

A Novel Throughput and Collision for City Environment in V2V Communication

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Abstract— VANET uses CSMA/CA as its MAC method, in spite of its inability to support real-time deadlines. However the CSMA/CA cause unbounded delays before channel access and collisions on the channel. On the shared communication channel, the MAC protocol decides who has right data/packet to transmit next. To reduce the collision, distribute MAC is needed for channel allocation. For the channel allocation. Many existing approach adopted Cognitive Radio and Time Division Multiple Access (TDMA). Therefore these existing models do not utilize bandwidth efficiently. To solve these issues this paper presented a solution to maximize the throughput and minimizes collision which is experimentally proven. The experiment was evaluated in terms of throughput, collision, considering City environment.

Keywords—VANET, V2V, CSMA/CA, MAC.

I. INTRODUCTION

VANETs has become a major research motivation of governments, car manufacturers and academic institutions, Because of the wide variety of applications, high effectiveness and low-cost constructions, and also attract more and more interests of them.

Smartphone, Global Positioning System (GPS), Bluetooth media players are some of the intravehicular networks which allow wireless communication between the vehicle and electronic gadgets in the most modern car. But the Inter vehicular communication network is still not obtained. Vehicular ad-hoc Network technologies are emerging to provide inter-vehicular communication VANET. Vehicular ad hoc networks (VANETs) are explained as a subset of mobile ad hoc networks (MANETs) with the differentiating property that the nodes available in here are vehicles. So node i.e. vehicle movement has been restricted. VANET is supported by some fixed infrastructure that assists with some services of the VANET due to restriction and provides access to stationary networks. Like roadsides, service stations, dangerous intersections or places with hazardous weather conditions are critical locations which are deployed by the fixed infrastructure.

Many researches have been taken place to get a solution and to overcome this problem; one part of them is communication between the vehicles. To communicate with each other Vehicle to Vehicle (V2V) Communication and also Vehicle to Infrastructure (V2I) Communication based on

Wireless technologies have been designed to help vehicles and can also communicate with Road Side Units (RSU) Fig. 1. Vehicle to Vehicle (V2V) and Vehicle to Infrastructure (V2I) assumed to use for the road safety and convenient. The safety applications are capable of sending and processing messages in real time is the most notable difference between safety and non-safety application. Using wireless access technologies the drivers and passengers can assess both kinds of services from the nearby infrastructure effortlessly.

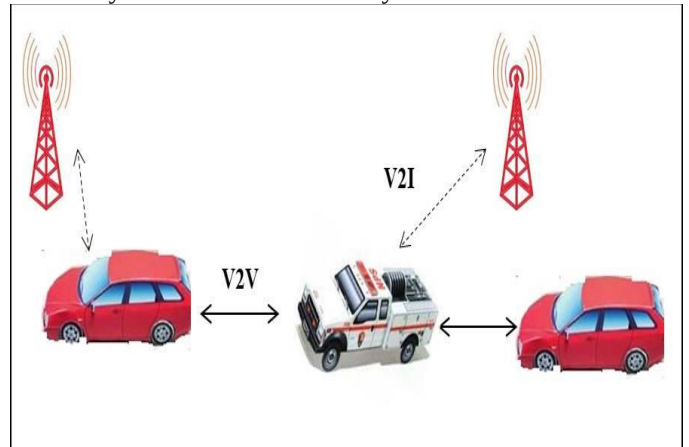


Fig.1. VANET Architecture

VANET has Specific Characteristics.

- **High Dynamic Topology:** in VANET the Dynamic topology is highly existable. There is a rapid change in communication links between the nodes. Communication between two nodes will be there for a very limited time. For example, if two vehicles traveling off from each other with a speed of 25m/sec and if the range of transmission is about 250m, later the link will only last for only 5 seconds (250m/50ms-1). So this is how highly dynamic topology exists in VANET.
- **Frequent disconnected Network:** We can see that connection between two or more vehicle remains for 5 seconds or so, from the above characteristic. The vehicles need another connection nearby immediately to maintain the continuous connectivity. But the vehicles can connect with Road Side Unit (RSU) if a

failure occurs. Whenever the vehicle density is very low in the rural area, the frequent disconnected network will occur.

