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An Efficent Distributed Medium Access Control for V2I VANET

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ABSTRACT

Provisioning smart intelligent transport for vehicular ad hoc networks (VANETs) depends on dissemination of safety-related messages. The performance of VANET 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 (MAC) which address the precise constraint of smart intelligent transport system in the highly dynamic VANET environment. Extensive survey carried out in this work shows TDMA (Time division medium access) based MAC approach outperform carrier sense medium access/ collision avoidance CSMA\CA based approach. However, TDMA based approach incurs bandwidth wastages. To utilize bandwidth more efficiently cognitive radio (CR) technique is adopted for designing efficient MAC. However, the existing CR model incurs computation overhead and is not evaluated under different environmental condition such as rural, highway and urban (RHU). To overcome research challenges, this work present efficient decentralized distributed MAC (DMAC) that minimize collision and maximize throughput. Experiment are conducted to evaluate the performance of DMAC over state-of-art model in terms of throughput, success transmission and collision achieved. The outcome shows significant performance over state-of-model.

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1. INTRODUCTION

$VANET$ is self-organizing network that aims to enhance the safety and efficiency of transportation and also provide infotainment on the go over vehicle-to-infrastructure ($V2I$), vehicle-to-vehicle ($V2V$) and combination of both ($V2X$). The $U.S.$ Federal Communications Commission (FCC) allotted 75MHz frequency of licensed band in 5.9 GHz for dedicated short range communication ($DSRC$) [1], under $IEEE$ $802.11p$ and $IEEE$ 1609 standards for both safety and non-safety application under $VANET$ environment. As a result various application has been presented in recent times. In the period of $5G$ era, $VANET$ is been used in Internet of vehicles ($IoVs$) to provision ubiquitous smart infotainment services such as vehicular cyber-physical system [2], vehicular cloud networking [3].

To provision the above application requirement, the beaconing message should be transmitted over control channel (CCH) with less latency reliably so that the $VANET$ can assure the high speed and real-time data delivery application over service channel (SCH). VANET are prone to high mobility hence periodic beaconing is required in order to obtain real time network related information in a cooperative manner. So it is quite a challenging task to design MAC. 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. A maximum latency for provisioning safety-related application is $100\ ms$ as suggested in [4]. In [5] stated that the packet delivery ratio should not be less than 90% and the experimental outcome presented in [6] shows the impact of high density on packet delivery ratio and latency. Therefore, QoS cannot be guaranteed, if the MAC design is not scalable.

To address the above research challenges, many MAC protocol is been presented. The $CSMA/CA$ (Carrier Sense Multiple Access/Collision Avoidance) based $802.11p$ [7] has been standardized as the standard MAC protocol for vehicular communication. However, if traffic density is high, it induces high collision probability, specifically for broadcasting packets [8]. $CSMA/CA$ has the problem potentially unbounded channel access delay [9]. If the $VANET$ device has multiple packets, it has to contend for multiple times. Further, 802.11p suffers from interference problem due to hidden terminals. Since it cannot use RTS (Request to Send)/CTS (Clear to Send) mechanism for broadcasting packets [10]. Considering this scenario, the collision of packet cannot even be identified right away. No exponential back-off methods can be used for broadcasting packet and the likelihood of packet collision is significantly very high [8].

To overcome the limitation of $802.11p$, [11] presented a clustered based distributed multi-channel and mobility aware medium access control ($DMMAC$) design, which permits device to transmit their network related information to its cluster head every$100\ ms$. However, they are not efficient for safety related application [12]. Since, communication range is reduced to assure communication among cluster members. The extensive survey conducted by [13] shows that the clustered based MAC protocol performance are significantly affected by mobility of devices.

