A Multi-parametric Hybrid Cooperative Localization Scheme for Mobile Communication Network

D. Pavankumar and H.R. Mahadevaswamy

Abstract In this chapter, as proposed in the research proposal, here in this initial research phase a novel model for mobile node localization and tracking has been developed for wireless-interfaced networks for next-generation communication. In this research proposal, "A multi-parametric hybrid cooperative localization scheme for mobile communication Network" has been proposed that can be a potential solution for next-generation wireless mobile communication system functional on the basis of decentralized behavior and self-organizing nature. The proposed system can play the significant role in next-generation communication systems with ad hoc-based technologies such as MANET, VANET, VASNET, and interfaced network (LTE-based) as well as advanced sensor networks (WSNs) to be employed in interfaced communication networks (ICNs), industrial applications as well as in under sea networks (USNs).

Keywords Non-line of sight · Wireless sensor network · RSSI · Mobile node

1 Introduction

In the present-day application scenario, the highly pace increase in wireless mobile communication, there is an inevitable need of advanced and optimized communication system that could ensure quality of service (QoS) in real-time applications.

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On the other hand, optimal QoS in the wireless communication network is one of the predominant needs of the next-generation wireless communication technologies. Meanwhile, for the next-generation communication techniques such as Third-generation partnership projects (3GPP), Long-term evolution (LTE) technologies, Universal mobile telecommunication services (UMTS), and other paradigms for wireless mobile communication as well as wireless sensor-based communication systems, there is the requirement of optimization in node localization so as to increase the optimal connectivity and data delivery in real-time applications. The effective significance of node localization in the communication system makes the overall system delivering optimal results. Evolved packet core (EPC) is an IP-based communication approach which ensures QoS in real-time communication applications in LTE technologies [1]. Even in LTE communication to ensure the optimal efficiency, the handover is needed to be optimized and the effective localization of certain node can play a significant role for it. Similarly, in case of wireless sensor networks (WSNs), the exact node localization is must. On the other hand, nowadays in advanced communication systems, the static wireless nodes are being interfaced with the mobile nodes so as to ensure optimal communication performance for real-time broadband application (3G, UMTS, and LTE) [2].

This is the matter of fact that a number of researches have been done for effective node localization in wireless communication system. Considering our research-oriented literature survey (Internet resources, IEEE survey for 2011–2014), it has been found that most of the researches have been done either based on conventional node positioning approach such as Monte Carlo positioning, and GPS technologies or the conventional techniques which cannot ensure optimal performance, especially in the situation of indoor applications, under sea network, tunnels, non-line of sight (NLOS) communication scenario with higher nonlinearity, and many more [3]. Similarly, in major cases especially for WSNs, the traditional RSSI-based systems have been developed which sometime gets confined due to changes or nonlinear behavior of environmental conditions. Some of the systems have been developed based on time of arrival (TOA) or difference of angle (DOA) or some works employed the hybrid one called TDOA, but still these systems lack a proper optimized function with LOS communication as well as NLOS requirements. Therefore, considering these all limitations of the existing systems in this research proposal, a robust and efficient system has been proposed with optimized localization facility without compromising with any performance parameters. The proposed system encompasses multiple approaches for system optimization, and optimization of the better performing system has been done so as to ensure optimal behavior of the system for node tracking and positioning [4].

2 Implementation of Localization and Dynamic Triangulation Algorithm

In general, three nodes are needed for mobile user localization using dynamic triangulation-based node tracking or localization approach. Thus, taking into consideration this need, 4 nodes have been employed. Dynamic triangulation approach eliminates the weak RSSI signals that make the nodes to explore for the node having strongest RSSI. DTN also plays a significant role in selecting strongest RSSI signal to be employed for localization and mapping mobile node in communication network [5].

In this developed model, mapping circle is nothing else but the *estimation distance* d_1 existing between the master node [6] and the mobile users in the network. This can be estimated by the angle on the mapping circle using DTN and employing a novel concept of cost function or cost factor analysis that selects the optimal pair of observed distance [5].

In this system, for creating the mapping circle, the optimal localization ($x_1 + d_1\cos\theta$, $y_1 + d_1\sin\theta$) or location estimation of the mobile user is estimated by dynamic triangulation approach by employing all feasible distances ($d_2\theta$, $d_3\theta$) between the mobile user and slave nodes. Once it is done, the estimation of the mobile user distance from master node is the estimation distance and the possible error between the estimation distance and the practical location or distance is achieved by dynamic triangulation approach. Here, the cost factor analysis is accomplished where the cost function for each angle is evaluated, and finally using dynamic triangulation-based function, the minimal cost function is retrieved in terms of estimation angle on the mapping circle [8].