- **Mobility Modeling and Prediction:** As we saw in the above two features for connectivity needs the knowledge of positions of vehicles and their motion but this is very complicated to predict therefore vehicle can move randomly and it doesn't have a pattern. So mobility models node prediction which based on the study of predefined road roadway model and vehicle speeds are used.
- **Communication Environment:** According to the different environment the mobility model highly varies from s to that of the city environment, from a rural area to an urban area. So according to these changes mobility modeling and vehicle movement prediction and routing algorithm must be adapted. Because of vehicle movements are one dimensional, the mobility models are very simple. But in the case of the city environment, the communication application is very complex in VANET because lots of vehicles and different obstacle like building are present.
- **Hard Delay Constraints:** Accident, sudden break, and emergency call are some of the Safety aspects of VANET application which depends upon the delivery time of data. In this type of applications, it cannot compromise for the delay of data. Therefore in VANET hard delay constraint is very important than the high data rate.
- **Interaction with on-board sensors:** The on-board sensor exists in vehicles. These sensors are used for effective communication between the vehicles and also to find vehicle location, vehicle speed, and vehicle movement.

The identical medium access scheme in IEEE 802.11, CSMA/CA is adopted by IEEE 802.11p [1].

The stations are allowed by the CSMA/CA to share the same channel in an efficient manner. The summary of CSMA/CA has been listed below.

- 1) The station including a frame to be transmitted senses the channel prior to transmission;
- 2) The frame is ready to be transmitted, only if the channel is idle;
- 3) If the channel is busy, countdown step waiting for the idle status of the channel has been set up by the station. Back off is also known as the waiting time before transmission, by the multiplication of a randomly-selected number and the duration of the time slot they are determined. If the channel is idle and pauses as the channel is busy again only then the countdown begins. The frame is to be transmitted when the channel is idle and the countdown reduces to zero;
- 4) Before the frame is transmitted, a Request-To-Send (RTS) packet and the intended receiver responds to the station with a Clear-To-Send (CTS) packet have been sent by the station, which provides information that other stations in the same channel, like a station is ready to send a frame and the channel becomes busy

immediately. Possible collisions are avoided by the Application of RTS/CTS and they partially solve the hidden-terminal problem;

- 5) The receiver sends an acknowledge (ACK) packet to the transmitter upon the completion of reception, to inform it that the frame has been successfully received;
- 6) After transmitting the frame if the transmitter fails to receive an ACK, after a random back off time a re-transmission is executed.

To overcome the drawback of IEEE 802.11p, TDMA (time division multiple access) based MAC protocols is presented to provision efficient transmission in VANET [2]. However, their approach is centralized which takes advantage of RSUs (Road side units). As a result, requires large amount of RSUs. Hence, it is applicable for City environment. To address in [3] presented a distributed MAC to utilize bandwidth efficiently. The model overcomes the bandwidth inefficiency of Space Division Multiple Access (SDMA) [4]. Their model reduces collision for highway environment. However, their model did not consider maximizing system throughput. To maximize the throughput the work in [5] used cognitive radio (CR) technique to design MAC in the name Enhanced Cooperative Cognitive division Multiple Access (ENCCMA). ENCCMA adopts TDMA based spectrum/channel allocation. However, if more users are there in network ENCCMA might not be efficient. To overcome, distributed spectrum access is required. For distributed spectrum access realization ENCCMA adopted CR technique. For example if 20 slots are available at certain instance of time and only 15 slots are used so the remaining 5 slots are not used. As a incurs collision and fails in maximizing system throughput.

II. PERFORMANCE ENRICHED CHANNEL ALLOCATION

Here we present a low-complexity and efficient technique for channel allocation for non-shared and shared channel vehicular network. The model aims to maximize system throughput and minimize MAC overhead (collision).

a) Non-Shared Channel Allocation (NSCA):

Let V_x be the set of channel exclusively allocated for vehicle x (i.e. $V_x \cap V_y = \emptyset$, $x \neq y$). The NSCA technique iteratively assign channel to vehicle that maximize the network throughput.

In each iteration of channel assignment, each vehicle x computes its gain in throughput if best channel is allocated considering following condition.

$$y'_x = \operatorname{argmax}_{y \in V_z} l_{x,y}, \quad (1)$$

The gain in throughput can be computed as

$$\begin{aligned} \delta S_x &= S_x^z - S_x^q = \left[1 - (1 - l_{xy'_x}) \prod_{y \in V_x} (1 - l_{xy}) \right] \\ &\quad - \left[1 - \prod_{y \in V_x} (1 - l_{xy}) \right] \\ &= l_{xy'_x} \prod_{y \in V_x} (1 - l_{xy}) \end{aligned} \quad (2)$$

It can be observed from Eq. (2), δS_x will be decreased with every iteration of allocation, because as V_x increases, $\prod_{y \in V_x} (1 - l_{xy})$ tends to zero.

b) Shared Channel Allocation (SCA):

Our channel allocation model composed of two stages. Firstly, we compute channel assignment information of single vehicle using (2). Then, we process multi-user channel assignment by allocating channels that have been allocated to some vehicle to other vehicles in second stage.

