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A mobility aware environmental channel modelling for DSRC based STS for V2V

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ABSTRACT

Wireless communication for automobile industry has aided growth of Smart Transportation System (STS) which solves numerous vehicular based application services. Wireless technologies play an important part in assisting both Vehicle to Infrastructure (V2I) and Vehicle to Vehicle (V2V) correspondence in VANET. The existing model suffers from throughput efficiency due to improper channel modeling which does not consider environmental factor. To cater this in this work the author proposed an environmental model for varied scenario such as City, Expressway and Village (CEV) to sturdy the impact of throughput performance and packet drop considering environmental factor for DSRC based V2V communication in IEEE 802.11p mac protocol. The simulation is conducted for collision and throughput efficiency for varied traffic density and mobility speed of vehicle. The experimental result shows the proposed environmental model impact on collision and throughput efficiency for varied environment and thus helps improving QoS for DSRC based V2V application services.

Keywords: DSRC, IEEE 802.11p, Path loss, VANET, V2V, WAVE.

1. INTRODUCTION

As Vehicular ad hoc network (VANET) has no any fixed infrastructure it has a type of wireless communication among vehicle-to–vehicle (V2V). VANET give the new idea for road safety, traffic control management, and uses of commercial application or entertainment things etc. Dedicated short range communication (DSRC) spectrum is especially dedicated to V2V communication given by U.S. federal communication commission [1]. In V2V communication every vehicle is act a wireless router or node or we can say that like guest or host. Concept of V2V is that if at any time of point some vehicle leave from the communication network at that time of point other vehicle may join the network in that manner continuity of communication between vehicles has maintained [2]. Range of communication in V2V is varied from few meters to few kilometers between vehicles which acts as transmitter or receiver. V2V communication faces some challenges while communication due to fast moving of both sender and receiver, geographical condition, physical condition of area and short range of communication. In wireless communication here like V2V sender transmitted signal can propagate via different path to reach at the receiver. Transmission of data via different path is called multipath propagation. Geographical condition (like tree, building, rain etc.) affect the transmission of data due to which scattering, reflect, diffraction of data occur which lead to transmission delay or loss of packet [3]. These issue can be resolved by using appropriate technologies based on area researchers can divide their approach because urban, highway or village area has different geographical condition based on that communication in V2V get affected.
Expressway: Speed of vehicle in highway is varied between 25 to 40 m/s and 2 to 4 lane is there so traffic density is moderate.

City: Speed of vehicles in urban or city area is low but traffic density is high physical condition like tall building is very dense which also affect communication.

Village: speed of vehicle is more than city environment but very low traffic density. Number of vehicle is very less, open environment.

Here author proposed model is based on vehicle location physical location like city, Highway, and rural or sub-urban area. Path loss of data transmission may due to shadowing (wave propagation affecting by obstacle) or distortion occur due to various path taken by the signal in propagation. In inter vehicle communication line of sight condition occur due to frequent mobility of vehicle. Density or concentration of vehicle on road is also uncertain. This uncertainty involved in measurement of traffic on road. A relationship exists between the speed, traffic flow and density as well as delay of road system. In V2V communication direction of transmitter and receiver also affect statistics of V2V channel. Several companion on moving direction of transmitter or receiver when sender or receiver are moving on same direction and when they are moving in opposite direction to find the channel characteristic [4,5].Wideband measurement of channel at 2.4GHz, and 5.9 GHz in V2V environment for Doppler-delay given in [5]. Velocity of vehicle and separation of vehicle is also considerable in Doppler Effect [5]. Transmission of message by different vehicle at same time may cause problem if all vehicle uses single channel or same channel for transmission (asymmetric radio link). In highway or city area these problem may increase due to channel congestion or traffic density [6]. Traffic control message is may broadcast in city area which is the interest of public not for individual but when each vehicle broadcast the message at same time packet may collide or lost or increases the overhead of network traffic. Figure 1 shows the V2V communication scenario.

