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Performance Analysis of Mobile Anchor Assisted Circularized Localization Scheme in Wireless Sensor Networks

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Abstract

A wireless sensor network is a large network with plenty of nodes for sensing and tracking network changes. High network mobility causes quality issues and may reduce delivery rate. Locating sensor node aids in accurate and loss-free data transmission to the destination. To locate the mobile nodes in a sensor network, a novel Mobile Anchor Assisted Circularized Localization Scheme has been proposed in this work. This proposed method uses a mobile assisted anchor node for determining the location of sensor nodes in a circularized manner. The position of the anchor node is determined by using control messages sent from the base station. Following the identification of the anchor node, the coordinates of nearby nodes are calculated using the circularized position and the Euclidian distance. This localization scheme aids in determining the precise position of the sensor node. Since the data is transmitted between known localized sensor nodes, the drop rate reduces while the delivery rate increases. The simulation result examines the performance of the proposed scheme using Quality of Service parameters such as throughput, drop rate and delivery rate. The proposed model achieves a higher delivery ratio and improves the overall network performance of the sensor network.

Keywords: Wireless sensor network, localization, delivery rate, anchor node, mobile node

1. Introduction

Wireless Sensor Network (WSN) comprises of small sensor nodes with limited energy level for sensing and for communicating the information to others. It consists of limited computing resources for data transmission. This sensor network senses the environmental changes and transmit the required information to the users. This network is

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more helpful in all applications such as medical healthcare, military, smart home appliances, industrial and education fields. The size of the sensor node is small, and the storage level of battery is also small. The major drawback in the wireless sensor network includes shorter network lifetime due to the lesser energy level. Nowadays, many solutions have been provided to overcome the energy consumption issues in the sensor network. Another drawback includes localization of the sensor nodes. To find and track the position of sensor node is one of the most important issues in the wireless sensor network.

Figure 1 shows that the sensor network architecture which consists of sensor nodes with random deployment. The sensor network transmits the data with the help of base station, and it acts in a centralized environment. The sensor nodes are connected to various nodes via wireless medium. It reduces the complexity of wiring deployment. It is easy to access the sensor nodes via base station.

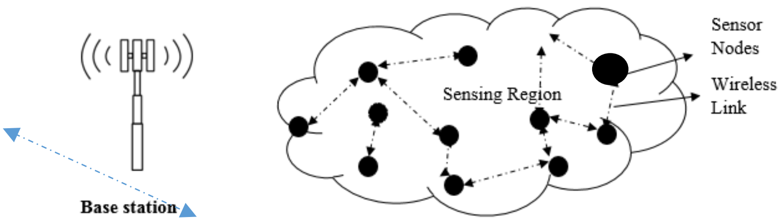

Figure 1. WSN Architecture

The research issues included in the wireless sensor network are listed below:

- Localization of sensor node
- Interference due to open space
- Low speed of communication
- Lesser storage space
- Small battery in size
- Continuous monitoring
- Mobility management
- Energy reservation

1.1 Localization in WSN

The physical coordinates of the nodes are identified in the process of localization. Due to the large-scale system in wireless sensor network, localization is more important to track and monitor the localization of the sensor node. The localization provides the efficient routing information between the users, and this will lead to high network performance. In wireless sensor network, tracking and monitoring the sensor node improves the network performance with proper routing information between the sensor nodes.

There are two different types of localization which includes:

1. Global based localization – It presents the localization based on the global positioning systems.
2. Relative based localization – It presents the localization of sensor nodes with respective to the relative coordinates of the system.

The various methods involved in the localization approaches are as follows:

- Centralized localization – It tracks the position based on the centralizer server.
- Distributed localization – It tracks the position based on the nearby nodes.
- Anchor free localization – It identifies the position of the sensor node without using anchor nodes.
- Anchor based localization – It identifies the position of sensor node with the help of anchor nodes.
- Range free localization – It identifies the position based on the hop counts.
- Range based localization – It identifies the sensor node's location based on the ranging techniques such as received signal strength, angle of arrival, etc.

2. Related works

Wang et al. [1] proposed cooperative localization scheme for wireless sensor network based on the angle of arrival measurements. Two types of localizers were implemented such as type – 1 localizer and type -2 localizer. Type -1 localizer was measured by using the Bayesian inference approach, and the least square problem was resolved by using gradient function. Type-2 localizer was measured by using the convex optimization and the positioning problem was resolved by using the gradient function. The proposed localizer was obtained by using the types 1 & 2 localizer and approximate message passing localizer. This approach helped to reduce the nonlinear error and the noise distortions.

