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Collision Aware Distributed Multicast Routing Protocol for Vehicular Adhoc Networks

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Abstract
An effective multicast routing protocol becomes very essential to construct intelligent vehicular ad hoc networks (VANETs). Hence this network model consists of highly complex vehicle mobility achieving efficient routing is complicated in an urban environment. The data transmission between the sources to the destination becomes highly challenging because of the packet loss occurrence between the high speed vehicles. So that to achieve effective communication it is very essential to establish a collision free routing protocol to transmit the information among the source to the destination with high quality. For that purpose, in this paper Collision Aware Distributed Multicast Routing Protocol in VANETs (CDMR-VANETs) is developed which consists of the subsets like routing design and the protocol functionalities. The routing design creates connections among each vehicle and with the infrastructure. Through the protocol functionalities the topology control is improvised with the help of Optimized Link State Routing Protocol (OLSR). Using the proposed CDMR routing protocol, the network collision is reduced that leads to increase the effectiveness of communication among the vehicles. The implementation of this method is done with NS2 in Ubuntu with SUMO mobility generator. The output parameters which are calculated in results section are packet delivery ratio, end-to-end delay, routing overhead, and energy efficiency and as well to performed comparative analysis the baseline methods which are concentrated are ECA-RSM and CAMD-DRF. At the end of this analysis it gets understood that the proposed CDMR routing protocol produce lower delay and overhead when compared with the earlier methods.

Index Terms: Vehicular Ad hoc Networks (VANETs), Collision Aware Model, Multicast Routing Protocol, Optimized Link State Routing Protocol (OLSR)

1 Introduction

To developed various communication technology at the earlier times wireless communication is used in terms of wireless local area network, 3G and 4G technologies which helps to perform intelligent transportation systems (ITSs). To exclusively support for smart cities applications Vehicle Ad- hoc networks (VANET) are developed which is one among the category of Mobile Ad-hoc Networks (MANET) and it offers real time traffic in a city environment or highway and it also highly concentrate on safety and ease drive [1]. In VANETs certain drawbacks like delay and overhead occurs because of the characteristics like dynamic topology and high speed among the vehicles etc. Any vehicle in the network wills communication with another vehicle or to the Road Side Units (RSU) to transmit the information. The wireless data transmission is carried out among the vehicles using IEEE 802.11p standard, and the data exchange takes place in the high-speed vehicles in the licensed band of 5.9 GHz. The VANETs network architecture is shown in figure 1 [2].

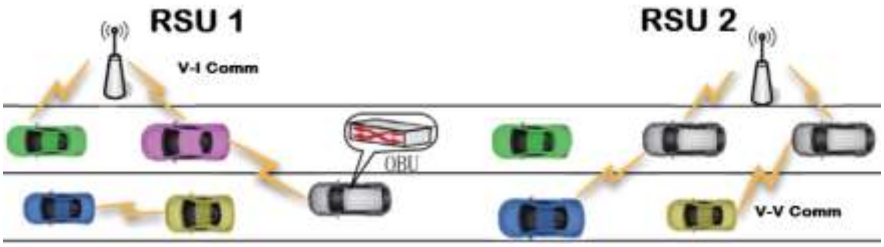

Figure 1 - VANETs Network Architecture

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Due to the VANETs characteristics frequent link failure and fragmentation are created among the vehicles so that it becomes very essential to develop a routing model to handle this critical and real-time data transmission in the effective manner [3]. Currently several routing protocol are employed for VANETs to create efficient route formation but still this topic is under the open research area because the network still contains this flaws like delay, overhead, link failure, lower scalability, and throughput [4]. Currently an effective routing protocol is needed in term of lower power utilization, stable link lifetime and high bandwidth. For that purpose in this paper collision aware distributed multicast routing protocol is developed and its contribution is described.

This paper mainly concentrated about the development of a novel routing protocol which can able to reduce the collision creation among the vehicles in the network. This multicast routing protocol is categorized into two sections they are routing model design and its protocol functionalities. In the routing model section the vehicles are equipped with global positioning system (GPS) and On-Board Unit (OBU) and as well the basic routing process is carried out like the request sending, hello message transmission, receiving the acknowledgement and error message transmission if needed. In terms of protocol functionalities part, improved OLSR routing is activated with the help of its topology control process. Through this method the network collision is highly reduced among the vehicles.