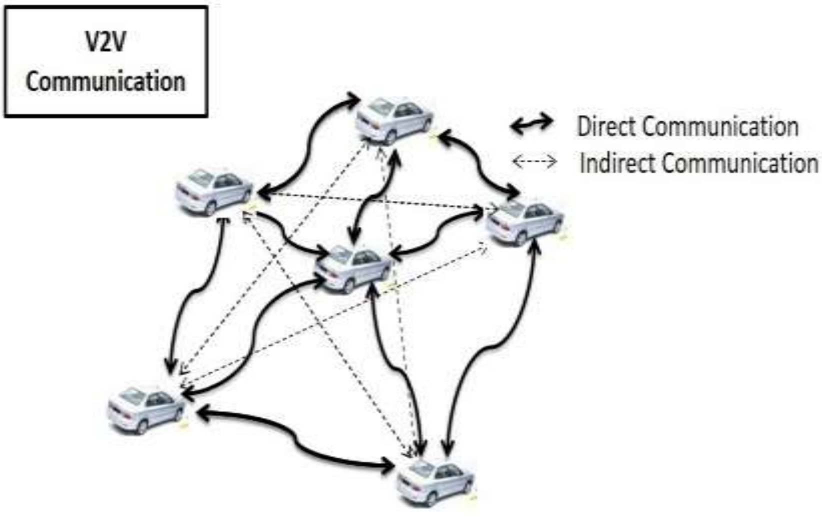

Figure. 1 Vehichle to vehichle communication scenario

Network bandwidth is limited so we don't want to waste it. In urban or city area communication may get affected by tall building because if sender transmit the message at corner of building it not broadcast in all direction because of these building or lost their path. To avoid channel congestion or limited bandwidth for message broadcasting in V2V it is necessary to enhance the used MAC layer protocol, IEEE 802.11p (DSRC) standard defining the physical or medium access control layer. Additionally, these phenomena should be considered as the normal case for VANET, thereby requiring error-compensation instruments at higher-layers. The other general challenges are Limited transmission capacity, Discontinuous coverage and Vehicles unsystematically arriving/leaving the area. Following Table 1 is the list of a few challenges that exist with respect to Transport Layer TCP and network layer IP over DSRC and other generic challenges on 802.11 based vehicular wireless network.

Table 1: Physical network standard overview

Standard	Frequency Band in GHz	Speed in Mbps	Indoor Signal Range in Mtr.	Approximate Outdoor Signal Range in Mtr.	Mobility support in ≈ km/h	Suitable for Outdoor Network
Wi-Fi 802.11a	5.1-5.8	25-54	30	45	40-120	Low
Wi-Fi 802.11b	2.4-2.5	11	30	100	40-150	Low
Wi-Fi 802.11g	2.4	6-54	35	140	40-120	Low
Wi-Fi 802.11n	2.4/5	2-54	70	250	40-120	Low
DSRC 802.11p	5.8-5.9	3-27	30	1000	40-150	High
WiMax 802.16	2.3, 2.5 & 3.5	1-3Gbps	NR	≈50km	60-250	High
GPS	1.575					Medium

Focus on all these issues like environment condition, Traffic density or limited bandwidth, different condition of city, highway or village area author proposed a model which includes all these things. Here author proposed a dynamic environmental model for varied environmental condition such as Village (V), Express-Way (E) and City (C) for V2V environment considering the geographical and environmental factor. The proposed CEV model is incorporated into the NCCMA in IEEE 802.11p or DSRC MAC protocols which served as a spine for catering Safety application and Non-Safety applications. The 802.11p also known as DSRC/WAVE technologies support low latency V2I communication.

The paper organization is as follows: The literature survey is presented in Section two. The proposed environmental model considering environmental factor are presented in Section three. The results and the experimental study are presented in the section four. The concluding remark is discussed in the last section.

2. LITTERAURE SURVEY

Every technology has some strength and weakness in terms of reliability, effectiveness, efficiency, cost, maintenance and ease of use. The primary objective of almost all the vehicular wireless technology is to provide safety. The architecture of DSRC is so defined that it is suitable for safety as well as non-safety applications. Various researches have been conducted on DSRC technology and confirmed its effectiveness. According to vehicular wireless technology comparison depicted in Table 1, it is evident that DSRC is most suitable in terms of cost, data transfer rate and signal range. DSRC works on Wi-Fi pattern and there are various previous researches made on802.11 based infotainment based services. Vehicular Ad hoc network is vast area for researchers day by day research is going on. VANET for V2V communication provided a specific range DSRC by the IEEE standard. Here the author surveys some of the existing protocol that is intended to provide QoS based infotainment application service to its end users.

Here [7] author purposed a model based on position of vehicle, high mobility of vehicle in V2V break the communication path between vehicles. Both sender and receiver may move in same direction or in opposite direction in case of city or highway. Position based routing protocol is for ensuring the connectivity between vehicles. Author uses an approach of store and carry- forward to reduce the packet loss. A device or vehicle any time leave the communication network or may join the group for communication. Store and carry forward approach may delay in transmission or real time information like safety information can’t avoid the delay. Author V2V communication give idea about only City and Highway model but did not consider rural scenarios.

