Position Verification in Vehicular AdHoc Networks using Location Estimation Techniques

Pankaj Kumar[1], Amanpreet Kaur[2]

M.Tech Scholar[1], Assistant Professor [2]

Computer science and Technology, Central University of Punjab, Bathinda

ABSTRACTVehicular Ad-Hoc Networks (VANET) is being developed to provide an ad-hoc wireless communication infrastructure between vehicles and authorities to support road safety and driving assistance applications. In VANET, The correctness of position and other vehicle, kinematics information play important roles for Safety applications in VANET. Forged position information will make a severe impact on both performance and security of VANET. The main challenges in developing secure position verification schemes for VANETs are the highly dynamic environment and cost constraints. We propose a position verification scheme using location estimation techniques over short-term observation of the vehicle. Then we simulate the proposed scheme in various vehicular mobility in ns-2 environments. Finally, we evaluate the performance of proposed scheme for position verifications with parameters Detection ratio and false alarm rate. The performance evaluation results show that our scheme is suitable for quick verification of position and also useful for detecting roadside attacks. We also discuss the limitation of the proposed position verification scheme and future enhancement required.

Keywords: Vehicular AdHoc Networks, False Position, Position Verification, Vehicle Kinematics.

I. INTRODUCTION

World Health Organization (WHO), reports states that each year an estimated 1.2 million people are killed in road crashes worldwide, and approximately 50 million are injured. Projections indicate that these figures will increase by about 65% over the next 20 years unless there is a new commitment to prevention. Now a time has to come to apply a technology on the road. In Recent years, VANETs have gained a lot of popularity in industry and academic field. VANET has tremendous potential to improve vehicle and road safety, traffic efficiency, and convenience, as well as comfort to both drivers and passengers. A vehicular network will consist of vehicles, equipped with sensors (GPS, Radar, speedometers, etc.) and communications equipment. VANET is commonly used to refer to vehicular networks that function in an ad hoc mode and do not depend solely on infrastructure in their operation [3]. At intersections of a road RSUs will typically exist to assist VANET application, so a system design should not depend solely on RSUs in its functionality.

Vehicular networks will provide the opportunity for communication-based road safety applications to have an extended vision of the road beyond what is typically provided by vehicle onboard sensors. Most of the envisioned safety applications of vehicular networks require the knowledge of vehicles locations, which is made available via the exchange of periodic position information among vehicles [2]. The required level of accuracy of such information is usually high for safety applications [4]. When vehicles send false position information in their beacon messages is a critical issue that may cause loss of lives and money. The fake position of nodes may be generated by the malfunctioning of node's location finding system i.e. GPS or the malicious node itself. In VANET, Vehicle depends on the positioning system, to find their position. Volpe, 2001 explain several different ways how positioning systems can be attacked and make it malfunction. So before taking any decision first need to verify the position information of the vehicle containing in their beacon messages. Before the deploying of VANET in public is required simple and effective position verification method.

Communications-based applications for vehicular networks depend for their operation on the exchange of three general types of data messages [2]: periodic beacon, event messages and infotainment messages. VANET-enabled vehicles broadcast periodic messages over a single hop. These periodic safety messages termed as heartbeat/beacon [4] messages, which are intended to keep the neighbor vehicles aware of a node's position and kinematics. This information helps the VANET application to take various types of decisions for its future activity. Event messages are event-driven messages over multi-hop to disseminate various event alerts such as emergency brake, congestion warning, crash notification, etc. Each of these message types needs to verify upon reception in order to ensure that they hold correct information.

In this paper, we propose a position verification scheme, which can help to identify the misbehaving node, who is disseminating false position information through its periodic beacon messages. The proposed position verification scheme models the movement of vehicles on the road network to estimate a vehicle's current position based on its expected movement according to its location history. The current position announcement of the vehicle is then compared to estimated location to check it lies within the plausible area. The proposed scheme works in real-time and considers the short-term observations for decision-making. The uniqueness of the proposed scheme lies in the fact that it neither requires any additional sensors nor overload the VANET communication channel by using additional messages.