Based on the throughput gain requirement the user selects the best available channel. Here, the user does not share the channel. The users access the channel for a stipulated session of time and then leave the channel for other user to access it. However this does not utilize the bandwidth efficiently. Since channel is not shared. To address, shared channel allocation is presented. Let consider a setup where channel y is the shared channel of vehicle $x_1, x_2, x_3, \dots, x_V$, where V is the number of vehicles who shares the channel. Here we compute throughput gain for a specific vehicle x if channel y is allocated this vehicle. In fact, this throughput gain can be accomplished, because vehicle x may utilize channel y if this channel is not utilized by other vehicle $x_1, x_2, x_3, \dots, x_V$ or the channel is not accessible. The throughput gain of vehicle x and channel y considering practical scenario (i.e. $l_{x,y}$ is closer to 1 (e.g., at least 0.8) is computed as

$$\delta S_x^{V,b}(y) = \left(1 - \frac{1}{V}\right) (1 - \mathcal{D}) l_{xy} \left(\prod_{o \in V_x} \bar{l}_{xo}\right) * \left(1 - \prod_{o \in V_x^c} \bar{l}_{xo}\right) \sum_{n=1}^V [\bar{l}_{xny} (\prod_{m=1, m \neq n}^V l_{xmy})]. \quad (3)$$

In general to achieve maximal throughput we don't require large number of channels. Let us consider that each vehicle can access spectrum with likelihood of 0.8, then the throughput achieved by the contenting vehicle that was assigned three channels is not smaller than $1 - (1 - 0.8)^3 = 0.992$, which is less than 1% below maximum throughput. Post completion of algorithm 1, we can compute the set of channels assigned to each vehicles, from which we compute its throughput by using (3).

III. SIMULATION RESULT AND ANALYSIS

The experiments are conducted on windows 10 operating system, 64-bit I-5 Quad Core processor with 16GB RAM and Dedicated 4 GB Nvidia CUDA GPU card. The Proposed PECA and existing ENCCMA is written in C# object oriented programming language using Visual studio framework 4.5, 2012. In our previous works [6], [7] we have incorporated the city environment into the simulation tool [8], [9]. The PECA and city environment are both incorporated into the simulator. The throughput performance, successful packet transmission performance, and collision performance are evaluated by varying vehicles under city environmental condition. The parameters considered in the simulation are presented in table 1.

TABLE 1. CONSIDERED SIMULATION PARAMETERS

Network Parameter	Value
Network Size	30km * 30km
Number of Vehicles/Devices	20,40, 80
Modulation scheme	QAM-64
Mobility of devices	4m/s
Bandwidth	27 Mbps
Number of Frequency Channels	7
Number of time slots	8 μ s
Environment used	City
Message information size	27 bytes
MAC used	ENCCMA & PECA

A. Throughput Performance:

Experiments are conducted to evaluate the performance of PECA and ENCCMA in term of throughput achieved per channel for City as shown in Fig. 1. It is seen from Fig. 1, the PECA improves throughput by 16.17%, 9.25% and 8.26% considering 20, 40 and 80 vehicles respectively over ENCCMA. An average throughput improvement of 11.23% is achieved by PECA over ENCCMA for city environment. The overall result achieved shows that PECA performs significantly better than ENCCMA considering varied vehicle in the city environment.

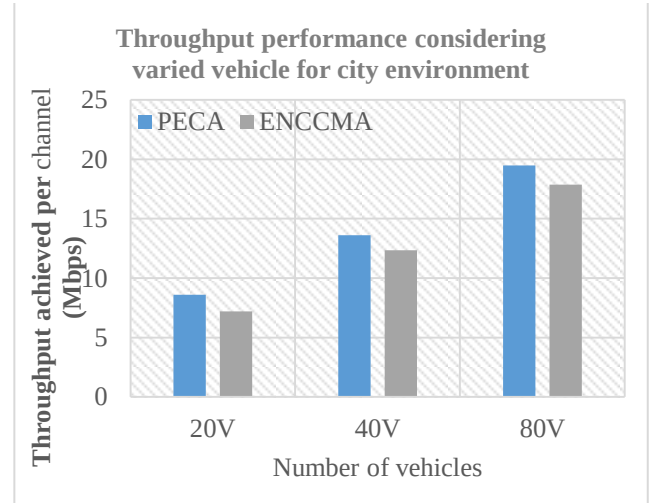


Fig. 1. Throughput performance considering varied vehicle for city environment

B. Successful packet transmission Performance:

Experiments are conducted to evaluate the performance of PECA and ENCCMA in term of successful packet transmission for City environment as shown in Fig.2. It is seen from Fig. 2, the PECA improves packet transmission by 14.58%, 11.06% and 6.54% considering 20, 40 and 80 vehicles respectively over ENCCMA. An average packet transmission

improvement of 10.93% is achieved by PECA over ENCCMA for city environment.