The article organization is given; in the section 2 the earlier routing protocols which are mainly used for VANETs communications are discussed where its drawbacks are identified. In the section 3 the proposed CDMR-VANETs approach is elaborated and its advantages are shown. In section 4 and 5 the proposed work is experimentally analyzed and its results are discussed. In section 6 the paper is concluded and the future direction is shown.

2 Related Works

In [5], author Tarik El explained bio-inspired adaptive routing protocol in VANET that allows the less traffic congestion in the network with minimal throughput and delay in variation but the drawback here is high energy consumption. In [6], L.K. Vishwamitra analyzed and established various VANET routing protocols like AODV, DSDV & OLSR by using network simulator, the IEEE 802.11p which is used in the simulator results in demonstrating the AODV in optimal method among the other nodes the disadvantage here is high delay. In [7], author Jing Wang introduced (CR-VANETs) to avoid the failures in the spectrum and to enhance development in the vehicle to vehicle communication. This main focus to increase the delivery ratio and reduce the delivery overhead but the drawback here is high energy consumption. In [8], author Ankita Srivastava described the up gradation of the road safety they engaged the examination with the VANET. In order to avoid continuous link breakage and loss in packet and delay the WAVE + LTE method is used. In [9], author M. Ye proposed target-driven and mobility prediction (TDMP) based routing protocol in VANET to improve the high speed mobility and dynamic topology of vehicles, also to avoid problems in the traffic flow, the TDMP protocol also enhance the packet transformation by analysing the inter vehicular link status. The advantage of this framework increases the packet ration and decreases the delay but the disadvantage is high energy consumption.

In [10], Shahab Haider author described Direction Aware Best Forwarder Selection (DABFS) in VANET to analyze the motion direction of the nodes Hamming distance and forwards warning messages. This helps to increase the throughput and decrease the packet loss and the disadvantage here is high energy consumption. In [11], author Liang Zhao proposed the intelligent fuzzy-based routing protocol for urban SDVN and for the highest link stability the hierarchical greedy routing method is used which results to increase the performance in its counterparts and the disadvantages are high delay, In [12], author Osama Rehman analyze the speed differences between the vehicles through the performance of furthest distance and link quality method and this will cause the robustness to the adverse effects which results in major differences in mobility speed and further distance method struggles suffers. In [13], author Mohamed Elhoseny used quality of service (QoS) in VANET to avoid failure in communication and to maintain proper data transformation also firefly with Levy distribution (FF-L) method is used to manage the issues in the multicast routing model and this method helps to provide the stability but the disadvantage here is high routing overhead.

In [14], the author developed a novel approach called An Efficient Context-Aware Vehicle Incidents Route Service Management (ECA-RSM) to effectively handle the emergency situation in vehicular

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communication. The new routing protocol is developing which is context-aware vehicle incidents based routing approach to achieve intelligent transmission among the vehicles. This method greatly helps to reduce the delay during communication but however it fails to achieve lower power utility among the vehicles. In [15], the author created a new method called Congestion-Aware Multi-Drone Delivery Routing Framework (CAMD-DRF) to reduce the collision among the vehicles so that it can able to provide a way to create collision-free paths rapidly followed by that the network density can be increased. As the result the network packet delivery ration and throughput can be increased but however this process is not cost effective and as well it consume more power during data transmission. In after analyzing the earlier researches it is confirmed that the development of collision free network is still in an open research area. For that purpose in this article collision aware distributed multicast routing protocol is developed which is detailed in the upcoming section.

3. Proposed CDMR-VANETs Approach

This proposed scheme is mainly designed to create a collision free routing protocol for the vehicular network and the major concentration is about the routing model, then the core protocol functionalities with OLSR and multipoint relay. The workflow of the proposed CDMR-VANETs approach is described in figure 2 below.

