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Stable and Secure Routing Algorithm for VANET

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***Abstract*—In vehicular ad hoc networks (VANET), the communication links break more frequently than the other networks because of the frequent and high-speed vehicles. The communication between the vehicles through Dedicated Short Range Communication (DSRC) or mobile cellular networks. The number of researches are going on in the data transmission between the vehicles using Long Term Evolution (LTE) technique. The linking of vehicles and forming clusters among the vehicles are not an easy task. Since, the high mobility nature and fast convergence among the nodes increases the need for clustering. The clustering algorithm followed in other networks such as MANET, WSN are not able to use in VANET due to the speed and other features of vehicles. In this paper, a stable and secure routing algorithm (SSRA) is proposed, which concentrates in forming stable clustering and drops the change frequency between two vehicles. In addition, the proposed algorithm elects a novel Cluster Head (CH) to reduce the impact of difference between vehicle motion and improves the security of the network. The simulation results shows that the proposed work outperforms than the existing schemes in terms of high stability, packet delivery ratio, end to end delay, throughput and so on.**

***Keywords*—stable, secure, VANET, high stability, throughput**

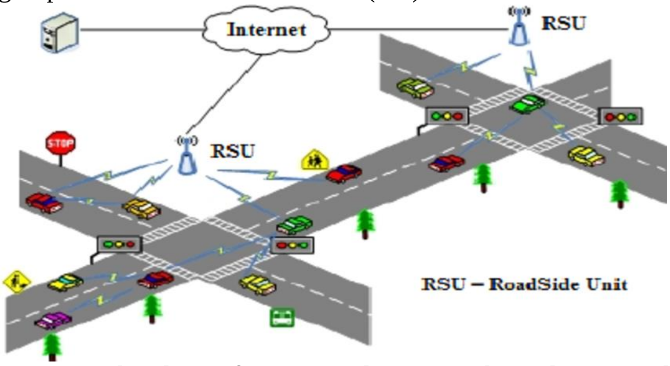
I. Introduction

In recent years, VANET attracts enormous researches and plenty of research efforts are made in the network to enable the latest features. VANET enables both vehicle-to-vehicle and vehicle-to-infrastructure communications [1]. The Roadside Units (RSU) plays an important role in VANET for exchanging information for navigation, safe driving and so on to improve road safety and prevent vehicles from road accidents.

VANET are special form of Mobile ad hoc Networks (MANET), which contains a specially equipped On Board Unit (OBU) to communicate between vehicles. Other than the basic communication system, it also maintains vehicle-to-sensor, vehicle-to-internet and vehicle-infrastructure communication for speedy communication [2,3]. The primary goal of the VANET is to support safety and non-safety information between vehicles on time.

To cope with the dynamic nature of VANET, an effective and intelligent routing scheme is need for data dissemination [1,4]. The scheme also to cope with speed convergence of data transmission between vehicles and RSU else the need scheme may not able to exchange current status of the road safety to the vehicle. There are more number of existing schemes are proposed and divided into five subcategories: position-based schemes, route-discoveryschemes, clsuter based schemes, broadcasting based schemes and infrastructure based schemes. All these protocols and schemes are available with some forms of limitations and practical use. Some of the limitations are, the broadcasting based schemes broadcast more number of messages, which creates communication overhead in the network [5,6,7]. Route-discovery based schemes are not suitable for real-time applications because of fixed route, fixed route maintenance and long end-to-end delay. The position based schemes forwards a periodic position update to its neighbors and RSU for routing updation which delays the message exchange. The infrastructure based routing schemes are cost effective and area specific. It needs to install an expensive base station for communication.

Figure 1. Typical VANET Scenario[1].



The cluster based routing schemes aims in reducing the transmission of number of control messages between the vehicles by developing a group of vehicles as a cluster and group head called Cluster Head (CH) leads the cluster. CH maintains the cluster formation, cluster member selection and data transmission between intra cluster communications and inter cluster communication. The intra cluster communication the CH have to handle traffic and Quality of Service (QoS) provisions [2,8,9]. In VANET, CH acts as a backbone for handling fundamental activities like routing, channel allocation and so on. Transmitting session from one RSU to another RSU (handover) is a challenging task in VANET. In addition, individual data transmission from vehicle to Base Station (BS) is a tedious process because it creates communication overhead and long delay [10,11]. Therefore, the communication range should be short and fast for speedy data transmission and it achieved through handover technique.

