A Research of Node Localization technique Using RSSI-D and LQI for Wireless Sensor Networks

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***Abstract**- Low-cost precise localization is crucial for wireless sensor networks. RSSI based localization is cost effective when compared to TOA, AOA, TDOA, ultrasonic and acoustic localization as it does not require any extra hardware, power or bandwidth. The radio of sensor nodes provides information about both the RSSI and LQI of a received radio signal. Localization error can be decreased by simultaneously observing both RSSI and LQI. We propose two novel techniques for localizing a target node using RSSI-D+LQI. A comparison between these techniques is done with the existing Mean-RSSI technique. We show that RSSI-D- LQI gives the best results in terms of localization error and computational complexity. The root mean square error of the RB-RSSI-LQI is 53.35% less than Mean-RSSI in case of stationary target node. The root mean square error of RSSI-D- LQI is 51.15% and 52.88% less than RSSI-LQI in case of stationary and mobile target nodes. A combination of simulation and experimental evaluation is used to develop and validate the proposed techniques.*

***Keywords**: Localization, RSSI-LQI, Wireless Sensor Network.*

I. INTRODUCTION

Wireless Sensor Networks (WSN), which consists of a lot of small devices deployed in a physical environment called sensor nodes which have special capabilities, such as communicating with their neighbors, sensing and recording data and processing, has been widely used in many areas [1], such as object detection, target tracking, security surveillance, and environmental monitoring etc. Most of these applications require the knowledge of the position of sensor nodes in WSN. In all of these applications collected data are not usable without knowing about the location of an event which is the location of the sensor.

Localization is an essential issue in the WSN technology. Localization problem refers to the process of estimating and computing the positions of sensor nodes [2]. The importance of this fact led researchers to seek a solution for localization problem. One easy way is manual configuration but this is impractical in large scale or when sensors are deployed in inaccessible areas such as volcanoes or when sensors are mobile. Another way is to add global positioning system (GPS) to each sensor. GPS has affected by heavy trees and buildings because it requires line-of-sight between the receiver and satellites. So, it has low accuracy due to poor signal reception. In additional, using GPS in large scale is not cost efficient. Therefore, several localization algorithms introduced to solve localization problem.

Localization is estimated through communication between localized node and unlocalized node for determining their geometrical placement or position. Location is determined by means of distance and angle between nodes.

Localization schemes are classified as anchor based or anchor free, centralized or distributed, GPS based or GPS free, fine grained or coarse grained, stationary or mobile sensor nodes, and range based or range free.

II. PROPOSED ALGORITHM

2.1 RSSI-D Model

Gaussian Mixture Model (GMM) that describes the relationship between the RSSI values and the distance is established with the offline RSSI values measured by anchor sensor nodes, which is called the RSSI-D model.

The Path Loss (PL) model that means the relationship between received power and distance is formed as:

$$PL\ (d) = PL\ d_0 + 10n \log_{10} (d/d_0) + X\sigma \quad (1)$$

Where n = [2, 5], n=2 for free space. The PL d_0 is the received power from the transmitter at a known distance d0that is usually set to one meter and Xσ denotes a zero

Mean Gaussian random variable that reflects the interference from indoor environment [15].

As described in (1), the injective function from the RSSI value to the distance can't be established because of the random variableXσ. In order to improve the accuracy of RSSI, we study on the statistical property of the RSSI values firstly and try to establish a most accurate model.

2.2 RSSI-LQI

Localization is done by measuring the received RF signal strength during communication between nodes. Link Quality Indicator (LQI) associated with the radio gives an idea about the quality of the received signal and is strongly correlated with RSSI. The fluctuations in RSSI cause error in localization. To reduce the error, different estimation techniques are used. The most common of these techniques is by taking Mean or Mode of the received RSSI values. Some advanced techniques like adaptive filtering on RSSI and LQI data are used to reduce the error in distance prediction

Grid L= 100
Square L= 500
Initialize Error= 0
All node= [X(rand_index),Y(rand_index)]
Chk Position= RSSI-D
Chk Position= LQI
While(all node true)
Estimated Position= All node[(1: anchor)+[GPS_error. GPS_error]*cos(error_angle) sin(error_angle)]
End while
All node. Actual= All node
Error= Estimate position –All node. Actual
End

III. EXPERIMENT AND RESULT

3.1 Simulation Platform

For the evaluation of out proposed algorithm a processor of 1.5 with 2.5 GHz laptop is used, with operating system of having window 8.1 and all the simulation is being done one Matlab 2014, we have used Matlab for simulation because it provide RAD application development environment and we can quickly analyse the graphical output and compare it with previous result.

