-D estimation	**3 m x 3 m**	**3 m x 3 m**	**3 m x 3 m**
RSSI-D estimation points	**50**	**50**	**50**
Height of node	**0.1 m**		

Table 1. Experimental temperature conditions and parameters

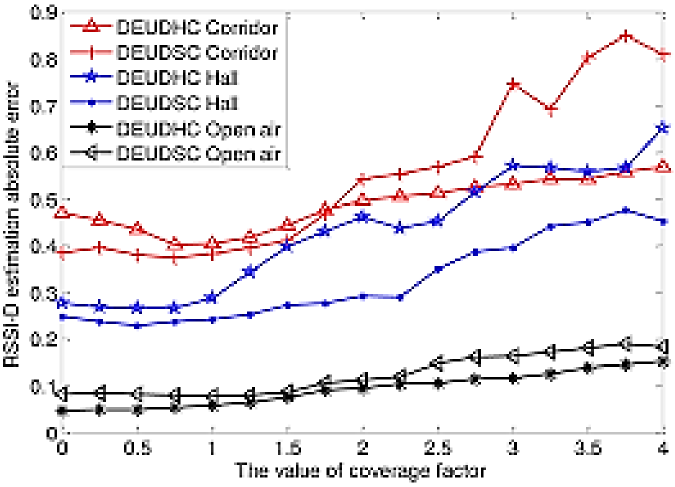

Figure 5. Implementation of Distributed DEUDC RSSI-D Estimation

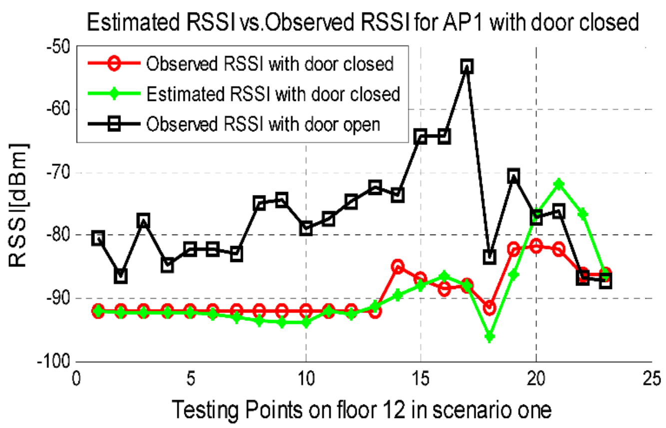

Figure 6. Changes in distance estimation with coverage factor in three environments.

CONCLUSION

In this better-quality technique of RSSI capacity has been contemporary. Experimental measurement and simulation results show that the computation time has been increased, but measurement accuracy can be improved greatly. The proposed method can reduce the error of RSSI measurement, which can improve the localization accuracy. This measurement method is an option in wireless sensor node localization.

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