ISSN: 2278 – 7798

II. RELATED WORK

It is necessary to have some position verification schemes. Many researchers suggested a method for position verification in VANET. Existing position verification method suitable for V2V communication can categorized into two: Autonomous position Verification and cooperative position verification. In autonomous verification schemes, each vehicle can verify the claimed location of neighboring vehicles independently. In cooperative verification schemes, each vehicle can overhear the transmission of location information of other vehicles and informs its view to the verifier cooperatively.

Yan, *et al*., [5] proposed a solution to secure localization by verifying announced position of neighboring vehicles using radars that reads the physical parameters of nearby cars. The solution has a number of challenges that has identified. However, the line of sight is required for two vehicles. Obstacles such as trucks can block the signal causing miss classifying neighbors.

Abumansoor, *et al*., [6] proposed a cooperative multi-hop approach to verifying a claimed location when direct communication is not possible because of the existence of an obstacle. The protocol assumes that there is at least one shared neighbor that has a direct Communication between the requester and the questioned vehicle. Without a shared neighbor, the requester will fail to receive a verification reply and drop the vehicle record from its database.

Zhang, *et al*., [7] proposed Cooperative Location Verification (CLV); the claimed location is to verify using a time of flight of the signals in those two challenge-response procedures. It used two vehicles, a Verifier, and a Cooperator, to complete the verification of a vehicle.

Das & Saha, [8] used the periodic retransmission of beacons for confirmation of the position of vehicles. But the average position estimation error increases with the distance between the target vehicle and the observer vehicle, and the error increases with the speed of the observer vehicle. If the observer vehicle is moving at a lower speed, then successive reference points are in proximity to each other. It is also undesirable in an emergency situation as it introduces a delay in the position estimation due to the longer sampling period.

Fiore, *et al*., [9] proposed a distributed solution for NPV. It allows any node in a mobile ad hoc network to verify the position without relying on a priori trustworthy nodes. But the overwhelming presence of the unlikely presence of fully collinear network topologies or colluding adversaries in the neighborhood of the verifier or, can degrade the effectiveness of our NPV.

Fogue, *et al.* [10] propose a Cooperative Neighbor Position and Verification (CNPV) protocol based on a proactive approach. The verification process uses a message exchange mechanism that takes place in two rounds with the same duration. The advertised position of nodes verified in three phases: Direct Symmetry (DS) Test, Cross-Symmetry (CS) Test, Multilateration (ML) Test. But the issue is the latency while ensuring the accuracy of the information when a dangerous situation occurs.

Abu-Elkheir *et al*., [2]a map-guided trajectory-based location verification algorithm was proposedin which the plausibility area is constructed by using a prover's history location and map information (*e.g.* road dimensions). But it involved complex calculation to draw a trajectory of a vehicle on the road map and false alarm rate is also high.

Barnwal *et al*., [4] have presented a short term misbehavior detection scheme which can detect a malicious node that is spreading fake position and speed information through its heartbeat/beacon messages. But Heartbeat message based misbehavior detection scheme include complex calculation to find the virtual zone, and if the vehicle is falsified their position within virtual zone then this scheme is unable to detect.

Works above depict that the misbehavior detection in VANET is a point of concern among security researchers. VANET is an active area of research as the existing schemes are having their limitations. The present work is an attempt to devise a robust self-dependent misbehavior detection scheme for identification of vehicles, which are disseminating false positional or kinematics information in an ephemeral network like VANET.

III. PROPOSED METHOD

A. System Model

The system consists of vehicles equipped with OBU (On-Board Unit), antenna, GPS (Global Positioning System) and other sensing devices. Each OBU is capable of sensing their position, speed, steering angle and current time. The vehicle can communicate with each other with the help of OBU and antenna following DSRC standard of communication. The vehicles move on the roads and broadcast beacon messages at a fixed interval, say Δt.

B. Misbehavior Model

The vehicle, which disseminates inconsistent information and broadcast false position in the periodic beacon characterized as a misbehaving node. This inconsistency may arise due to a bad intention of reporting node viz. to misguide other nodes in the network or because of faulty sensing devices like GPS. In a simulation, a false position of the malicious node is generated by random generation of position at a certain time.