3.2 Results and Discussions

The screen shorts of over graphical user interface is shown sequentially, like figure 5.1 is shows Initial representation of GUI left panel is showing the requirement of our algorithm to be executed and sky blue box will show the output in later on, the title is showing above, in figure 5.2 initial steps of our algorithm is showing where the localization of Mean RSSI is showing, having large error in locating the target node, in next figure 5.3 we are showing the enlarge screen shot of the screen we can easily analyse from the screen that it possess large localization algorithm.

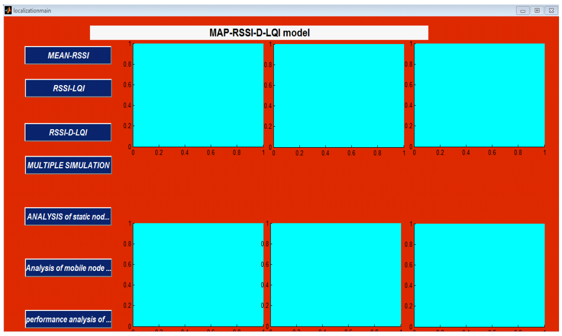

Figure 5.1: Initial representation of GUI

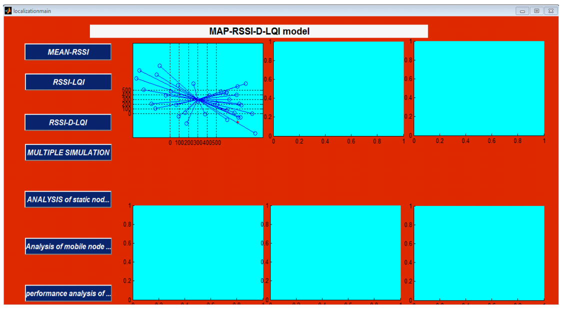

Figure 5.2: Localization of Mean RSSI

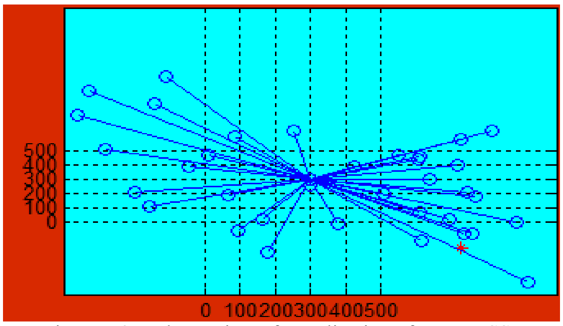

Figure 5.3: Enlarge view of Localization of Mean RSSI

In this screenshort of figure 5.4 is shows 2nd of our algorithm where the localization of RSSI-LQI is showing, having less error as compare to MEAN RSSI in locating the target node,in next figure 5.5 is shows enlarge view of loclization of RSSI-LQI screen shot that we can easily to analysis from the screen.

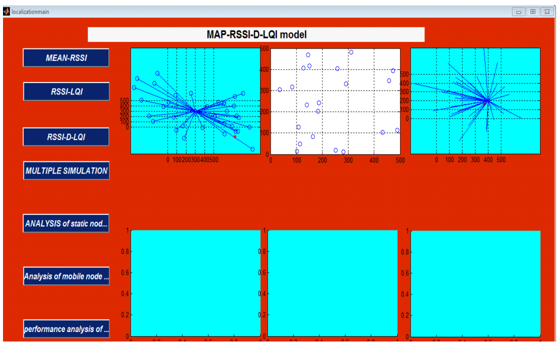

Figure 5.4: Localization of RSSI-LQI

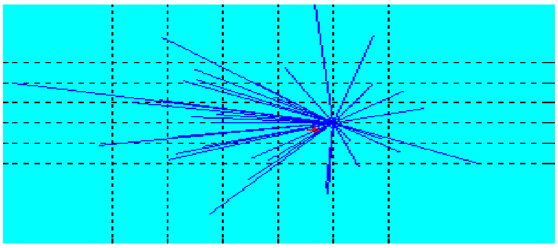

Figure 5.5: Enlarge View of Localization of RSSI-LQI

Figure 5.6 is shows 3th of our algorithm where the localization of RSSI-D-LQI is showing, having less error as compare to localization of RSSI-LQI in locating the target node, in next figure 5.7 shows enlarge view of localization of RSSI-D-LQI screen shot, we can easily analysis from the screen.

