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Enhanced Hazard Routing Mechanism with Collision-Avoidance for Smooth Vehicular Movement

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Abstract: **The VANET models are accounting the popularity every years in the communication professionals. The automatically driven vehicle based VANETs are gaining the researcher's interest and new numbers of researchers are contributing to the VANET models development. The VANETs still survive from many prominent problems like hurdle detection and backup or bypass route marking, Sybil or Prankster attacks, flooding attacks, etc. The proposed model is accounting for multi-level security model which protects against the movement hurdles produced by the hazards or the Sybil attacks. Also the proposed model has been designed for the one-hop connectivity with the RSUs, which solves the problem of the connectivity by connecting the nodes within the one-hop range to the RSU through the neighboring RSUs.**

Key words- **Bypass Routing, Hurdle Detection, Lost nodes, Sybil Detection**

I. INTRODUCTION

VANET is a part of Mobile Ad hoc Network (MANET) which says that any node can move freely within the network range and stay connected to communicate with other nodes. VANETs are the Intelligent Transport System (ITS) which allows the nodes to get information earlier so that they can safely change their route if required because of any hazardous situation. The hazards which can disturb the routine of vehicles can be tree falls, snow pile up, road blocks, landslide, boulders on road, road maintenance work etc. With the increasing number of vehicles, the danger of their collision is also increasing. Hence, it is the major issue to be resolved by informing all the vehicles about the related conditions of roads. VANETs include two types of communication between the nodes to transfer information: 1) Vehicle to Road-Side-Unit (V2R) and 2) Vehicle to Vehicle (V2V). In V2R communication, messages are transferred by Road Side Unit (RSU) to the vehicles and in V2V communication messages are transferred from one vehicle to another within the range. V2V communication is not possible when traffic is light.

Messages to be transferred between nodes can be of two types: 1) delay tolerant messages and, 2) delay sensitive messages. Collision forming situations comes under delay sensitive messages which require timely delivery so that nodes can re-route and avoid accidents. Comfort applications are the example of delay tolerant messages which contains information like nearest filling station, restaurant etc.

Collision is a sensitive issue because it can lead to the danger of human lives and economic loss as well. Collision can take place because of the delayed information to nodes. The factors which are responsible for the delayed information can be traffic, retransmission of information etc. There are some pranksters who disturb the flow of transferring information by sending wrong information which can lead to a major or minor vehicular collision and hence, can block the road. So, these pranksters are detected by VANETs to improve the efficiency of the network. Actual location of the node is calculated. If the node is moving then it is a valid node, but if not, it is a malicious node which is delivering malicious information. These nodes can be termed as stationary nodes which increases the network load. Sometimes, the connection problems between the wireless device on vehicle and the RSUs can be a reason of collision. Because that particular node will not get the updated information regularly and can create hazard. To overcome this problem, an updated table is kept with all the nodes which include the details of the nodes within range along with nodes which dropped in between. Some other factors responsible for collision can be driver's mental or physical condition, and natural disasters. Solutions to these problems depends on the driver himself by keeping his mind alert all the time to protect himself and others from collision which can lead to a major loss sometimes.

II. RELATED WORK

M A Berlin[1] et al. proposed a Direction based Hazard Routing Protocol (DHRP) for vehicles to transfer information about the road hazards like landslides, tree falls, snow pile ups, accidents etc. This work focused on transferring information in case of sparse traffic. It is also proposed that the RSUs are responsible for the fast and timely delivery of the messages

Thomas D.C. Little[3] et al. proposed a protocol and a new algorithm which helps to travel the message in VANETs without the use of fixed infrastructure like access points or satellites. The focus of this work is to propagate the local information that originates in a vehicle and can be useful for other vehicles and termed as Information Warning Functions (IWF). This algorithm can perform irrespective of the traffic density. The scheme proposed was Direction Propagation Protocol (DPP) which uses the directionality of data and vehicles for information propagation. Also, the mechanism for transferring custody has been adopted from Delay Tolerant Networking concepts for the implementation of the dissemination algorithm.

Nawaporn Wisitpongphan[4] et al. discussed about the calculation of time for a message to reach to a vehicle in disconnected VANETs. He observed that the delayed time can vary from several seconds to a few minutes which is a very sensitive issue to be resolved for the vehicular safety. The simulation results of the proposed study verified that the store-study-forward mechanism provides a potential solution to routing in disconnected networks. Also, they analyzed two different networks to be handled seamlessly: well-connected networks and disconnected networks. Both these networks can be handled properly with broadcast-storm. But, the latter case that is disconnected network is somewhat difficult to handle. In this, one vehicle have to broadcast and re-broadcast the same message until it reaches the other vehicle and that vehicles start broadcasting. This broadcasting will stop in two cases only: a) either the other vehicle receives the message, or b) the message lifetime expires.

