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Trust and Group Leader based Model to Avoid Broadcast Storm Problem in Vehicular Ad-hoc Networks

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Abstract

Vehicular Ad-hoc Networks (VANETs) place an important role in the development of better transportation systems. Road Side Unit (RSU) is the one of the main component of VANETs. In this paper, we propose a mechanism for registration of the arrival of new vehicle into the networks. RSU acts as a local registration unit for the network registration of any vehicle. In VANETs most of the interaction or communication occurs on broadcasting mode. To avoid the broadcast storm problem we propose a Group Leader based Trusted Vehicular Ad-hoc On-demand Distance Vector routing protocol (GL-TVAODV) which is the modification of Ad-hoc On-demand Distance Vector routing protocol (AODV). In our GL-TVAODV protocol, a vehicle can broadcast important information through Group Leader (GL) to other nodes in the network. To broadcast a message a vehicle needs to send request to the GL. If broadcasted message does not come through GL then other nodes will not consider this information as authenticated information. In such ways we can reduce the broadcast storm in VANETs. RSUs are playing the role of GL in their region or area and vehicles are the members of particular group. RSUs are taken as GL because of its high processing power, unmoving so no need to change the GL frequently etc. Because of high mobility characteristics of VANETs, mobility plays important role in selection of GL. In the absence of RSU or RSU down, our GL-TVAODV protocol selects the GL among the numbers of vehicles presents in that area based on Slowest Moving Vehicle (SMV) and trust. The transmission range of RSU is more than vehicle transmission range. So, more than one group may be formed. All the members in a group are one-hop Group Members (GMs) i.e. all the GMs are within one-hop communication range of the GL. Finally, we have conducted the simulation to show the accuracy and performance of our proposed GL-TVAODV protocol based on the assumption that traffic roads are one way road i.e. all the vehicles are moving in the same direction. Proposed model performance and accuracy is validated using the Network Simulator (NS2).

Keywords: VANETs; RSU; GL-TVAODV; SMV; GM; NS2

1. INTRODUCTION

VANET [1], is the subclass of Mobile Ad-hoc Networks (MANETs) [2], that enables the communication between vehicles using Ad-hoc wireless devices. There are basically three modes of communications are: Vehicle to Vehicle communication, Infrastructure to Infrastructure communication and Vehicle to Infrastructure communication [3]. In VANETs the devices are on board unit (OBU) which are installed in the vehicle, the road side units (RSU) are located on the road. Existing research work shows that with the help of RSU we can achieve better performance in VANETs. Research in VANETs plays an important role to minimize traffic deaths, enhance the driving safety, reduce the injuries etc.

The communication is not possible through RSUs if the vehicles are moving at a very high speed on highway where less numbers of RSUs are deployed or the RSU is down. The existence of malicious vehicles can minimize the network performances through continuously broadcasting false information to the network. To overcome the issue address, in this paper we applies a GL-TVAODV protocol which potentially resolves the issue. The main issue is to form a stable group and also selection of GL must not be a malicious vehicle. To address this challenge in GL-TVAODV protocol GL is selected based on the vehicle mobility along with the trust evaluation. Trusting [4] someone means they are reliable, having confidence on them etc.

In this paper neighborhood relationship of vehicles are shown in Fig 1.

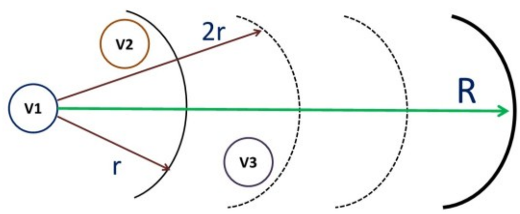

Fig. 1: Neighborhood Relationship of Vehicles

In the Fig. 1, r represents service channel transmission range of a vehicle and R represents the control channel transmission range of a vehicle. The vehicle V3 is the neighbor of vehicle V1 form the view point of control channel transmission range. The Vehicle V3 is not a neighbor of vehicle V1 from the view point of service channel transmission range because its distance from vehicle V1 is greater than r which is the maximum range of service channel. The vehicle V2 is the neighbor of vehicle V1 from the view point of service channel transmission range as well as control channel transmission range. Vehicles are using the control channel to exchange the periodic message and obtain the information about neighborhood. Service channel are used by the vehicle to define the GL radius and for performing the communication tasks.

In this paper GL plays an important role to reduce the broadcast storm. GL formation in presence of RSU is shown in Fig. 2. Here group leader (GL3) is the RSU which is deployed at the road side and all vehicles within the transmission range of RSU are the members of that GL3 group.

