Obstacle Aware Efficient Bandwidth Utilization Model for Vehicular Adhoc Network

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Abstract*—Provisioning smart intelligent transport for vehicular ad hoc networks VANE depends on dissemination of safety-related messages. The performance of VANE are highly affected due vehicle density, mobility and environmental condition. Recently several research has been under development, the design of a rapid, flexible, efficient and reliable medium access control M which address the precise constraint of smart intelligent transport system in the highly dynamic VAN environment. Extensive survey carried out in this work shows TDMA (Time division medium access) based *M* approach outperform carrier sense medium access/ collision avoidance CSMA based approach. However, TDM based approach incurs bandwidth wastages. To utilize bandwidth more efficiently cognitive radio technique is adopted for designing efficient M. However, the existing model incurs computation overhead and is not evaluated under different environmental condition such as rural, highway and urban To overcome research challenges, this work present efficient decentralized distributed MAC DM that minimize collision and maximize throughput. Experiment are conducted to evaluate the performance of DM over state-of-art model in terms of throughput, success transmission and collision achieved. The outcome shows significant performance over state-of-model.

Keywords—Cognitive radio, DSRC,MAC, Multi-channel, VANET.

I. INTRODUCTION

Since the birth of the car in 1886, driving safety has a point of concern among the government and the public. In particular, the emergence and development of autonomous driving technology in recent years has made safe driving a pertinent issue. According to the Tencent’s 2018 Travel Report, traffic congestion, parking difficulties, and lack of real-time traffic information are three major problems to be addressed for drivers [1]. The vehicular ad-hoc network (VANET) has been recognized by academics and industry as a program that can realize intelligent transportation systems (ITS) [2], thus providing necessary auxiliary functions for driving. However, VANETs involve diverse needs and Quality of Service (QoS) communication requirements differ. To meet the various needs of VANETs, designing a reasonable media access control (MAC) protocol is crucial. Safety-related services, such as collision warnings, and emergency messages, have higher requirements for communication delays; non-safety services, such as video downloads and high-definition maps, have higher throughput requirements.

The new smart car is equipped with a variety of sensors, usually called the onboard unit (OBU). Although these sensors can sense the environment around the vehicle in real time,providing road safety information to the driver, the need to detect potential hazards requires coordinated communication between the vehicle and the infrastructure. In a large-scale vehicle nodes network, the information obtained by the OBU is efficiently and reliably transmitted with surrounding nodes by means of V2V and V2I technologies. The node uses the information from the sensor and collaborative system to reconstruct driving environment in real time to meet the vehicle node’s demand for safety applications.

Radar is a key technology for frontal collision avoidance. Vehicular radars have several advantages over competing sensor technologies. For example, although considerableprogress has been made on improving light detection and ranging (LIDAR) sensors, they are still expensive relative to vehicular radar and exhibit sensitivity issues in low-visibility conditions [3], [4], ultrasonic sensors have limited range and suffer from degraded performance in several common environments [5], [6], and dedicated short range communication (DSRC) networks (which can be used to exchange GPS-based location and velocity information) only work when the colliding vehicle has a radio [7].

VANET are prone to high mobility hence periodic beaconing is required in order to obtain real time network related information in a cooperative manner [8], [9], and [10]. So it is quite a challenging task to design MAC [11], [12], [13], and [14]. Another issue is channel congestion in MAC layer due to high network density. There are very high density of device that transmit their status message in its transmission range, which incurs packet collision overhead and increase packet delivery latency [15], [16], and [17]. Further, presence of obstacle in line of sight of communicating affects the scheduling or MAC performance [18]. Thus, QoS cannot be guaranteed, if the radio propagation model is not accurate and MAC design is not scalable considering multi-channel vehicular adhoc network [18], [19].

For overcoming research, this work present a novel radio propagation model for highway environment considering presence of obstacle in LOS among communicating device. Further, present a MAC that is distributed in nature considering multi-channel network.

The Contribution of research work is as follows:

- This work presented new radio propagation model for highway environment.
- Presented MAC design which is distributed and adaptive in nature considering varied speed and vehicle density.
- Proposed model minimize collision and attain better throughput. Thus, proposed model utilize bandwidth more efficiently than existing model.