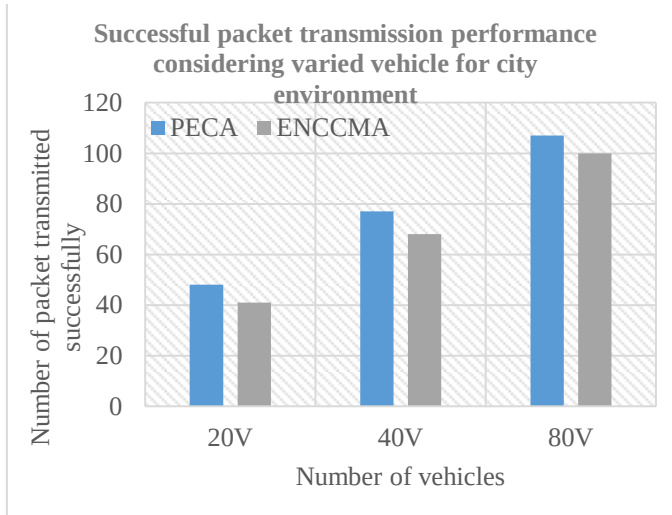


Fig. 2. Packet Transmission performance considering varied vehicle for city environment

C. Collision Performance:

Experiments are conducted to evaluate the performance of PECA and ENCCMA in term of packet collision for City environment as shown in Fig. 3. It is seen from Fig. 3, the PECA reduces packet collision by 64.70%, 26.66% and 5.3% considering 20, 40 and 80 vehicles respectively over ENCCMA. An average packet collision reduction of 32.22% is achieved by PECA over ENCCMA for city environment.

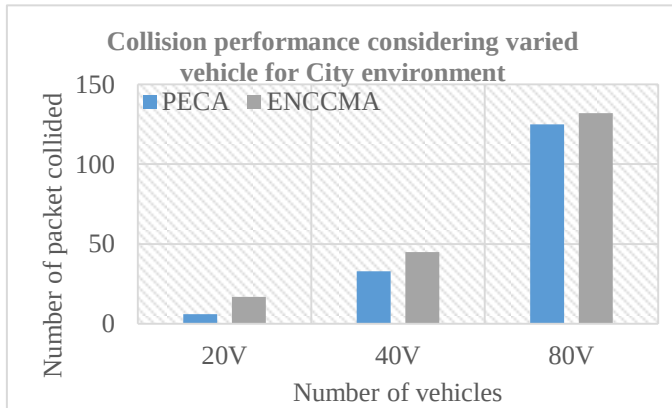


Fig. 3. Packet collision performance considering varied vehicle for City environment

IV. CONCLUSION

In this paper, we proposed distributed MAC for channel allocation in shared channel network namely PECA. CSMA/CA is unsuitable because of the unbounded channel access delays for real-time vehicle-to-vehicle communication (High collision). To reduce the collision, distribute MAC is

needed for channel allocation. The PECA overcomes problem due to channel access delay of CSMA/CA.

To maximize the throughput the ENCCMA used cognitive radio (CR) technique to design MAC in the name Enhanced Cooperative Cognitive division Multiple Access (ENCCMA). ENCCMA adopts TDMA based spectrum/channel allocation. However, if more users are there in network ENCCMA might not be efficient. To overcome, distributed spectrum access is required. PECA maximize system throughput and minimize MAC overhead (reduce collision) by adopting distributed channel allocation technique which is experimentally proven. The experiment was evaluated the performance of proposed PECA and existing ENCCMA in terms of throughput, collision, and successful packet transmission considering varied vehicles in the city environment.

The Experiments are carried out considering 30km * 30km for network size, 20, 40, 80 vehicles moving at the speed 4 m/s, 27 Mbps for Bandwidth, QAM-64 Modulation scheme, 7 for Frequency Channels, 8 μ s for time slots, message information size 27bytes, and MAC used PECA & ENCCMA.

Certainly, there are still many open issues and challenges that exist in V2V communication that need to be considered in further researches. Therefore, the future work would consider different radio propagating environment such highway and rural area network.

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