Centralized RSU Deployment Strategy for Effective Communication in Multi-hop Vehicular Adhoc Networks (VANETs)

Abstract:

Due to the advent of smart cities, vehicular technologies are high focus to perform intelligent transmission. Road traffic control and accident control becomes a primary tasks in Vehicular Adhoc Networks (VANETs). In VANETs communication is ineffective without presence of Road Side Units (RSUs). In some places due to lack of RSUs data transmission is improve as well as end to end delay and routing overhead is increased during the time of communication so effective RSU deployment is very essential to provide effective communication in multi-hop VANETs. In this paper, Centralized RSU Deployment Strategy is proposed to control and monitor the traffic density of the vehicle. The parameters which are considered for the process of centralized RSU deployment strategy are centralization scale, past transmission rate and location identification. To analysis the performance of the network the simulation is carried out in NS2.35 and SUMO. The parameters which are taken for the performance analysis are packet delivery ratio, end to end delay, routing overhead and packet loss. In order to execute comparative analysis the recent research works are considered which are AVRCV and RDSTDV. From the outcome it is understood that the proposed CRDSMV approach achieves 70ms to 200ms lower end to end delay, 7% to 14% improved packet delivery ratio, and 50 packets to 300 packets lower routing overhead and 50 Kbps to 240 Kbps improved throughputs when compared with the earlier methods AVRCV and RDSTDV.

Keywords: Vehicular Adhoc Networks (VANETs), Multi hop communication, RSU Deployment, Traffic density management, accident management.

1 Introduction:

Vehicular Adhoc Networks (VANETs) are emerging nowadays due to construction of smart cities using Intelligent Transportation System (ITS). The most important challenges in VANETs ate traffic density control due to fast moving vehicles congestion will occur. In order to overcome that traffic density need to get concentrated. Developing a network with connected vehicles with proper control and monitoring will manage the vehicle traffic. Communication in VANETs consists of two models such as vehicle-to-vehicle (V2V) model and vehicle-to-infrastructure (V2I) model. V2V communication consists of more disputes due to high speed dynamically carrying vehicles. V2I communication is not effective enough to manage those high speed vehicles. To address in issues Road Side Units (RSUs) are introduced in VANETs. Through RSUs, a vehicle management becomes easier as well as high performance in data transmission is achieved. The current RSUs based network is comfortable to manage huge number of vehicles and RSU deployment is the challenging task to prevail over this drawback [1], [2]. In general Vehicles are set with inbuilt sensors in order to collect various kinds of information such as traffic data, location details, pollution, etc. At the time of crossing an RSU, the vehicles shift the required information to the RSU. Significantly, the collected details are transmitted to the required places and get stored for the future. In outsized kind of cities the network topology is very complicated so lot of RSUs needs to get deployed to improve the effective of the communication and it is not a cost effective process so that many researchers are interested in RSU deployment oriented researches [3], [4]. In this paper a centralized RSU deployment method is proposed to control the traffic density in the high speed multi-hop VANETs environment. The contribution of the research is given below.

1.1 Contribution of the research:

- In order to improve the traffic density control as well as to provide effective communication in multi-hop VANETs effective RSU deployment is concentrated in this research.
- In this paper a centralized RSU deployment strategy is introduced to control and monitor the traffic of VANETs.
- The major parameters which are considered for the deployment of RSU are centralization scale, past transmission rate and location identification.
- The parameters which are taken for performance analysis are end to end delay, packet delivery ratio, routing overhead and network throughput.

The organization of the paper is given as follows. In section 2 the related works about the RSU deployment in VANETs are discussed. In section 3 the network environment is constructed. In section 4 the proposed CRDSMV approach is elaborated. In section 5 the performance of the proposed CRDSMV approach is analyzed and it is compared with the earlier works such as AVRCV and RDSTDV. In section 6 the conclusion and the future works are shown.