The rest of the paper is organized as follows. Extensive research survey is carried out in section II. In section III the proposed decentralized distributed M. model is presented. In penultimate section experimental study is carried out. The conclusion and future work is described in last section.

II. EXISITING SYSTEM

Increasing safety and automation in transportation systems has led to the proliferation of radar and IEEE 802.11pbased dedicated short-range communication (DSRC) in vehicles. However, current implementations of vehicular radar devices are expensive, use a substantial amount of bandwidth, and are susceptible to multiple security risks. In [18] used the IEEE 802.11 orthogonal frequency-division multiplexing communications waveform, as found in IEEE 802.11a/g/p, to perform radar functions. Here, they presented an approach that determines the mean-normalized channel energy from frequency domain channel estimates and models it as a direct sinusoidal function of target range, enabling closest target range estimation. In addition, they presented an alternative to vehicular forward collision detection by extending IEEE 802.11 DSRC and WiFi technology to radar, extending the foundation of joint communications and radar frameworks.

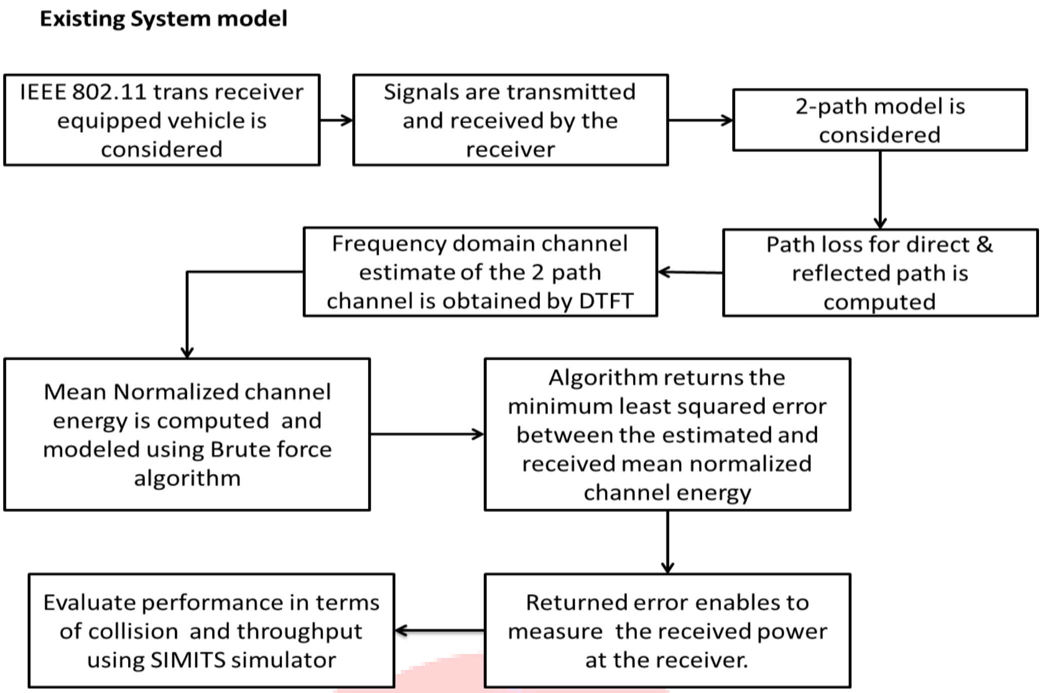

Fig. 1. The flow diagram of working structure of existing model

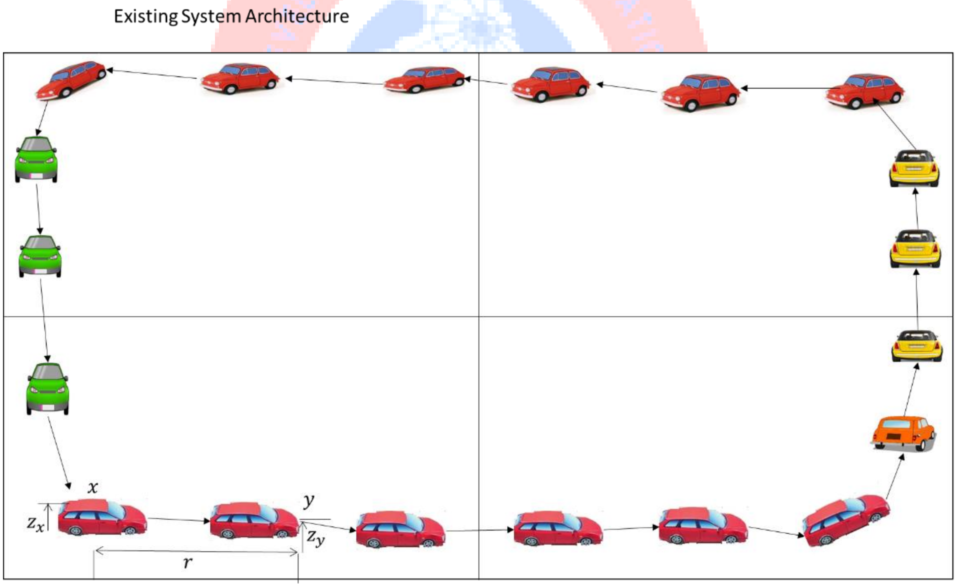

Fig. 2. The system model considering for modelling existing model

More detail of existing mathematical model and simulation information can be obtained in [18].