THE rest of the paper is organized as follows. Section 2 details the related work on other clustering algorithms. The proposed algorithm is presented in section 3. The proposed algorithm is tested and evaluated with the other recent schemes in section 4 and section 5 concludes the paper.

II. RELATED WORKS

Liu et al. [12] proposed a data dissemination scheme for VANET based on clustering and probabilistic broadcasting method. This scheme proposed a clustering algorithm

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according to the driving direction of the vehicles. Through this approach, the vehicles can exchange data with a necessary connection duration. In such constructive clustering the probabilistic forwarding method is used to disseminate the data between the vehicles. The data forwarding is followed between the CH and member vehicles through calculated probability by sending the packet to CH during one interval of time. For different applications with QoS requirements, data fusion and other techniques are not considered together.

Liu et al. [13] presents a naïve bayes classifier based driving habit prediction scheme for VANET in a stable clustering architecture. The model uses stable clustering technique where the cluster formation, CH election and cluster member working are predefined and which will not change until the simulation ends. The stable clustering is an efficient technique for VANET where the vehicles are unidirectional. To identify the driving habits the proposed work follows naive bayes classifier. The opposite drinving habits are aligned between two set of vehicles to estimate the alignment of vehicles with some of the factors, relative speed, vehicle type, traffic violation alerts and so on. The major pitfall of this research work is that the clustering for distributed network is not suits well in comparing with non-distributed networks.

Sugumar et al. [14] proposed a trust based authentication technique for cluster based VANET. The proposed authentication technique is efficient in detecting compromised nodes with accurate less complexity, less authentication delay and keying overhead. The trust degree is evaluated using the proposed technique. The obtained trust degree is compared with direct and indirect trust degree to elects CH. When the CH vehicle achieves higher or equal trust degree than the direct trust degree then the vehicle acts as CH. For secured data transmission, the messages are digitally signed by the sender and encryption is processed using public/private key. This verifies the identity of the sender and receiver.

Elhoseny and Shankar [15] discussed the energy efficient optimal routing communication via clustering model. The topology changes and other issues were identified commonly in VANET due to the short of energy among nodes. Theseissues reduces the node lifetime and link lifetime in the network. K-Medoid clustering model is proposed with energy efficient data transmission with compelling communication. Enhanced Dragonfly Algorithm (EDA) optimize the parameter as minimum consumption of energy for VANET. The proposed K-Medoid clustering model exhibits the V2V communication. The less execution time also accomplished compared with the existing techniques.

Cheng and Huang [16] presents a center based secure and stable clustering algorithm for VANET. High mobility of vehicles makes VANET a different architecture form other types of networks. A center based clustering is proposed in this scheme to self-organize the network and from stable clustering. Thus, the status change frequency of vehicles reduce the impact of vehicle motion differences. The scheme also elects CH based on stable formula works good on initial rounds and it may not considered properly in later rounds is one of the major setback of the scheme.

Ahmad et al. [17] details LTE based heterogeneous vehicular clustering for driving assistance and for route planning applications. The model proposed a novel destination and interest aware clustering mechanism (DIAC). This work incorporates strategic game theory concepts and self-location calculation algorithm to identify the location and to form clusters. It enforces a fair-use policy to maintain a goodwill between CH and member vehicles. Vehicle mobility and LTE link quality also considered in this scheme.

Zhang et al. [18] discussed a new multihop clustering algorithm for VANET. Proposed novel passive multi-hop clustering solves stability and reliability of clustering. It ensures the coverage of the vehicle members. Priority based neighbor selection model is proposed to select an optimal neighbor nodes to raise join request to join in the same cluster. It maintains high reliability and stability in inter cluster formation and communication. In cluster maintenance phase, cluster-merging mechanism is presented to improve the robustness and reliability of the node.