2 Related Works

In [5], the author F. Yang developed the Energy Harvest RSU to improve network reliability, reduce transmission delay, and lower RSU deployment costs. The main advantage of this framework is that it immensely improves coverage and connectivity. But this framework struggles to maintain its performance in real-time due to both human and environmental factors. In [6], the author Z. Gao presented greedy algorithm to solve the issue of 1D RSU deployment. This framework provides results very near to optimal solution that is more than 98%. But main flaw of this framework is it requires more energy for the RSU deployment. In [7] the author A. K. Sutrala employed Elliptic Curve Cryptography (ECC) to develop batch verification-based security mechanisms in the VANET environment that preserves conditional privacy. This scheme provides comparable storage, improved security, and functionality features but fails to reduce computational complexity. In [8], the author H. Li used SDN's deep programmability and the joint optimization strategy to dynamically reconfigure RSU in the network for hosting and routing services. With the smallest number of hosts, this approach reduces cloud latency to the absolute minimum. However, this framework's primary flaw is that it ignores complex network scenarios. In [9], the author Y. Zhang presented a co-directional multilane adaptive message return (CMAMR) scheme for RSU deployment based on edge computing. This framework offers seamless coverage and supports the dynamic change of network topology. But this framework increased the communication latency which results in low service quality in VANET.

In [10], the author M. Mao developed an enhanced hotspot search algorithm for the RSU deployment based on the popularity of road intersections, traffic factors, and intersection connection. The coverage time ratio and the number of cars each trip can both be enhanced using this framework. However, this framework does not have QoS components like data transmission delay and speed. In [11], the author H. Yu established RSU deployment strategy based on the traffic demand. The key benefit of this architecture is that it maximizes both the number of cars covered by RSUs and the typical data delivery time in VANETs. Yet when deciding where to place the available RSUs, this analysis does not account for the street configuration of each location. In [12], the author E. Twahirwa, presented a travel matrix scheme for the intelligent RSU deployment. The main advantage of this framework is that it guarantees that the information-exchanging time won't go beyond a certain limit. However, this framework does not improve the communication success rate of mobile vehicles in the coverage area. In [13], the author S. Y. Lina predicted a k-hop-limited multi-RSU (PKMR) scheme to offload the traffic data. This framework provides performance in terms of data offloading and reduced the RSU installation cost. But no realistic urban topography can be used with this proposal. In [14], the author A. A. Almazroi examined the use of cost-effective dynamic deployment of RSUs depending on the volume of traffic on the roads and by guaranteeing Line of Sight (LOS) between RSUs and cellular network antennas. The main benefit of this structure is that it can provide continuous connectivity with moving vehicles. However, a vast coverage area is not appropriate for this architecture.

In [15], the author Sami projected a Reliability Aware routing model using improved Optimization and Gaussian Mutation Harmony Searching. Data communication become more optimal using this method but however the overhead is occurred during communication with increased the delay. In [16], the author Mustafa proposed a cluster based method to do data forwarding and improved optimization. The algorithm which is used for this process is performed using firefly algorithm. This algorithm increases the packet delivery ratio and minimizes the end-to-end delay. However it fails to produce lower overhead. In [17], the author Chang introduced a model to reduce the delay and packet loss produced in the high speed VANETs called V2R communication classification approach. This method utilize the dynamic influence factors to provide appropriate path selection to the vehicle to connect with the RSU, Through this method the delay is reduced but it achieves moderate results in terms of routing overhead so this method need improvement to achieve effective and stable communication in VANETs. In [18], the author Haiyang proposed an approach to improve the traffic control in connected automatic vehicle (CAV) technology. Through this approach effective RSUs are deployed with low traffic demand. The performance is good but the density of vehicles is moderate and it is not suitable for densely populated area. As the results of analyzing the earlier research works if it identified that the effective RSU deployment process is still an open research area. In this paper effective communication in VANETs is concentrated using centralized RSU deployment strategy. The process of the proposed method is elaborated in the upcoming sections.

3. Network Environment

The network environment consists of two types of communication model such as vehicles to vehicles and vehicles to RSUs. Both this model is elaborated below.

3.1 Vehicle to vehicle model: Each individual vehicles in the network consists certain devices for wireless communication. They are On-Board Unit (OBU), IBC mechanism and PKI mechanism for data transmission, tamperproof device (TPD), global positioning system (GPS) and graphical user interface (GUI). Additionally it requires a routing protocol for wireless data transfer, energy and storage capacity. The vehicle to vehicle communication will occur frequently in VANETs. Each vehicle can able to transmit the data to another vehicle which is present in its coverage area and line of sight.

3.2 Vehicle to RSU model: In the network vehicle to RSU transmission takes place when the destination vehicle is not present inside the coverage area of the source vehicle. RSUs are present in the road sides and it is static in nature. It is mainly used to give service to the normal vehicles. In order to perform the operation of communication with vehicles RSU uses the routing protocols. RSUs will authenticate the vehicles communication from various environments.