III. PROBLEM STATEMENT

Here the problem statement is described. A flow diagram to describe research problem statement is described in Fig 3.

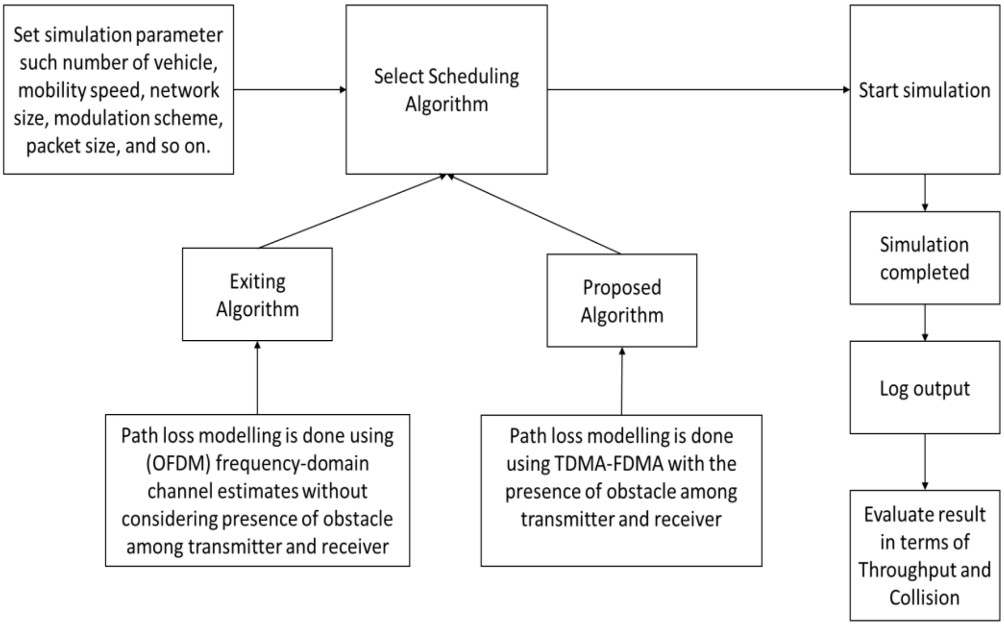

Fig. 2. The system model considering for modelling existing model

- In the existing model they used the IEEE802.11 orthogonal frequency-division multiplexing communications waveform, as found in IEEE 802.11a/g/p, to perform radar functions.
- They present an approach that determines the mean normalized channel energy from frequency domain channel estimates and models it as a direct sinusoidal function of target range, enabling closest target range estimation.
- Furthermore, they presented an experimental demonstration near DSRC spectrum using IEEE 802.11 standard compliant software defined radios with potentially minimal modification through algorithm processing on frequency-domain channel estimates.
- They compute path loss component between transmitter and receiver based on RADAR reflection path. However, their model did not considered the presence of obstacle (such as large vehicle, buildings, tree etc.) between transmitter and receiver. As a result, incurs collision and degrades throughput performance.
- Further, the considered OFDM based scheduling strategy used in the system is not efficient under high speed and high vehicle density environment where frequent hopping among channel exits. As a result, it incurs bandwidth wastage. The model is designed considering generic environment.