Communication between vehicle to vehicle is needed a better protocol because vehicle mobility is high here [8] author purposed a work based on hop count and routing metric at MAC layer which reduced the delay and improve link quality. Multipath routing protocol is used for discovery of route which reduced the route discovery frequency. Author purposed model AOMDV is only suits for urban area.

In [9] Cooperative Vehicle-Infrastructure Systems (CVIS) equipment’s are used to measure and study the effects of the 802.11p communication channel in various environments. Measurements are carried out based on the packet transacted data and the received signal strength indicator (RSSI). The results presented in the paper show the effects of the environments on Packet Loss Rate and Network throughputs. The effects of vehicle mobility speeds are not clearly described in the research work presented in [9].

In [10] inter vehicle communication range of transmitter and receiver is less for this Dedicated Short-range Communication (DSRC) provided a specific spectrum band of 5.9 GHz. Its MAC and physical layer defined in IEEE standard 802.11p. Here author only focus on analyzing existing DSRC and try to enhance. In some RF environment challenges is remain to perform better DSRC. Author faces challenges of deployment in frequent movement of vehicle or in dense area like city. Here the author fails to operate DSRC in multi-channel.

In [11] a model based on IEEE 802.11p protocol for the throughput of the EDCA mechanism is discussed. Result obtained by the simulation in this paper proves the accuracy of analytical mode which is proposed by author. When speed of vehicle or user is high in that scenario throughput is reduced it is shown in result. Here author consider the analytical model with generic noise which is not the case of real world. In real world scenario three different kind of physical condition of area is present like city, express-way and village area based on that need to develop an analytical model for the throughput enhancement in the transport layer.

Here [12] author discussed the effect of mobility of vehicle and speed of vehicle on network throughput. When speed of node or vehicle is high result shows the throughput is less. In [6] it is determined that mobility of vehicle is an important parameter to be considered in network performance analysis.

In [13] the hybrid Vanet network field testing results conducted in the city of Bologna, Italy is presented and the communication and measurements results are discussed. A WAVE point coordination function (WPCF) is proposed in [14] for mobility management. The paper highlights the drawbacks of the 802.11p MAC in handling high number of users and high mobility speeds [15] of vehicles in the Vanet hybrid network scenario. In [15] an analytical model for the throughput of the EDCA mechanism in IEEE 802.11p protocol is discussed. The simulation results described in the paper prove the accuracy of the analytical model developed by the authors. The results also prove that the throughput reduces when the mobility speed of the users is high. The authors in [15] have considered generic noise in the analytical model which is not the case in the real world scenario. There is a need to develop an analytical model for the throughput of the transport layer considering urban, rural and highway conditions. In [16] the effects of user node or vehicle mobility speeds on network throughput are discussed. The research presented shows throughput degradation when the user node speed is increased. In [16] it is concluded that the user node mobility parameter is important factor to be considered in network performance analysis. Based on the literature review it is clear that the environmental conditions are critical to achieve accurate and acceptable simulation studies.

3. PROPOSED V2V ENVIROMENTAL MODELING IN VANETS

Before The authors aim to design efficient environmental model such as city, expressway and village, so that it is well-suited with the IEEE 802.11p prototype that is designed to accommodate the provision of wireless admittance in VANET [17], [18]. The proposed environment model is incorporated in to NCCMA [23] and experiments are conducted for collision and throughput efficiency. The author is intendent to designing an efficient environmental model for V2V.

Here in this work the author consider different environment models such as city, expressway and village (CEV), where vehicles moves and communicated by several vehicle located along these environment models and gain service access for stipulated session. Let consider that automobile require to transmit a packet when it is in the coverage ranges of the other vehicle, and pays for channel access attempts. As both the achievable bandwidth and channel contention level fluctuate over session period, the automobile needs to take decision when to transmit packet by considering channel availability, the infotainment applications quality of service necessity, and requirement level of contention in current and forthcoming session slots considering signal degradation of environment factor.

A. CEV V2V Environmental Model

In this work the author consider a different scenario such as city, expressway and village environmental model for V2V, where multiple vehicles are set up and they are interconnected to provide infotainment facilities to automobiles or end user within their range of coverage. In this work the author focus on a automobile that wants to transmit a packet of size PS when it pass through a part of this CEV environment model with a set of vehicles $U = (1, \dots, b)$, where the vehicles pass through the a^{th} vehicle before the b^{th} vehicle for a $< b$ with $a, b \in U$. The author assumes that the b^{th} vehicle has a communication ranges RT_b . The author assumes that the automobile is associated to one vehicle at a period. Here the author considers that the vehicles are set up in such a way that any location in this network of CEV environmental model is concealed by a vehicle. The proposed model can be extended to consider the situations where the area of coverages of adjacent vehicles is inaccessible from each other.