Khan et al. [19] details evolutionary game theoretic framework (EGT) to automate the clustering technique. The nomination of CH and it automates the clustering of nodes to improve the stability of nodes. Lyapunov function tests the stability of the network. This scheme suits for both static and mobile network scenarios. The effectiveness and robustness of the network is tested with the other existing schemes. This also reduces the clustering overhead and frequent cluster reformation also reduced.

Fahad et al. [20] presents grey wolf optimization technique to form clustering in VANET. Due to frequent topology changes improves the instability of the network. This work, replicates the social behaviour and hunting mechanism of the grey wolf for cluster formation. Earlier coverage is the major advantage of this scheme, which enables the fast cluster formation. It also accomplish quality communication and reliable data delivery also ensured.

III. STABLE AND SECURE ALGORITHM FOR VANET

The proposed work SSRA focused in introducing stable and secure algorithm for VANET to maintain stable clustering and efficient routing for data transmission with secured environment.

A. *Assumptions*

To form stable clustering the following assumptions are formed. They are

1. LTE and 802.11p interfaces are equipped in all vehicles.
2. All vehicles are enabled with Global Positioning System (GPS) to ensure the accurate geolocation of vehicle nodes.
3. All vehicles are designed with different speed, maximum acceleration and its destination.
4. All vehicles knows their destination node location, speed and acceleration.
5. Distance between points are not lesser than DSRC.

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6. Intersection will not processed by any clusters.

Based on these assumptions, the research work is proposed. The density of vehicles is obtained and with its density the vehicles are placed to form clusters.

Input: Vehicle set V_s
Output: Initial clusters
Initialize center set $C_S = \emptyset$;
Locate the center in C_S and add into C_s;
Initialize point set $P_S = C_S$;
while $P_S \neq \emptyset$ ***do***
  foreach $point\ p$ in P_S do
    Initialize nodeset $cluster_p = \emptyset$;
    foreach Vehicle e in V do
      if $d_{ep} \leq R$ Then
        Add e into $cluster_p$;
        Remove e from V;
      end
    end
    if $cluster_p \neq \emptyset$; then

> **Input:** Vehicles in one cluster
> **Output:** Cluster head C_h of the corresponding cluster
> 1 Set $M_{min} = +\infty$;
> 2 foreach $vehicle_k$ do
> 3   Calculate the relative mobility metric M_k;
> 4   If $M_k < M_{min}$ then
> 5 $M_{min} = M_k$;
> 6 $C_h = k$;
> 7 end
> 8 end
> 9 return C_h;

Return set $cluster_p$;
Estimate S_{tc} of the CH $C_h$of $cluster_p$;
if S_{tc} is remarkable high then
  Check all nodes in $cluster_p$ to detect attacker;
end
C_h check S_a value of each C_m;
if S_{am} is remarakable high then
Check all the nodes in $cluster_p$ to detect attacker;
end
end

Figure 2. Stable and secure clustering algorithm

B. Cluster formation

In initialization stage, each vehicles in the network forwards beacon messages to eNodeB. The beacon message consists of vehicle ID, current position, current speed, maximal acceleration and direction. The direction of angle is calculated as in Eq. 1,

$$dir_{angle} = \frac{dest_{position}}{current_{position}} \quad (Eq.1)$$

Where dir_{angle} is direction of angle,$dest_{position}$ is destination position and $current_{position}$ is current position of the node. When the direction of angle,

dir_{angle} for $[0^\circ \quad 90^\circ] = 1.$

dir_{angle} for $[90^\circ \quad 180^\circ] = 2.$

dir_{angle} for $[180^\circ \quad 270^\circ] = 3.$

dir_{angle} for $[270^\circ \quad 360^\circ] = 4.$

The clustering algorithm is described in Fig.2.

After receiving beacon messages the system identifies the vehicle position, detects the higher range of vehicles center point, and applies the highest-degree algorithm. The algorithm is also used to maintain higher value of distance than the DRSC range. The detected vehicles maintains a center position of each clusters. To decrease the computing complexity and analysing time, the proposed algorithm use dots to show the nearby vehicles.