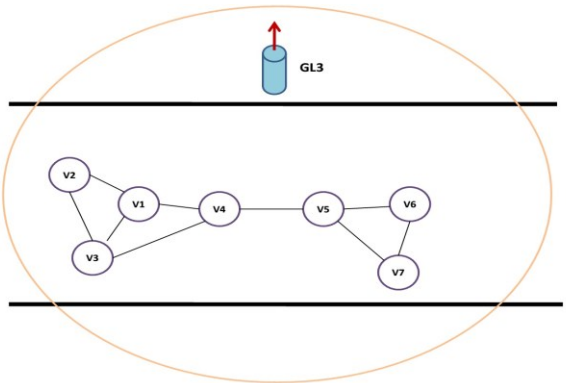

Fig. 2: Proposed Model Structure in presence of RSU

GL formation in absence of RSU is based on the vehicle mobility and trust is shown in Fig. 3. Here vehicle V1 is selected as a GL because it is moving slowly and also having the satisfied trust value among the other members in this group. The vehicle V2 is also selected as a GL using the same process. Vehicle V2, V3 and V4 are the group members of GL1 group. Vehicle V5 and V7 are the members of GL2 group.

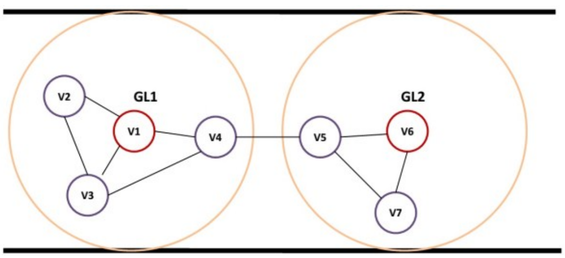

Fig. 3: Proposed Model Structure in Absence of RSU

The rest of the paper is organized as follows: In section 2 the related works are reviewed. In section 3 discuss about the proposed model. In section 4 discuss about the configuration of simulation. In section 5 discuss about the performance matrices used in simulation. In section 6 discuss about the simulation results and analysis. Conclusion is given in section 7. Finally future work reported in section 8.

2. LITERATURE REVIEW

Several studies have been done to develop an efficient protocol for VANETs. Due to the high mobility characteristics of VANETs it becomes a challenging task. RSUs will play an important role in the way of developing an efficient protocol. There are numbers of research work has been done based on the formation of group among vehicles on the highway to investigate the performance of VANETs. Most of the papers the groups are called as clusters, the leader of the group are called cluster head (CH) and the group member's presents in a group are called as cluster members (CM). Extensive numbers of research work has been done on cluster architectures and algorithms; in this section we discussed some of them.

C. Wang et al. [5], proposed an approach for RSU deployment using mobility cluster for enhancing the network performance. The authors used affinity propagation algorithm for RSU deployment based on the spatial temporal mobility influence at different periods of time. Greedy Perimeter Stateless Routing (GPSR) protocol is used to evaluate the RSU deployment performance. The RSU deployment solution is the union set of cluster centers having the maximum influence to its members. In future have a plan to include an approach to predict traffic.

M. Hadded et al. [6], proposed an Adaptive Weighted Clustering Protocol (AWCP) for VANETs. The protocol is based on the multiple metrics: collects the highway ID, vehicles speed, position, direction and numbers of neighboring vehicles. Multi-objective problem is defined for optimizing the protocol. The inputs are AWCPs parameters and goal to provide stable cluster structure, minimizing the clustering overhead and enhancing the data delivery rate. They have addressed the multi-objective problem with the Non-dominated Sorted Genetic Algorithm version 2 (NSGA-II).

Y. Luo et al. [7], proposed an cluster based routing protocol for VANETs (CBR). Geographical area is divided into foursquare grids. Data packets move forwards grid by grid. In each grid there is one cluster header. This scheme improves the packet delivery ratio and reduces the packet delivery delay.

Y. Wang et al. [8], proposed a protocol distributed traffic information acquisition based on IVC. A wireless sensor networks (WSN) is formed for traffic information acquisition, sharing and fusion. RSU acts as a local access point. They verified that clustered VANET shows better performance by reducing the redundancy of traffic data and saving the communication resources. In future have a plan to improve the packet loss rate (PLR).

R. Chai et al. [9], proposed an adaptive K-Harmonic Means clustering algorithm for VANETs. Here vehicle can interact directly within a cluster and for interaction with the vehicle which are indifferent cluster through cluster heads (CHs). The different matrices are take into the consideration are: available bandwidth of candidate CHs, distance and the speed between CHs and CMs. The numbers of cluster and the centroids are chosen, the weighted distance between vehicles and centroids are defined, then the optimal CHs and connection between CMs and CHs are determined.

F. P. Rezha et al. [10], proposed an adaptive transmission power control in cluster based routing mechanism to maximize the performance of message delivery in VANETs. Transmission power is selected depending on the distance between CH and vehicles. To get the better performance of the protocol the uncertainty of vehicle mobility is also considered. The scheme offers less transmission delay and better throughput.