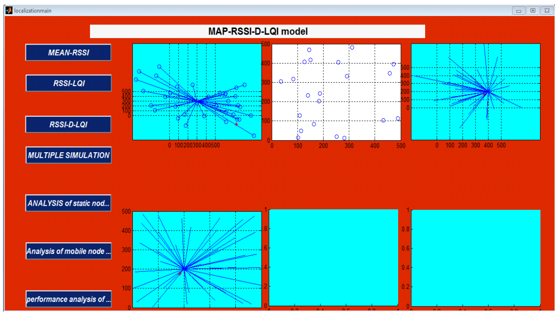

Figure 5.6: Localization of RSSI-D-LQI

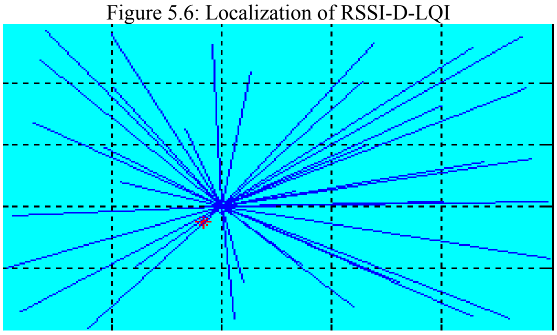

Figure 5.7: Enlarge View of Localization of RSSI-D-LQI

Figure 5.8 is shows 4t of our algorithm where the localization of multiple simulation is showing, having multiple error in the localization and get multiple values.

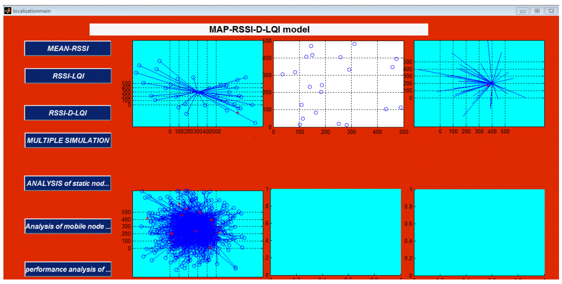

Figure 5.8: Localization of Multiple Simulations

Figure 5.9.1 is shows 5th step of our algorithm where the analysis of static node is showing the less value of root mean square (RMS) in a graph as comparing the three model MEAN RSSI, RSSI-LQI and RSSI-D-LQI. 5.9.2 shows 5th of our algorithm where the analysis of static code is showing, having less error in a graph as comparing the three model MEAN RSSI, RSSI-LQI and RSSI-D-LQI. This graph is shows, having less error in RSSI-D-LQI proposed model.

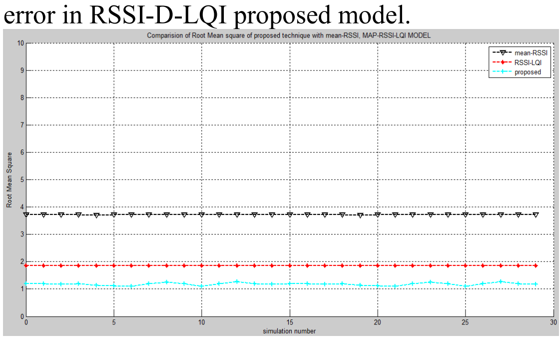

Figure 5.9.1: Analysis of Static Node

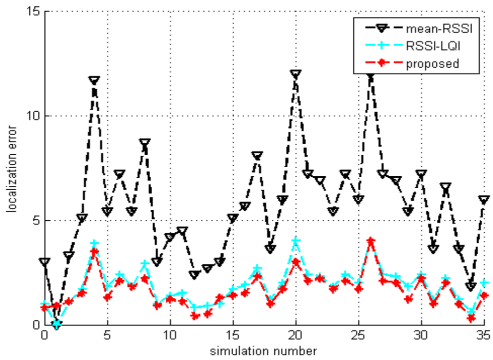

Figure 5.9.2: Analysis of Static Node

Figure 5.10 is shows 6th of our algorithm where the analysis of mobile node is showing, figure 5.11 shows the localization of mobile node with a comparison of base paper from the figure we can easily analyse that our proposed technique has much lower localization error.