Tarik Taleb[6] et al. proposed a cooperative collision avoidance (CCA) scheme for Intelligent Transport Systems. Rather than flooding the vehicular network with a large number of emergency messages related to accidental events, a cluster based organization for the target event is proposed. A risk-aware medium-access control (MAC) protocol is designed to increase the responsiveness of the proposed CCA scheme. To inform all the vehicles about the risk, the medium-access delay of each vehicle is set as a function of its emergency level. Due to the cluster based and risk-conscious approaches the proposed strategy is referred to as the cluster-based risk-aware CCA (C-RACCA) scheme. The results of C-RACCA scheme verifies its effectiveness in mitigating collision risks of the vehicles arising from accidental hazards.

Tarik Taleb[7] et al. proposed a Vehicle Heading based Routing Protocol (VHRP) for vehicular networks. The basic idea behind this proposed scheme is to group vehicles according to their velocity vectors. The proposed system is able to predict a link breakage between two vehicles of different groups. So, to keep safe the network from links breakages, the route is preferred to make between the vehicles of same group. The proposed scheme reduces the number of packet drops and improves the throughput. The paper focuses on the scheme of proactive routing rather than reactive routing. The proactive schemes undertaken are Destination-Sequenced Distance Vector (DSDC) and Topology Broadcast based on Reverse Path Forwarding (TBRPF) in which groups of vehicles are made in accordance with their direction to avoid link breakages and enhance the performance of network.

Tamer Nadeem[5] et al. proposed a formal model for data dissemination in VANETs. He discussed about two kinds of data: a) generated data; which is vehicle's own data, and b) relayed data; which is the stored data about the vehicles ahead. He proposed three models for better performance: a) same-dir; in which each vehicle broadcasts both is generated and relayed data in the same data packet, b) opp-dir; in which vehicles don't broadcasts both types of data. Instead, they broadcast only the generated data for vehicles in same direction as of theirs, and c) bi-dir; which is a combination of both same-dir and opp-dir. In this model, both generated and relayed data are propagated by vehicles in same direction while vehicles in the opposite direction propagate only relayed data. Performance comparison of all these schemes showed that opp-dir gave better results in many scenarios..

Marco Fiore[2] et al. proposed VanetMobiSim, a freely available generator of realistic vehicular movement traces for network simulators. It is an extension to the CanuMobiSim. CanuMobiSim is a user mobility framework which is capable of producing realistic vehicular mobility traces for several network simulators. The micro-mobility and macro-mobility models of CanuMobiSim are compared with the models of VanetMobiSim and the respective studies showed that macro-mobility models of CanuMobiSim are unable to give that much realistic view to the simulations as provides by VanetMobiSim. The progressive introduction of stops signs, multiple lanes, traffic lights and overtaking demonstrates that how the modeling of these impressive features brings noticeable changes to the system performance.

III. EXPERIMENTAL DESIGN

The proposed model has been based upon the hazardous routing model, which is used to avoid the situations, where the hurdles occur in the VANETs due to tree falling, road destruction, avalanche, node failure or inter-cluster node collisions. The major problem can occur with the automatically driven vehicles in such situations. Unlike the human driven vehicle, who can easily take the backup paths due to the human intelligence, the computer driven or automatically driven vehicles are not intended to take auto-backup paths without using any specific collision or hurdle detection and the backup path formation module. The backup path formation module is the module which calculates the position of the hurdle and reconfigures the VANETs nodes, which are affected by the hurdle or hazard, to take the backup paths in order to avoid the situations of traffic jams and stuck situations.

A. PROTOCOL DESCRIPTION

The proposed model uses two protocols for its working: Ad Hoc On-demand Distance Vector (AODV) and Enhanced Direction based Hazard Routing Protocol (EDHRP). AODV routing protocol is used for routing and it establishes a route to a destination only on demand. AODV routing protocol uses a broadcast route discovery mechanism and dynamically establishes the route from source to destination for sending HM. Selective Forwarding can happen only if the highway has enough vehicles to forward the HM and this procedure minimizes network overhead and improves reliability of the transmission. If there are no other vehicles on the highway, it would not be possible for the Hazard Observer to locate a forwarder node. Then one of the following two things can happen: in the first instance, Hazard Observer would take a U turn and proceed back in the direction from which it originally came. When it reaches the communication range of any RSU, it would receive the HM and reply with the hazard message. In the second instance, it could proceed further in the same direction in the opposite lane and send hazard message to the corresponding RSU.

