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Statistical Approach for Location Identification in MANET

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Abstract: Localizing nodes in MANET is significant as it serves several purposes. Various issues such as routing, security and so on could be resolved if the exact the location of the nodes is known. There exist several localization techniques such as Received Signal Strength (RSS), Time of Arrival (TOA), Time Difference of Arrival (TDOA) and Angle of Arrival (AOA) and so on. But these techniques produce inaccurate location estimates. Thus in this paper a Statistical Approach for Location Identification (SALI) has been proposed to estimate the location of the mobile nodes. This technique is independent of TOA, TDOA and AOA measurements. This technique estimates the location of the mobile node with reference to the mutation point. In addition the behavior of the nodes is monitored to identify malicious node and these nodes are localized using proposed location identification approach.

Keywords: Localization, MANET, Received Signal Strength, Time of Arrival, Time Difference of Arrival, Angle of Arrival.

1. INTRODUCTION

Mobile ad hoc network (MANET) is a self-organized infrastructure less network in which the mobile nodes are interconnected via wireless link [1, 2, 3]. Because of the limited transmission range of the network, multiple hops are desirable in order for a node to transmit data to another node in the network. Therefore accurate location information is necessary for a node to establish an effective communication path. Thus, the design of localization system or technique is vital problem [4].

Location is described as the phenomenon of acquiring nodes location data. Under the context of MANET localization is the problem of finding the position of the mobile node. Various localization techniques have been proposed to compute the position of the mobile nodes. The location information acquired from localization techniques are useful for obtaining several location based services such as rescue operation, habitat monitoring and so on.

The localization algorithms are divided into direct and indirect approaches [5]. In direct approach all the nodes are equipped with GPS receiver to obtain their location information. In indirect approach the unknown nodes are localized with the help of beacon node or anchor nodes, the nodes whose position are already known. In indirect approach the localization can be performed either by employing range based approach or range free approach.

The range based approach computes the location a node that is relative to other node in its neighborhood. This approach uses signal strength, time or time difference and angle measure to compute the position of the unknown nodes. However these measurements are noisy and could lead to inaccurate estimations. Thus a good localization technique has to be developed that provides precise location of the mobile nodes.

In this paper, a Statistical Approach for Location Identification (SALI) has been proposed to estimate the location of the mobile node. This technique is independent of the range free localization techniques and it provides precise location of the mobile nodes. Here an intrusion detection system has been used to monitor the behavior of the mobile nodes. If a malicious node is found the location of the node is identified and the node is eliminated from the network.

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The rest of the paper is organized as follows: section II presents the previous research works that has been done to localize the nodes in MANET, section III presents the problem statement. In section IV the proposed SALI for localizing the nodes has been discussed, section V discusses the results and finally section VI concludes the paper.

2. RELATED WORK

Various localization techniques have been proposed to locate the position of the node in MANET. In [6] the mobile nodes are localized using time-of-arrival and direction-of-arrival measures. Both the time-of-arrival and direction-of-arrival is fused using kalman filter.

In [7] Distributed Position Localization and Tracking (DPLT) approach has been proposed to localize nodes in MANET. This approach utilizes time of arrival and time of departure measures. Then trilateration approach with best criterion function is used to estimate the position of the node and multi-lateration technique is employed to estimate the location of the malicious node.

In [8] Time-of-Arrival based ranging approach is used to estimate the distance measure. This approach is applied in cooperative positioning technique that employs circular trilateration for computing the positioning of the node. In [9] a localization algorithm has been developed that works in two stages. The first stage is referred as naïve activation stage that functions as a bootstrap for the estimation stage. The estimation stage comprises predictive minimal energy consumption algorithm that includes the TOA estimations of the node.

Ultra Wide Band (UWB) is used in [10] to localize the nodes in MANET. A train of low amplitude pulses of high bandwidth is used in this method to reduce the energy consumption, dispersion in time and frequency and effects due to small scale fading. The network is simulated in NS-2 with the method and the results shows that the location accuracy is improved by using the UWB. In [11] Time Bounded Efficient Localization (TBEL) algorithm has been proposed for localizing sensor and nodes in MANET. This algorithm localizes sensor or the node within the specific time limit by utilizing two-hop technology. In [12] Mobile Secure Neighbor Discovery (MSND) approach has been proposed to detect the location of the worm hole node in mobile ad hoc network.

3. PROBLEM STATEMENT

Definition: Given a set of mobile nodes $n_i \in N$, where N is the total number of mobile nodes, the goal of the localization problem is to compute the location of every node n_i such that the error is minimized.