L. Sun et al. [11], proposed an RSU assisted cluster head selection and backup protocol for VANETs. The protocol having two parts: CH selection and backup selection, where CH selection is done by the RSU and the backup selection is initiated by the CH that does not received any probing packet from the previous CH during the specified period of time. Three types of nodes are there: Ordinary vehicles, CHs and RSUs. Under the suitable configuration the protocol shows better performance by lower the rate of error and high efficiency. In future have a plan to minimize the duplicate beacons for enhancing the protocol efficiency.

R. Chai et al. [12], proposed a clustering based mechanism for data transmission in VANETs. The model is mainly focus on the QoS requirements of delay sensitive service and throughput sensitive service. They propose algorithms for CH selection and cluster switching.

S. A. Bugti et al. [13], proposed a mechanism Cluster-based Address in VANET (CAVNET) for configuring the IP address based on the clustering. It removes the problem of assigning unique IP address. In future have a plan to include the discovery of RSUs.

B. Chaima et al. [14], proposed an approach to manage the keys based on the cluster for VANETs. Optimized Link State Protocol (OLSR) is used. Propose a scheme for certificate distribution which is based on the cluster based certificate chaining with migration of certificate. They developed a mechanism to reduce the numbers of certificates in the VANETs.

Y. Aoki et al. [15], proposed a distribution of information mechanism based on the cluster and P2P network in VANETs. Information spreads between vehicles by using the ad-hoc connection of nodes and cellular connection of CHs in the P2P networks. In future have a plan to dynamically select nodes for receiving the information message from source and a scheme for more flexible route selection.

X. Tang et al. [16], proposed a stable clustering algorithm for n-hop to forward the data packet cooperatively in VANETs. They have used 1-hop degree, reputation and the relative delay in weighted clustering algorithm. They proposed a two level graph game model.

Y.-C. Lai et al. [17], proposed a region based clustering mechanism for medium access control (MAC) to timely distribute the safety message. MAC consists of contention period and because of that it may not possible to disseminate data timely. To reduce the contention period a region based clustering mechanism (RCM) is used.

K. Abboud et al. [18], proposed a cluster based routing in VANET. They present the impact of instability of cluster head on routing overhead. Cluster membership change rate is used to derive the probability distribution of routing overhead in inter cluster and formed a rooted tree. Nodes in the tree signify overhead value and the edges signify probability of cluster overlap state change.

T.O. Kim et al. [19], proposed a clustering based multi channel medium access control (MAC) protocol (CMMP) and check the condition of the channel in V2V communication. The protocol shows better performance by increasing the transmission ratio and decreasing the delay during transmission.

S. Jiang et al. [20], proposed an linear cooperative mechanism for detection of accident message by using the clustering technique. Accident is identified based on the linear combination of information collected by each vehicle. The main aim is to minimize the broadcast storm and reduce the false information dissemination. For alarm detection proposed two algorithms: local detection and global detection. In future have a plan to incorporate constrained communication between vehicle and CHs.

W. Liu et al. [21], proposed an autonomous road side infrastructure network for managements of infrastructure VANETs. In addition to the CA, a distributed IDS is included for providing more security. Authentication is accelerated by the certificate caching and forwarding schema.

S. A. Umre et al. [22], proposed an mechanism for improvement of communication performance by using clustering and Bio-Inspired computing. The protocol provides maximum utilization of VANETs in case of communication between nodes. Genetic algorithm used to get the most optimal way to reach source node to destination node. It provides less delay, less energy consumption, less numbers of loss of data.

Y. Ohta et al. [23], proposed a data dissemination scheme for VANETs based on the clustering using the positions and direction of moving vehicles. It creates multiple clusters in the network. Cluster Head (CH) only can store the data packet. When cluster meets new cluster head (CH), the cluster will decide before relay the data packets to new CH depending on its own position, destination position, cluster direction. In future have a plan to calculate the threshold angles effect.

D. Tian et al. [24], proposed an location based clustering multi hop routing mechanism for spreading information between the vehicles and the infrastructure. To form the cluster Hebb neural network is used and virtual cluster heads is used for to represent this clusters.

F. Yang et al. [25], proposed cooperative MAC protocol based on clustering (CCB-MAC) for VANETs to enhance the reliability of safety message. The nodes that are failed in receiving the message during the broadcast period the selected helpers will send them the safety message. Cooperation is done on idle slots.

K. A. Hafeez et al. [26], proposed distributed multichannel mobility aware MAC protocol based on clustering (DMMAC) for VANETs. Fuzzy logic inference system (FIS) is consists of channel scheduling and adaptive learning mechanism. To avoid the hidden terminal problem different sub-channel are used by each cluster for its neighbors. The mechanism shows better performance by increasing the reliability and reducing the delay during the transmission. Stability of the cluster is increases by increasing the lifetime of cluster heads (CHs).