To improve performance and address the limitation of clustered network, various slotted MAC has been presented. In [14] and [15] presented a MAC based on $RR-ALOHA$ where each node obtain status of slot reserved. Another widely adopted slotted MAC is $TDMA$-based approach [16], where time is divided into frames and each frames is composed of fixed number of time slots. Each vehicle access one slot in each frame. In [17] presented $VeMAC$ using $TDMA$, in which each vehicle obtain one slot in a frame to transmit slot allocation information acknowledgement and data to its neighbor. However, their model incurs collision overhead due to hidden node problems. To address collision overhead in [18] presented prediction-based $TDMA$ ($PTMAC$) which is distributed in nature. In [19] presented a self-sorting MAC which aided superior performance than [18] and scalable and cooperative MAC layer protocol ($SCMAC$) [20]. The model overcomes the bandwidth inefficiency of Space Division Multiple Access (SDMA) [21] and reduces collision for highway environment. However, their model did not considered maximizing system throughput which is a critical factor for provisioning infotainment application. To provision infotainment application [22] presented a MAC protocol adopting cognitive radio technique namely, enhanced non-cooperative cognitive division multiple access ($ENCCMA$). The $ENCCMA$ attained significant performance over state-of-art model. However, performance evaluation under different environment condition such as urban, rural and highway is not considered.

To address the research challenges, this work present a decentralized Distributed MAC ($DMAC$) protocol that minimize the collision and maximize the system throughput under different environment condition. The Contribution of research work is as follows:

1. This work presented an optimal access mechanism to compute optimal objective function considering arbitrary vehicular traffic movement under single RSU.
2. $DMAC$ is adaptive in nature considering varied environment condition such rural, highway, and highway.
3. The $DMAC$minimize collision and maximize system throughput under different environment condition [23].
4. The research outcome shows $DMAC$ is scalable irrespective of network density.

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 MAC model is presented. In penultimate section experimental study is carried out. The conclusion and future work is described in last section.

2. RELATED WORK

In this section extensive survey is carried out on various MAC protocol designed to improve the performance of $VANET$. In [24] studied the latency incurred by $CSMA/CA$ based MAC due to traffic and vehicle density variation. To address [25] presented a decentralized congestion control (DCC) mechanism. It overcome the limitation of Enhanced Distributed Channel Access ($EDCA$) by adopting queuing mechanism for safety related application data. Experiment is conducted to minimize the delay under varied environment load for highway environment. However, it adopts cross layer architecture.

In [26] presented a cross layer based MAC model to minimize interference among communicating device in routing and MAC layer. They designed performance metric to minimize signal to interference ratio (SIR) among communication devices. Experimental outcomes show good packet delivery ratio and throughput performance. However, their mode induces high collision probability due to computation and transmission of channel state information in control channel. To minimize collision overhead [27] showed neighborhood knowledge discovery benefit in reducing collision in network. Their model minimized data loss by adopting distributed synchronized beaconing scheduling techniques. However, when traffic is very the network utilization is very less.

In [18] presented $PTMAC$ which aid in minimizing collision due to presence of hidden device in network under density traffic. They presented a prediction technique for variable traffic load of two way architecture. Their model minimized collision for varied traffic and network density. However, their model did not considered maximizing network throughput. In [20] presented $SCMAC$which adopts slot reservation strategy to handle idle slots for newly joined user. It address strict delay constrain when node density is less. Beaconing message overhead is addressed for dynamic varying network density. However, throughput performance and varied environmental condition is not considered for experiment evaluation.

In [19] a threshold queuing based self-sorting MAC is presented which aided superior performance than [18] and [20] that addressed bandwidth inefficiency of Space Division Multiple Access (SDMA) [21] and reduces collision for highway environment. However, self-sorting MAC did not considered maximizing system throughput which is a critical factor for provisioning infotainment application. To provision infotainment application [22] presented a MAC protocol adopting cognitive radio technique namely, enhanced non-cooperative cognitive division multiple access ($ENCCMA$). They combined $FDMA$ (frequency division multiple access), $TDMA$ and cognitive radio technique to design MAC for multi-channel network. The $ENCCMA$ attained significant performance over state-of-art model. However, performance evaluation under different environment condition such as rural, highway and urban is not considered. Extensive survey is carried out, shows a new MAC scheme is needed to be designed to maximize system throughput, minimize collision, use bandwidth more efficiently and also radio propagation of different environmental condition. Therefore, the future MAC design should consider these requirement in designing an efficient MAC for $VANET$.

