# EFFICIENT MULTIPATH ROUTING PROTOCOL FOR VANET USING PATH RESTORATION

J.Jayavel <sup>#1</sup>, R.Venkatesan <sup>\*2</sup>, D.Vinoth <sup>#3</sup> <sup>#</sup>Department of Information Technology, Anna University Regional Centre, Coimbatore Coimbatore, India <sup>1</sup>jayavel.jana@gmail.com <sup>3</sup>vinowin02@gmail.com <sup>\*</sup>Department of Computer Science and Engineering, P.S.G College of Technology Peelamedu, Coimbatore, India <sup>2</sup>ramanvenkatesan@yahoo.com

*Abstract*— Vehicular Ad hoc Networks (VANET) is a highly dynamic field due to the fast movement of vehicles acting as nodes. Designing a routing protocol capable of dealing with multiple limiting conditions such as long congestion periods, link failures and handoffs is a challenging task, where most of the existing multipath routing protocol shows poor performance. In this paper, a Multipath Route Restoration Protocol (MRRP) is proposed that focuses not just on route change in case of link failure due to congestion, but also on the route restoration of the link failure path from source to destination. The proposed protocol is implemented on a lattice topology in an urban scenario using Network Simulator-2(NS-2). Simulation results show that compared to the existing protocols, the throughput and average end-to-end delay is better in our proposed work.

# Keyword- congestion, Multipath, link failure, throughput, VANET

# I. INTRODUCTION

A promising area for the application of Mobile Ad hoc Networks (MANET) is in the automotive sector. Vehicular Ad-hoc networks (VANET) are a special category of MANETs which are composed of moving vehicles acting as nodes. These nodes take on the role of sender, receiver and router [1] to broadcast information to the vehicular network. They do not require any infrastructure and use On-Board Units (OBU) and Road Side Units (RSU) like traffic signals and base stations for communications.

IEEE 802.11p is the approved amendment to the IEEE 802.11p standard to add wireless access in Vehicular environments (WAVE) [2]. It is the basis of Dedicated Short Range Communications (DSRC) in the USA and ITS-G5 in Europe, supporting the geo-networking protocol for vehicle to vehicle and vehicle to infrastructure communication. The IEEE 802.11p amendment allows the use of 75 MHz of spectrum in the 5.9 GHz frequency band (5.850-5.925 GHz). Out of the 75 MHz spectrum, 5 MHz is reserved as the guard band and seven 10-MHz channels are defined as shown in Fig 1. [3].

VANET Communication can be classified into Vehicle to Vehicle (V2V) communication and Vehicle to Infrastructure (V2I) communication.GPS devices fitted to vehicles can be used to track the current position and movement of vehicles. MANET routing protocols can be used as a reference for designing VANET routing protocols because VANET is considered as a special class of MANET. These are three classes of MANET routing protocols [4]: proactive, reactive and position based routing protocols. However, VANET communication is highly challenging due to the fast moving nature of the vehicles leading to very high link failure rate [5].



## Fig.1. US DSRC Spectrum Allocation

Some of the unique characteristics of VANET include geographically constrained topology, self-organization and unpredictability [6]. Thus the protocols that were designed for MANET are ill-equipped in this environment and need to be modified. Unlike MANET protocols, which were designed for energy crunch situations, VANET has unlimited power at its disposal.

A key constraint in designing VANET protocols is that of the limited bandwidth availability due to high overhead of control messages [7]. To reduce these overheads, on-demand or reactive routing protocols which carry route information on a need to know basis are preferred over proactive protocols. However, their performance can get affected by frequent route discovery attempts in dynamic networks as well as by high route discovery latency.

VANET protocols can be classified into three categories based on the number of path by which information is sent: Single path, Multipath routing and carry-and-forward mechanism. Single path routing uses a prediction mechanism based on vehicle velocity and vehicle direction for computing the most reliable path or link. This approach, however does not address major real-world traffic conditions. Carry-and-forward type routing protocols suitable for sparse environments, carry the data packet along with them and transfer to the next node that comes near its vicinity. Thus it is highly imperative that instead of relying on not just a single route, thereby causing more congestion on it, it is viable to focus on multipath routing.



Fig.2. VANET Communication

Multipath routing makes use of VANET modifications of AODV and DSR routing protocols. In AODV, (design for MANET) hop count between vehicles is used to determine the main routing link. The probability of such a link breakage due to weak signal strength remains high. Unlike AODV which focuses on single route abstraction, AOMDV uses a "multiple loop free and link disjoint path" [8] technique.

The problem of channel load due to periodic status messages has not been adequately addressed in the congestion control mechanism proposed in the IEEE 802.11 p draft. This issue is especially valid when vehicles

have high penetration rates and will seriously degrade the wireless communication system. To overcome these challenges, the wireless channel should not be allowed to reach the level of saturation. The objective of this paper is to identify the shortcomings of the existing multipath routing protocols and suggest a methodology that could achieve better network performance.

The rest of this paper is organized as follows. In Section II, we present the related works. Section III provides the details of our proposed Multipath Route Restoration Protocol (MRRP). Section IV gives the simulation setup; Section V presents the results obtained and its analysis and in section VI we present the conclusions and future work that can be done.