4. Centralized RSU Deployment Strategy for Multi-hop VANETs (CRDSMV)

In order to perform effective RSU deployment in multi-hop VANETs, centralized RSU deployment strategy is proposed. The work flow of the proposed CRDSMV is shown in the figure 1.

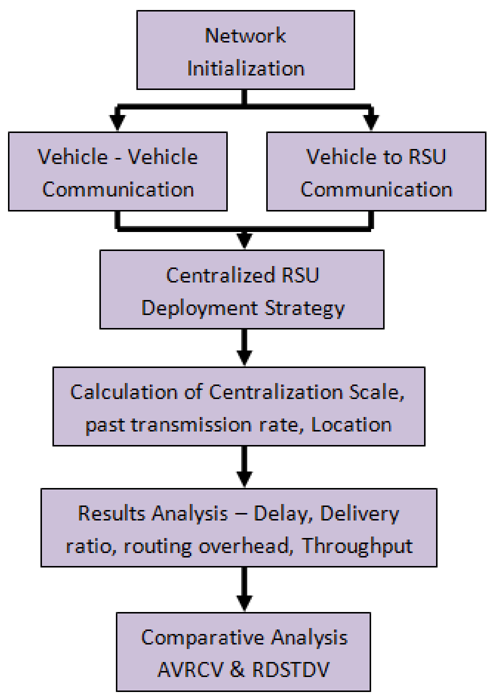

Figure 1 - Work flow of the proposed CRDSMV method

The parameters which are considered for the centralized deployment of RSUs are centralization scale, successful transmission rate and location identification. Centralization mainly concentrate in the principle that it coverage maximum utility area of the vehicles that is the region which has more possibilities to pass the vehicles are provided high priority for RSU deployment. For that purpose centralization scale is measured and it is mathematically expressed below.

$$CS_{vehicle} = \frac{\sum_{i=1}^{N} \frac{STR_{vehicle}}{t}}{N-1} \qquad (1)$$

In equation (1), the terms $TR_{vehicle}$ denotes the successful transmission rate of the vehicle and N denotes the total number of vehicles. The successful transmission rate $STR_{vehicle}$ expressed below.

$$TR_{vehicle} = \frac{\sum_{i=1}^{N} RP_{vehicle}}{\sum_{i=1}^{N} TP_{vehicle}} \qquad (2)$$

In equation (2), the terms $RP_{vehicle}$ and $TP_{vehicle}$ are they received and transmitted packets from the source and the destination vehicles. Followed by this location identification is performed. To obtain effective location for the RSU the following procedures has to be done. At the initial stage the coverage area of the RSUs are declared as CA_{RSU} as well as the length of the travel region is declared as L. Then the location of RSU is fixed according to the following procedures. They are, at the initial stage it should satisfy the condition $L = 2CA_{RSU}$, the RSU which satisfies this condition can directly elected as RSU and located at that particular region. Simultaneously, in case if the $L \neq 2CA_{RSU}$ then the process of uniform distribution takes place. RSU randomly elects the location for its deployment. This is the principle process of centralized RSU deployment strategy. Using this method RSUs are deployed in the network to perform effective communication in VANETs.

5 Performance Analyses:

To perform the simulation in proposed CRDSMV approach the software which is used is NS2.35 and for the process of generate mobility SUMO (Simulation of Urban Mobility) is used in VANETs with open street maps. Four parameters are taken for performance calculation; they are packet delivery ratio, end to end delay, routing overhead and packet loss. In order to perform comparative analysis the earlier recent researches which are taken into consideration are AVRCV [17] and RDSTDV [18]. The simulation parameter setup is given in the table 1.

Table 1 – Simulation parameter settings

Input Parameters	**Values**
NS Version	NS-2.35
Mobility Generator	SUMO
Running Time	200 ms
Network Size	3000m*3000m
No of Vehicles	300 vehicles
Antenna Type	Omni-directional Antenna
Propagation Model	Two Ray Ground Model
Queue Type	DropTail
Traffic Flow	CBR
Speed	100 km/hr
Transmission Power	0.500 Joules
Receiving Power	0.050 Joules

5.1 End to end delay: Figure 2 shows the end to end delay of the proposed CRDSMV approach and it is compared with the earlier works like AVRCV and RDSTDV. Table 2 shows the simulated values and it proves that the end to end delay produced by the proposed CRDSMV approach is lower than that of the earlier methods. As a result of using the effective RSU deployment in proposed CRDSMV approach congestion in the network gets reduced that reflects in the reduction of the end to end delay.