B. CEV V2V Vehicle Load and Environment Channel Modelling

Let δ represent mean amount of automobiles moving through a V2V network per cycle. Let consider that the amount of automobiles passing into this section of the CEV scenario follows a regression method as in [19] with the mean rate of arrival δ. Let l represent the load of vehicle i.e. the amount of automobiles per unit distance along the CEV fragment, and s be the speed at which vehicles is moving. From [20], we have

$$\delta = ls. \tag{1}$$

The context between the speed s and automobile load l is represented by the following equation [17]:

$$s = s\_ffs\ (1 - l/l\_max), \tag{2}$$

where s_{ffs} is the free-flow mobility speed of automobile on the road without any other automobile, and l_{max} is the maximum automobile load.

As we are evaluating the vehicle movement in steady state, all the automobiles within the communication range of vehicle are presumed to travel with the identical speediness s in (2). The floor function is represented by $\lfloor . \rfloor$. The maximum amount of user automobile that can be put up within the communication area of the b^{th} vehicle is represented by

$$N_{max,b} = \lfloor 2A_{bl_{max}} \rfloor, \qquad \forall\, b \in U. \tag{3}$$

Wireless signal radio propagations are affected from factor such as fading, shadowing, and path loss. Subsequently the communication remoteness among the vehicle and the user vehicle differs in the CEV environment, due to signal degradation of path loss the author focus on the foremost effect of channel attenuation for different environmental model. The bandwidth at slot t time is represented as

$$b_t = C_B \log_2\left(1 + \frac{T^p}{N_o C_B d_t^\gamma}\right), \quad (4)$$

where T^p is the transmission power of the user automobile, C_B is the network channel data rate, d_t is the distance between the closest automobile and the automobile at slot t time , and γ is the exponent of path loss. The author considers that the power spectral density $N_o/2$ and zero mean Gaussian noise. The author also considers a scenario with fixed data rate. Since Lognormal shadowing path loss model provides an efficient way in finding path loss receptions compared to the other model that are available, the author have selected it as the channel model [21]. In log-normal environment shadowing path loss model, the signal to noise ratio $(d)_{dB}$ at a distance d from the transmitter to receiver is represented by.

$$\gamma(s)_{dB} = P_t - PL\,(s_o) - 10_\eta \log_{10}\left(\frac{s}{s_o}\right) - X_\sigma - P_\eta, \quad (5)$$

where $PL\,(s_o)$ signifies the path loss at a reference distance s_o, P_t signifies the transmission power in dBm, η means the exponential path loss, P_η represents the noise power in dBm and X_σ represents a zero mean Gaussian random variable with standard deviation σ.

Based on equation (5) the path loss $\gamma(s)_{dB}$ obtained for different environment model. Based on the path loss values for different environment model γ the bandwidth of the destination vehicle is estimated using equation (4) and thus cater in improving throughput efficiency and reducing collision of our model.

The proposed CEV environmental model with bears the closest similarity to our work and is used for comparisons in the experimental study presented here are [17], [18], [19], [20].

4. SIMULTION RESULT AND ANALYSIS:

The system environment used is windows 10, 64-bit quad core operating system with 16GB of ram and 2GB dedicated CUDA graphic card. The author have used dot net framework 4.0 and C# 6.0 programming language for the proposed work and conducted experimental study on following parameter for Packet collision and throughput efficiency for varied mobility speed and number of vehicle users and evaluate the performance of varied environmental model. The authors have considered IEEE 802.11p also known as DSRC/WAVE which has six services channel and one control channel and NCCMA as MAC scheduling algorithm. The modulation scheme used is QAM-16 which has as a transfer rate of 12 Mbps (Megabits per seconds) with coding rate of 0.5 and in experiment 1 the mobility speed (it represent number of frames per cycle) is varied 4, 6 and 8 (where 4 represent the maximum speed and 8 represent the minimum speed) and the number of vehicle is fixed to 25 and in experiment 2 the number of vehicle is varied to 5, 15, 25 and 50 and simulation is conducted for Village (V), Expressway (E) and City (C) environmental model.

C. Experiment 1: Successful transmission, Collision and Throughput efficiency considering varied mobility speed for CEV environmental model.