C. Location Estimation Techniques

The proposed Location Estimation techniques worked on a continuous basis and meant for use by the vehicle to monitor other neighboring vehicles in the vicinity of their position. Short term Location Estimation techniques are for detecting the possible inconsistency in disseminated information using consecutive beacons. Here, the word short-term signifies that the detection is done based on very short-term observations for faster decision-making. The short-term decision-making can be a basis for predicting the future behavior of a node. In this work, we use two-dimensional position coordinate, which is realistic.

As per DSRC standard, the average communication range of an OBU has been taken as R = 300m. Considering the average width of lanes of a road is 4m. The speed of a vehicle lies 0-120 km/h and beacon sampling rate at 1 per sec. Here, an observing vehicle, running proposed

ISSN: 2278 – 7798

verification scheme is represented as Vo and the reporting vehicle, which broadcasts information through beacons, is represented by Vs. For the purpose of this work,beacon is defined as six tuples data structure and representedas $\beta < t, X^{cur}(t), Y^{cur}(t), S^{cur}(t), \Psi^{cur}(t) >$, where, t is the current messagetime, $X^{cur}(t)$ &$Y^{cur}(t)$ are components of positioncoordinate of Vsat time t, $S^{cur}(t)$ is the speed of Vsat timet and $\Psi^{cur}(t)$ is the heading angle of Vsat time t. Vehicles are assumed to store and update the periodic position information sent by their neighbors. A neighbor's entry will expire if no communication is received from that neighbor for a limited period, in which case the neighborhood is considered "lost".

In the context of position verification, the observing vehicle receives periodic beacon messages from nearby vehicles. It has no access to other vehicles internal information; only the information they announce periodically. After receiving the beacon message from Sending vehicle Vs, the receiving vehicle Vo calculates the expected position of the sending vehicle. The calculation based on last received information like position, speed and heading angle of the same sending vehicle at time $t - \Delta t$. Based on that information Vo calculates the expected distance for the sending vehicle Vs at time instant t. However, Vo also calculates the current distance directly from the beacon received from Vs at time t. If the difference between the estimated distance and the current distance is above a misbehavior threshold, the vehicle announcing that position is considered misbehaving and flagged accordingly.

The expected position of the sending vehicle Vs at time t is predicted using equation 1 and equation 2.

$$X_{V_s}^{exp}(t) = X_{V_s}^{exp}(t-\Delta t) + S_{V_s}^{cur}(t-\Delta t) \times \Delta t \times \cos\left(\psi_{V_s}^{cur}(t-\Delta t)\right) \quad \ldots..(1)$$

$$Y_{V_s}^{exp}(t) = Y_{V_s}^{exp}(t-\Delta t) + S_{V_s}^{cur}(t-\Delta t) \times \Delta t \times \cos\left(\psi_{V_s}^{cur}(t-\Delta t)\right) \quad \ldots..(2)$$

The expected and observed distance of Vs with respect to Vo are calculated using equation 3 and equation 4 respectively.

$$D_{V_s}^{exp}(t) = \sqrt{\left(X_{V_s}^{exp}(t) - X_{V_0}^{cur}(t)\right)^2 + \left(Y_{V_s}^{exp}(t) - Y_{V_0}^{cur}(t)\right)^2} \quad \ldots.(3)$$

$$D_{V_s}^{obs}(t) = \sqrt{\left(X_{V_s}^{cur}(t) - X_{V_0}^{cur}(t)\right)^2 + \left(Y_{V_s}^{cur}(t) - Y_{V_0}^{cur}(t)\right)^2} \quad \ldots.(4)$$

If the difference of observed distance and expected distance is greater than the threshold value, the vehicle is marked as suspicious and increment the suspicious index by 1, otherwise broadcast the position of vehicles is genuine. If the vehicle marked as suspicious, increment the suspicious index by 1 and wait for next periodic beacon to verify the position.

Algorithm: Distance based position verification

Input:

Position beaconV_s (X_t, Y_t, S_t, ϕ_t);

Neighborhood listDNr for Vr

Output:

T/F- Is Vs falsifying position?