3. PROPOSED DECENTRALIZED DISTRIBUTED MAC DESIGN FOR V2I NETWORK ENCODING

This work presents decentralized medium access control design for $V2I$ network which is distributed in nature. Let consider a MAC design, where time is segmented into identical slot time of length δs and there exist seamless synchronization among Vanet subscribers/Vehicles and the RSU (Road side unit). The total amount of time the subscriber stays in x^{th} RSU coverage area can be represented as

$$S_x = \left\lfloor {}^{2K_x}/_{d\delta s} \right\rfloor. \quad (1)$$

The $\mathcal{S}^{th}$ time slot when subscriber is in range of l^{th} RSU is obtained as follows

$$\mathcal{A}(x, \mathcal{S}) = \sum_{h=0}^{x-1} S_x + \mathcal{S}, \quad \forall \mathcal{S} \in \{1, \dots, S_x\}, \quad (2)$$

where $S_0 = 0$. The set of time slots in x^{th} $RSU$with respect to time line representation is $\mathcal{S}_x = \{\mathcal{A}(x, 1), \dots, \mathcal{A}(x, T_x)\}$

The optimal communication problem of a subscriber is considered as a finite-horizon sequential quality specifier (QS) problem. The QS time/iteration of the subscriber is

$$s = \mathbb{S} = \bigcup_{x \in \mathcal{X}} \mathcal{S}_x = \bigcup_{x \in \mathcal{X}} \{\mathcal{A}(x, 1), \dots, \mathcal{A}(x, S_x)\}, \quad (3)$$

where $\mathbb{S}$ is the cumulated collection of all time slots in X^{th} coverage range, where the mode $t \in T = [0, T]$ depicts the outstanding size (in bits) of a packets to be sent. If we represent the number of subscribers in x^{th} RSU coverage range as $v \in \mathcal{V}_x = \{1, \dots, V_\uparrow, x\}$, then $l^{+ve} \in \mathcal{L}_x = \{z_x(v): v \in \mathcal{V}_x\}$.

The subscriber has two possible states at any modes (t, l^{+ve}), which can be represented as

$$m \in \mathcal{M} = \{0,1\}, \tag{4}$$

where states $m = 1$ infers that the subscriber agrees to request to transmit, and states $m = 0$ the subscriber does not agrees to request to transmit.

The cost incurred at mode (t, l^{+ve}) with instance m at time slot $s \in \mathcal{S}_x$ in the x^{th} coverage range is

$$a_s(t, l^{+ve}, m) = mz_x, \qquad \forall s \in \mathcal{S}_x \tag{5}$$

Once the subscriber leaves the x^{th} coverage area at instance $\mathcal{A}(X, S_x + 1)$, the overhead incurred for subscriber for not completing his packet transmission is computed as follows

$$\hat{a}_{\mathcal{A}(X,S_x+1)}(t, l^{+ve}) = r(t), \tag{6}$$

where $r(t) \geq 0$ is a non-decreasing parameter of t with $r(0) \geq 0$, which is associated with quality of service requirement of the application. Therefore, the cost of transmission incurred by the subscriber is composed of two things. Firstly, the communication cost in each time slot in Equation (5) and the overhead incurred after leaving the X^{th} coverage range in Equation (6). The mode transitional likelihood $\left((\bar{t}, l^{\overline{+ve}})\middle|(t, l^{+ve}), m\right)$ is the likelihood that network will be in mode $\left(\bar{t}, l^{\overline{+ve}}\right)$ if states m is taken at mode (t, l^{+ve}) at time slot $s \in \mathbb{T}$. The transition from l^{+ve} to $l^{\overline{\overline{+ve}}}$ is not a determined by t but determined by time s, thus we have

$$l_s\left((\bar{t}, l^{\overline{+ve}})\middle|(t, l^{+ve}), m\right) = l_s\big((\bar{t})\big|(t, l^{+ve}), m\big)l_s\big(l^{\overline{\overline{+ve}}}\big|l^{+ve}\big) \tag{7}$$

