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Routing Efficiency Improvement in Vehicular Ad-Hoc Networks Using Neighbor Coverage Based Probabilistic Re-Broadcast Algorithm

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Abstract— **In vehicular ad hoc networks as the nodes are highly mobile in nature, there is a chance for frequent link breakage. This will lead to frequent path discovery and data packet loss. The mobile nature of the nodes will decrease the performance of vehicular ad hoc networks. The overhead incurred for path discovery is not negligible. This will result in high routing overhead and less packet delivery ratio. In this paper, the work proposes a new protocol which exploits the neighbor node information with a rebroadcasting timer and rebroadcasting probability. The approach combines the merits of neighbor knowledge and probabilistic methodology. This will reduce the frequent transmission of route request and route reply. Whenever the link is broken the node will buffer the data packet till the link is re-established or new route is discovered. The network manager will set a timer value based on the rebroadcast delay value and will wait till the timer expires for the re-establishment of broken link; else it will forward the packet through new route with the calculated rebroadcast probability.**

***Keywords*-Additional coverage ratio, connectivity factor, neighbor coverage, packet delivery ratio, rebroadcast timer, routing overhead, rebroadcasting probability, rebroadcasting delay, vehicular ad hoc networks**

I. INTRODUCTION

Vehicular ad hoc networks (VANETs) are infrastructure less networks where each node in the network is mobile in nature. These nodes will form a temporary network when they need to communicate with each other. In a VANET, the connectivity between nodes can change frequently, leading to the multi-hop communication that can allow communication without the use of base station or access point .The challenge exist in wireless network is in routing the data packets. Many routing protocols have been proposed and implemented for VANET.

The present protocols like Ad hoc On-demand Distance Vector Routing (AODV) [2], Dedicated Short Range Communication (DSRC), Destination Sequenced Distance Vector routing protocols (DSDV), Optimized Link State Routing (OLSR), will flood the Route REQuest (RREQ) packets which incur redundant retransmission of these packets and results in broadcast storm problem .These on-demand protocols can improve the reliability of the network by limiting the overhead. In general, broadcasting protocols are grouped into four groups: simple flooding, area based methods, neighbor knowledge methods, and probability based methods. The simple flooding will receive packet from a node and it will flood the packet through every outgoing links. Using area based methods for routing is suggested as a way to achieve scalability. However, area-based routing is difficult in mobile ad hoc networks because the nodes are highly mobile. Neighbor knowledge methods allow a node which receives a packet to rebroadcast the same packet, if its rebroadcasting results have any additional neighbors to be reached. In probability based methods each node will forward each packet with a probability. Among these four classes the performance of neighbor knowledge based methods is better, in a mobile ad hoc network.

The neighbor based methods performs the best compare to other methods, so as an initial step to the protocol implementation network manager have to exploit the neighbor knowledge. Neighbor knowledge is exploited by using the rebroadcast timer and rebroadcast probability [1]. The rebroadcast timer is used to find the forwarding order. The rebroadcast probability finds the information about uncovered neighbors. This consists of calculation of additional coverage ratio and connectivity factor.

The rest of the paper is organized as follows: Section II Existing protocols. Section III Neighbor Coverage Based Probabilistic Rebroadcast Algorithm (NCPR). In section IV deals with simulation and performance evaluation. Section V concludes the protocol.

II. EXISTING WORK

In VANETs the route discovery is done by broadcasting the route request packets to the network, this will affect the QoS. It goes in hand with routing overhead, packet delivery ratio, MAC collision rate, and average end-to-end delay. The existing protocol tries to optimize these metrics and to improve the performance of network. The frequent broadcasting of route request will induce congestion in the networks. In DSRC [12] exchange of beacons are done for updating the positions. Routing in Ad hoc scenario can be small scale routing or large scale routing. The small scale routing is again classified into sender oriented and receiver oriented routing algorithms. V-TRADE (Vector-based Tracking Detection) algorithm is a sender oriented algorithm where it piggybacks the identity of the neighbor in the data packet. DDT (Distance Differ Time) is a receiver oriented algorithm, uses the next hop selection strategy. The transmitted vehicles append its location with the message. BPAB(Bin Partitioning Assisted Broadcasting) algorithm reduces the delay of emergency messages.CAR (Connectivity Aware Routing) is a large scale routing protocol where, more frequent beacons used when fewer neighbors are reported.

Back Bone Assisted Hope Greedy (BAHG) Routing is used for city environments [9]. Routing path is selected with minimal number of intermediate node considering connectivity. The protocol will track the movement of source and destination. Back-Bones are used to maintain the connectivity. Three backbone nodes are considered, stable, primary, secondary. When a node needs a new node to forward the packets it will consider these backbone nodes prior to other nodes.