Liang et al. [2] introduced the technique, opposition -based optimization algorithm, to reduce the localization error. The optimization algorithm utilized artificial gorilla troop optimizer. This optimization algorithm focused on the reduction of localization error in the wireless network. Results were compared with different types of optimization algorithms, and it was found that the proposed algorithm achieved better efficiency than others. Karagol et al. [3] suggested a new path planning model to overcome the localization issues in wireless sensor network. Nested hexagons curves were implemented in the mobile path which helped to localize the mobile anchor node. This structure was divided into six flows based on the accuracy priority trilateration. The simulation result provided efficient results which was higher in the proposed algorithm when compared to the other existing approaches.

Sabale et al. [4] investigated the localization issues in the wireless senor network. Anchor localization approach was the first technique which helped to identify the sensor node location based on the beacon transmission between the neighbor nodes. The process of anchor node was implemented in the approach to improve the success rate of localization between the neighbor nodes. The scheme reduced the collinearity problem and identified the localization based on the beacon signals. Cheng et al. [5] recommended the received signal strength -based localization scheme which helped to identify the anchor node. This anchor node selection scheme identified the accurate position of sensor node and reduced the localization errors.

Wei et al. [6] presented the division of regions and nested equilateral triangles approach for an effective path planning model implementation in wireless sensor network. The region was divided into smaller regions and named as inter and intra regions. Shortest path algorithm was used to estimate the shortest distance over the nearby nodes in both regions. This scheme provided the efficient result by reducing the energy consumption and improving the localization accuracy compared to the other existing models. De Oliveira et al. [7] presented the detailed review of localization schemes in wireless sensor network. The challenges included in the localization were revealed and importance of localization was discussed. It was suggested that the localization is most important aspect in wireless sensor network which detects the sensor node location, and it improves the communication compatibility between the sensor nodes.

Khattak et al. [8] proposed the localization approach through anchor nodes to reduce the localization issues. The approach helped to identify the position of sensor nodes based on the beacon point's shortest distance. This technique will be applied in 5G and Internet of things for better and efficient communication. Liu et al. [9] explained about the static anchor node selection strategy for the localization issues including coverage problem, position identification and anchor node selection. The position of the sensor node was predicted based on the received signal strength. The closeness centrality theorem was applied to identify the threshold range for the nearby and faraway nodes. The nodes were sorted based on the closeness level in the descending order. The least value of the closeness node was considered as the anchor node. The scheme provided an efficient solution to overcome the localization issues.

Huang et al. [10] suggested a scheme to overcome the energy consumption issue and localization errors in underwater sensor network. The approach implemented the dynamic path planning model to find the sensor node's location It reduced the energy consumption as well as overcame the localization communication overhead with the help of autonomous underwater vehicles systems. This approach is suitable for underwater wireless sensor network. Nain et al. [11] introduced the hybrid optimization algorithm. Artificial butterfly algorithm was implemented to identify the distance between the sensor nodes to track the position of the sensor node. This algorithm helped to change the non-localized nodes to localized nodes. The scheme reduced the localization error and delay, and improved the network performance. Kumar et al. [12] analyzed the localization issues in the underwater wireless sensor network. Hybrid localization technique was presented which combined the received signal strength and angle of arrival algorithms. This approach determined the location of the sensor node, reduced the localization fault, and improved the network efficiency. Arya et al. [13] investigated the localization issues through anchor nodes. Mathematical implications were presented with various boundary conditions to track the location of the sensor node. This scheme successfully extracted the localization of the sensor nodes with the help of anchor nodes.

Walia et al. [14] proposed the neural network algorithm to find the exact position of sensor nodes and to reduce the computation error. The target nodes were computed randomly to track the position of other sensor nodes in the network. The experimental results were analyzed. The performance of the neural network algorithm provided accurate result than the other existing models. Bochem et al. [15] extended the Monte Carlo Localization (MCL) scheme with the help of sensor nodes to enhance the robustness in the localization. Robustness enhanced sensor assisted MCL scheme reduced the malicious attack from intruders, reduced faulty identification inside the network, improved the energy optimization and monitored the position of the sensor node.