And, EDHRP is enhanced protocol of DHRP for safely delivery of hazard messages. The biggest challenge for VANETs is when the traffic is sparse. In that case, EDHRP provides the hazard related information to all nodes via RSUs. Instead of flooding the entire data, only the valuable information is sent to the nodes and false information is rejected. RSUs broadcasts the hazards related message to all the nodes only once and if somehow any node disconnects and could not get the message; in that case, RSUs keeps an updated table which have entries for all the connected or disconnected nodes and thus if any node disconnects then RSU re-sends message to that particular node only after the connection is established again. Thus, network load is highly reduced and performance is greatly increased. It provides messages regarding collision, when a fix hazard is blocking the way, and Sybil attack, when fake hazard is created by some prankster. It intimates the node to change their route safely at an interspacing distance of 20 meters between the node and the hazard. It also helps to join the nodes which are out of any RSU's range by connecting them with the one of the nodes among the in-range nodes. Thus information is passed as RSU-to-node-to-node structure. RSU decides the edge node which is in its range and nearest to the out-of-range node. If somehow that edge node fails, RSU gives this connecting responsibility to another node which is nearest to the out-of-range node.

B. RESEARCH WORK

In the proposed model we have focused upon the following parameters, which are used for the working of the movement control and backup path allocation. For the hurdle detection or the collision detection, the distance plays the major role in finding the correct location of the hurdle or collision. The distance formula is used to compute the gap between the nodes and the hurdle that will be calculated by the following formula:

$$\sqrt{(X1 - X2)^2 + (Y1 - Y2)^2}$$

Where $(X1, Y1)$are the coordinates of node 1 and $(X2, Y2)$are the coordinates of node 2.

The displacement can be used to get the movement or distance travelled by the VANET node in the given interval. It is the distance calculated of a particular node's location at two different time intervals and is calculated by the following formula:

$$\sqrt{(X - X')^2 + (Y - Y')^2}$$

Where (X, Y) is the position of node at time interval t1 and (X', Y') is the position of node at time interval t2.

Direction of the movement is important in order to know whether the detect hurdles come in the way of the given VANET node or not. The movement of a node from initial location to final location confirms its direction.

Point of Hurdle (Position) is also an important factor for the proposed model. It is the present location of a node which is defined as (X, Y). If the position of node is not moving then it can be termed as a point of hurdle.

The proposed model is entirely based upon the hazard or hurdle routing for the VANETs. The proposed model calculates the node positions and look for the hurdles continuously in the travelling path of the nodes in the cluster. The proposed model is aimed at finding and avoiding the hazard situations in the VANET clusters. The proposed model is designed to protect the VANETs from the occurring of the collisions due to the hurdles or hazards in the given VANET paths. The following is the hurdle or hazard detection algorithm for the VANET cluster:

Algorithm 1: Hurdle Detection Algorithm (HDA)

1. The nodes in the cluster scan their locality and objects in the range of their distance sensors deployed for obstacles.
2. The nodes are programmed to find the obstacle with the given distance or threshold.
3. The programmed nodes actively scan the distance from objects in their way.
4. If an object is found on the distance lower than the given threshold
   a. The object is marked as the hurdle.
   b. The node stops itself for the moment.
   c. All of the following nodes are updated about the hurdle position and situation.

d. The node calculates the alternative path around the hurdle.
e. The node takes the backup path and crosses the hurdle with uninterrupted movement module.
5. End IF

The nodes in range are updated about the hurdle and take the backup paths according the given alternative path using the hurdle detection algorithm. The nodes update their information and follow the calculated instructions by the HDA module.

In case, a node is left out of the reach during the transmission range of an RSU (road side unit), the node finds the way to the RSU through the other nodes in its range as well as in the range of the road side unit (RSU). The proposed model is equipped with the hurdle detection algorithm with the unicast updates for the newly joined member in the cluster to update them about the hurdles produced in the given interval.