Begin:

WhenVr received a periodic beacons

-Get last observation of V_s

If no information of Vs // new neighbour

-StoreDN_r U V_s (X_t, Y_t, S_t, ϕ_t);

-return false;

Else

-Get last observation of V_s $(X_{t-1}, Y_{t-1}, S_{t-1}, \phi_{t-1})$;

-get V_s $(X_{t-1}, Y_{t-1}, S_{t-1}, \phi_{t-1})$; at time t-1;

- Calculate $X_{V_s}^{exp}(t)$,$Y_{V_s}^{exp}(t)$,$D_{V_s}^{exp}(t)$,$D_{V_s}^{obs}(t)$

$$E = D_{V_s}^{exp}(t)) - (D_{V_s}^{obs}(t))$$

If (E<w) then

Return True;

Else

StoreDN_r U V_s (X_t, Y_t, S_t, ϕ_t);

Increment I;

Return false;

IV. SIMULATION

In this section, the simulation setup and environment used for implementing the verification scheme are detailed.

A. Simulation Setup

The proposed scheme was implemented using the NS-2 [11] network simulator. The NS-2 simulation parameters and network configurations are shown in Table I. Simulations are conducted for a period of 1000 seconds 1051*1052 area.

Table 1. Simulation and Experiments Parameters

Parameter	**Value Setting**
Number of Nodes	100
Average road length	1000m *1000m
Number of Lanes/Road	4
Average lane width	3.7 m
Average vehicle length	2.5m*5.0m
Beacon Interval	1 sec
Beacon size	64 byte

ISSN: 2278 – 7798

Radio Propagation	Two Ray Ground
Antenna type	Omni-directional
Simulation Time	1000 s
MAC Protocol	IEEE 802.11p
Radio Range	300m

Experiments were performed over four different scenarios representing different speed range; 0-30km/h, 0-60km/h, 0-90km/h, 0-120 km/h of vehicles. To generate realistic vehicular topology and movements, we used MOVE (Mobility model generator for Vehicular Networks) [12] on top of the SUMO (Simulation of Urban Mobility) [13]. SUMO and MOVE have been used to generate realistic movement traces to use by NS-2 and Qualnet network simulators. In the simulations, SUMO and MOVE are used to define our vehicular topology and generate mobility models that introduced to the NS-2 simulations. Fig. 1 shows a snapshot of the simulated vehicular topology and vehicles movements visualized by SUMO GUI. The vehicles' injection point is point A, B, C, and D. They come towards junction E; some of them take a turn left some of them take turn right, and others go straight. Traffic lights deployed on the junction, to provide more realism to the topology.

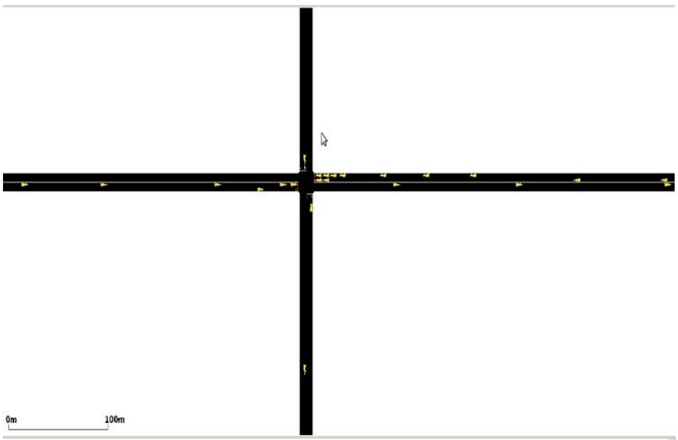

Fig 1. The Simulation Scenario

In the simulation, about 10% of the nodes for each scenario would fake their positions at various times during the simulation. The falsified positions are chosen by malicious vehicle to be at random points on the roads defined by the topology. The simulation was run five times per scenario with different seeds, and the averages of the performance measures were taken. The misbehavior threshold 'w' was set as the width of lanes. So if the difference of observed distance and estimated distance is more than w, then the vehicle is marked as malicious. When a vehicle is verifying a position announce in periodic beacon, it will consider only the most recent observations of a sending vehicle.We assume a normal traffic scenario that involves road is straight, and a vehicle is following own lane, no accidents, no message loss in the network. The genuine nodes send true position, and false position is generated by a random function. The heading direction is according to sign the convention in trigonometry.