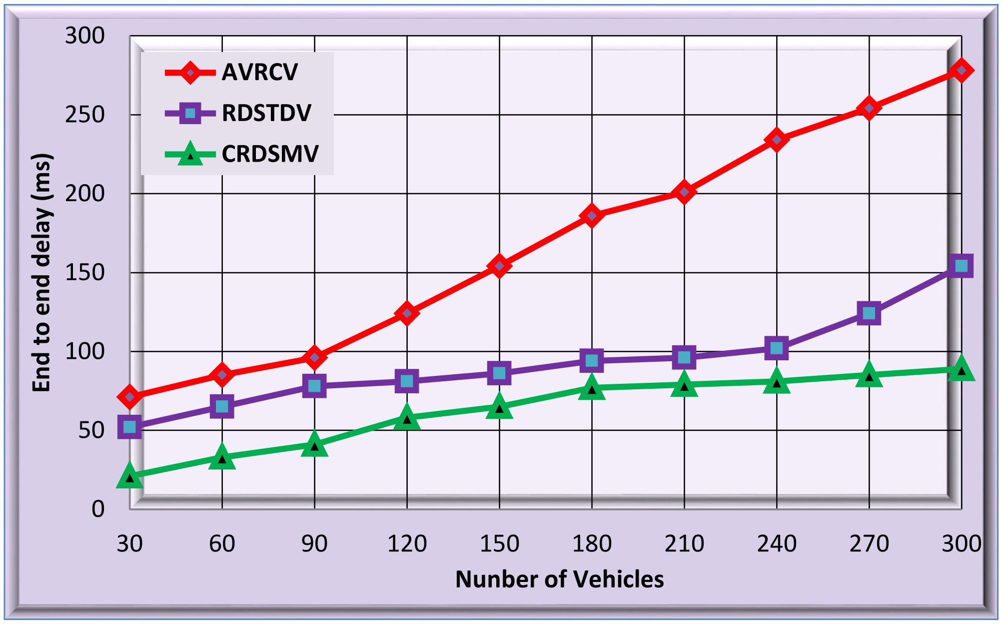

Figure 2 – End to end delay calculation

The end to end delay calculated by the working protocols are AVRCV (278 ms), RDSTDV (154 ms) and proposed CRDSMV approach (89ms). Lastly it shows that the proposed CRDSMV approach produce around 70ms to 200ms lower end to end delay when compared with the earlier methods.

Table 2 - End to end delay Measurements

Number of vehicles	AVRCV	RDSTDV	CRDSMV
30	71	52	21
60	85	65	33
90	96	78	41
120	124	81	58
150	154	86	65
180	186	94	77
210	201	96	79
240	234	102	81
270	254	124	85
300	278	154	89

5.2 Packet Delivery Ratio: Figure 3 shows the packet delivery ratio of the proposed CRDSMV approach and it is compared with the earlier works like AVRCV and RDSTDV. Table 3 shows the simulated values and it proves that the packet delivery ratio achieved by the proposed CRDSMV approach is higher than the earlier works. Consequently the CRDSMV approach concentrates on effective RSU deployment to perform stable data transmission in VANETs.