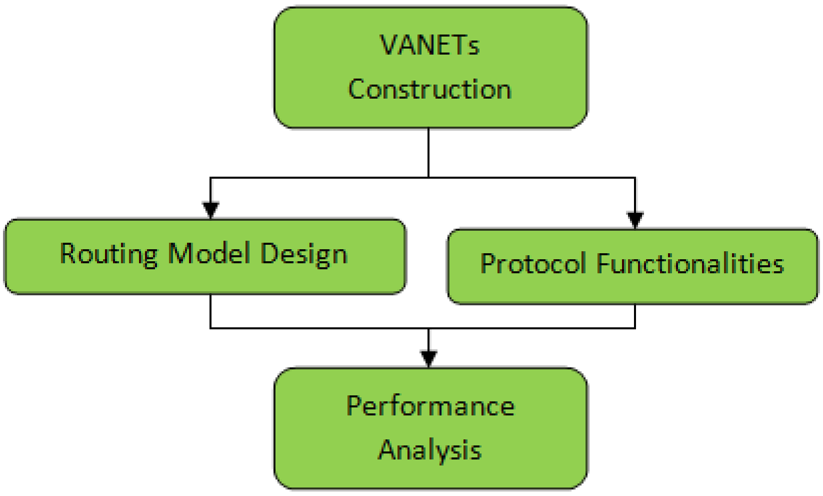

Figure 2 - Workflow of the Proposed CDMR-VANETs Approach

3.1 Routing Model Design

Here, we outline a few fundamental presumptions and lay out the specifics of our suggested approach. The notations utilized in the following are described in Table 1. We start with the following fundamental assumptions for a better analysis: The data packet is forwarded through vehicle-to-vehicle communication without taking account roadside infrastructure. To find the location of nearby junctions, each vehicle has a global positioning system (GPS) and an embedded digital road map. Every vehicle has on-board units (OBU), which are used to send, forward, and receive data packets between that vehicle and its nearby vehicles. All vehicles are in the same communication range and may receive information about nearby vehicles, such as location, speed, direction, and acceleration, through regularly broadcast Hello packets. A length of road's vehicle density may be estimated using distributed traffic density estimation systems used by all vehicles or traffic sensors positioned adjacent to intersections. The location service provided by grid and it guarantees that the destination's location is known as GLS.

3.2 Protocol Functionalities

In an ad hoc network, mobile nodes benefit more from the proactive routing strategy known as OLSR. The OLSR protocol is recommended because it generates routing tables that are immediately available upon request and is proactive, using the consistency of the provided topology-control (TC) messages or link-state procedure/messages. For mobile nodes in ad hoc networks, the suggested method-based OLSR is an improved implementation of the standard topology control (TC) messages and link-state procedure (LSP) messages. Topology control (TC) messages are proposed in OLSR. are shown in Fig. 3.