With state $m = 1$, we obtain

$$l_s(\bar{t}|(t, l^{+ve}), 1) = \begin{cases} l^{+ve}, & if\ \bar{t} = \left[t - b_s\delta s_{packet}\right]^*, \\ 1 - l^{+ve}, & if\ \bar{t} = t, \\ 0, & otherwise, \end{cases} \tag{8}$$

where $[j]^+ = max\{0, j\}$. The case one and two depicts positive and negative data transmissions, respectively. With states $m = 0$, thus we obtain

$$l_s(\bar{t}|(t, l^{+ve}), 0) = \begin{cases} 0, & if\ \bar{\bar{t}} \neq t, \\ 1, & otherwise, \end{cases} \tag{9}$$

where the remaining packets size to be transmitted will not change. The derivation of $l_x\big(l^{\overline{\overline{+ve}}}\big|l^{+ve}\big)$ are discussed in later subsection of this paper.

Let $\Delta_s: T \times L_x \to \mathcal{C}$ be the QoS specifier (QS) that defines the communication optimization of the subscriber at mode (t, l^{+ve}) at time slot $s \in \mathcal{S}_x$ in the x^{th} range of coverage. Now we express the objective function as QS covering all modes as $(\Delta_s(t, l^{+ve}), \forall\, t \in T, l^{+ve} \in L_x, s \in \mathcal{S}_x \forall\, x \in \mathcal{X})$. The mode at time slot s if objective function $\mathcal{O}$ is used can be represented as $\left(t_s^{\mathcal{O}}, l_s^{+ve,\mathcal{O}}\right)$ and we consider $\mathbb{O}$ be the realistic set of $\mathcal{O}$. The subscriber aim at minimize the cost and satisfying objective function as an optimization problem

$$\min_{\mathcal{O} \in \mathbb{O}} Y_{\mathcal{O}}(T, l_1^{+ve}) \left[\sum_{x=1}^{\mathcal{X}} \left[\sum_{k=1}^{S_x} a_{\mathcal{A}(x,\mathcal{S})\left(t^{\mathcal{O}}_{\mathcal{A}(x,\mathcal{S})}, l^{+ve,\mathcal{O}}_{l(x,\mathcal{S})}, \Delta_{\mathcal{A}(x,\mathcal{S})}\left(t^{\mathcal{O}}_{\mathcal{A}(x,\mathcal{S})}, l^{+ve,\mathcal{O}}_{\mathcal{A}(x,\mathcal{S})}\right)\right)}\right] + \hat{a}_{\mathcal{A}(\mathcal{X},S_{\mathcal{X}}+1)\left(t^{\mathcal{O}}_{\mathcal{A}(\mathcal{X},S_{\mathcal{X}}+1)}, l^{+ve,\mathcal{O}}_{\mathcal{A}(\mathcal{X},S_{\mathcal{X}}+1)}\right)}\right], \tag{10}$$

where $Y_{(\mathcal{O},l_1^{+ve})}$ represent the probability with respect to likelihood distribution by objective function $\mathcal{O}$ with an initial mode (T, l_1^{+ve}) at time slot $s = \mathcal{A}(1,1) = 1$.