3. PROPOSED MODEL DESCRIPTION

3.1 Model Registration Layout

Registration processes for an arrival of new vehicle into the networks must follow the following steps. The registration process of a proposed model layout is shown in Fig. 4. These are:

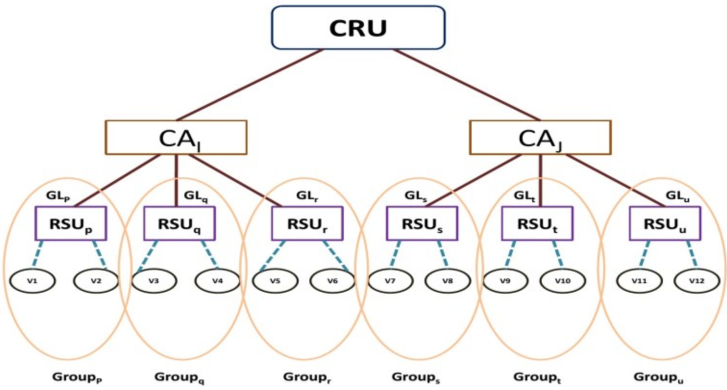

Fig. 4: Registration Process of Proposed Model Layout

Step 1:

A new vehicle will send a network registration request (Net_Reg_Req) to the nearest road side unit (RSU). All the RSU's are the group leader (GL) within their area of transmission. The request packet will contain Vehicle identity number (Vehi_Iden_no) and organization type (Org_type). The meaning of organization type is whether it belongs to government organization, private or public (taxi, bus etc.) which are not under the government organization.

Step 2:

In reply to the request message, RSU may either accept or reject the message.

If the message contained the information all are valid then {

RSU will set the trust value for that newly arrived vehicle depending on the organization it belongs.

If government vehicle then {

Set trust value for it to 1.

}

Else {

Set trust value for it to 0.

}

Step 3:

RSU will attach the trust value into the request packet which has sent by the newly arrived vehicle to it. So the Net_Reg_Req packet will now contain Vehi_Iden_no, Org_type and Trust_Value. After inclusion of Trust value to the Net_Reg_Req packet, it will forward the packet to central authority (CA).

Step 4:

CA will perform the operation to generate the unique vehicle network registration number (Vehi_net_reg_no) for that newly arrived vehicle and save the details of information about that vehicle to the central repository unit (CRU) for future use.

Step 5:

CA will send a vehicle network registration confirmation message to that newly arrived vehicle into the network through RSU. Now the newly arrived vehicle can start using the networks.

3.2 Trust Measurements

The trust measurement means how much we may trust a vehicle. The trust level is shown in table 1.

Table 1. Level of Trust

Trust Level	Trust Value	Meaning
1	0	Unknown or untrustworthy
2	0.1 - 0.2	Very less Trustworthy
3	0.3 - 0.4	Less Trustworthy
4	0.5 - 0.6	Medium Trustworthy
5	0.7 - 0.8	High Trustworthy
6	0.9 - 1.0	Very High Trustworthy

3.3 Network Details

Vehicles which are already registered into the networks must announce its presence into the networks to get the service of the networks.

3.3.1 Presence Announcement

Presence announcement will be verified by the RSU or GL using the following steps. These are:

Step 1:

Vehicle will announce its presence to the nearest RSU by broadcasting a HELLO message. The broadcast HELLO message will contain Vehi_net_reg_no, its mobility information etc.

Step 2:

RSU will confirm whether it belongs to any other GL or RSU and also whether it has joined the networks earlier by sending a request message to the CA containing Vehi_net_reg_no.

Step 3:

If the information is present in CA about the vehicle then {

If the vehicle is not under any RSU or GL then {

CA will give a reply message to the RSU containing L_RSU (RSU or GL under which the vehicle was in last time) and Trust_Value of that vehicle.

}

Else {

CA will give a reply message to RSU containing the Current_RSU (RSU or GL under which the vehicle is currently having the membership).

}

}

Else {

CA will enquire it to the CRU.

If it gets the information from CRU then {

If the vehicle is not under any RSU or GL {

CA will give the reply message to the RSU containing both L_RSU and Trust_Value of that vehicle.

}

Else {

CA will give a reply message to RSU containing the Current_RSU.

}

}

Else {

CA will give a data does not exists message to the RSU.

}

}

Step 4:

If the RSU gets the message from CA containing L_RSU and Trust_Value about that vehicle then {

The neighbors also should know its presence because vehicles are moving continuously from one group to another group. Therefore RSU will broadcast the new incoming vehicle presence in the networks through a broadcast message "Vehicle$_i$ successfully entered into the group". Now it can start using the networks.

}

Else if RSU gets the message from CA containing Current_RSU about the vehicle then {

RSU will reply a broadcast message "vehicle$_i$ is the member of other RSU or GL".

}

Else {

RSU will broadcast a message "Vehicle$_i$ has not given valid information it may be a malicious vehicle".

}

}

3.3.2 Algorithm to Find Slowest Moving Vehicle

The slowest moving vehicle is found using the following steps:

Step 1:

Calculate the total number of vehicles present in the area where to select the GL, say n.