In figure 2 it shows the average throughput achieved by varying vehicle mobility (cycle per frame) speed and its impact on throughput for CEV environmental model. In figure 2 it shows that the average throughput achieved in city environment is high when compared to expressway and village model and the average throughput achieved in the village is low when compared to city and expressway model. The average throughput for achieved 4 cycles per frame for expressway environment is about 6.26 Mbps, for village environment is about 5.15 Mbps and for city environment is about 6.39 Mbps. The average throughput achieved for 6 cycles per frame for expressway environment is about 6.61 Mbps, for village environment is about 6.23 Mbps and for city environment is about 6.84 Mbps. The average throughput achieved for 8 cycles per frame for expressway environment is about 7.42 Mbps, for village environment is about 6.78 Mbps and for city environment is about 7.61 Mbps. From simulation result obtain we can see that efficiency of throughput depend on mobility speed of user vehicle as we can see when speed is maximum (4 cycle per frame) the throughput achieved is low and when speed is minimum (8 cycle per frame) the throughput achieved is high for all CEV environment model which is shown in figure 2.

In figure 3 it show the number of packet transmitted successfully between V2V for varied cycle per frame (mobility). The packet transmitted successfully is high in city model when compared to expressway and village model and packet transmitted successfully is low in village model when compared to expressway and city model and also we can see that the packet transmission increases with increasing in mobility speed.

In figure 4 it show the number of packet collision in V2V for varied cycle per frame (mobility). The packet collision is high in village model when compared to expressway and city model and packet collision is low in city model when compared to expressway and village model and also we can see that the packet collision increases with increasing mobility speed.