Let consider that there exist only one RSU and precise traffic pattern of subscriber is not known and Poisson process of subscriber arrival of α is considered. The transition likelihood of l^{+ve} is obtained as follows

$$l_s\left(l^{+ve'}\middle|l^{+ve}\right) = l_s\left(l(\bar{v})\middle|l(v)\right) = l_s(\bar{v}|v)$$
$$= \begin{cases} \dfrac{(\alpha\delta s)^{\bar{v}-v+n_{s+1}}}{(\bar{v}-v+n_{s+1})!\,\beta_s(v)}, & if\ v-n_{s+1} \le \bar{v} \le V_\uparrow, \\ 0, & otherwise, \end{cases} \quad (11)$$

where $\beta_s(v) = \sum_{i=0}^{V_\uparrow - v + n_{s+1}} \frac{(\alpha\delta s)^i}{i!}$ is a normalization function. Since l^{+ve} is a rigorously reducing function of v, there is one-to-one mapping among l^{+ve} and v as depicted in the first two equalities in Equation 11 and the third equalities depicts the likelihood with $\bar{v} - v + n_{s+1}$ arrival due to Poisson process and n_{s+1} deterministic displacement at instance $s+1$. $\bar{v}$ is upper bounded by $V_\uparrow$ and lower bounded by $v - n_{s+1} \ge 0$ when there is no subscriber arrival.

The problem of Equation 10 considering $RSU = \{1\}$ can be simplified as follows

$$\min_{\mathcal{O}\in\mathbb{O}} Y_{\mathcal{O},(T,l_1^{+ve})}\left[\sum_{s=1}^{S} a_s\left(\left(t_s^{\mathcal{O}}, l_s^{+ve,\mathcal{O}}, \Delta_s\left(t_s^{\mathcal{O}}, l_s^{+ve,\mathcal{O}}\right)\right)\right) + \hat{c}_{T+1}\left(t_{S+1}^{\mathcal{O}}, l_{S+1}^{+ve,\mathcal{O}}\right)\right]. \quad (12)$$

Let $d_s(t, l^{+ve})$ be the minimal projected total cost that the subscriber has to pay for contention from time s to time $S+1$ when it is range of coverage considering network is in mode (t, l^{+ve}) before the decision at time slot $s \in \mathcal{S}$. The optimization of minimal projected total cost at different modes for $s \in \mathcal{S}$ is as follows

$$d_s(t, l^{+ve}) = \min_{m\in\mathcal{M}}\{\gamma_s(t, l^{+ve}, m)\}, \quad (13)$$

Where

$$\gamma_s(t, l^{+ve}, m) = a_s(t, l^{+ve}, m) + \sum_{\bar{t}\in T}\sum_{l^{+ve'}\in\mathcal{L}} l_s\left(\left(\bar{t}, l^{+ve'}\right)\middle|\left(\bar{t}, l^{+ve}\right), c\right) d_{s+1}\left(\bar{t}, l^{+ve'}\right) \quad (14)$$

$$= cu + \sum_{l^{+ve'}\in\mathcal{L}} l_s\left(l^{+ve'}\middle|l^{+ve}\right)\left[cl^{+ve}d_{s+1}\left(\left[\bar{t} - b_s\delta_{s_{packet}}\right]^*, l^{+ve'}\right) + (1 - cl^{+ve})d_{s+1}\left(t, l^{+ve'}\right)\right]. \quad (15)$$

The first term in Equation 14 indicates the actual cost of selecting c for the remaining time slots in coverage range and the second term in Equation 14 indicates the future cost expected for selecting c for the remaining time slots in coverage range. Equation 15 computes Equation 14 directly by using Equation 7, 8 and 9. For instance period $s = S+1$, we possess that limiting factor that

$$d_{S+1}(t, l^{+ve}) = \hat{a}_{S+1}(t, l^{+ve}) = r(t). \quad (16)$$

The value of $\gamma_s(t, l^{+ve}, m)$, $\forall s \in \mathcal{S}$, can be computed as follows