IV. PROPOSED RADIO PROPAGATION MODEL AND MAC MODEL FOR VANET

In this section of the work, we have presented the environmental channel and the radio propagation modelling for the VANET V2V network. In the proposed model we have presented the realistic channel modelling in case of highway environment which consist of set of vehicles that are in the cover range of one another and it is depicted in the Fig. 3.

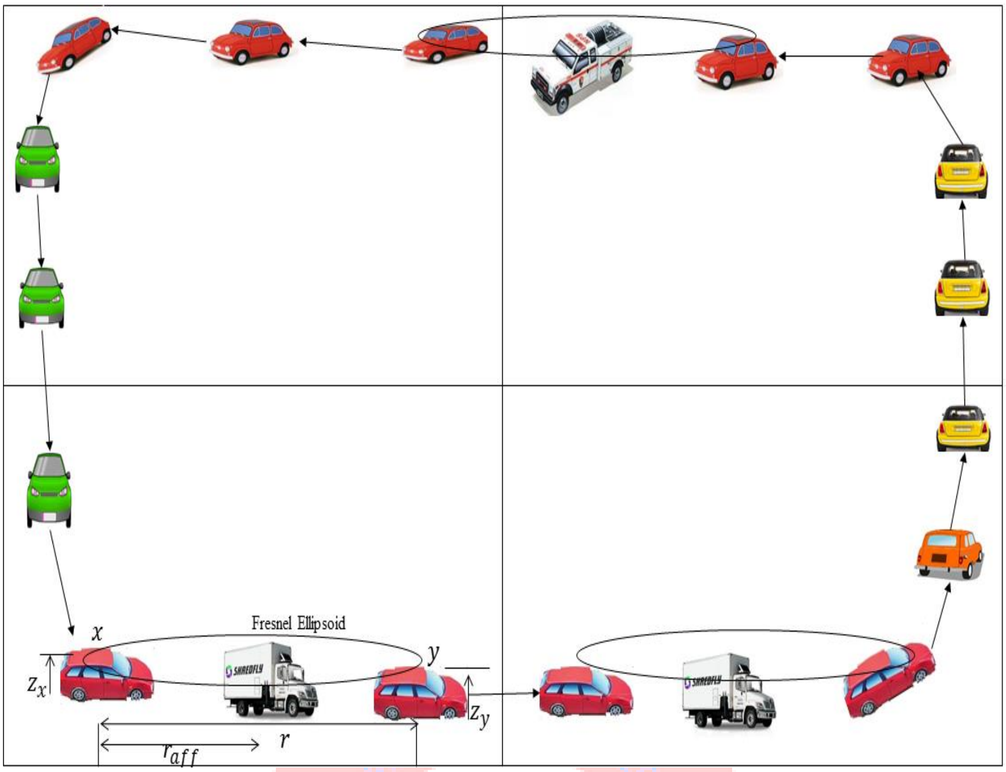

Fig. 3: Proposed obstacle based radio propagation and environment model

Let's assume that the subscribed vehicle transmits a packets set of size , when it is travelling through the particular section of the highway environment along with the vehicle set. user $\mathcal{A} = \{1, \dots,$, here each and every vehicle constitutes almost same radius and it communicates with the one vehicle at a time, let us also assume as the devices mean which is passing through the highway environment and it follows Poisson method along with the average arrival rate . The user density who has already subscribed are represented through (i.e. subscriber in the highway environment) and subscribed user speed is represented by . The wireless channel signal propagation is affected by various factors such as fading, shadowing and path loss. Since the transmitter and the receiver distance varies in highway environment model. Let's consider the path loss impact on channel attenuation. The data transmission rate at slot time is obtained as follows

$$c_n = C \log_2\left({}^{G}/_{P_0 C r_n^{\alpha}} + 1\right), \qquad (1)$$

where is the VANET device transmit power, is the transmission rate of the wireless channel, is the distance among transmitter and the receiver at slot instance and is the path loss exponent. To evaluate in Eq. (6), [26] shows that log normal shadowing provides an efficient way in finding path loss exponent. Here the signal to noise ratio $(r$ at distance from the transmitter to receiver is represented as follows

$$\alpha(r)_{dB} = \mathcal{P}_t - \mathcal{PL}(r_0) - 10_n \log_{10}\left({}^{r}/_{r_0}\right) - \mathcal{X}_\sigma - \mathcal{P}_n \qquad (2)$$

where and is the transmission power and noise parameter in decibel watt respectively, $\mathcal{PL}($ is the path loss at a reference distance , is zero mean Gaussian arbitrary parameter with standard deviation . The log normal shadowing models do not consider attenuation overhead due to obstacle in LOS (Line of Sight) among transmitter and the receiver.