A junction based multipath source routing (JMSR) [11] finds multiple path towards destination. It is having a junction centric logic. It maintains two paths to destination and route information injected into the packets. Here junctions' positions are having more importance than node positions. The injected information contains information about junctions a packet should visit.

The OLSR (Optical Link State Routing) [7] routing algorithm is furnished to suite for VANET scenario. It is a proactive routing algorithm. Status of each link is known immediately. The operation is simple, but it has to maintain a route table. OLSR is capable of managing multiple interface address of same host.

Shortest path based traffic light aware routing (STAR) is an intersection based routing for urban environment [5]. The traffic light determines how packets are forwarded. Each vehicle is equipped with GPS (Global positioning System) and digital map. Each vehicle moves smoothly when green light is ON. And those vehicles clusters when a red signal is ON. So when red signal is ON high chance for disconnection is there and can also cause additional delay. Vehicles reaching intersection will broadcast connectivity information. A new scalable hybrid routing protocol has been worked out for VANET scenario. It combines the advantages of re-active routing protocols and location based geographic routing protocols. Here the AODV is modified [8]. The route discovery is done in an on demand fashion.

III. NEIGHBOR COVERAGE -BASED PROBABILISTIC REBROADCAST PROTOCOL

The section explains the Neighbor Coverage Based Probabilistic Rebroadcasting protocol (NCPR). The protocol works on two key terms. The rebroadcast delay and rebroadcast probability. While calculating rebroadcast delay for each node in the network NCPR have to consider the delay ratio of each node and neighbor set of each node.

The network manager has to identify the uncovered neighbor set for each node [1]. The pre-calculation of this will increase the performance. Whenever a node receives a RREQ packet from another node it will calculate the uncovered neighbor set of that node in terms of source node. So the current node need not broadcast the packet to all neighbors. It can forward it to the uncovered neighbors alone. This will decrease the routing overhead, and increase the packet delivery ratio. For a node ni, the uncovered neighbor set is,

$$UN(n_i)=N(n_i)-[N(n_i)\cap N(s)]-\{s\}, \qquad (1)$$

Where $N(n_i)$ and $N(s)$ are neighbor set of node n_i and s. Node s sends the request to node n_i.

In order to exploit the neighbor knowledge each node should calculate the delay for rebroadcasting the request for each node. The rebroadcast delay $T_{rd}(n_i)$ for the node ni is,

$$T_{nd}(n_i)=1-\frac{|N(s)\cap N(n_i)|}{|N(s)|} \qquad (2)$$

$$T_{rd}(n_i)=MaxDelay * T_{nd}(n_i)$$

Where MaxDelay is a fixed value. $T_{nd}(n_i)$ is the node delay ratio of node n_i. The delay value is calculated to exploit the neighbor knowledge; from this network can determine the forwarding order. When a node s sends a RREQ packet, assume node n_j has the highest common neighbor. So forwarding the packet to that node will cover more nodes and other nodes can adjust their uncovered neighbor set according to n_j. The aim of calculating this delay is not to send this packet to more nodes but, to gather neighbor knowledge quickly.

The protocol next calculates the rebroadcast probability. According to delay network manager will calculate set a timer value. When this timer value expires the node will update its final uncovered neighbor set. The nodes in the neighbor set are the nodes which have not yet received the RREQ. Here NCPR define additional coverage ratio $R_{add}(n_i)$ is,

$$R_{add}(n_i)=\frac{|U(n_i)|}{|N(n_i)|} \qquad (3)$$

The nodes that have to additionally covered have to receive RREQ packets again. The rebroadcast probability should be always high, this will indicate more number of nodes have to receive RREQ and have to process it. Now, network has to define the connectivity factor. The connectivity factor reveals the number of neighbor nodes for a particular node. The connectivity factor $Cf(n_i)$ is ,

$$Cf(n_i)= \frac{N_c}{|N(n_i)|} \quad (4)$$

Where N_c is 5.1774 log n, and n defines the number of nodes in the network. By calculating both additional coverage ratio and connectivity factor NCPR now define the rebroadcast probability $P_{re}(n_i)$,

$$P_{re}(n_i)= Cf(n_i) * R_{add}(n_i) \quad (5)$$

If the value of probability exceeds 1 that node set it to 1.This calculation is not depended on local density of the network. The value of Cf is inversely proportional to local node density. This factor makes the NCPR to work efficiently in both dense and sparse area. So whenever a link breakage occurs the protocol has to calculate these parameters and should exploit the neighbor knowledge. So the additional overhead of broadcasting the RREQ is reduced and as the node buffers the packet till the timer expires will increase the packet deliver ratio. The NCPR protocol avoids the use of HELLO packet mechanism. But whenever the timer expires the node have to start from initial stage by broadcasting RREQ and calculating the rebroadcast delay and rebroadcast probability from that node to the destination. Using these parameters NCPR works better compare to other existing protocols. Now the following section will discuss how the NCPR protocol works, the algorithm depicts the working,