The M X N network model consists of two to three mutation points' i.e. base stations and a set of mobile nodes $n_i (1 \le i \le N)$, where is the number of mobile nodes in the network. The distance between the mutation points is represented as d_{AB} ($d_{AB} = ||A - B||$). The location of the mobile node $(\hat{p}_i)$ (is obtained with reference to the mutation point utilizing Pythagoras theorem. The location of the mobile node is computed at every time t_i under two conditions: parallel and perpendicular. The network contains an intrusion detection system that monitors the entire network activity. A location of the node that is suspected to be malicious is found and the node is eliminated from the network.

4. STATISTICAL APPROACH FOR LOCATION IDENTIFICATION (SALI)

The Statistical Approach for Location Identification computes the location of the mobile nodes in case of two conditions; (i) when the node moves along a straight line between two mutation points (*A* and *B*), and (ii) when the node moves perpendicular with reference to the two mutation points (*A* and *B*). Fig 1 illustrates location of node with reference to two mutation points *A* and *B*.

Consider that the node moves in a straight line between two mutation points (*A* and *B*).Initially the node '*M*' is at the mutation point *A* so the distance between the node and the mutation point *A* is zero ($d_{AB} = 0$). The distance between '*M*' and '*A*' is estimated using eqn. (1) and it is computed for every time instant '*t*'.

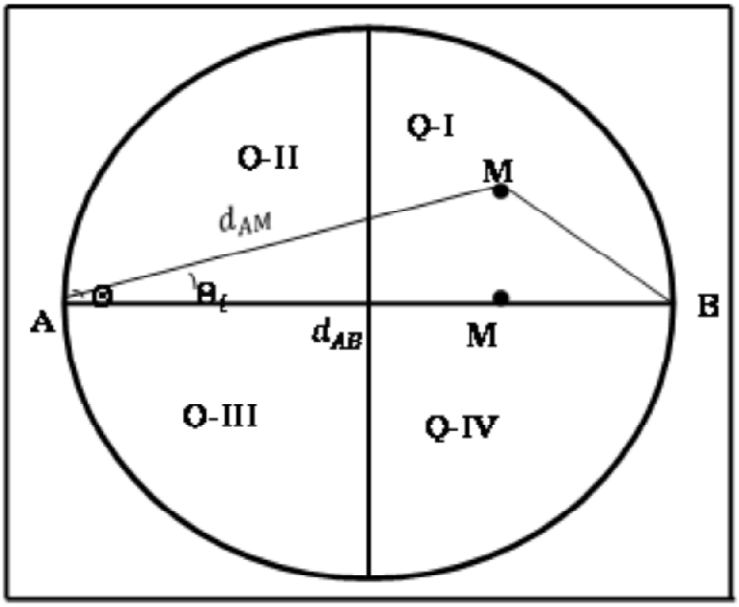

Figure 1: localizing a mobile node in reference with two mutation points

The expression for computing the distance is given as follows

$$d_{AM} = \sqrt{(x_M - x_A)^2 + (y_M - y_A)^2 + \Theta} \tag{1}$$

Here (x_A, y_A) are the coordinates of the mutation point *A* and (x_M, y_M) are the coordinates of the mobile node, Θ indicates the angle of deviation between the node *M*' and the mutation point '*A*'.The angle of deviation provides the direction of the nodes movement. When the node moves in a straight line path along the lining joining the two mutation points '*A*' and '*B*', then the angle of deviation is zero. If deviation in the nodes direction is observed then the angle of deviation (Θ) is computed by first identifying the location of the nodes in the quadrants. If the node is located either in the first quadrant or the fourth quadrant then the angle of deviation (Θ) is obtained using

$$\Theta = \sin(180 - \Theta) \tag{2}$$

If the node lies in the second quadrant or fourth quadrant then the angle of deviation (Θ) is obtained using

$$\Theta = \cos(180 - \Theta) \tag{3}$$

The finally the position of the node is obtained by using eqn (1) and the value of Θ depends on the placement of the nodes in the quadrants.

To calculate the position of the node moving in perpendicular direction another mutation point *C* is assumed to exist such that the three mutation points forms a triangle. The distance between the mobile node and the mutation point *C* is obtained using the distance equation as shown in eqn (1). Here the Θ is considered as 90° since the node moves perpendicular with reference to the two mutation points *A* and *B*. Then depending on the placement of the nodes in the quadrants the angle of deviation (Θ) is expressed as

$$\Theta = \sin(90 - \Theta) \tag{4}$$

$$\Theta = \cos(90 - \Theta) \tag{5}$$

Then the location of the node is obtained using the following expression

$$d = \sqrt{(x_2 - x_1)^2 + (y_2 - y_1)^2}.\sin\Theta \tag{6}$$

$$d = \sqrt{(x_2 - x_1)^2 + (y_2 - y_1)^2}.\cos\Theta \tag{7}$$

5. PERFORMANCE ANALYSIS

5.1. Simulation setup

Simulations are done in order to evaluate the performance of the proposed Statistical Approach for Location Identification a localization technique. Here NS2 is utilized as a simulating environment. Here AODV protocol is used to perform simulations comprising of 60 mobile nodes in an area of 1600 × 1000 square meter area. Table 1 illustrates the simulation parameter utilized in this study.