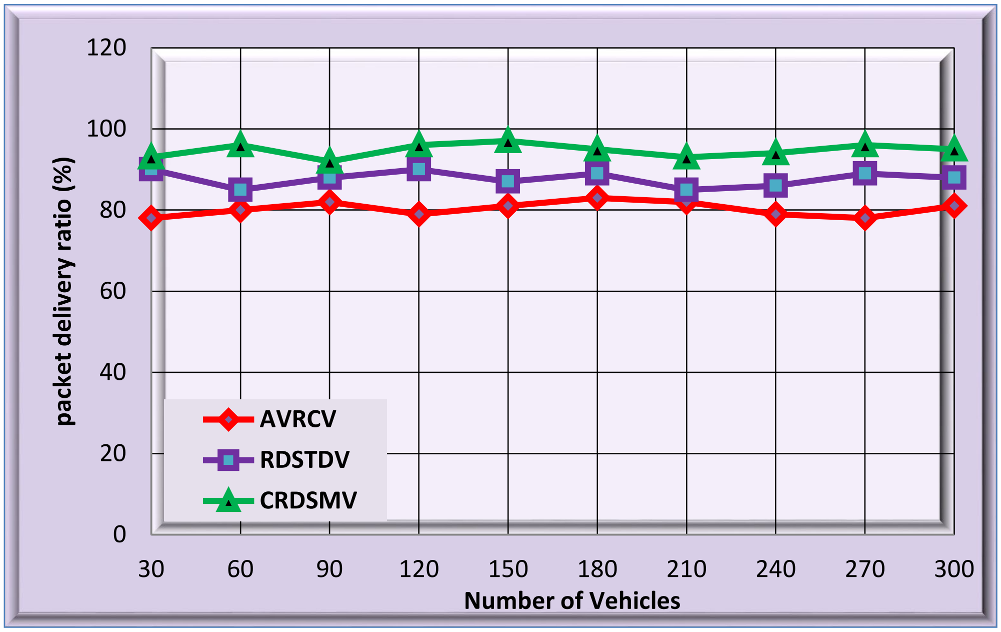

Figure 3 – Packet delivery ratio calculation

The packet delivery ratios calculated by the working protocols are AVRCV (81%), RDSTDV (88%) and proposed CRDSMV approach (95%). As a final point it implicit that the proposed CRDSMV approach achieves 7% to 14% improved packet delivery ratio when compared with the earlier methods.

Table 3 - Packet delivery ratio Measurements

Number of vehicles	AVRCV	RDSTDV	CRDSMV
30	78	90	93
60	80	85	96
90	82	88	92
120	79	90	96
150	81	87	97
180	83	89	95
210	82	85	93
240	79	86	94
270	78	89	96
300	81	88	95

5.3 Routing Overhead: Figure 4 shows the routing overhead of the proposed CRDSMV approach and it is compared with the earlier methods like AVRCV and RDSTDV. Table 4 shows the simulated values and it proves that the routing overhead measured by the proposed CRDSMV approach is lower than that of the earlier methods. By using the effective RSU deployment strategy in proposed CRDSMV approach this result is achieved.

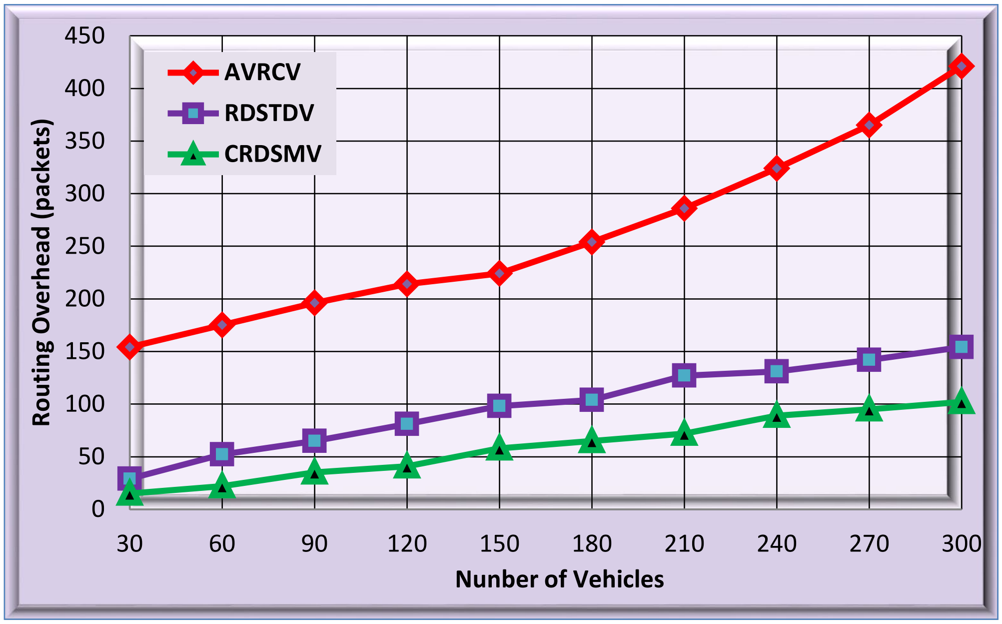

Figure 4 – Routing Overhead calculation

The routing overhead calculated by the working protocols are AVRCV (421 packets), RDSTDV (154 packets) and proposed CRDSMV approach (102 packets). Finally it illustrates that the proposed CRDSMV approach produce around 50 packets to 300 packets lower routing overhead when compared with the earlier methods.