Here we consider the LOS based on highway environment channel modelling [27], the model in [23] combines the obstacle effect of environmental factor such as building, trees, walls that affect the signal strength received, rather thantraditional mean additional attenuation model will lead to stochastic obstacle fading model. Here we consider an adjacent devices or the vehicle as the impact due to obstacle. Since considering other obstacle will decrease the likelihood of LOS among source and the receiving devices. The proposed modelling consist of three stages, firstly, the device that probably affects the transmission of LOS among source and destination devices is represented as $obtProbAff(x_{,}$. If the distance among the LOS of and devices is greater than that of center of LOS device, then the device is considered to be probable obstacle.

Secondly, the devices that hampers the LOS among device and are selected from group of probable affecting device found from previous iteration is represented as $obtLOSaff([ProbableAf_{,}$. An important note, the LOS is not assured with presence of visual line of sight among source and receiving devices considering propagation of electromagnetic waves. The communicated signal might get affected due to obstruction of Fresnel ellipsoid by VANET devices which is obtained as follows

$$z = (z_y - z_x)\frac{r_{aff}}{r} + z_x - 0.6s_k + z_t \tag{3}$$

where $r_{,}$ is distance among obstacle and source device, and are the altitude parameter of source and receiving device of and respectively, is the device antenna altitude, is the distance among transmitting and the receiving devices and is the range to obtain primary Fresnel zone ellipsoid as follows

$$s_k = \sqrt{W r_{aff}(r - r_{aff})/_r} \tag{4}$$

where represent the wavelength. Finding the altitude of all probable obstacle devices is prior to transmission is a key factor and consider that the device will obstruct LOS among source and the receiving devices if is higher than its altitude. Therefore, the likelihood of LOS among device and is computed as

$$L(LOS|z_x, z_y) = 1 - Q(^{z - \varphi_z}/_{\omega_z}) \tag{5}$$

where and is the mean and standard of amplitude of the obstructing devices, represent the likelihood obstruction between transmitting and receiving device and Q represent function.

At last the attenuation amplification is needed the signal power received is calculated for the LOS of obstructing device in theprevious iteration and it is obtained using the $obtAttenuation([AffDevice$. In here we have considered the MKE(multiple knife edge) models where the entire list of devices of LOS obstacle is maintained, and it is based on the device/automobile distance from the wavelength size , automobile height , source device, electromagnetic wave and the location of automobile position. Moreover RPM (radio propagation model) for the highway environment and it performs the computations for amplification of attenuation among the source device and which considers the obstacle due to the adjacent devices.

This work use path loss and designed a TDMA-FDMA MAC scheduling model for providing the channel hopping, this helps in aiding in utilized system resource (Bandwidth) in efficient way. Here we have considered the MAC, where the time is divided in to equal length of slot . The total amount of time that a device be range of adjacent $\jmath$ device is $N_y = \left\lfloor {}^{2S_y}/_{u\dot{c}}\right.$. To compute $\mathcal{N}$ slot time when VANET device is in range of adjacent device is represented as follows

$$\mathcal{V}(y, \mathcal{N}) = \sum_{x=0}^{y-1} N_x + \mathcal{N}, \quad \forall \mathcal{N} \in \{1, \dots, N_y\}, \tag{6}$$

where $N_0 =$. The collection of time slots in $\jmath$ device, the time line is represented as follows

$$\mathcal{N}_y = \{\mathcal{V}(y,1), \dots, \mathcal{V}(y,N. \quad (7)$$

The optimal slot optimization problem for meeting QOS of a subscriber is described using following equation

$$n = \mathbb{N} = \bigcup_{y \in Y} \mathcal{N}_y = \bigcup_{y \in Y} \{\mathcal{V}(y,1), \dots, \mathcal{V}(y,\mathcal{N}_y)\}, \quad (8)$$

where is the cumulated collection of all time slots in coverage range.