## II. RELATED WORKS

# A. Ad-hoc On-demand Distance Vector Routing

Ad-hoc On-demand Distance Vector Routing (AODV) [9] is a well known reactive algorithm suitable for dynamic self starting networks. It does not depend on periodic global routing messages to establish a communication link between source and destination, unlike table-driven algorithms, but nodes store the route information that is on an on-demand basis. This technique reduces memory requirements, minimizes broadcast needs, achieves quick response to link breakages and provides loop free routes.

## B. Ad-hoc On-demand Multipath Distance Vector Routing

Ad-hoc On-demand Multipath Distance Vector Routing (AOMDV) [7] extends the technique of the single path Ad-hoc On-demand Distance Vector Routing (AODV) to address the issue of frequent link breakages. Link failure is a common scenario in VANET environment because of the dynamic nature of the nodes. AOMDV computes loop-free and link-disjoint paths by mean of an advertised hop count mechanism. However, it does not address issues related to vehicle mobility, route cut off problem and issues related disjoint paths arise when the source-destination is far apart.

# C. Fast Restoration On-demand Multipath Routing

Fast Restoration On-demand Multipath Routing (FROMR) [10] as the name suggests focuses mainly on maintaining route connectivity between nodes. It is an extension of the single path AODV protocol into the multipath domain. FROMR does not emphasis that nodes be completely link-disjoint from one another but has the ability to send an error message along the reverse route with alternate route information to the destination. However, FROMR does not include moving vehicle parameters to the route selection mechanism. Apart from this, the grid leader switching procedure needs to be tested for better results.

## D. Probabilistic Protocol for Multipath Routing in VANETs

This protocol [11] tries to address the issue of frequent topology changes in VANETs by pre-computing the probability that communication takes place along a particular path. The algorithm presented in this paper has been designed under certain mathematical assumptions. The proposed protocol has a better delivery ratio, average delay time than GPSR protocol and the results can be better understood using real time road density information.

## E. CAMP (Congestion Adaptive Multipath Routing Protocol)

Congestion Adaptive Multipath Routing Protocol (CAMP) [12] focuses on addressing the issue of network congestion by sending periodic notification messages so as to prevent the overuse of any single path for communication. The performance of CAMP is compared with that of Ad-hoc On Demand Multipath Distance Vector (AOMDV) and is found to better address congestion related issues. However, once the congestion is reduced, the original shortest path is not restored. This will invariably decrease the throughput and increase end to end delay within the network. These issues are addressed in this work.

#### F. Ad-hoc On-demand Multipath Distance Vector Routing with Backup Route Update

Ad-hoc On-demand Multipath Distance Vector Routing with Backup Route Update (AOMDV-BU) protocol [13] is based on AOMDV and it tries to improve the performance of the original protocol by trying to maintain at least one backup route. This feature helps to keep the route discovery frequency low and also helps in the continuous working of the active node without the interruption to invoke route discovery mechanisms.

All the protocols discussed so far have their own merits and demerits. While [9] reduces memory requirements due to the on-demand nature of the information stored, it has longer latency for route establishment. Link breakages are not reported immediately and routes are not quickly re-established. In [6], although they have tried to overcome the above mentioned problems by introducing multipath routing protocols, they have not taken into account vehicle mobility and issues related to disjoint paths. In [10], the focus is mainly on maintaining route connectivity and has not considered route restoration. In papers [11], [12] and [13], the authors have not adequately addressed measures to reduce congestion caused by redundant relay messages and have not taken into consideration road density information. Our proposed Multipath Route Restoration Protocol

(MRRP) involves a novel mechanism by which the performance of the existing CAMP [12] protocol has been modified to allow for route restoration, once the congestion in the original optimal path is cleared.

# III. PROPOSED WORK

In Multipath Route Restoration Protocol (MRRP), we assume vehicles to be fitted with GPS device. Each vehicle is aware of its position and that of its neighbours within its transmission range. The main aim of our protocol is restore the original path once the congestion which pre existed is cleared. Our routing protocol comprises of the following main parts (1) Route Discovery (2) Route Selection (3) Route Maintenance and (4) Route Restoration.

## A. Route Discovery

When a source node needs route information to a destination, a route discovery process is initiated. MRRP broadcasts route request (RREQ) packet in the direction of the destination node and waits for a route reply (RREP). When an intermediate vehicle receives an RREQ, it uses the hop information of the packet to create update the route information of the previous node in its table. It also forwards the RREQ message to its nearest neighbour node. MRRP uses the same "advertised hop-count" mechanism found in AOMDV to identify multiple loop-free paths.

# B. Route Selection

The mechanism followed in AOMDV to identify disjoint paths has been used in our work. The general condition for a path to be disjoint is that the path should independently fail. In our route selection process, multiple next hop information is stored in a routing table. Based on the RREPs arrival time, the next hop neighbour with higher rank is chosen for forwarding the packets. We use the equation derived in CAMP [12] to calculate the average queue length based on Exponential Weighted Moving Average (EWMA).