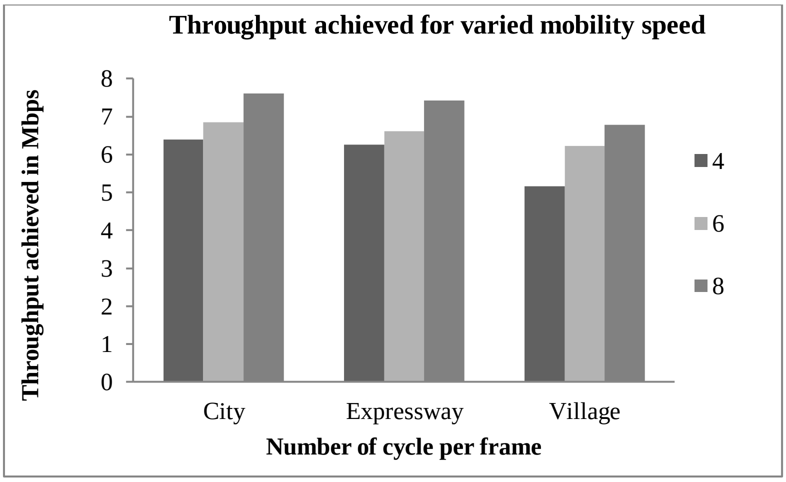

Figure. 1 Average throughput achieved for varied mobility speed

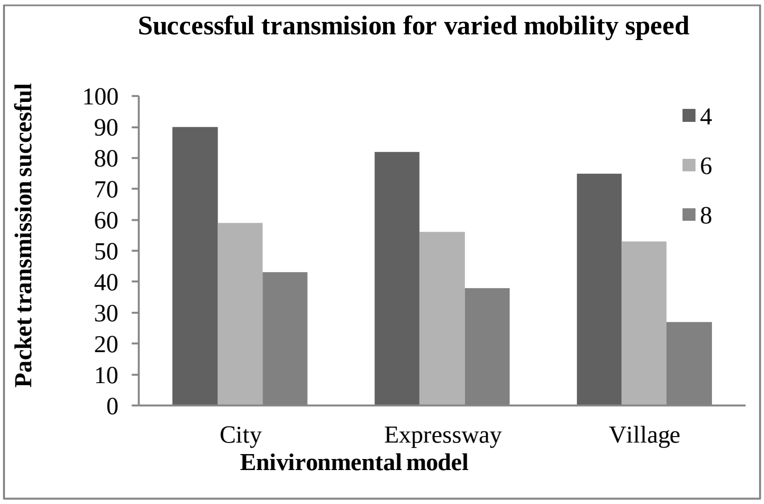

Figure. 2. Packet transmission successful for varied mobility speed

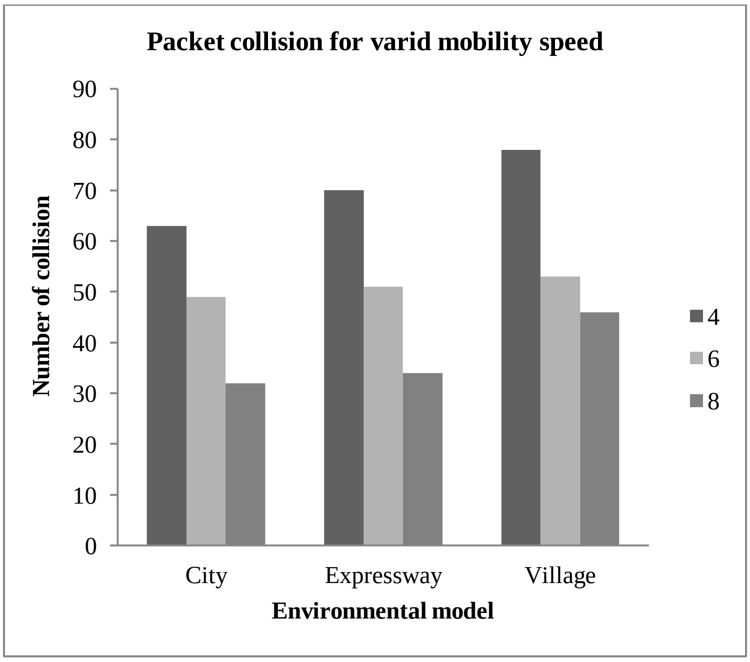

Figure. 3. Packet collision achieved for varied mobility speed

D. Experiment 2: Successful transmission, Collision and Throughput efficiency considering varied vehicle density for CEV environmental model.

In In figure 5 it shows the throughput efficiency for varied user in expressway environmental model. Figure 6 shows the throughput efficiency for varied user in village environmental model. Figure 7 shows the throughput efficiency for varied user in city environmental model. From all three environment model in figure 5, 6 and 7 it can be seen that throughput achieved is increased when the number of user vehicle is increased.

In figure 8 it shows the average throughput achieved by varying user vehicle and its impact on throughput for CEV environmental model. In figure 8 it shows that the throughput achieved in city environment is high when compared to expressway and city model and the throughput achieved in the rural is low when compared to city and expressway model. The average throughput achieved for 5 users for expressway environment is about 2.43 Mbps, for village environment is about 2.37 Mbps and for city environment is about 2.51 Mbps. The average throughput achieved for 15 users for expressway environment is about 5.44 Mbps, for village environment is about 5.09Mbps and for city environment is about 5.69 Mbps. The average throughput achieved for 25 users for expressway environment is about 7.69 Mbps, for village environment is about 6.03Mbps and for city environment is about 8.48 Mbps. The average throughput achieved for 50 users for expressway environment is about 8.67 Mbps, for village environment is about 7.1Mbps and for city environment is about 8.78 Mbps.

In figure 9 it show the number of packet transmitted successfully between V2V. The packet transmitted successfully is high in city model when compared to expressway and city model and packet transmitted successfully is low in village model when compared to expressway and city model and also we can see that the packet transmission increases with increasing number of users.

In figure 10 it show the number of packet collision in V2V. The packet collision is high in village model when compared to expressway and city model and packet collision is low in city model when compared to expressway and city model and also we can see that the packet collision increases with increasing number of users.

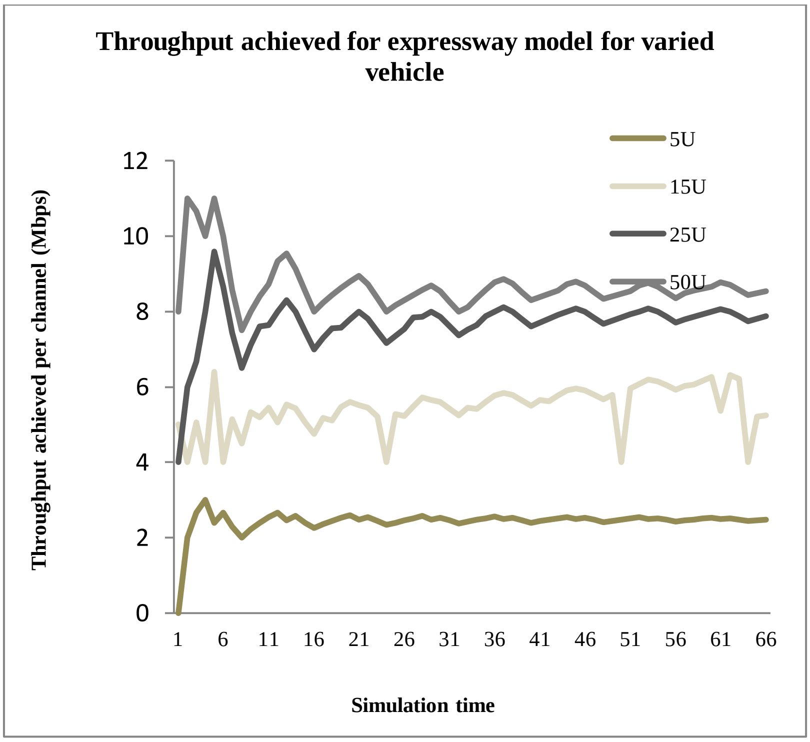

Figure. 5 Throughput achieved per Channel for varied user in expressway environmental model