B. Evaluation Metrics

Two performance metrics was used to evaluate the performance of the proposed verification scheme: Detection rate and false alarms rate. Detection rate refers to the ratio of the correctly detected nodes that falsify their positions and total malicious nodes. False alarms rate refers to the percentage of the incorrectly flagged nodes that did not falsify their position information. The ultimate goal of any position verification scheme is to target a high detection rate while keeping the false positives rate at a minimum.

V. RESULTS AND DISCUSSION

A. Simulation outcomes

The simulation result of proposed verification techniques is achieved in fig.2 and fig. 3. The detection rate and false negatives rate calculated on the limited road environment. The road is straight, and width of a lane is fixed. All types of vehicles are considered to be of same size and shape. The number of vehicles is taken 100. The detection rate and false alarm rate calculated over a different speed range of vehicles.

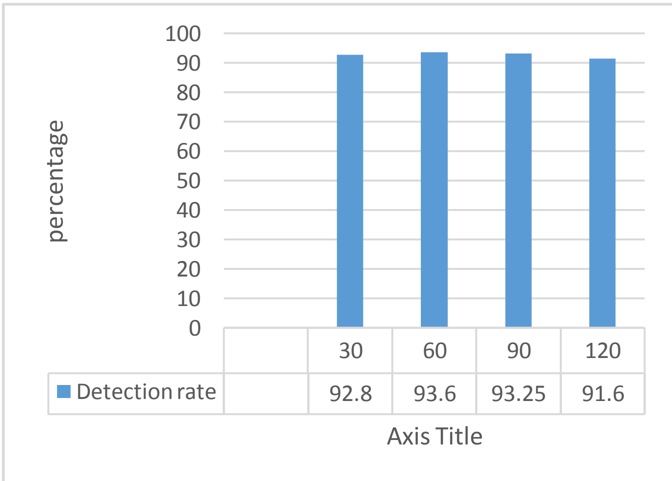

Fig 2. Detection rate of proposed scheme

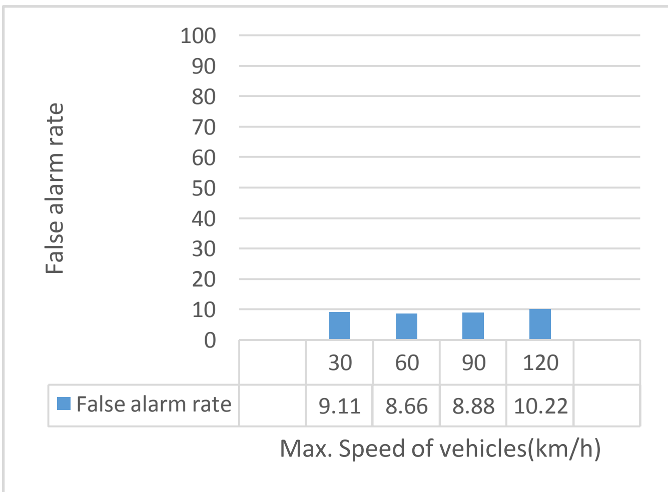

Fig 3. False alarm rate of proposed scheme

It can see that the scheme achieves a detection rate between 93% and 95% when misbehavior threshold is 2w.

ISSN: 2278 – 7798

The scheme also gives a good result when misbehavior threshold is w. The scheme shows a good performance when all vehicles are maintaining velocity and lanes.

The false alarms rate of the proposed scheme, shown in Fig. 3, ranges from 9 to 11%, when a speed limit is 0-120 km/h. The false alarms generated in the scenario are all due to the irregular movement of the vehicle. In general, the performance concerning the false alarms rate can be decreased by adding acceleration of vehicle and lane change parameter.