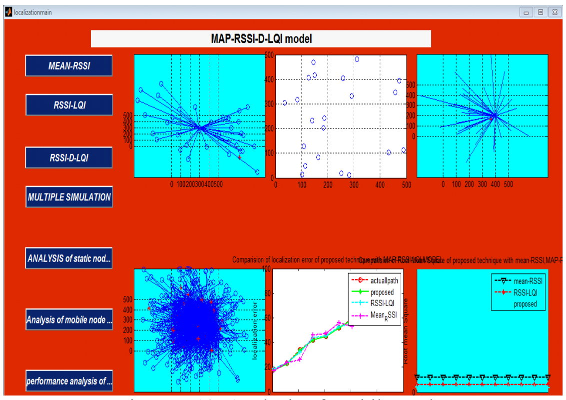

Figure 5.10: Analysis of Mobile Node

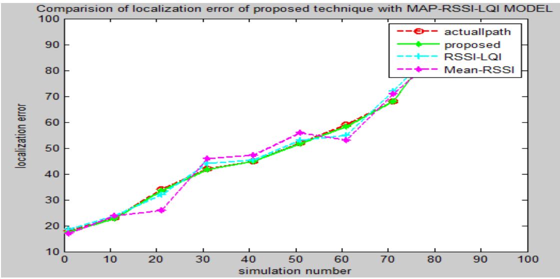

Figure 5.11: Enlarge View of Analysis of Mobile Node

Figure 5.12 is shows 7th of our algorithm where the performance analysis of node, First graph shows, having more Commulative Distributive function (CDF) in graph as comparing RSSI-LQI and Mean-RSSI. Second graph shows, having less error in graph to comparing the localization error between proposed RSSI-D-LQI and RSSI-LQI. In this graph shows RSSI-D-LQI is batter then RSSI-LQI because RSSI-D-LQI have less error in the localization.

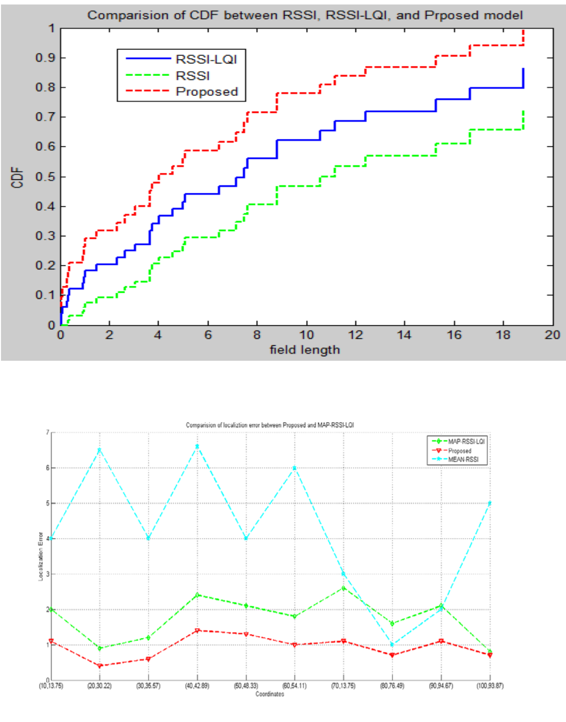

Figure 5.12: Performance Analysis of Localization Node

IV. CONCLUSION

Localization in wireless sensor networks have received increasing attention over the last one decade. It not only provides the geographical position of a sensor node but also fills the pre-requisite for geographic routing, spatial querying, and data dissemination. With the continuous research in localization of sensor networks, a number of effective algorithms have been proposed, but the stability has not yet reached. This is because of the meager resources (storage, battery, and processor) and the harsh deployment environments. Currently, none of the localization techniques is able to full-fill all these constraints. Most existing localization algorithms for static WSNs were designed to work with at least three anchor nodes except in those cases where directional antenna is used. Usage of antenna not only increases the cost, but also the size of node as well as complexity of the algorithm. As the number of anchor nodes required in a network increases, overall cost of the network also increases. In addition, energy drainage of the network increases, but the localization time of the whole network decreases. Further, anchor nodes installed with GPS do not work well everywhere. Therefore, at present we are in the need of a novel technology that will solve the following problems: (i) reduce the number of required anchor nodes, (ii) localize sensor nodes in areas where GPS do not work well, (iii) minimize the localization error. In this thesis we have proposed localization technique for static as well as mobile WSNs. In the reminder of this concluding chapter, we briefly summarize the original contributions of the study. Finally, some suggestions for future work are given.

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