Step 2:

Find the position ($X1_{T1}$, $Y1_{T1}$) coordinate of n vehicles are at time T1.

Step 3:

Find the position ($X2_{T2}$, $Y2_{T2}$) coordinate of n vehicles are at time T2.

Step 4:

Calculate the distance covered by each vehicle from previous to new location using the Eq. 1.

$$\text{Vehicle\_dist}(n) = \sqrt{(X2_{T2} - X1_{T1})^2 + (Y2_{T2} - Y1_{T1})^2} \quad \text{Eq. 1}$$

Step 5:

Find the minimum distance among all calculated distance using the following code.

```
{
Set Min = Vehicle_dist(1) is the Distance covered by first vehicle.
For I = 1 to length of the array
{
If Vehicle_dist(I) is less than Min then
{
Min = Vehicle_dist(I)
}
}
Return I
}
```

Set this minimum distance covered vehicle as slowest moving vehicle (SMV).

3.3.3 Group Leader Selection Process

The area in which we want to select the GL if the RSU of that area is working well or active enough then the RSU will be GL of that area. The RSU will be selected as a GL because RSU is having greater processing power than mobile nodes, it is fixed or unmoving therefore no need to change the GL frequently and it can provide more reliable service than other mobile nodes. But if the RSU of that area is absent or down or not working properly then the GL will be selected from the vehicles are present in that area. Basically the transmission range of the RSU is greater than the transmission range of any vehicle present in the networks or mobile nodes therefore more than one group may be formed in that area. GL formation steps are as follows:

Step 1:

Find the set of vehicles are present in that area. Say VS (vehicle set).

Step 2:

Select the slowest moving vehicle (SMV) in that area using the algorithm stated for to find the slowest moving vehicle which does not belongs to any other GL.

Step 3:

Set the threshold trust value. (In our simulation we have set it to 0.5).

Step 4:

Find the trust value of that SMV using the following Eq. 2.

$$TV_{SMV} = \frac{\sum_{i=1}^{n} TK_{Di}(SMV)}{\text{Total numbers of vehicle replied}} \quad \text{Eq. 2}$$

Where, TK_{Di} is the direct trust knowledge given by each vehicle present in that area on SMV. The TK_{Di} is calculated using the Eq. 3.

$$TK_D = \text{round}\left(\frac{\sum_{i=1}^{n} WE_i \times PK_i}{TE}\right) \quad \text{Eq. 3}$$

Where, TE is the total number of experiences having the particular vehicle on SMV, WE_i is the weight of the experience which signifies the importance level of each experience and PK_i denotes the number of positive knowledge. The value of PK_i is 1 if the experience is positive. Round function is used to round the decimal value to the nearest tenth.

Step 5:

If TV_{SMV} is greater than equal to threshold trust value then {

Select the SMV as GL of that area.

}

Else {

Remove that SMV from the set of vehicle VS and repeat Step 2 to Step 5.

}

Step 6:

GL will broadcast its GL_ID to all its neighbors to announce itself as the GL and Initiate the group formation process.

Step 7:

GL will broadcast an HELLO message to all its neighbors to give the information about their position for to make group members.

Step 8:

All other vehicles will give a broadcast reply with their position in terms of X, Y, Z coordinates, mobility etc. Here coordinate Z is 0 because vehicles are not flying.

Step 9:

GL will set the group boundary as the radius of radio rang r of its own and broadcast it to all neighbors.

GL will assign a specific or unique Id to all its r members.

Step 10:

GL will frequently check its group members through broadcasting of HELLO message.

{

If any vehicle goes out of GL radio range r i.e. GL does not receive any packets (reply HELLO packet) from the group member GM_i consecutively for say $R+1^{th}$ frame then {

GL will delete the GM_i from its group member table. This means GM_i will lose its membership from this GL.

}

GL will not directly remove the GM_i if it doesn't receive the packet for the first time which may be due to the poor quality of wireless network performance.

If GL received the packets from GM_i within the next frame say $R+1^{th}$ frame then {

GL will not remove the GM_i from its group member table.

}

If GM_i come under the radio range of two GL then {

GM_i will calculate its distance from both the GL and join to the nearest GL.

}

If two GL say GL_1 and GL_2 come within the radio transmission range r of each other then {

GL having the large number of group members will be act as a GL say it is GL_2 and the other one GL_1 will join to the acting GL_2 network as a group member of it.

The all other vehicles which are the member of the GL_1 may also join to the network if it is come under the radio range r of acting GL which is GL_2 or it may start GL selection process.

}

}

Step 11:

If GM_i finds that it is moving slower than other vehicles in that group then {

GM_i will start the GL selection process through broadcasting.

}

4. SIMULATION CONFIGURATION

The performance of the proposed GL-TVAODV algorithm is evaluated using the network simulator (NS2). Parameters are used in simulation to configure the simulation environment given in Table 2.