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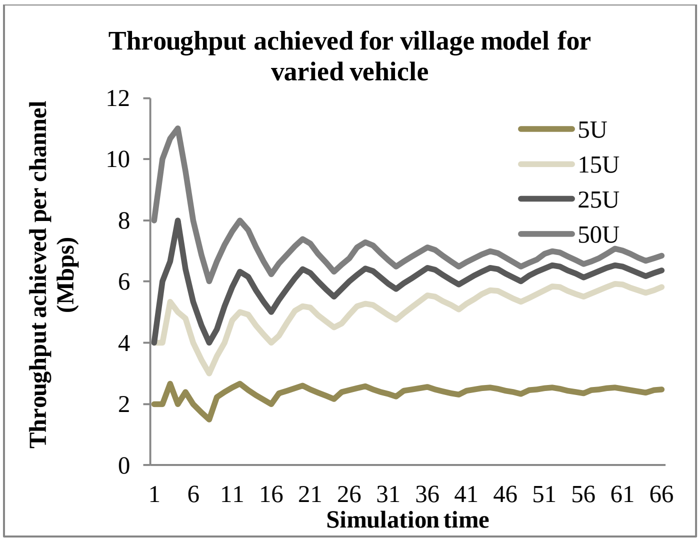

Figure. 6 Throughput achieved per Channel for varied user in village environmental model

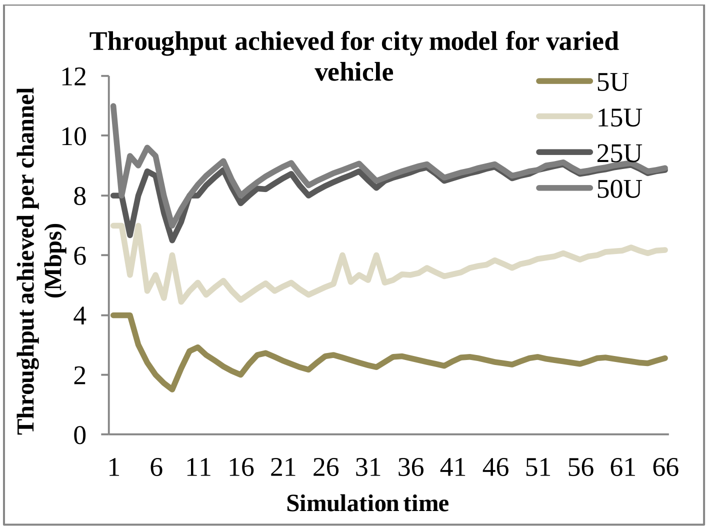

Figure. 7 Throughput achieved per Channel for varied user in city environmental model