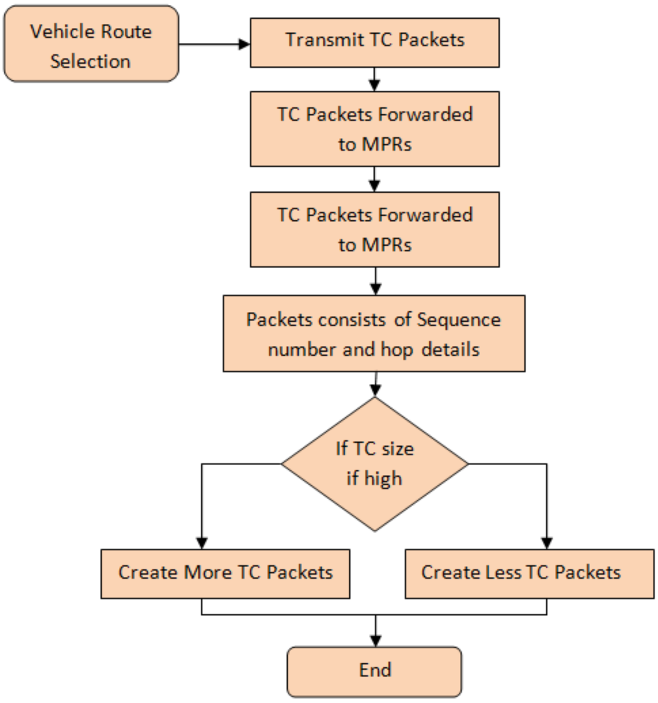

Figure 3 – OLSR Topology Control Process

The proposed topology control (TC) messages in OLSR enhance the traditional link-state approach designed to expressly address the requirements of mobile nodes in wireless LANs in real-world scenarios. The proposed idea is based on the multipoint relay (MPR) principle. With the use of MPR, duplicate packets are transmitted less frequently. Using this method, a group of mobile devices can only request packet retransmission from a specific subset of the entire network. The design of the underlying network determines how large a subset is. During overflow operations, MPR decides which nodes will forward broadcast packets. This method drastically minimizes the packet overhead compared to the conventional flooding methodology, in which each mobile station resends each packet after receiving the initial version. In OLSR-based topology control, the MPR mobile station is solely responsible for generating the link-state data channel. See Algorithm 1 below for the Pseudo code.

Algorithm

```
For the OLSR VANET, every MPR route
distribute (TC message),
only send TC messages to MPR,
Type <= TC message,
TTL = 225,
Top_Hold = v-time,
Number in the sequence = extract from the packet,
Neighbor _Address = take the packet's address,
If the Neighbor _Address > the TC message size,
begin_If
{
additional TC messages to be produced,
Continue doing so until the whole neighbor in the network is covered.
}
end_if,
Declare just one TC message if not,
End,
```

Therefore, a second optimization is achieved by reducing the quantity of control messages flooding the networks. MPR nodes have the option to send solely link-state between themselves and the MPR elector as

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part of the third optimization step. Consequently, fractional link status information is spread across the networks, which is different from the traditional link-state paradigm. The MPRs use this information to calculate routes later on. A sub-optimal route is provided by OLSR-based control messages. As the approach at MPR works well in this context, the suggested method is mostly applicable for the large and condensed network.

Step 1 - Every mobile station should monitor HELLO packets to determine the types of neighborhoods it has (asymmetric and symmetric Asym/Sym). We will now just consider Sym neighbors for simplicity.

Step 2 - The smallest subset of $Ni + 2$ must be chosen by each mobile station. Each neighbor's status is represented by a bit that's also NOT MPR/MPR in the HELLO packets. Each MPR therefore recognizes the group of its electors. Only the MPR station, by retransmitting the messages from their constituents, contributes to flooding packets.

Step 3 - TC packets can only be generated by MPR stations. Each TC packet contains the elector group of the MPR that established it.

4 Research Experimentations

In the part, the proposed CDMR-VANET simulation result calculation is described and compared with prior methods like ECA-RSM [14] and CAMD-DRF [15]. The findings are calculated by taking into consideration the packet delivery ratio, end-to-end delay [15], routing overhead, and energy efficiency. The simulation is run on the Ubuntu operating system using the NS2 simulation with SUMO. The other parameters which are used in experiments are given in table 1.

Table 1 – Simulation parameters

Input Parameters	Values
Simulation Time	100 ms
Propagation Model	802.11
Coverage Area	1000m*1000m
Vehicles Numbers	300 Vehicles
Initial Energy	100 Joules
Vehicles Speed	20 km/hr
Network Layer	Tuned OLSR
Transport Layer	RTP/UDP

4.1 Energy Efficiency Calculation: The measurements of the residual energy that are made after the simulation with a configurable number of nodes are finished. Achieving maximum energy efficiency is crucial for improving network connection. As shown by Figure 4, which displays a graphical depiction of energy efficiency calculations, the proposed CDMR-VANET achieves greater efficiency when compared to existing approaches such as ECA-RSM and CAMD-DRF. The proposed CDMR-VANET used improved OLSR based topology control which helps to increase the energy efficiency of the network.