In next section experimental study is carried out to evaluate the performance of proposed model over existing model.

V. SIMULATION RESULT AND ANNALYSIS

The experiment are conducted using windows 7operating system, intel I-5 class, 64bit, quad core processor, 8 GB RAM, 4 GB dedicated NVIDIA CUDA graphic card. The existing model [18] and proposed model is implemented using C# programming language, Dot net visual studio 4.0 framework using SIMITS simulator [19], [20]. The experiment are conducted to evaluate the performance of proposed model over existing model in term of collision and throughput achieved considering different environmental condition such as rural, highway and urban. The simulation parameter used for experimental study are shown in table I.

TABLE I. SIMULATION PARAMETER CONSIDERED

Network Parameter	**Value**
Network Size	50m * 50m
Number of Vehicles	20, 30 &40
Modulation scheme	QAM-64
Number of Frequency Channels	7
Number of time slots	8 µs
Bandwidth	27 Mbps
Mobility of devices	3 cycle per frame
Coding rate	0.75
Message information size	27 bytes
Environment used	Rural, Highway & Urban
MAC used	Proposed MAC and existing MAC

a) Collision performance:

Experimentsare conducted to evaluate the collision performance of proposed model over existing model considering varied vehicles. The vehicles is varied as 20, 30 and 40 and each vehicle is moving at speed of 3 cycle per frame. The Fig. 4show the collision performance of proposed model over existing model for highway environment considering varied vehicles. An average collision reduction of 27.02% is obtained by proposed model over existing model considering varied vehicle.Secondly, experiment are conducted to evaluate the collision performance of proposed model over existing model considering varied speed. The Fig. 5 show the collision performance of proposed model over existing model for highway environment considering varied vehicle speed. The speed of vehicles is varied as 4, 6 and 8 and with fixed vehicle size of 40. An average collision reduction of 25.93% is obtained by proposed model over existing model considering varied speed of vehicle. The outcome shows that when vehicle density and speed is increased the packet collision increases for both existing and proposed model.