3. Proposed Methodology

The Mobile Anchor Assisted Circularized (MAAC) Localization Scheme is proposed to overcome the localization issues in the wireless sensor network. This proposed method identifies the position of the sensor nodes with the help of mobile assisted anchor node in a circularized manner. The sensor nodes are deployed in the random region. The non-availability of GSM module proposes the MAAC Localization Scheme to identify the position of the sensor node. The anchor node is the reference node with known position information, which is identified based on the received signal strength. This anchor node is located near the base station. After identification of the anchor node, by using the circularized position, the nearby nodes coordinates are calculated with the help of Euclidian distance. This helps to identify the position of the sensor nodes. Figure 2 shows the proposed network architecture.

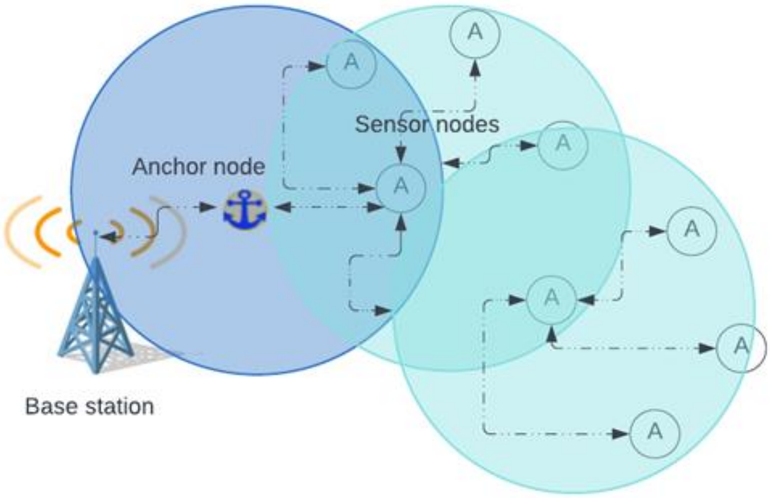

Figure 2. Architecture of the Proposed Network

The steps for MAAC Localization Scheme are:

Step 1: Random Node deployment

$$G (V, E)$$

Where, G denotes Graph network, V denotes Vertices and E denotes Edges of the network.

Step 2: Identifying Anchor Node Position

Base station transmits the beacon signals to the neighbor nodes. Beacon signal contains the control messages like RTS (Request to Send)/Hello data. If any one of the nodes responds CTS (Clear to Send) to the base station, the base station will identify the position of the responded node based on the RSSI (Received Signal Strength Identification). The responded node is named as anchor node and is denoted as A(x, y).

Step 3: Applying Circularization Approach

The anchor node identifies the position of the sensor node by using circularized localization scheme. Anchor node coverage range is fixed as 100 meters. The anchor node's diameter and radius are identified by using the coverage range of the particular node. The center node is the anchor node. By applying circularized polarization scheme, the distance between the corner node and center node value is known.

Step 4: Applying Euclidean Distance

The distance between the anchor node and corner node is the radius of the anchor node. The anchor node is denoted as $A(X_1, Y_1)$. The corner node is $C(X_2, Y_2)$. The distance between the anchor node and the corner node is denoted as D_{ac}.

Euclidean distance is given in equation 1:

$$D_{ac} = \sqrt{((X_2 - X_1)^2) + (Y_2 - {Y_1}^2))}$$

The above equation helps to identify the position of the corner nodes. By applying this proposed MAAC Localization Scheme, the exact position of the sensor node can be found. This improves the network performance by reducing the loss rate and delay.

4. Results & Discussion

The proposed concept was analyzed in network simulator version 2.34. The network factors which were analyzed involve drop rate, delivery ratio and throughput. The proposed MAAC technique was compared with the two existing techniques that include Hybrid Localization Technique (HLT) and Monte Carlo Localization (MCL).

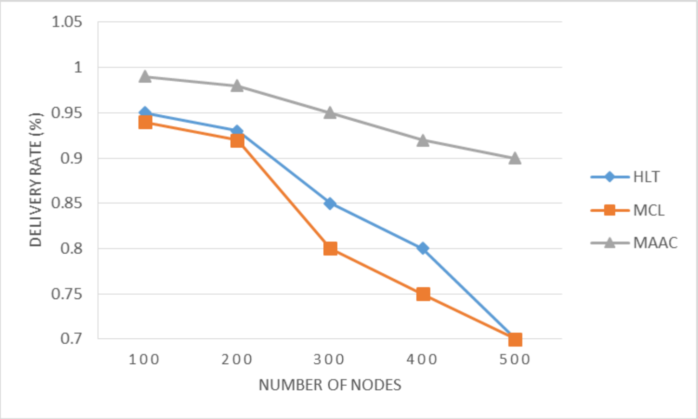

Figure 3. Analysis of Delivery Rate

Figure 3 explores the delivery rate attainments. The deliver rate is expressed by the ratio of the number of packets successfully transmitted to the difference on the number of packets transmitted and received. Compared to other existing protocols, the proposed approach provides the high delivery rate due to the easy localization of sensor nodes. Figure 4 depicts the drop rate analysis. The drop rate is defined as the ratio of the number of packets dropped to the number of packets successfully transmitted.