$$\begin{aligned} &\gamma_s(t, l^{+ve}, m) = mu \\ &+ \sum_{g=0}^{V_\uparrow - n + n_{s+1}} \frac{(\alpha\delta s)^g}{g!\,\beta_s(v)} \\ &\times \left[ml^{+ve}d_{s+1}\left(\left[t - b_s\delta s_{packet}\right]^*, z(v+g-n_{s+1})\right)\right. \\ &\left.+ (1 - ml^{+ve})d_{s+1}\left(t, z(v+g-n_{s+1})\right)\right], \end{aligned} \quad (17)$$

where $v = z^{-1}(l^{+ve})$ is the vehicle density in coverage range of RSU. The outcome follows directly by computing Equation 15 using Equation 11. Instinctively, the minimal projected cost $d_S(t, l^{+ve})$ must be smaller when outstanding packet size t to be sent is smaller which can be assured when $d_S(t, l^{+ve})$ is a non-decreasing parameter in $t, \forall l^{+ve} \in \mathcal{L}, s \in \mathcal{S}$. Therefore, the optimal objective function $\mathcal{O}^*$ is obtained as follows:

$$\mathcal{O}^* = \left(\Delta_s^*(t, l^{+ve})\right), \forall t \in T, l^{+ve} \in \mathcal{L}, s \in \mathcal{S}, \tag{18}$$

where

$$\Delta_s^*(t, l^{+ve}) = arg \min_{m \in \mathcal{M}} \{\gamma_s(t, l^{+ve}, m)\}. \tag{19}$$

The objective parameter $\mathcal{O}^*$ is an optimal solution of problem Eq. (12).

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

4. SIMULATION RESULT AND ANALYSIS

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 $ENCCMA$ [22] and proposed $DMAC$ is implemented using C# programming language, Dot net visual studio 4.0 framework using $SIMITS$ simulator [22]. The experiment are conducted to evaluate the performance of $DMAC$ over $ENCCMA$ in term of collision, successful packet transmission and throughput achieved considering different environmental condition such as rural, highway and urban. The radio propagation model for different environment are obtained from [23] which is incorporated in to $SIMITS$ simulator. The simulation parameter used for experimental study are shown in Table 1.

Table 1. 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	$ENCCMA$ & $DMAC$

4.1 Collision Performance

Experiments are conducted to evaluate the collision performance of proposed $DMAC$ over $ENCCMA$ 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 Figure 1, Figure 2 and Figure 3 show the collision performance of $DMAC$ over $ENCCMA$ for rural, highway and urban environment considering varied vehicles. The outcome shows that when vehicle density is increased the packet collision increases for both $DMAC$ and $ENCCMA$. From Figure 1 it can be seen $DMAC$ reduces collision by 62.16%, 36.7% and 13.01% for 20, 30 and 40 vehicles respectively, over $ENCCMA$ for rural environment. From Figure 2 it can be seen $DMAC$ reduces collision by 47.61%, 38.8% and 19.37% for 20, 30 and 40 vehicles respectively, over $ENCCMA$ for highway environment. From Figure 3 it can be seen $DMAC$ reduces collision by 76.19%, 36.73% and 11.67% for 20, 30 and 40 vehicles respectively, over $ENCCMA$ for urban environment. An average reduction of 37.29%, 35.26% and 41.53% is achieved $DMAC$ over $ENCCMA$ for rural, highway and urban environment respectively.

4.2 Successful Packet Transmission Performance

Experiments are conducted to evaluate the successful packet transmission performance of proposed $DMAC$ over $ENCCMA$ 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 Figure 4, Figure 5 and Figure 6 show the successful packet transmission performance of $DMAC$ over $ENCCMA$ for rural, highway and urban environment considering varied vehicles. The outcome shows that when vehicle density is increased the successful packet transmission increases for both $DMAC$ and $ENCCMA$. From Figure 4 it can be seen $DMAC$ improves successful packet transmission by 34.41%, 25.92% and 13.01% for 20, 30 and 40 vehicles respectively, over $ENCCMA$ for rural environment. From Figure 5 it can be seen $DMAC$ improves successful packet transmission by 23.52%, 35.44% and 27.52% for 20, 30 and 40 vehicles respectively, over $ENCCMA$ for highway environment. From Fig. 6 it can be seen $DMAC$ improves successful packet transmission by 26.49%, 17.28% and 13.51% for 20, 30 and 40 vehicles respectively, over $ENCCMA$ for urban environment. An average improvement of 25.23%, 28.83% and 19.07% is achieved $DMAC$ over $ENCCMA$ for rural, highway and urban environment respectively.