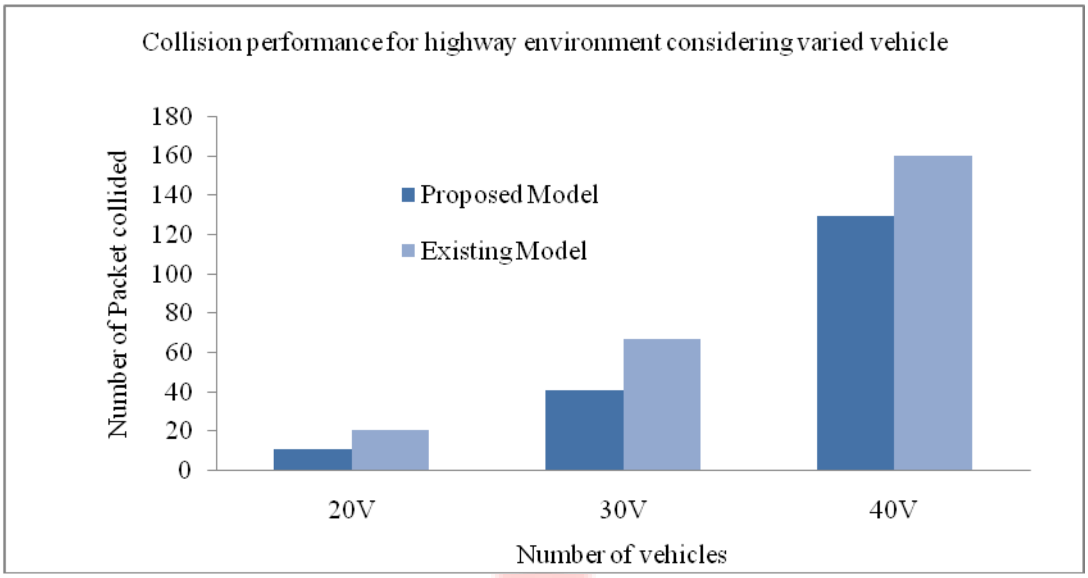

Fig. 4. Collision performance for highway environment considering varied vehicle

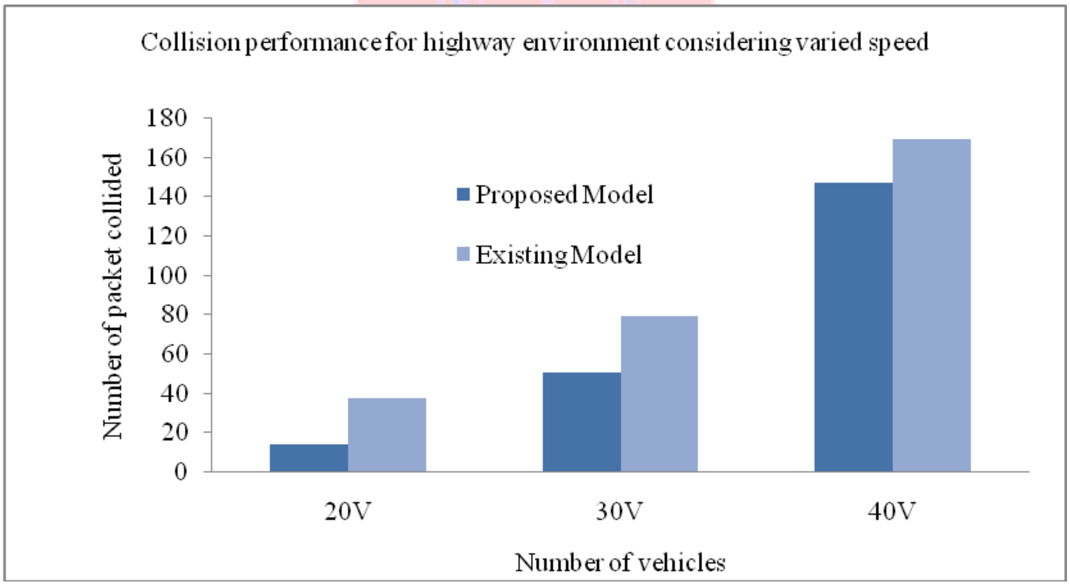

Fig. 5. Collision performance for highway environment considering varied speed

b) Throughput performance:

Firstly, experiments are conducted to evaluate the throughput performance of proposed model and existing model considering varied vehicles. The vehicles is varied as 20, 30 and 40 and each vehicle is moving at speed of 3 cycle per frame. The Fig. 6 show the throughput performance of proposed model over existing model for highway environment considering varied vehicles. An average throughput improvement of 20.93% is obtained by proposed model over existing model considering varied vehicle. Secondly, experiment are conducted to evaluate the throughput performance of proposed model over existing model considering varied speed. The Fig. 7 show the throughput performance of proposed model over existing model for highway environment considering varied speed. The speed of vehicles is varied as 4, 6 and 8 and with fixed vehicle size of 40. An average throughput improvement of 24.36% is obtained by proposed model over existing model considering varied speed of vehicle. The outcome shows that when vehicle density and speed is increased the packet throughput increases for both existing and proposed model. The outcome shows that when vehicle density and speed of vehicle is increased the throughput increases for both existing and proposed model.

