The International Journal Of Engineering And Science (IJES)
||Volume||2 ||Issue|| 7 ||Pages|| 30-34||2013||
ISSN(e): 2319 – 1813 ISSN(p): 2319 – 1805

Design and Simulation of Range Estimation In Residential Building Using IEEE 802.11b WLAN Networks.

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---***ABSTRACT***---
Location estimation is a critical step for many location aware applications. In this paper we present cost effective and simplified location estimation in residential building. The technique is based only on Received Signal Strength Index (RSSI) measurements taken at receiver nodes using WLAN cards. The localization performance is computed in terms of Cramer-Rao Lower Bound (CRLB) of range estimate under residential environments which is relatively less complex computation technique. This system is designed and tested in MATLAB tool. Simulation results reveal that the CRLB range estimation has better performance than the multilateration with linearization for access point localization algorithm and Eglis propagation model.

KEYWORDS : *CRLB, Indoor localization, WLAN, MATLAB, RSSI.*

Date of Submission: 8 July 2013, Date of Publication:25 july,2013

I. INTRODUCTION

The need for localization of wireless nodes in a wireless network is of great importance. The location information is necessary in positioning, tracking, context aware applications. The most commonly used localization technique is the global positioning system (GPS). The indoor localization system has passed through a lot of improvements over the years. From the global positioning system (GPS) and the time of arrival (TOA), to the time difference of arrival (TDOA) and the received signal strength (RSS), researches have been on in areas of analysis and improvements. Among the techniques listed above, only the RSS technique is used mainly for indoor environment. A lot of researches are being under taken in the indoor localization system because of its interesting applications and the numerous factors that affect the propagation of radio frequency (RF) signals in an indoor environment. The indoor radio propagation channel is characterized as site-specific, severe multipath fading and low probability of line-of-sight (LOS) signal propagation path between the transmitter and the receiver [1]. The main contribution of this work is to present improved localization estimation technique. The method proposed exhibits higher localization accuracy, is calibration free and simple. The CRLB's presented in this paper quantify the localization performance. The proposed method demonstrates better performance as compared to the multilateration for AP localization and Eglis propagation model.

II. CRAMER – RAO LOWER BOUND

Parameter estimation in many signal processing systems is designed for applications in:

- Instrumentation —estimate the sinusoidal signal amplitude for DSP based instrumentation [2].
- Power systems —estimate the time varying frequency for single phase electric systems.
- Speech Processing —estimate the spectral envelope and fundamental frequency component.
- Radar systems- estimate target velocity for multi input-multi output radar.

In estimation technique the estimator takes the measured data as an input and produces estimate of the parameters. Cramer-Rao lower bound (CRLB) is the widely used estimator and also the estimation method in evaluating performance of wireless localization [2]. The RSSI model and associated CRLB are assessed in this section. The real time RSSI value obtained by the mobile node is taken as Gaussian random variable.
Using the log normal shadowing signal propagation model RSSI values are given by:

$$P_r = P_0 - 10nlog_{10}\left(\frac{d}{d_0}\right) + X_\sigma \qquad (1)$$

where α is the power measured at a reference distance *do* assumed to be of 1 m, *d* is the distance between mobile node and the access point (transmitter), *n* is the path loss exponent, *X* denotes a Gaussian random variable with zero mean caused by shadowing. The power measured at a reference distance, α depends on several factors: fast and slow fading, antenna gain, and transmitted power.

In general, CRLB is defined as the theoretical lower bound for any unbiased estimator of an unknown parameter . CRLB is obtained for the range dependent model described in Eq. (1) as [2] [5],

$$\sqrt{var(\hat{d})} = \frac{\sigma_i d}{10nlog_{10}(e)} \qquad (2)$$

where $\hat{d}$ is the maximum likelihood estimator (MLE) of distance between the access point and the ith position σ_i is the standard deviation of P_{Ri} measurements at the ith location. Given the measurements P_{Ri} at the ith location, the maximum likelihood distance from access point is given by,

$$\hat{d} = 10^{\frac{(P_0 - r_i)}{10n}} \qquad (3)$$

The MLE offers a straightforward solution to convert RSSI values into range estimates. Error can be formulated as,

Error = Actual distance – Estimated distance

$= d_i - \hat{d}$

III. EXPERIMENTAL SETUP

The Performance of wireless node localization is carried out in residential building i.e., Prashanth Nilay resides in Belgaum, where AP is located at fixed height and the mobile node can be placed anywhere in the propagation environment or line of sight scenario (LOS). The realistic RSSI measurements are collected in LOS scenario as shown in fig. 1 below.

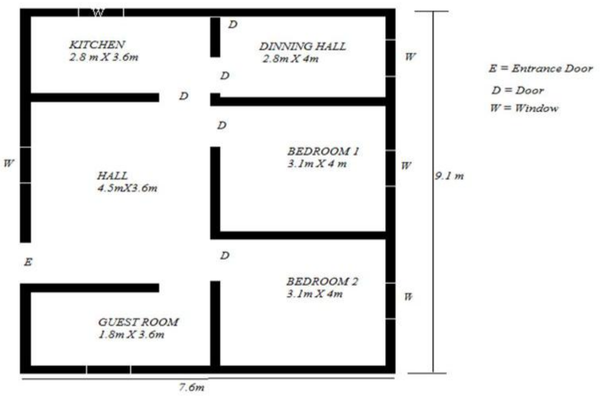

Figure 1: Floor layout for localization performance evaluation

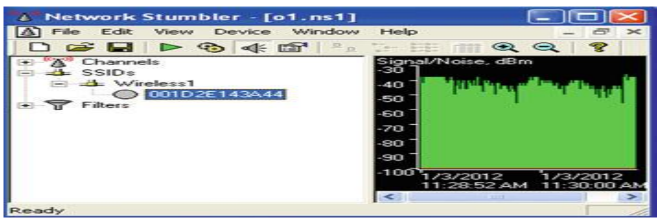

Figure 2: Snapshot of Net Stumbler

The figure 1 and 2 shows the floor plan of residential building which has area of 69.16m^2 and RSSI measurements are collected using net stumbler [3] software. The Wireless router (NetGear) with a unique medium control address is used as an access point. The snap shot of the measurement of RSSI in residential building is as shown in fig. 3.The Standard Deviation of measured RSSI is 7.1899 dB.