The one-hop distance is allowed using the existing model for the connectivity of the unassigned, non-connected and non-covered nodes in the RSU coverage. The extended coverage algorithm for the RSU coverage elongation is allowed till the nodes located on the one-hop distance from the member nodes of the given cluster. The RSU stores the updates about all of the hurdles produced in the cluster in the given interval length. The given interval length is the length of the period for which the RSU will store the information of the hurdles in the unicast table. The newly joined nodes are updated about the hurdles found in the given interval by the unicast update propagation model. This algorithm is as following:

Algorithm 2: RSU recursive updates and membership program (RSU-RUMP)

1. When a node found itself not in the reach of any RSU
2. Node sends the query to the nodes in range for their distance from any RSU.
3. The nodes reply with their membership with RSU.
4. The nodes on the one-hop distance are shortlisted.
5. The node with the minimum distance from target node is selected as the next-hop member.
6. The node joins the nearest RSU through the next-hop member node.
7. The RSU forwards the hurdles updates in the form of unicast update packets.
8. The newly joined member will update itself about the hurdle information and will follow the given movement protocol designed for the hurdle avoidance protocol.

Algorithm 3: Hazard Routing Algorithm

1. Start the Road side Unit.
2. Start the VANET nodes in the cluster.
3. Each node shares its coordinate (X, Y) information with all the nodes in cluster.

Note: The nodes not sending the coordinate information will not become the member of cluster.

4. Calculate the following:

a. Distance
b. Displacement
c. Direction
d. Position
e. Flexibility for connectivity:

$N_s = \int_{n=1}^{N} (d) \leq 250$

If $N_i = (1,2,3 \dots \dots N)$ is RSU

Connect N_i to N_s.

IV. RESULT ANALYSIS

The results from the simulation has been obtained in the form of various performance parameters which includes the End-to-end delay, Packet Loss, No. of Hello Messages (HM) at RSU, No. of HM transmitted when 100% vehicles are in hazard zone and Throughput. Packet loss increases the retransmissions and hence the network load increases which ultimately gives a rise to end to end delay. The proposed work has been entirely based upon the detection and updation of the hurdles in the vehicle paths which are responsible for flooding data and delivering wrong information and the membership of nodes within the VANET cluster.. For the updates, the vehicles flood the data in the cluster, due to which the network load increases than the normal situations. The aim of this research is to lower the data volume during the detection and updation periods in comparison with the existing schemes. The proposed model has been designed with the communication efficiency, which controls the data volumes during the proposed work simulation.

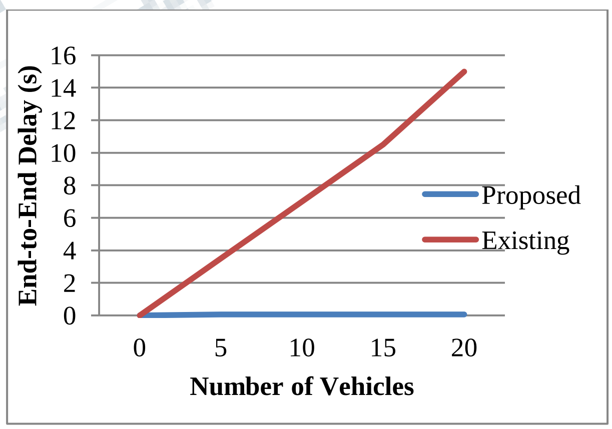

Figure1: End-to-End Delay

The transmission delay is the parameter which indicates the total time taken by a packet to travel across the transmission link. The delay is added at the maximum rate of 0.064 microseconds in the given simulation, which indicates the ideal data transfer across the given simulation. The transmission delay indicates the network latency caused due to the load across the path. The above graph indicates the comparison with the existing model results which have a maximum delay of 15. So, delay is reduced a lot and network performance is far much better than the existing scheme.

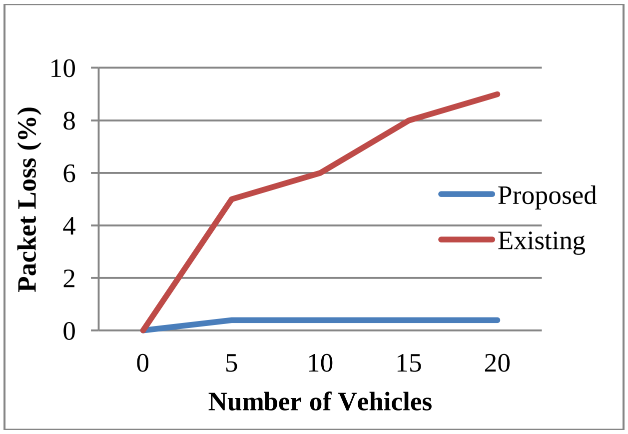

Figure 2: Packet Loss

The data loss is the parameters indicator of the loss of the packets due to the traffic flow overheads or the bottlenecks. The proposed model records the constant delay after the network convergence period. The packet loss has been recorded at less than 0.4 %, which is considerably very low. The low packet loss indicates the effectiveness of the proposed model in comparison with the existing model which have a variable packet loss at a maximum rate of 9 which is very high in comparison.