Table 2. GL-TVAODV Protocol Simulation Parameters

Parameter	**Value**
Routing Protocol	GL-TVAODV
Channel Type	Wireless Channel
Number of Nodes	200
Transport Protocol	UDP
Interface Queue Type	Queue/DropTail/PriQueue
Queue Length	50 Packet
MAC Type	Mac/802_15_4
Mobility	Random way point
Speed	60, 70, 80, 90 and 100 km/h
Communication Range or Radius (r)	50, 100, 150, 200, 250 and 300
Data Rate	2 Mbps
Data Payload	512 Bytes/Packet
Traffic Type	CBR
Radio Propagation Model	Propagation/TwoRayGround
HELLO Packet Period	200 ms
Threshold Trust Value	0.5
Area of Simulation	10000 m × 10000 m
Simulation Time	500 sec

5. PERFORMANCE MEASUREMENT METRICS

To evaluate the performance of the proposed model we have used the metrics are:

Packet Delivery Ratio (PDR)

It is the ratio of the numbers of packets delivered to the destination node to the total numbers of packets sent by the source node [27]. The packet delivery ratio is calculated using Eq. 4.

$$\mathrm{PDR} = \frac{\text{Received Packets}}{\text{Sent Packets}} \times 100\% \qquad \text{Eq.4}$$

Normalized Routing Load (NRL)

It is the number of routing packets transmitted for each data packet delivered at the destination node [28]. The normalized routing load is calculated using Eq. 5.

$$\mathrm{NRL} = \frac{\text{No. of Routing Packets Sent}}{\text{Data Packets Received}} \qquad \text{Eq. 5}$$

Throughput

It is defined as the number of bits receives by destination node per unit of time [29] [30]. It is measured in kilo bits per second (kbps). The throughput is calculated using Eq. 6.

$$\text{Throughput} = \frac{\text{Received Size}}{\text{End Time} - \text{Start Time}} \times \frac{8}{1000} \qquad \text{Eq.6}$$

Where, End Time – Start Time is the data transmission period.

Average End-to-End Delay

It shows the time taken to send a data packet from a source node to a destination node. It includes the delay due to queuing, route discovery process, retransmission in MAC level, propagation and transfer [31]. The average end-to-end delay is calculated using Eq. 7.

$$\text{Avg\_E2E\_Delay} = \frac{1}{N_{\text{succ\_Recvd}}} \sum_{i=1}^{n} (\text{rec}_i - \text{sent}_i) \quad \text{Eq. 7}$$

Where, N_{succ_recvd} is the successfully received packets. Rec_i is the time when the i^{th} packet was received and the sent is the time when i^{th} packet was sent.

6. SIMULATION RESULTS, ANALYSIS AND DISCUSSION

Simulation results are shown in figures Fig. 5-13 using gnu plot line graph. In our simulation we have used the vehicle or node transmission range and percentage of malicious node to evaluate the performance of the GL-TVAODV protocol. As shown in Fig. 5, we have evaluated the accuracy of the protocol in the absence of RSU by increasing the percentage of malicious nodes. In the worst case where 90% of the nodes are malicious and they are broadcasting false information to the network, in such case our GL-TVAODV protocol achieved 62 % accuracy of broadcasting actual information. So it means we are reducing 62% of false information broadcasting storm. When 10% of the nodes are malicious our GL-TVAODV protocol achieved accuracy approx. 98%.

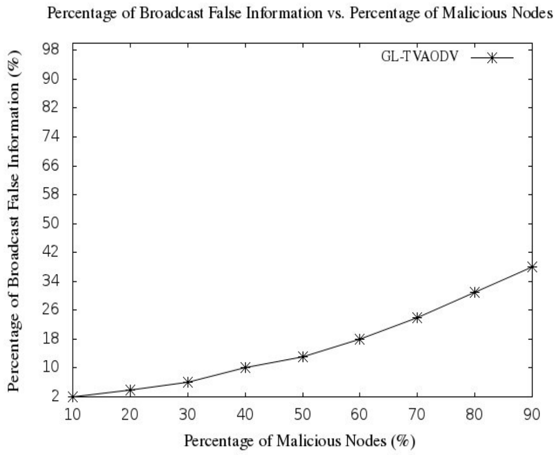

Fig. 5: GL-TVAODV Accuracy Evaluation

In Fig. 6, we have calculated the total numbers of GL formed with different transmission range of a node. Here, transmission range is the boundary of the GL. The Fig. 6 shows that by increasing the node transmission range i.e. by increasing the boundary of a GL node, the total numbers of group or GL formed is less.