# C. Route Maintenance

Our proposed protocol uses a similar approach like that of CAMP [12] in that, once a route is discovered, every node on the route calculated the average queue length. It sends a Route Streamline Packet (RSP) message to the sender whenever a pre-determined threshold value is exceeded. This causes a notification message to be sent from the intermediate node, which allows the sender node to switch to the next optimal path from the routing table.

## D. Route Restoration

A notable modification to the existing CAMP protocol lies in the route restoration component. Our proposed protocol continuously checks the queue status of the communication channel and once the queue size decreases below that of the threshold value; the sender node is notified by the intermediate nodes which cause it to select the originally selected optimal path. By this mechanism, we propose to improve the throughput and reduce end-to-end delay between the source-destination node pair.

The path restoration process is algorithmically represented as follows:

Path Restoration Algorithm:		
// newavg= new average queue size in packets		
//oldavg= old average queue size in packets		
// $\alpha$ = smoothing factor (queue weight) 0≤ $\alpha$ ≤1 and		
α= 0.9		
//cur_q= current occupied queue size in packets		
//RSP= Route Streamline Packet		
//EWMA=Exponential Weighted Moving		
Average//		
for each packet arrival		
send in oldpath( )// previous optimal path		
Calculate the new EWMA //queue size		
if (queue is non-empty)		
newavg $\leftarrow$ ((1- $\alpha$ )*oldavg)+( $\alpha$ *cur-q)		
if (newavg > threshold)		
{		
Identify newpath( )// new path from routing		
table		
send RSP message // source will select		
different path		
Qcheck() // to check queue size		
while(1)		
{		
if(newavg < threshold)		
send data in oldpath()		
else		
send data in newpath()		
}		
}		
else		
Send data in oldpath()		

Fig.3. Path Restoration Algorithm

# IV. SIMULATION SETUP

The need for VANET simulation tool can be better understood by looking into the drawbacks that outdoor experiments suffer from. It has been found that it is neither easy nor cheap to have a high number of vehicles in real scenario for evaluating safety related applications. It is also difficult to analyze the performance in a highly distributed environment. Another challenge lies in the ability to replicate a same situation to compare two protocols. All these factors make us rely more on using simulation tool for evaluation purposes.

The simulation program consists of two components: network model and mobility model. The network model, which is similar to that of MANET programs, identifies the communication stack i.e. wireless channel model,

antenna model, MAC layer, network layer and application layer. The mobility model differs from that of MANET, because of the need for identifying vehicle movement in a structured road environment. Mobility models can be classified into microscopic or macroscopic models. Macroscopic model focuses on roads, streets, cross roads and traffic lights, whereas microscopic model deals with traffic density, traffic focus, and initial distribution of vehicles.

A realistic mobility model should include accurate and realistic topological maps, lane changing models, and the features of the implemented protocol. We have used MOVE (MObility model generator for VEhicular networks) [14] to generate realistic mobility models. It is built on top of an open source micro-traffic simulator called "Simulation of Urban Mobility" (SUMO) [15]. The output of MOVE is a trace file that can be used with Network Simulator-2(NS-2). We have implemented MRRP on a lattice topology in an urban scenario. The above Table 1 shows the simulation parameters and the range of values.

TABLE I		
Simulation Parameters		
Parameter	Туре	
Simulation tool	NS-2	
Simulation time	1000 Sec	
Routing Protocols	AOMDV,CAMP,FROMR,	
	MRRP	
Traffic type	Constant Bit Rate(CBR)	
Number of nodes	50	
Transmission range	500 m	
Packet Size	1000 bytes	

## V. RESULTS AND ANALYSIS

In this section, we have compared our protocol with that of other protocols, under varying no of nodes. Figure (4) shows that our protocol has lesser end to end delay than other protocols due to better route restoration mechanism. Figure (5) shows that the throughput of MRRP is also better when using 50 vehicle nodes.

Figure (6) compares the packet loss rate of AOMDV, CAMP, FROMR and MRRP protocols. Packet loss occurs when an intermediate node moves away from the transmission range of the source node after the packet node has been sent. Packet loss rate has been found to increase when the node speed progressively increases. Another factor that contributes to increases in packet loss rate is the delay in path restoration once a link breakage occurs. MRRP tends to have lesser packet loss rate compared to other protocols due to its faster route restoration mechanism. Figure (7) shows the comparison of routing overhead for different speeds. MRRP is found to have lesser overhead compared to other protocols due to better route maintenance.



Fig.4. Speed Vs End-to-end Delay



Fig.5. Speed Vs Throughput



Fig. 6. Speed Vs Packet Loss Rate

Fig.7. Speed Vs Routing Overhead

## VI. CONCLUSION AND FUTURE WORK

The proposed Multipath Route Restoration Protocol (MRRP) introduces a path restoration algorithm that is found to have lower end-to-end delay, lesser packet loss rate, lesser routing overhead and better throughput compared to existing protocols. MRRP has been simulated by integrating NS-2 network simulator and mobility model generator tool called SUMO. The performance of MRRP can be improved by testing it under varied traffic scenarios. Route restoration process can also be streamlined by dynamically setting the limits for the threshold value and the packet queue length at the destination.

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