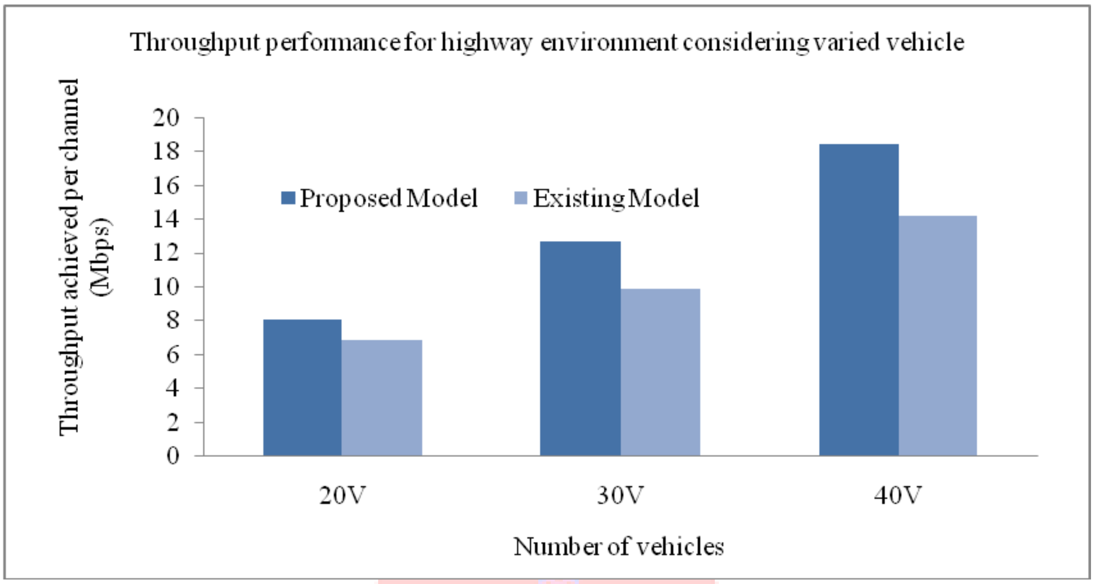

Fig. 6. Throughput performance for highway environment considering varied vehicle

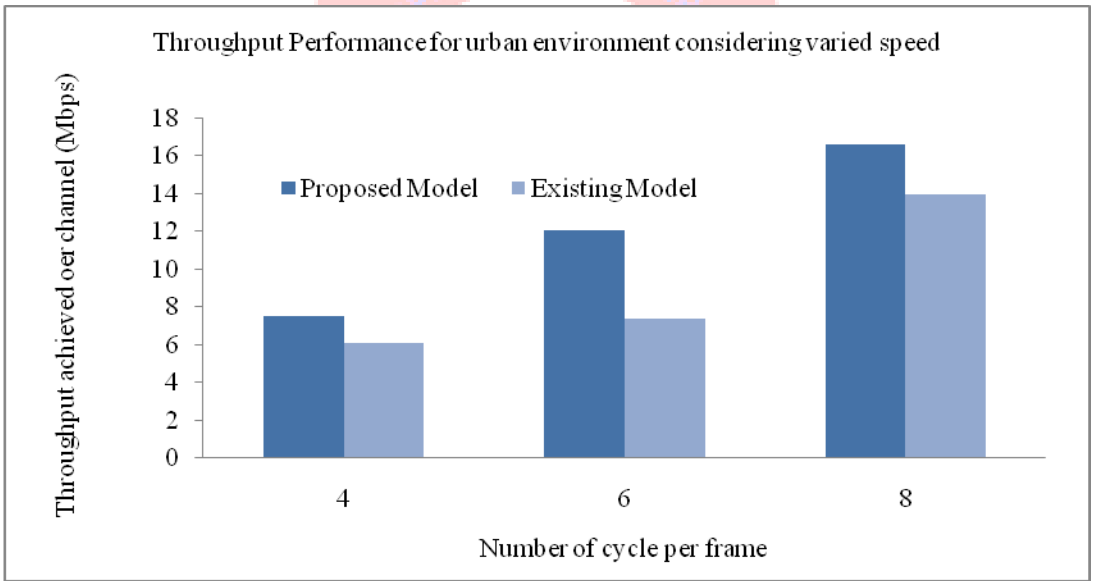

Fig. 7. Throughput performance for highway environment considering varied speed

VI. CONCLUSION

This work presented an efficient propagation and MAC design to maximize system throughput and minimize collision. Thus, aid in in utilizing bandwidth efficiently. The proposed model aims to utilizing bandwidth more efficiently for subscriber. Our model achieves an optimal solution for the research objectives. Experiment are conducted to evaluate proposed model performance over existing modelin term of collision and throughput achieved. The outcome shows proposed model reduces collision by 27.02%, and 25.93% for highway environment considering varied vehicle and mobility speed, respectively, over existing model. Proposed model improvesthroughput by 20.93% and 24.36% for highway environment considering varied vehicle and mobility speed, respectively, over existing model. The overall result achieved show that the proposed model is scalable irrespective of network density and, mobility speed of vehicle considering highway environmental condition. The future work would consider evaluation under varied different environment condition and further, enhance the propagation and MAC model considering provisioning QoS.

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