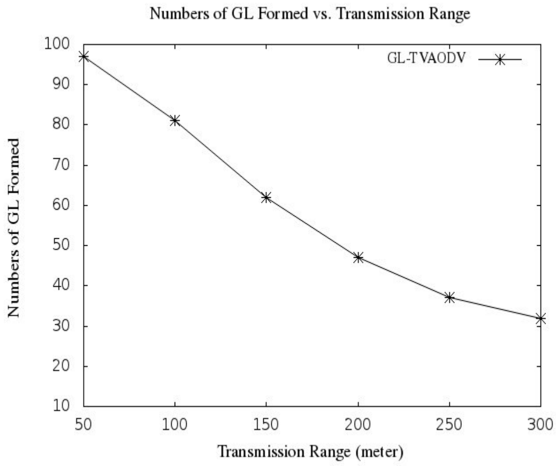

Fig. 6: Numbers of GL formed vs. The Boundary of GL

In fig. 7, we have calculated the average time taken to form GL with different transmission range. The Fig. 7 shows that the GL is formed on an average of 0.35sec i.e. less than .5sec.

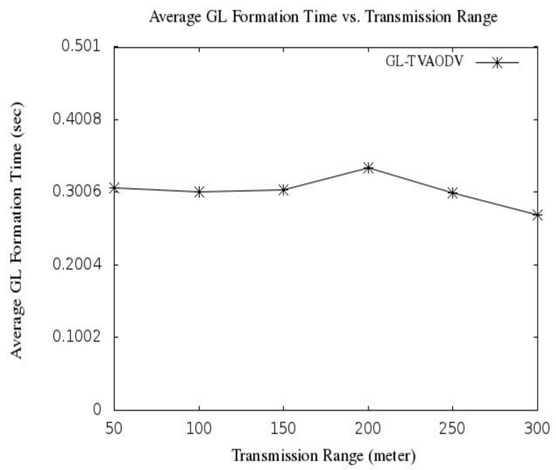

Fig. 7: GL Formation Time vs. Transmission Range

In Fig. 8, we have calculated the average lifetime of GL with different transmission range. The Fig. 8 shows that with the increase in transmission rage the lifetime of GL also increases. This is because with the increase in transmission range we are having more numbers of nodes within the transmission range. Therefore with the concept of SMV, say in a transmission range 300 meter the slowest moving vehicle will be remain in the group for more time as a GL because there is a less number of chances to come a vehicle slower than that compared to 50 meter transmission range.

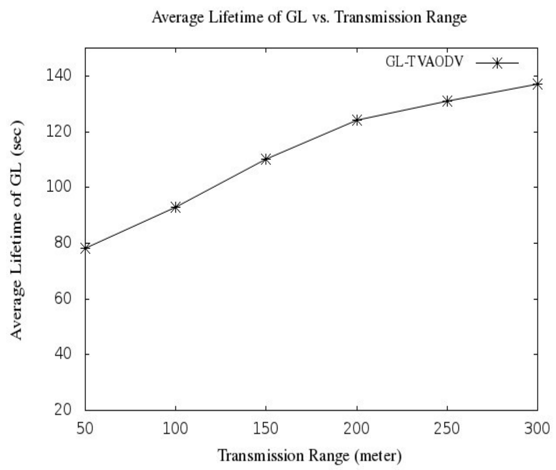

Fig. 8: Average Lifetime of GL vs. Transmission Range

In Fig. 9, we have calculated the average numbers of GL changed with different transmission range. The Fig. 9 shows that with the increase in transmission range the average number of GL changed is less.

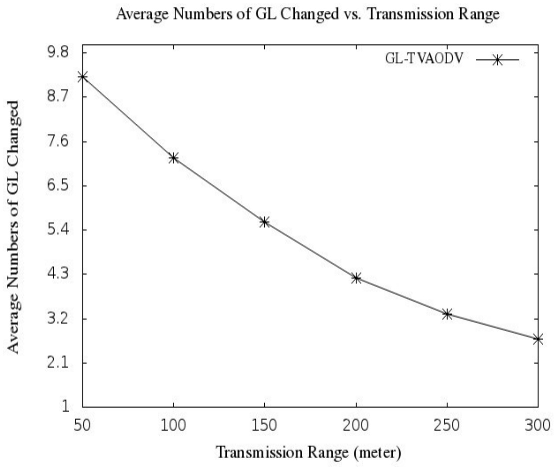

Fig. 9: Average Numbers of GL Changed vs. Transmission Range

In figures Fig. 10-13, we have evaluated the Throughput, End-to-End Delay, Packet Delivery Ratio and Normalized Routing Load with respect to different transmission range. The Fig. 10 shows that with the increase in transmission range the throughput decreases. The Fig. 11 shows that with the increase in transmission range End-to-End delay increases. The Fig. 12 shows that with the increase in transmission range the packet delivery ratio decreases. The Fig. 13 shows that with the increase in transmission range Normalized Routing Load increases.