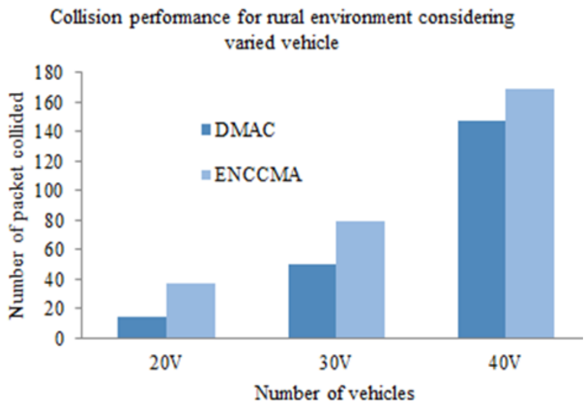


Figure 1. Collision performance for rural environment considering varied vehicle

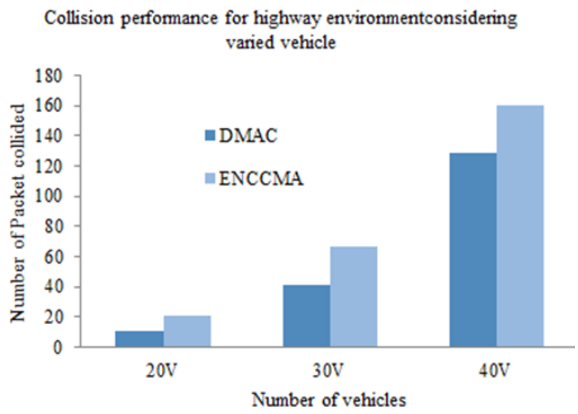


Figure 2. Collision performance for highway environment considering varied vehicle

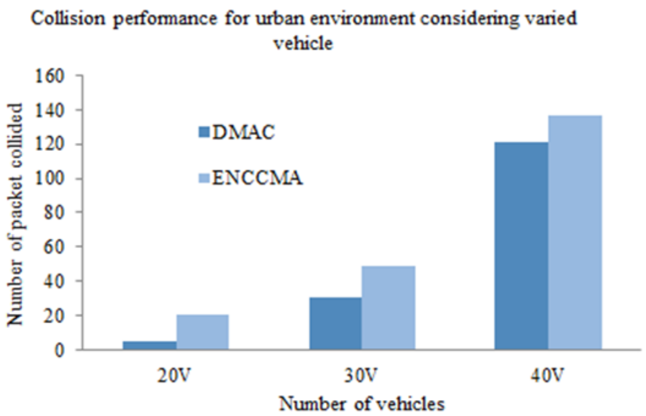
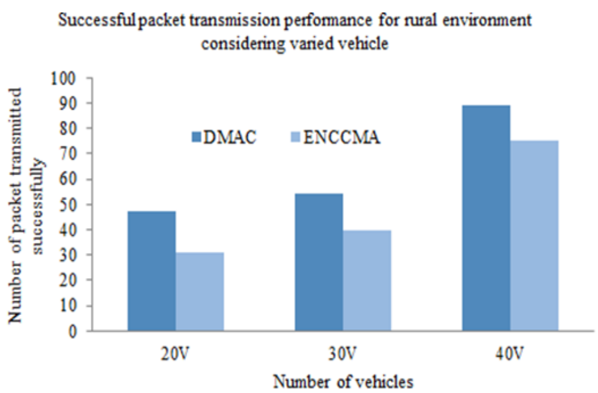