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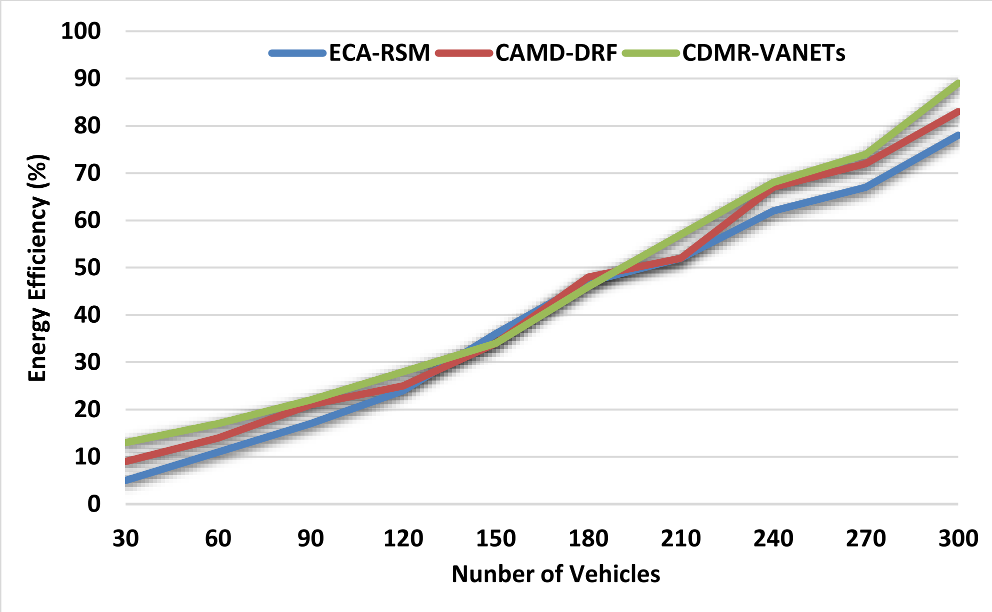

Figure 4 - Energy Efficiency Calculation

4.2 Packet Delivery Ratio Calculation: It is the ratio of data packets created at the source to those that reach the destination successfully. It is evident from Figure 5's graphical depiction of the packet delivery ratio calculation that the proposed CDMR-VANET performs better than other methods like ECA-RSM and CAMD-DRF. The proposed protocol functionalities control the topology in an effective manner that's leads to increase the delivery ratio at the time of communication.

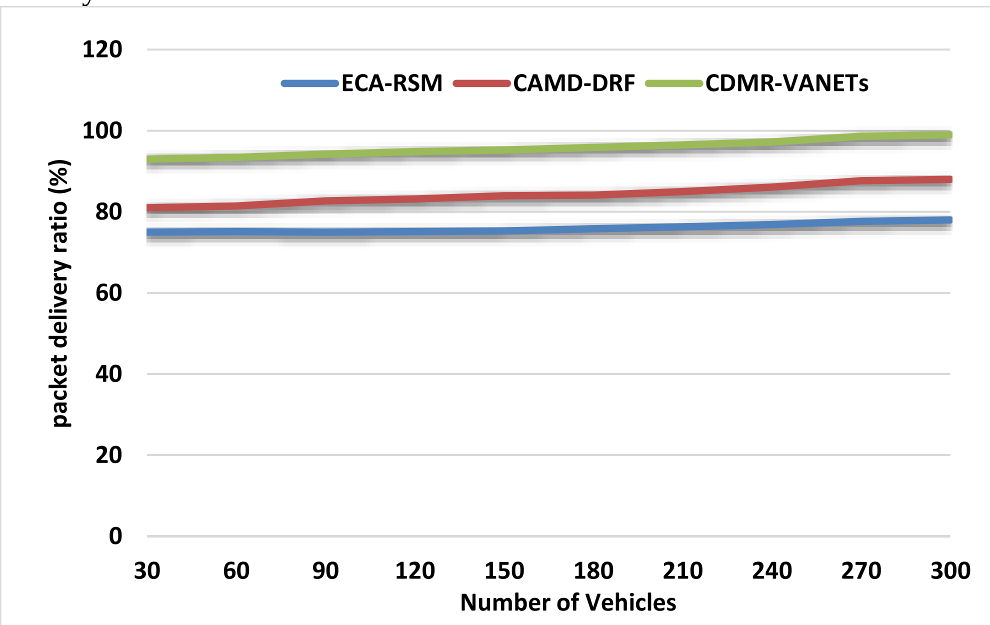

Figure 5 - Packet Delivery Ratio Calculation

4.3 Routing Overhead Calculation: It is the ratio of data packets created at the source to those that reach the destination successfully. It is evident from figure 5 the graphical depiction of the routing overhead calculation that the proposed CDMR-VANET performs better than other methods like ECA-RSM and CAMD-DRF. The proposed method is the depiction of effective topology control so that the data gets transmitted in an flexible manner as the results overhead is reduced among the vehicles.