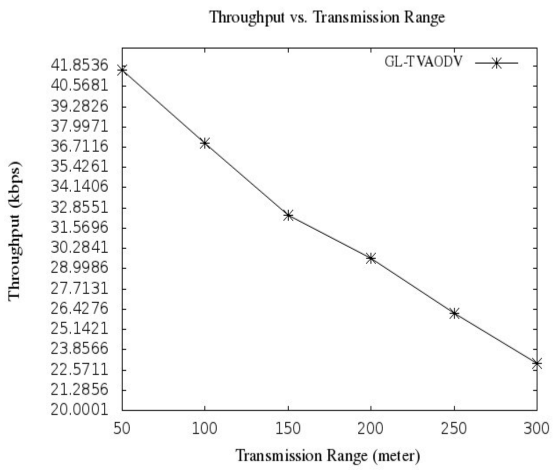

Fig. 10: Throughput vs. Transmission Range

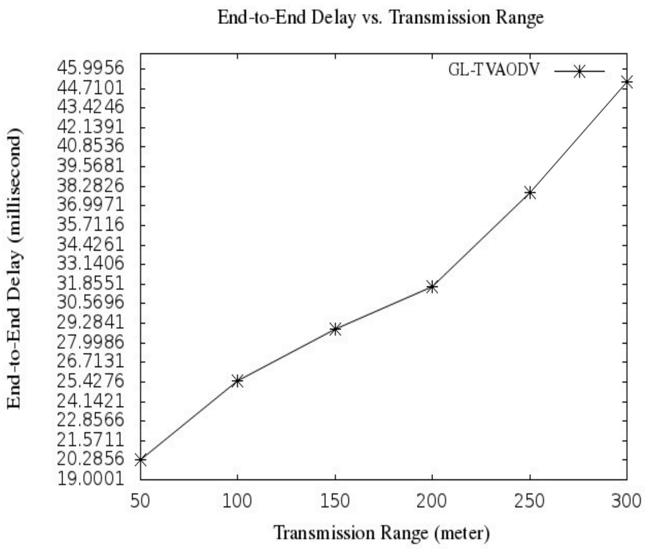

Fig. 11: End-to-End Delay vs. Transmission Range

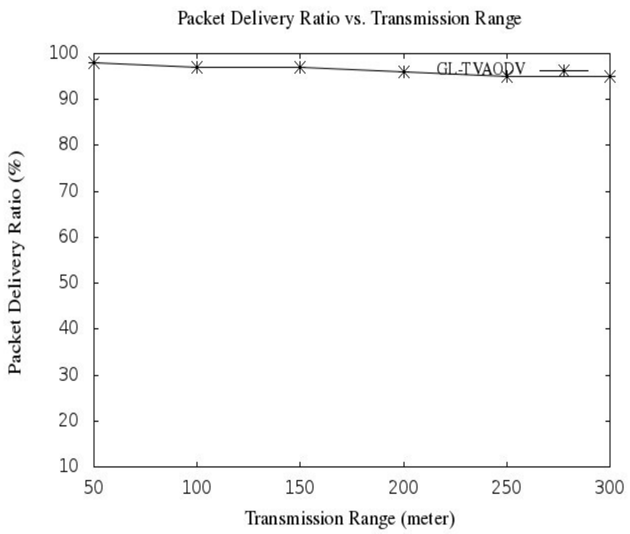

Fig. 12: Packet Delivery Ratio vs. Transmission Range

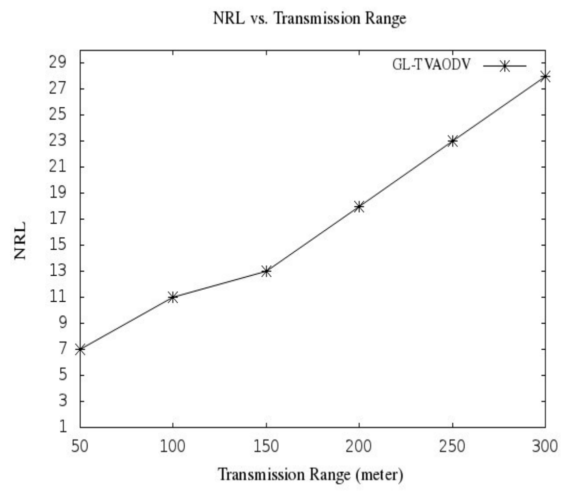

Fig. 13: Normalized Routing Load vs. Transmission Range

7. CONCLUSION

In this paper we have modified the AODV routing protocol named as GL-TVAODV protocol. Our GL-TVAODV protocol is a Group Leader based Trusted Vehicular Ad-hoc On-demand Distance Vector routing protocol. The simulation result shows that our GL-TVAODV protocol is performing well under the presence of different percentages of malicious nodes to reduce the broadcast storm. In this paper slowest moving vehicle algorithm and trust evaluation mechanism is used to select the GL. In this paper we have presented the accuracy of GL-TVAODV protocol to reduce broadcast storm approx. 98% in presence of 10% malicious nodes and an accuracy of approx. 62% in presence of 90% malicious nodes.

8. FUTURE WORK

In future, an improved protocol of this version can be developed to increase the accuracy of reducing the broadcast storm, less numbers of group formation. A method of cryptography can be added with this to achieve better security.

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