To achieve the higher density of member vehicles for each cluster, it uses the blob detection method. The blob detection is used to draw grey point in the cluster where it maintains higher density range of vehicles.

C. Cluster Maintenance

The unpredictable mobility and traffic in clusters detains the performance and decreases the lifetime of the network. The energy consumption for creating and maintaining clusters also considered. Therefore, the cluster maintenance is proposed in this algorithm to maintain cluster.

1. Cluster Forming: When a vehicle is elected as CH then it forwards the notice to eNodeB. eNodeB forwards the notice to the other nearby vehicles for cluster joining. Notice contains a distance, direction, traffic and time complexity. The nearby node checks the DSRC value and if finds the notice value is lesser than the DSRC value it join as cluster member in the cluster.

2. Less connectivity between CH and eNodeB: When the connection between eNodeB and CH is lost or no connectivity for a certain period then the eNodeB recalls the CH election algorithm and elects CH from the member.

3. Cluster Coupling: When two clusters are nearby then those clusters and combined and one among the CH is elected as CH based on the notice value.

4. No member cluster: Sometimes, the cluster may formed only with CH and no member nodes assigned. In such case, the nearby CH are identified using eNodeB and it elects any of CH and joins to that cluster. The cluster head algorithm also recalls identifying better CH.

5. Security: Maintaining the clusters is a tedious task. To improve the performance of the cluster, the security of the cluster should enhanced. To improve the security,

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the proposed algorithm follows two security processes. They are,

a. Sybil attack: the vehicle controlled by intruder presents multiple fake identity of vehicles on same direction, speed and acceleration. Hence, the malicious vehicle have the higher probability to elect as CH. To protect from Sybil attack the proposed algorithm follows the Eq. 2,

$$Sybil_{protection} = \sum_{i=1}^{N} \left(\frac{duration_i}{lifeitme_i}\right) \quad (Eq.2)$$

Where, $duration_i$ is duration of node i in same cluster. $lifeitme_i$ is the total lifetime of node i.

b. Denial of Service (DoS) attack: the attacker floods the CH or server to make the unavailability of network services. In addition, the connection between the CH and member vehicles also lost and connection cannot established again. To protect from DoS the Eq.3 is proposed,

$$DoS = \frac{\sum_{i=1}^{N} Req_{Total\,time} - Req_{period}}{\sum_{i=1}^{N} Req_{Total\,time}} \quad (Eq.3)$$

Where, $Req_{Total\,time}$ is the request sent on total time. Req_{period} is the total request sent on a period.

IV. SIMULATION PERFORMANCE

The proposed algorithm is evaluated using NS 3.25 and a traffic simulator SUMO [21]. SUMO is an open source microscopic road traffic simulator with General Public License (GPL). SUMO is developed in a collaboration between the center for Applied Informatics Cologne (ZAIK), Institute of Transportation System (ITS) at German Aerospace Center (DLR). The simulation and traffic specification are given in Table 1.

TABLE I. SIMULATION AND TRAFFIC SPECIFICATION

Parameter	***Value***
Protocol	AODV
Connection Type	UDP
Packet Sizes	500 Bytes
Number of Connections	10 % of connections
CBR rate	128 KB/s
Number of simulation run	10
I-5s length L	12 Km
Number of lane	4
Junctions	20
Maximum number of vehicles	1214
Mobility traces duration	400s
Traffic status	Low to high density
Road length L	2 Km
Traffic lights	2
Traffic status	continues arrival