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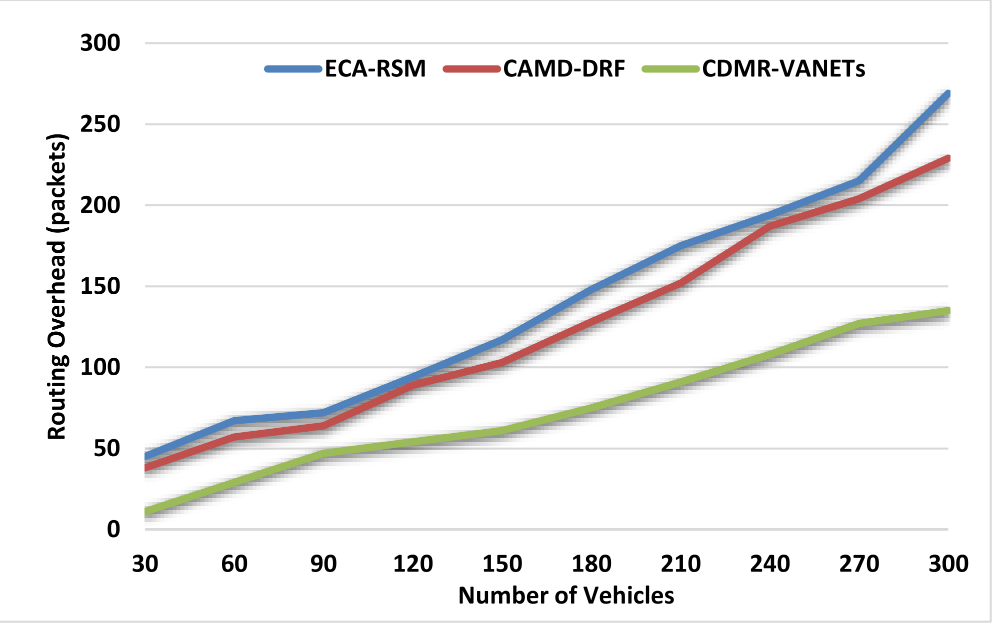

Figure 6 - Routing Overhead Calculation

4.4 End to End Delay Calculation: It is the time it takes the node to generate data packets before they can be successfully received. The end-to-end delay calculations for the methods used in this study with different numbers of nodes are shown in figure 7, and it is obvious from that the proposed CDMR-VANET produced the least amount of end-to-end delay when compared to earlier methods like ECA-RSM and CAMD-DRF with the help of improved OLSR based topology control.