In this work, the angle retrieved on the mapping circle represents the estimation of the mobile node location.

The step-wise discussion for accomplishing research objective-1 is as follows:

Step 1: Estimate the strongest RSSI parameter and then create or establish the mapping circle by equation:

$$d_1 - d_0 10\text{RSSI}_0 - \text{RSSI}_M/10n$$

Then, the mapping circle was generated using the following expression:

$$(x_\theta, y_\theta) = (x_1 + d_1\cos\theta,\ y_1 + d_1\sin\theta)$$

Step 2: Select the second and third strongest RSSI signal and estimate the distance between the mobile node and the sensor node in the deployed or considered wireless-interfaced network to be employed in the next-generation communication applications.

The derived simple expressions are

$$d_2 = d_0 10\text{RSSI}_0 - \text{RSSI}_1/10n$$
$$d_3 = d_0 10\text{RSSI}_0 - \text{RSSI}_2/10n$$

Step 3: Generation of the cost functions and the estimation of the minimal cost function angle

$$d_{2\theta} = \sqrt{(x_2 - d_1 \cos\theta)^2 + (y_2 - d_1 \sin\theta)^2}, \quad 0 \le \theta \le 360$$
$$d_{3\theta} = \sqrt{(x_3 - d_1 \cos\theta)^2 + (y_3 - d_1 \sin\theta)^2}, \quad 0 \le \theta \le 360$$

Error estimation

$$\text{Error}_{1\theta} = |d_{2\theta} - d_2|$$
$$\text{Error}_{2\theta} = |d_{3\theta} - d_3|$$

Step 4: Estimate the minimal cost function with associated angle

$$\text{Minimal Cost function} = \sqrt{\text{Error}_{1\theta}^2 + \text{Error}_{2\theta}^2}$$

In this model, to further optimize the accuracy and preciseness of the mobile node localization or tracking, an optimization in terms of predictive RSSI paradigm has been modeled, and for this, a gray prediction algorithm has been incorporated that employs gray system to predict the RSSI associated with the mobile node in the communication network. The dynamic RSSI of x employing the first-order equation has been developed in this work

$$\frac{\mathrm{d}X(1)}{\mathrm{d}t} + aX(1) = b$$

3 Simulation Results

In the specific simulation situations, when $k \geq 2$, it supposed (proposed) to employ minimal least square approach or similar algorithms which considers linear model $(yn = Ba)$.

In this research phase, the implementation of dynamic triangulation approach and gray prediction scheme has exhibited better for mobile node localization in wireless-interfaced network, comprising mobile nodes and sensor transceiver terminals. These technologies can be a potential approach for future- or next-generation communication system.