Table 4 - Routing Overhead Measurements

Number of vehicles	AVRCV	RDSTDV	CRDSMV
30	154	29	15
60	175	52	22
90	196	65	35
120	214	81	41
150	224	98	58
180	254	104	65
210	286	127	72
240	324	131	89
270	365	142	95
300	421	154	102

5.4 Throughput: Figure 5 shows the throughput of the proposed CRDSMV approach and it is compared with the earlier works like AVRCV and RDSTDV. Table 5 shows the simulated values and it proves that the throughput achieved by the proposed CRDSMV approach is higher than the earlier works. The CRDSMV approach carries out effective RSU deployment to achieve high throughput for VANETs.

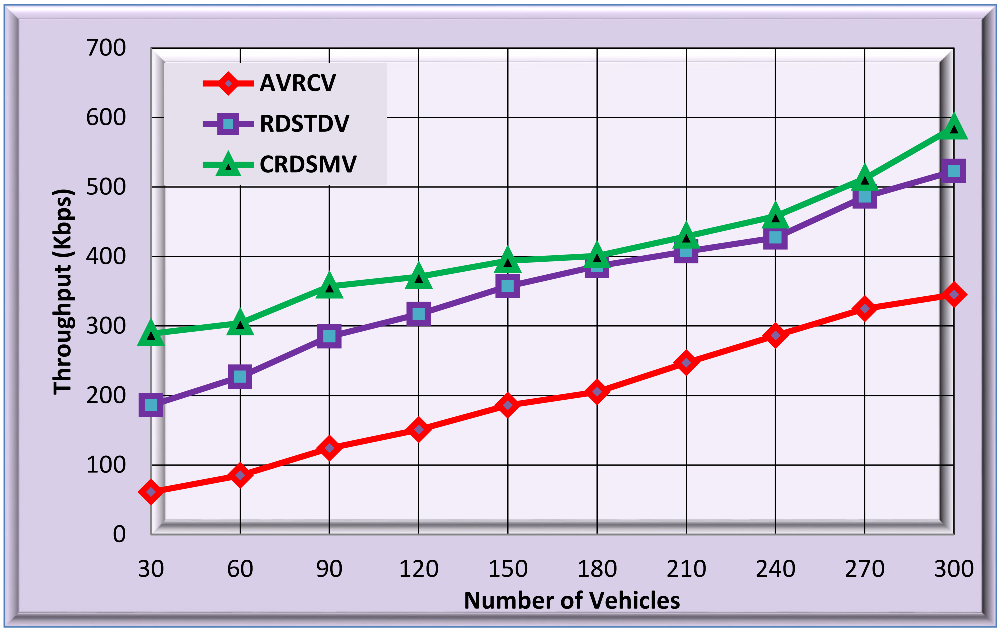

Figure 5 – Throughput calculation

The throughputs calculated by the working protocols are AVRCV (345 Kbps), RDSTDV (523 Kbps) and proposed CRDSMV approach (586 Kbps). As a final point it implicit that the proposed CRDSMV approach achieves 50 Kbps to 240 Kbps improved throughputs when compared with the earlier methods.

Table 5 - Throughput Measurements

Number of vehicles	AVRCV	RDSTDV	CRDSMV
30	61	186	289
60	85	227	304
90	124	285	357
120	151	317	371
150	186	357	394
180	205	386	401
210	247	407	429
240	286	427	458
270	325	486	512
300	345	523	586

6 Conclusion:

In this paper to improve the traffic control and the issues happened due to that such as increase of end to end delay and overhead, effective RSU deployment is performed. The traffic related drawbacks are highly controlled by using the Centralized RSU Deployment Strategy. The parameters used for this process are centralization scale, past transmission rate and location identification. These parameters make the process more effective in terms of achieving stable and effective communication for multi hop VANET networks. The simulation is performed in NS2.35 and the parameters used for results calculations are packet delivery ratio, end to end delay, routing overhead and packet loss as well as compared with the earlier research works such as AVRCV and RDSTDV. The simulation results shows that the proposed CRDSMV approach 200ms lower end to end delay where this is considered as one of the major drawback, 14% improved packet delivery ratio so that communication becomes stable, 50 packets to 300 packets lower routing overhead and Kbps improved throughputs when compared with the earlier methods AVRCV and RDSTDV. In future direction to improve the network from the ground level traffic drones are taken into consideration.

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