Algorithm:NCPR

Definitions:

RREQi: RREQ packet received from node i.
IDi:id: the unique identifier (id) of RREQi.
N(i): Neighbor set of node i.
UN(i): Uncovered neighbors set of node u for RREQ .
Timer(i): Timer of node i .
if node ni receives a new RREQs from source s then do step
Compute uncovered neighbors set $UN(n_i)$
For route request RREQs
$UN(n_i)=N(n_i)- [N(n_i)\cap N(s)] -\{s\}$
Compute the rebroadcast delay $T_{rd}(n_i)$
$T_{nd}(n_i)=1- \frac{|N(s)\cap N(n_i)|}{|N(s)|}$
$T_{rd}(n_i)=MaxDelay * T_{nd}(n_i)$
Set a $Timer(n_i)$ according to $T_{rd}(n_i)$
end if
if $Timer(n_i)$ expires then
Compute the rebroadcast probability $P_{re}(n_i)$
$R_{add}(n_i)= \frac{|UN(n_i)|}{|N(n_i)|}$
$Cf(n_i)= \frac{N_c}{|N(n_i)|}$
$P_{re}(n_i)= Cf(n_i) * R_{add}(n_i)$
if Random(0,1) ≤ $P_{re}(n_i)$ then
Broadcast Route request
else
Discard Route request
end if
end if

IV. Simulation and Performance Evaluation

The performance evaluation of the proposed protocol is done by comparing it with one of the existing protocol AODV. For this evaluation the simulator used is NS-2. NCPR considers the metrics routing overhead and packet delivery ratio of both protocols for the performance evaluation. In this work NCPR consider the application, discovery of route. In routing overhead NCPR are calculating the ratio of the total packet size of control packets to the total packet size of data packets send to the destination. In packet delivery ratio, it is the ratio of the number of data packets successfully received by the destination. Here NCPR considers the impact of random packet loss rate and it is uniformly distributed.

Figure. 1 shows the routing overhead of the AODV protocol. Whenever a route request or route reply is send through the network, it will incur high overhead. In AODV whenever a route failure occur the node which has the packet will suddenly broadcast the request and the congestion occurs.

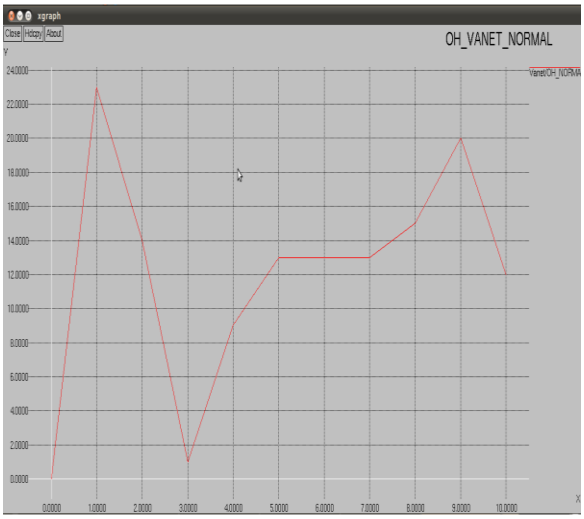

Figure. 1. Routing Overhead of AODV

Figure. 2 Depicts the packet delivery ratio of the AODV protocol, it will perform to the best if no link failure occurs in the network. Whenever a link failure happens as the protocol will discover a new route, the packet is lost and the delay is high. The AODV is shows is best perfomance if no link failure occurs or no random packet loss is addressed.

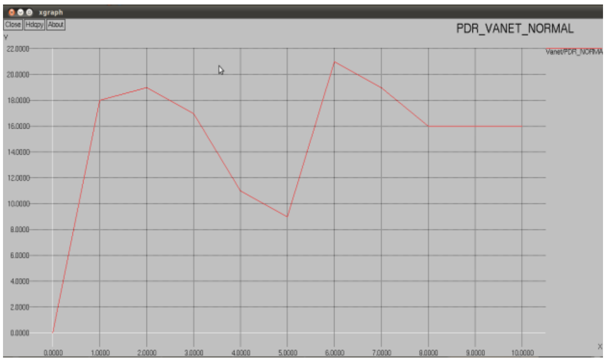

Figure. 2. Packet Delivery Ratio of AODV

Figure. 3. Shows the routing overhead of the proposed protocol. Here the routing overhead is high in initial phase only. The route request is done whenever a source want to send a data to the destination . If a link failure occure it wont send the route request as of sudden it will wait till the timer expires. In this timer network manager will monitor whether the route is re-established, so the overhead is low in NCPR. The approach of finding connectivity factor and the additional coverage helps to exploit the neighbor knwoledge.The protocol doesent calculate these to send the RREQ to more number of nodes. Instead its calculated to collect the neighbor information more quickly.