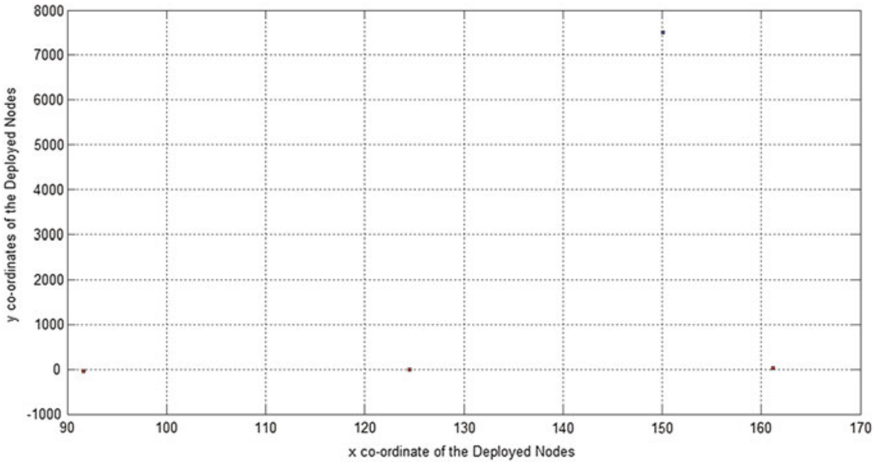

Fig. 1 With 4 numbers of cells

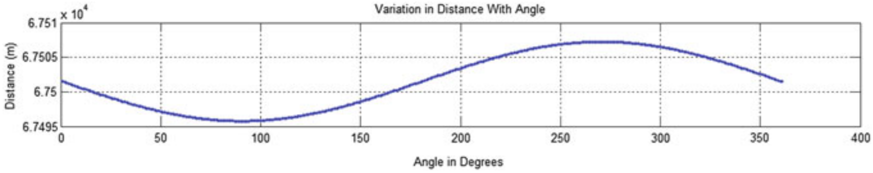

Fig. 2 Variation in distance with angle

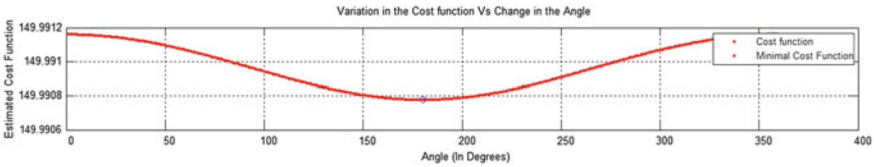

Fig. 3 Variation in cost function versus change in angle (Here, *Blue circle* represents the location of mobile user in the network)

The factor introduced in this research phase was the consideration of predicted RSSI estimation and associated mobile user tracking and localization along with the introduction of a unique weight-predicted scheme that exhibits better as compared to conventional localization or tracking systems in non-line of sight (NLOS) [9] communication environment (Figs. 1, 2, 3, 4 and 5).

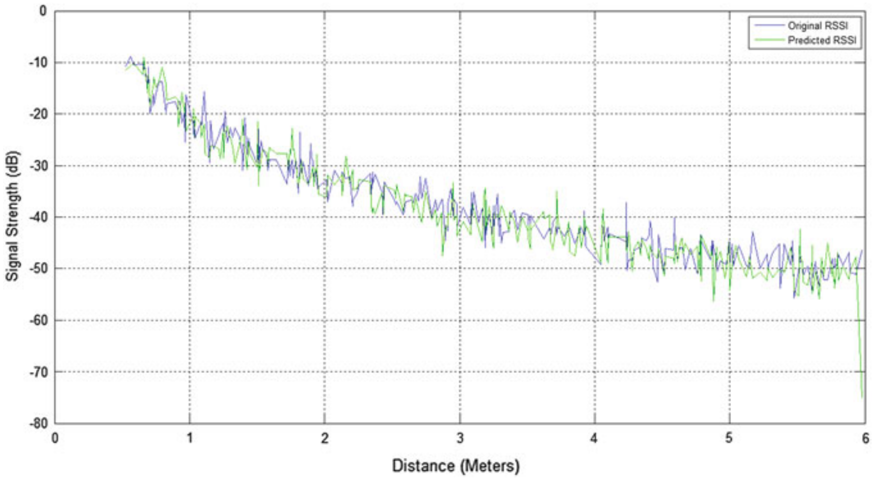

Fig. 4 Simulation result of original RSSI vs predicted RSSI

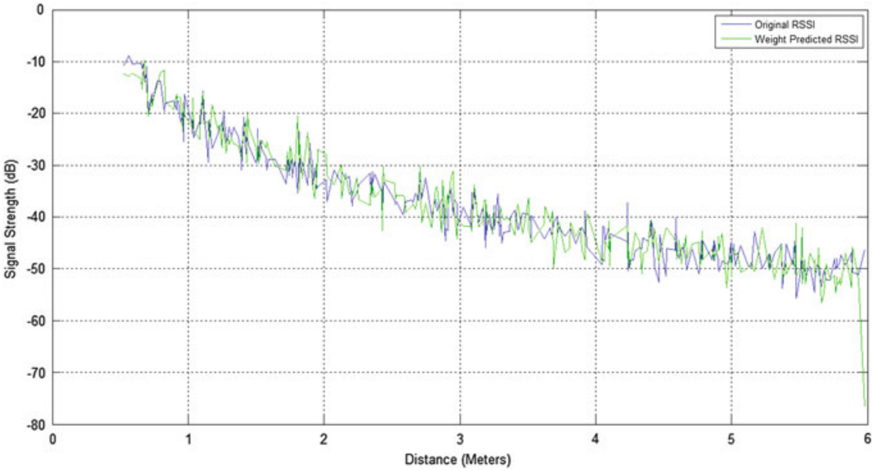

Fig. 5 Simulation result of original RSSI vs weight predicted RSSI

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