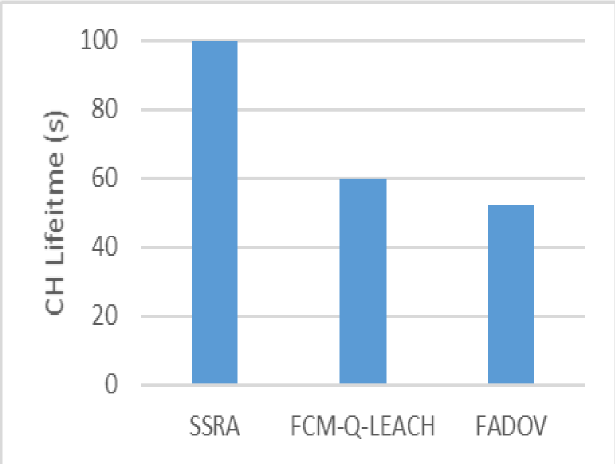
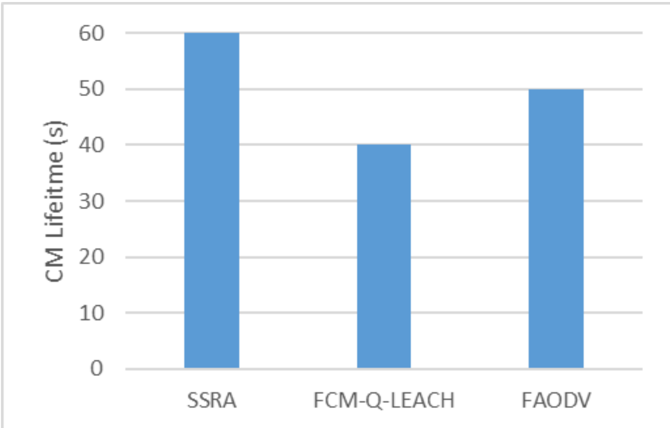


Fig. 3 shows average CH lifetime between the proposed algorithm and previous works FCM-Q-LEACH, FAODV.

Fig. 3 Average CH Lifetime

The Fig. 3 shows the average CH lifetime and the proposed SSRA algorithm achieves higher CH lifetime than the existing research works.

The Fig. 4 shows average CM lifetime between the proposed



SSRA and existing works.

Fig. 4 Average CM Lifetime

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The proposed SSRA maintains higher network lifetime for CM than the existing works. The Fig. 3 and Fig. 4 shows the SSRA maintains better cluster formation than the existing schemes.

The Fig. 5 presents network throughput between the proposed SSRA and existing works.

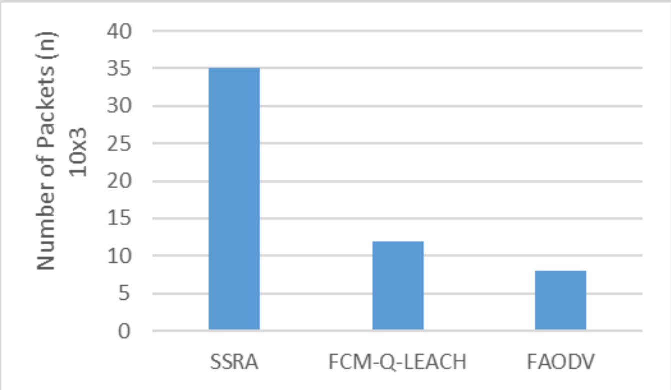

Fig. 4 Network Throughput

Figure 5 presents network throughput between the proposed SSRA and existing works FCM-Q-LEACH and FAODV. The proposed SSRA maintains 50% higher network throughput than the existing works.

The simulation result shows that the proposed SSRA and other existing works, FCM-Q-LEACH and FAODV. The results are compared using the parameters CH lifetime, CM lifetime and network throughput. Thus proves the proposed SSRA outperforms than the other schemes.

V. CONCLUSION

Clustering in VANET is a tedious process due to the network complexity. This paper propose a stable and secure routing algorithm for VANET. It utilizes the direction vector, center of vehicle dense areas, intersection of group between cluster members. The proposed algorithm use the relative mobility metric to reduce the influence of vehicle distance, velocity and maximal acceleration. The security also enhanced in detecting Sybil attack and DoS attack.The selection of CH on stable and reliable nodes based on the proposed value performs better cluster formation, cluster member grouping and data collection and aggregation. Through simulation experiment, the proposed stable and secure routing algorithm outperforms than the existing works. The proposed SSRA results in 75% of better performance in all evaluation parameters i.e. network throughput, CH lifetime and CM lifetime improvement. In future, the proposed algorithm may further improve for complex urban environment.

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