Figure 3: Prshanth Nilay Belgaum.

IV. SIMULATION RESULTS

4.1 Relation between RSSI and Distance

Received signal strength (RSS) values were measured within 10 meters of the access point (AP) with a step size of 0.5 meter. These measurements were repeatedly taken at different times in the same scenario. A possible method of predicting the RSS within the test bed environment is by using of a mathematical model given as [4],

$$P_r = -10n \log_{10} d + \alpha \quad (5)$$

Where in above eqn (5), P_r is RSS, n is the path loss exponent, d is the distance between access point and mobile node and α is the power level measured at 1 meter distance form access point. This relationship is obtained using curve fitting tool from collected RSSI in residential building and shown in fig. 4. and they are linearly related.

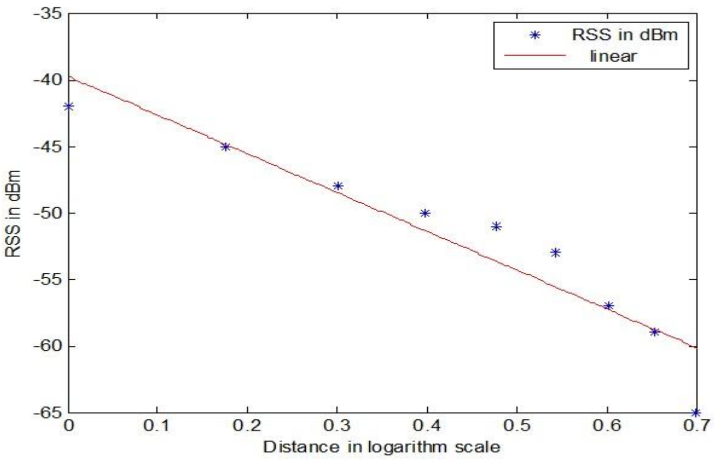

Figure 4: Relation Between RSSI and Distance

The Signal Propagation Model is given by,

$$P_r = -40 - 29 \log_{10}(d) \quad (6)$$

Comparing eqn (6) with eqn (5) the value of 'n' and 'α' can be estimated which can be used in CRLB computation. According to this,

α =-40 dBm

n = 2.9

4.2 Comparison Proposed method With Multilateration with RSS linearization

In this section we make a comparison between the proposed model in both residential building with the other existing localization algorithms. Fig. 5 shows the comparison of range estimation in residential building respectively. It shows that CRLB range estimating technique is better than other two techniques, Multilateration with RSS Linearization and Eglis propagation model [6], which is having less error comparing to others.

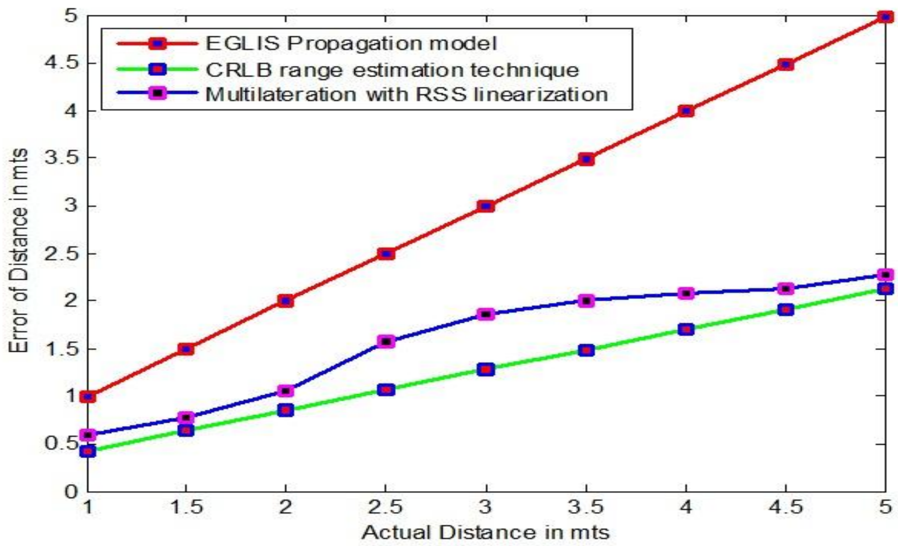

Figure 5: Comparison of distance in error using three techniques in residential scenario.

Table 1: Comparison of Mean Error in meters Of Three Techniques

	CRLB technique	Multilateration with RSS linearization	Eglis Propagation Model
Residential Scenario Mean Error in m	1.2757	2.5917	2.9932

Table 1 gives the comparison of mean distance error by using three different techniques in meter they are the proposed model with path loss exponent 2.9 from signal propagation model obtained by measured RSS, multilateration with RSS Linearization for AP localization and Eglis Propagation model.

V. CONCLUSION

Our work focuses on localization performance improvement in LOS scenario by placing the access point at fixed height. The CRLB computations based on real time RSSI values are used to evaluate the localization performance. The presented approach is calibration free and less complex. The proposed method gives better localization accuracy as compared to multilateration with linearization algorithm for AP localization and Eglis propagation model..

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BIOGRAPHIES AND PHOTOGRAPHS

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