B. Comparison with existing baseline Scheme

The proposed position verification scheme gives the result close to Map guided trajectory based position verification and Heartbeat message based misbehavior detection scheme. Considering that in the proposed scheme, the prediction accuracy is about 4m while in Map guided trajectory based position verification is about 12m and 30 m in Heartbeat message based misbehavior detection scheme. The proposed position verification scheme is a quick verification method because it involved simple calculation using only vehicle kinematics. While Map guided, trajectory based position verification draw a trajectory of a vehicle on the road, and it involved road map. Heartbeat message based misbehavior detection scheme include complex calculation to find the virtual zone, and if the vehicle is falsified their position within virtual zone then this scheme is unable to detect. `

As can be seen in Fig. 3, the proposed position verification scheme still has a percentage of false alarms higher than that of the baseline scheme. A motivation for the continuous development of the proposed scheme is to lower the false alarms so that normally behaving vehicles would not penalize.

VI. CONCLUSION

In this paper, proposed a position verification scheme for vehicular networks that estimate the current location of vehicles and match with location broadcast in a periodic beacon. We conducted experiments to evaluate the performance of the proposed scheme using Sumo and ns-2. Two well-known performance metrics, namely, detection rate and false alarm rate used for evaluating the efficacy of the proposed algorithm. It showed via simulations that the proposed scheme produces realistic and accurate predictions for straight road scenario. We are studying the performance of the proposed scheme in irregular topologies subject to different heading angle. This work is in progress, and more logical checks are being investigated order to increase the rate of detecting falsified positions and reduce the amount of false alarms. Future work would involve implementing a realistic VANET model.

References

[1]. Shladover, Steven E., and Swe-Kuang Tan. "Analysis of vehicle positioning accuracy requirements for communication-based cooperative collision warning."*Journal of Intelligent Transportation Systems* 10.3 (2006): 131-140.

[2]. Abu-Elkheir, Mervat, et al. "Map-guided trajectory-based position verification for vehicular networks." *Wireless Communications and Networking Conference (WCNC), 2012 IEEE*. IEEE, 2012.

[3]. Abu-Elkheir, Mervat, et al. "Position verification for vehicular networks via analyzing two-hop neighbors information." *Local Computer Networks (LCN), 2011 IEEE 36th Conference on*. IEEE, 2011.

[4]. Barnwal, Rajesh P., and Soumya K. Ghosh. "Heartbeat message based misbehavior detection scheme for vehicular ad-hoc networks." *Connected Vehicles and Expo (ICCVE), 2012 International Conference on*. IEEE, 2012.

[5]. Yan, G., Olariu, S., & Weigle, M. C. (2008). Providing VANET security through active position detection. *Computer Communications*, *31*(12), 2883-2897.

[6]. Abumansoor, O., & Boukerche, A. (2011, March). A cooperative multi-hop location verification for Non Line of Sight (NLOS) in VANET. In *Wireless Communications and Networking Conference (WCNC), 2011 IEEE* (pp. 773-778). IEEE.

[7]. Zhang, P., Zhang, Z., & Boukerche, A. (2012, June). Cooperative location verification for vehicular adhoc networks. In *Communications (ICC), 2012 IEEE International Conference on* (pp. 37-41). IEEE.

[8]. Das, S., & Saha, M. (2013, January). Position verification in vehicular communications. In *Communication Systems and Networks (COMSNETS), 2013 Fifth International Conference on* (pp. 1-2). IEEE.

[9]. Fiore, M., Ettore Casetti, C., Chiasserini, C., & Papadimitratos, P. (2013). Discovery and verification of neighbor positions in mobile ad hoc networks. *Mobile Computing, IEEE Transactions on*, *12*(2), 289-303.

[10]. Fogue, Manuel, et al. "On the use of a cooperative neighbor position verification scheme to secure warning message dissemination in vanets." *Local Computer Networks (LCN), 2013 IEEE 38th Conference on*. IEEE, 2013.

[11]. The Network Simulator NS-2 homepage. [Online]. http://www.isi.edu/nsnam/ns/

[12]. MOVE (Mobility model generator for vehicular networks). [Online].http://lens1.csie.ncku.edu.tw/wiki/doku.php?id=%E2%80%A7realistic_mobility_generator_for_vehicular_networks

[13]. SUMO (Simulation of urbanmobility). [Online]. http://sumo.sourceforge.net/

ISSN: 2278 – 7798