Table 1
Simulation Parameters

Network Area	1600 × 1000
Protocol	AODV
No. of Mobile Nodes	60
Network Topology	Flat Grid
IEEE Standard	802.11
Broadcasting Range	750mts
Application Type	CBR
Application rate	1.0mb
Mobility	Two way Ground model
No. of Packets	1500
Data Rate	1 mbps
Delay	10ms
Simulation Time	10s

5.2. Results and Discussion

The performance of the SALI is analyzed in terms of accuracy rate and error factor and the results are compared with the existing RSS, TOA, TOA-AOA approach that is employed for localizing a node. Fig 2 illustrates the error incurred in SALI, RSS, TOA and TOA_AOA approaches.In the graph the horizontal line indicates the throughput and the vertical line indicates the error incurred during the transmission.It is observed that the error in SALI approach is minimum when compared to the other three approaches.

Fig 3 illustrates the accuracy of SALI, RSS, TOA and TOA_AOA approaches. In the graph the horizontal line indicates the throughput and the vertical line indicates the accuracy transmission. It is observed that the accuracy in SALI more compared to the other three approaches.

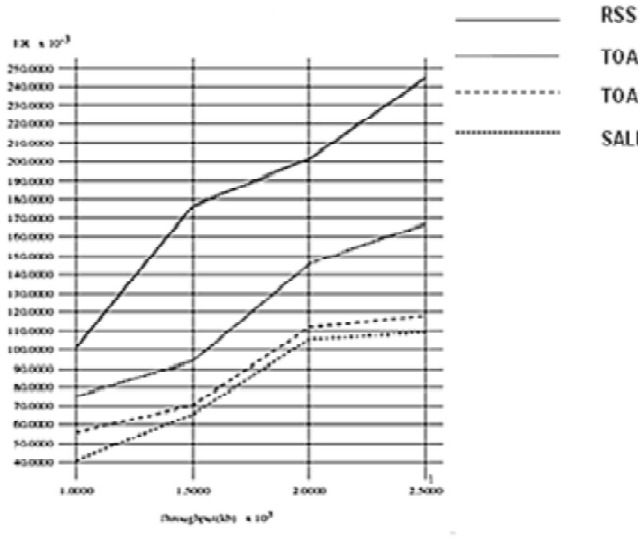

Figure 2: Error Factor

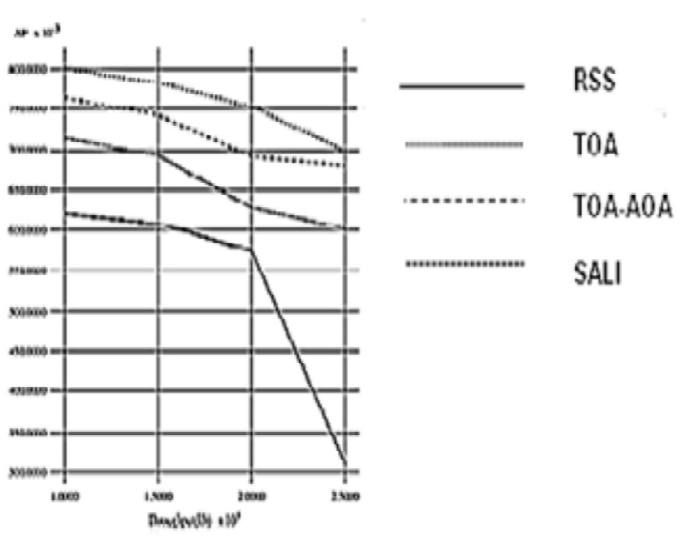

Figure 3: Accuracy Factor

6. CONCLUSION

In MANET because of the limited transmission range of the network, multiple hops are desirable in order for a node to transmit data to another node in the network. Therefore accurate location information is necessary for a node to establish an effective communication path. Various localization techniques such RSS, TOA, TDOA and AOA and so on have been proposed to compute the position of the mobile nodes. But these techniques produce inaccurate location estimates. Thus in this paper a Statistical Approach for Location Identification (SALI) has been introduced to estimate the location of the mobile nodes. This technique estimates the location of the mobile node with reference to the mutation point. In addition the behavior of the nodes is monitored to identify malicious node and these nodes are localized using SALI approach. The performance of the proposed SALI technique is analyzed in terms of throughput, accuracy factor, error factor and the results are compared with the existing RSS, TOA, and TOA-AOA and the results show that the proposed SALI approach precisely localizes the node.

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