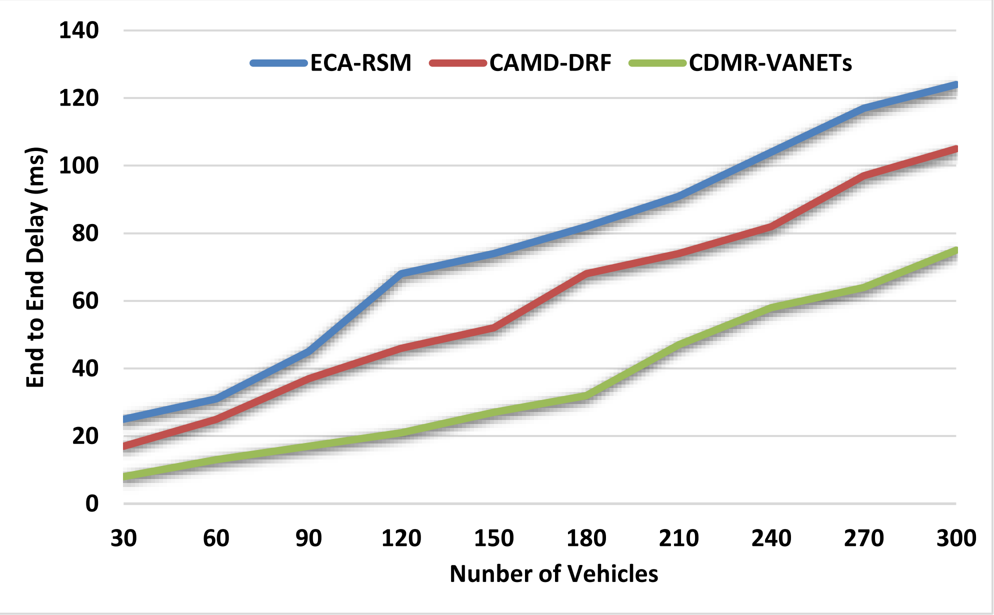

Figure 7 - End to End Delay Calculation

5 Results and Discussion: This section looks at the ECA-RSM and CAMD-DRF metrics, as well as the proposed CDMR-VANET approach, in terms of packet delivery ratio, end-to-end latency, routing overhead, and energy efficiency. Table 2 displays the metrics for those techniques.

Table 2 – Results Analysis and Measurements

Parameters / Methods	**ECA-RSM**	**CAMD-DRF**	**CDMR-VANET**
Delivery Ratio	78%	88%	99%
End to End Delay	124 ms	105 ms	75 ms
Energy Efficiency	78%	88%	93%
Routing Overhead	269	229	135

This simulation evaluates the proposed CDMR-VANET system against ECA-RSM and CAMD-DRF in terms of network transmission routing overhead, packet delivery rate, end-to-end delay, and energy efficiency. When compared to older systems like ECA-RSM and CAMD-DRF, the suggested CDMR-VANET system achieves a packet delivery rate of 99%, while ECA-RSM and CAMD-DRF achieve a packet delivery rate of 78% and 88%, respectively. As a result, in terms of packet delivery rate, the proposed CDMR-VANET system surpasses ECA-RSM and CAMD-DRF by 21% and 11%, respectively. Compared to earlier estimates by ECA-RSM and CAMD-DRF, which were respectively 124 milliseconds and 105 milliseconds, the end-to-end delay proposed by CDMR-VANET is 75 milliseconds. As a result, the end-to-end delay of the proposed CDMR-VANET system is 49 milliseconds less than that of ECA-RSM and 30 milliseconds less than that of CAMD-DRF. Compared to the former routing overhead of ECA-RSM and CAMD-DRF, which were over 269 and 229 packets respectively, the anticipated routing overhead of CDMR-VANET is 135 packets. As a consequence, the routing overhead of the suggested CDMR-VANET method is 134 packets lower than that of the ECA-RSM and 94 packets lower than that of the CAMD-DRF. The resulting energy efficiency of the proposed CDMR-VANET approach is 93%, which is 15% better than ECA-RSM and 5% better than CAMD-DRF. Due to the improved OLSR based topology control procedure, the proffered CDMR-VANET technique was able to achieve the maximum overall performance, according to the calculations of these parameters.

6 Conclusion

This article mainly concentrates on reducing the congestion of the vehicles at each instant of time to enhance the intelligent transportation system by reducing the packet loss occurrence of the vehicles. So an effective multicast routing is concentration which performs effective topology control using the improved OLSR routing protocol. This protocol provides effective routing in terms of reducing the congestion. The implementation of the process is done in NS2 with SUMO and the parameters considered for results measurements are packet delivery ratio, end-to-end delay, routing overhead, and energy efficiency were the results are compared with the earlier methods like ECA-RSM and CAMD-DRF. From the results analysis it is proven that the proposed CDMR-VANET achieves 21% higher packet delivery rate, 49ms lower end-to-end delay, 134 packets lower routing overhead and 15% better energy efficiency when compared with the earlier methods. In the future direction to reduce the power consumption in the densely populated area effective clustering methods can get concentrated.

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