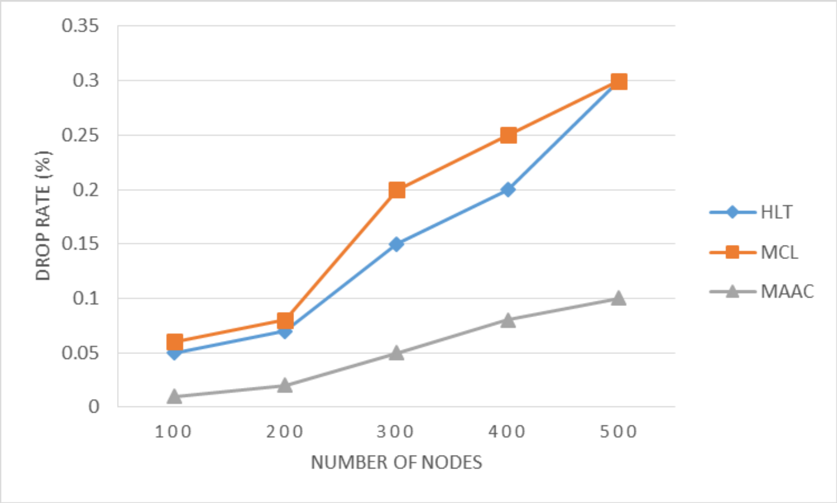

Figure 4. Analysis of Drop rate

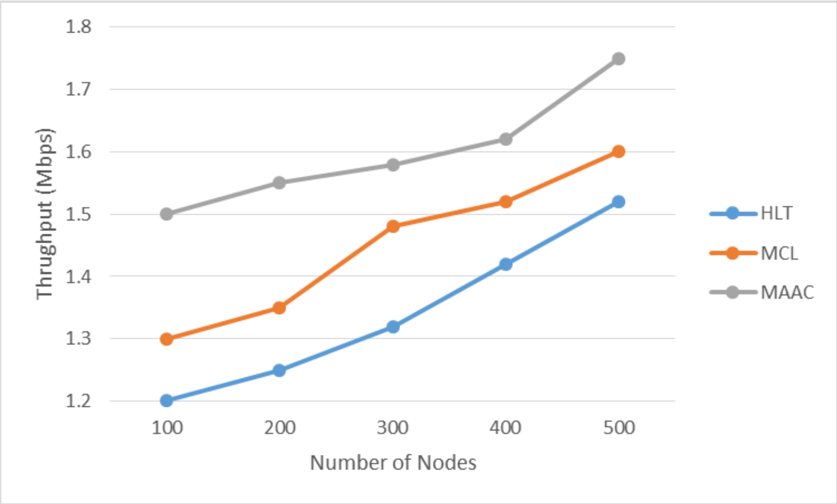

Figure 5. Throughput Analysis

The proposed model provides more efficient performance and lowers the drop rate. The throughput analysis is projected in the figure 5, which is defined by the ratio of the number of data packets transmitted successfully to the simulation time. The developed routing protocol attains high throughput because it tracks the position of sensor node. Hence it reduces the drop rate and improves the delivery rate.

5. Conclusion

The proposed Mobile Anchor Assisted Circularized localization scheme employs a mobile assisted anchor node to track the precise location of the sensor node within the coverage range of the base station. The anchor node is chosen based on the transmission of the control messages between the base station and the neighbor node. The anchor node coordinates the neighbors, and determines the sensor node's position. The proposed localization scheme achieves in finding the accurate position of the sensor nodes and improves the network efficiency. The network factors such as throughput, delivery rate, and drop rate are investigated. The proposed localization scheme improves the delivery rate and throughput, and reduces the drop rate when compared to previous approaches such as Hybrid Localization Technique and Monte Carlo Localization. The simulation results show that the proposed localization scheme outperforms other existing approaches in terms of network performance.

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