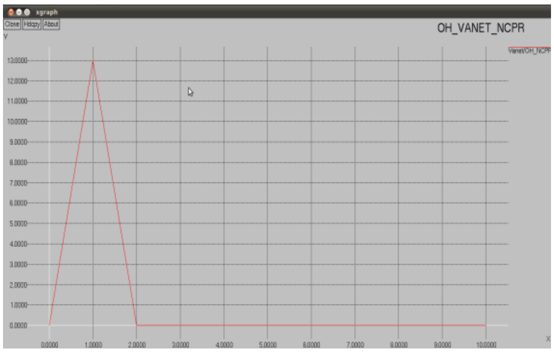

Figure. 3. Routing Overhead of NCPR

Figure. 4. Depicts the packet delivery ratio of the NCPR. As the figure depicts it is high in the proposed protocol. Whenever a link failure occurs may be due to the mobility of the nodes, the node will buffer the data packet and it will wait for a time period to check whether the route is re-established or not. So loss of packet is less here.

Figure. 5. Shows the comparison of the proposed NCPR and existing AODV. From the graph itself it can be concluded that the routing overhead is high for AODV comapred to NCPR. The consideration of rebroadcast delay and rebroadcast probability made NCPR to perform better compared to existing protocols.

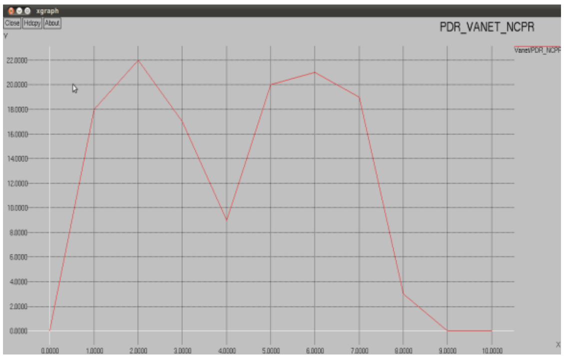

Figure 4. Packet Delivery Ratio of NCPR

Packet delivery ratio gives the number of packet successfully received by the receiver. As in VANETs the nodes are moving before the routing table gets updated the with new route ,the current node sends the packet. So the packet is on the way and its lost. This is overcome here by buffering the packts till the acknowledgment is received. If no acknowledgment received network manager will conclude that a link failure is occurred and the NCPR starts its working .

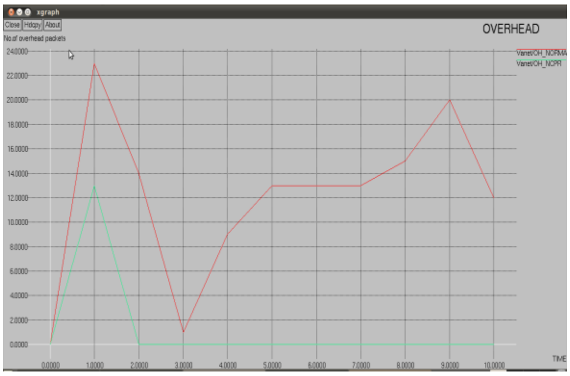

Figure. 5. Routing Overhead Comparison of Protocols

Figure. 6. Shows the comparison of the protocols AODV and NCPR based on the metrics packet delivery ratio. Whenever a link failure occurs the node which have the packet will buffer it this concept makes NCPR to increase it QoS in terms of packet delivery ratio.

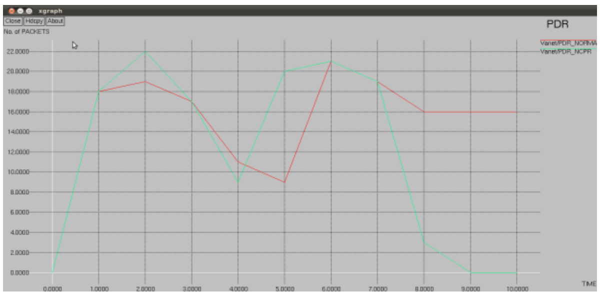

Figure. 6. Packet Delivery Ratio Comparison of Protocols

V. CONCLUSION

In this work, the proposed algorithm aims to improve the routing efficiency of VANET .Whenever a route fails it won't suddenly broadcast route request; it will wait till timer expires. At that time the node will buffer the packets. If route is re-established within timer it will send the packets through same link, else it will re-broadcast the route request. The calculation of re-broadcasting probability and rebroadcasting timer helps to improve the performance of the network by reducing the routing overhead. As the buffering of packets and less redundant re-transmission occurs this will lead to high packet delivery ratio. Simulation results show the NCPR protocol improves the QoS of the VANETs.

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