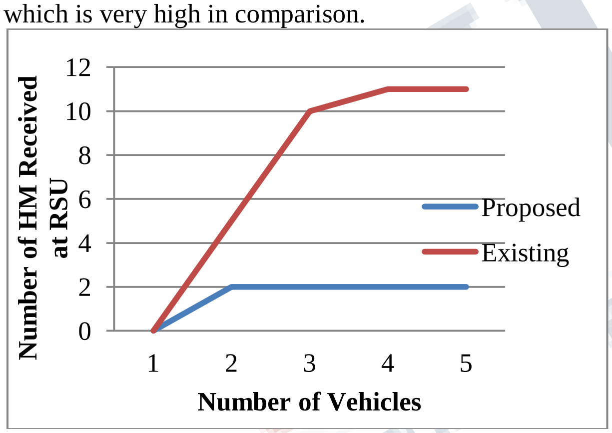

Figure 3: Number of HM Received at RSU

Number of HM received at RSU is the total number of Hello Messages received at RSUs for making connections with nodes which includes a new connection and connection after any disconnection. Thus, high network performance is obtained as the total load for connectivity at RSUs is 2 messages only.

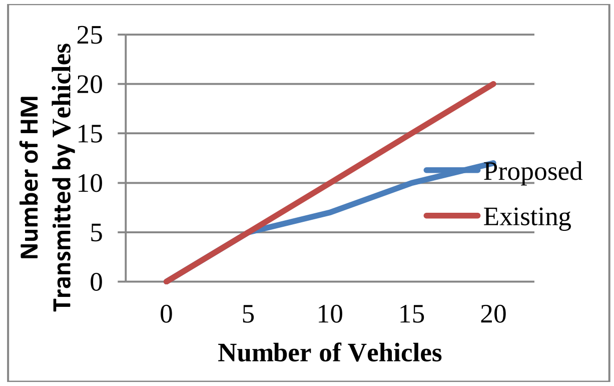

Figure 4: Number of HM Transmitted by Vehicles when 100% Vehicles are in Hazard Zone

Number of HM transmitted by vehicles to each other or to the RSUs when all the vehicles are in hazard zone and needs timely delivery of messages is reduced from 20 (existing) to 12 (proposed) which increases the reliability and decreases the network load for a better performance in real time scenarios.

The table given below contains comparison values between the existing and proposed schemes against the parameters of End-to-End Delay, Packet Loss, Number of HM received at RSU Number of HM transmitted by vehicles when 100% vehicles are in hazard zone:

Sr. No.	End-to-End Delay		Packet Loss		No. of HM Received at RSU		No. of HM transmitted by vehicles when 100% vehicles are in hazard Zone	
	Existing	Proposed	Existing	Proposed	Existing	Proposed	Existing	Proposed
1	0	0	0	0	0	0	0	0
2	3.5	0.054043652	5	0.4	5	2	5	5
3	7	0.057930573	6	0.4	10	2	10	7
4	10.5	0.058366259	8	0.4	11	2	15	10
5	15	0.064048666	9	0.4	11	2	20	12

Table 1: Comparison Values of Various Parameters with the Existing Model

CONCLUSION AND FUTURE SCOPE

The proposed model has been designed for the automatically driven vehicle based VANETs, which is capable of protecting against the collision or the hurdles produced by the hazards like tree falling, land sliding, or other natural or un-natural obstacles. The proposed model is also capable of solving the distance connectivity problems and hurdles produced through the Sybil attacks. The proposed model has been evaluated on the basis of various performance parameters. The proposed model has performed better than the existing models. The experimental results have proved its efficiency which are obtained by AODV and EDHRP. With the help of EDHRP, network overhead is highly reduced and high reliability is achieved. The protocol was implemented and tested using NS2.35 simulator for transmission range of 250 meters and after the connectivity of the out-of range nodes, the distance covered has been increased up to 500 meters. The proposed model can be enhanced for the security of the extended transmission range links through the one-hop nodes. Also the more bypass routing methods can be applied to the real time VANET application of the proposed model to create a highly robust and flexible security and movement management model.

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