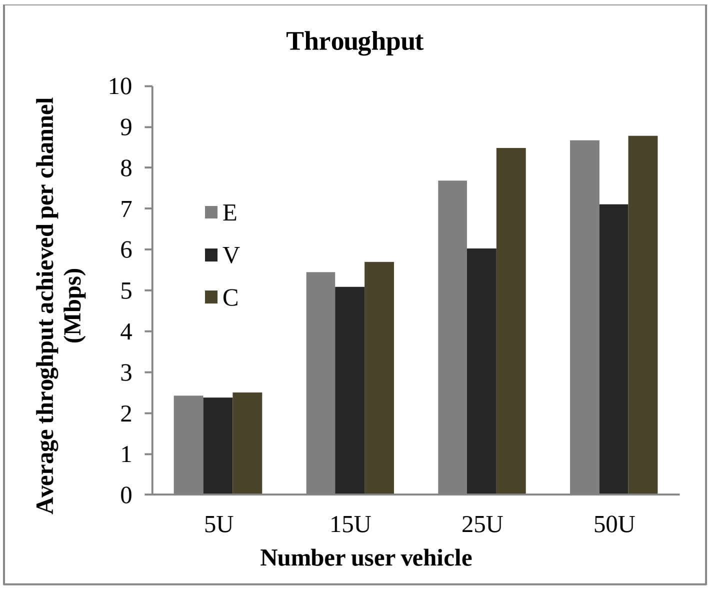

Figure. 8 Average throughput achieved per cycle for varied vehicle user

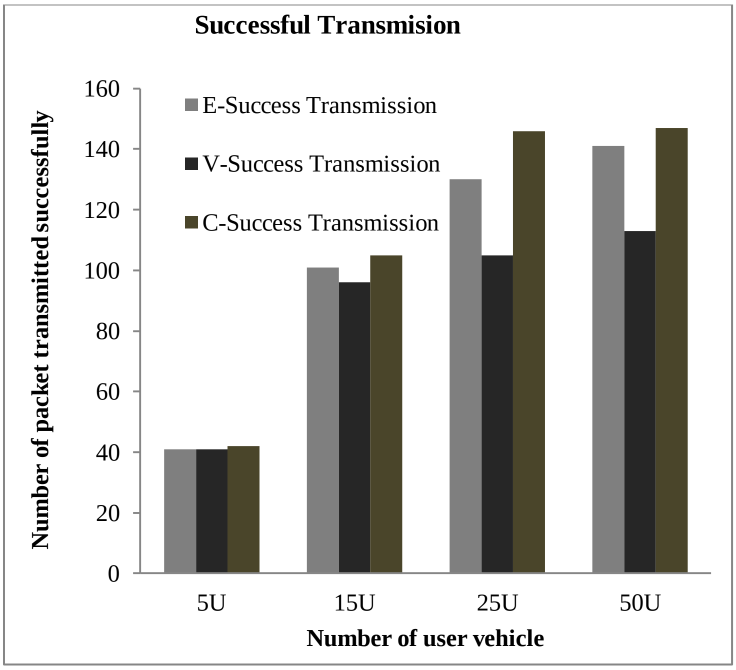

Figure. 9 Packet transmitted successfully for varied vehicle user

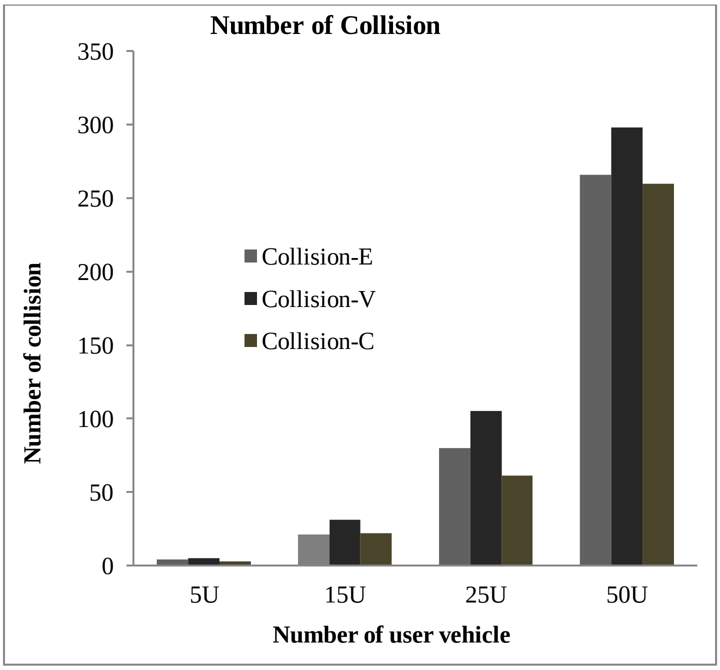

Figure. 10 Packet collision for varied user

5. CONCLUSION

The Smart Transportation System (STS) has been lately engrossed by various as well as academic world since it has the prospective to save environment, money, lives and travel time. A VANET is a vital element of STS which uses various wireless communication protocols in order to provision applications for V2V. In VANET choosing the right communication access protocols is a crucial factor since it determines the data rate, transmission range and security. The existing scheduling technique does not consider the environmental factor which degrades the throughput performance and increases packet collision. Here in this work the author propose an efficient V2V environment model considering the environmental factor. The efficient environmental model algorithm is incorporated into NCCMA in IEEE 802.11p MAC protocols which served as a spine for supporting both safety application and non-Safety applications. The 802.11p also known as DSRC/WAVE technologies support low latency V2V communication. Experiments are conducted for throughput efficiency and collision for different environment model such as city, expressway and village. The experiment are conducted by varying the vehicle density and by varying the speed of vehicle and evaluated the it impact on throughput and collision. The experimental result shows the proposed environmental model for NCCMA and its impact on collision and throughput efficiency and thus helps in aiding improving QoS for VANET application. In future work The author propose a new adaptive scheduler for varied environmental model proposed in this work to further reduce the collision in NCCMA and improve the throughput efficiency by considering various OFDM modulation scheme such QPSK and QAM-64 that are available for IEEE 802.11p DSRC Protocol.

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