Figure 3. Collision performance for urban environment considering varied vehicle



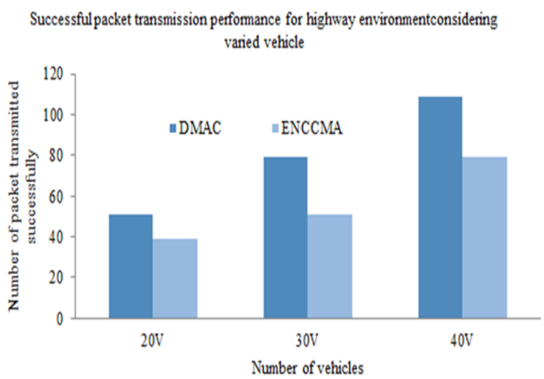


Figure 4. Successful packet transmission performance for rural environment considering varied vehicle

Figure 5. Successful packet transmission performance for highway environment considering varied vehicle

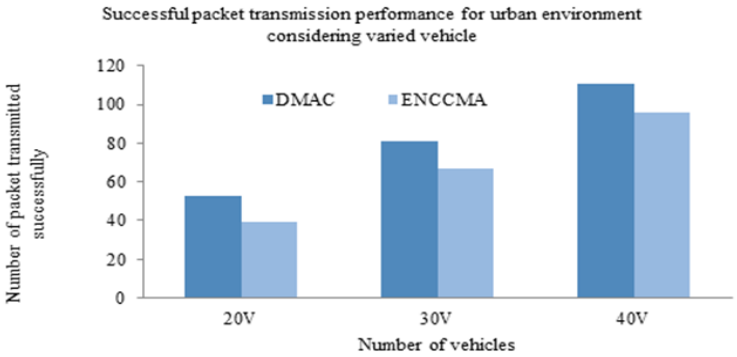


Figure 6. Successful packet transmission performance for urban environment considering varied vehicle

4.3 Throughput Performance

Experiments are conducted to evaluate the throughput performance of proposed $DMAC$ over $ENCCMA$ 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 Figure 7, Figure 8 and Figure 9 show the throughput performance of $DMAC$ over $ENCCMA$ for rural, highway and urban environment considering varied vehicles. The outcome shows that when vehicle density is increased the throughput increases for both $DMAC$ and $ENCCMA$. From Figure 7 it can be seen $DMAC$ improves throughput by 18.98%, 39.09% and 16.06% for 20, 30 and 40 vehicles respectively, over $ENCCMA$ for rural environment. From Figure 8 it can be seen $DMAC$ improves throughput by 14.64%, 22.1% and 22.85% for 20, 30 and 40 vehicles respectively, over $ENCCMA$ for highway environment. From Figure 9 it can be seen $DMAC$ improves throughput by 16.79%, 14.28% and 08.39% for 20, 30 and 40 vehicles respectively, over $ENCCMA$ for urban environment. An average improvement of 24.71%, 19.87% and 13.15% is achieved $DMAC$ over $ENCCMA$ for rural, highway and urban environment respectively.

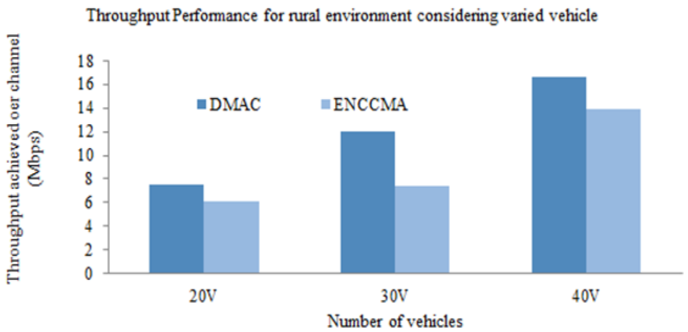


Figure 7. Throughput performance for rural environment considering varied vehicle

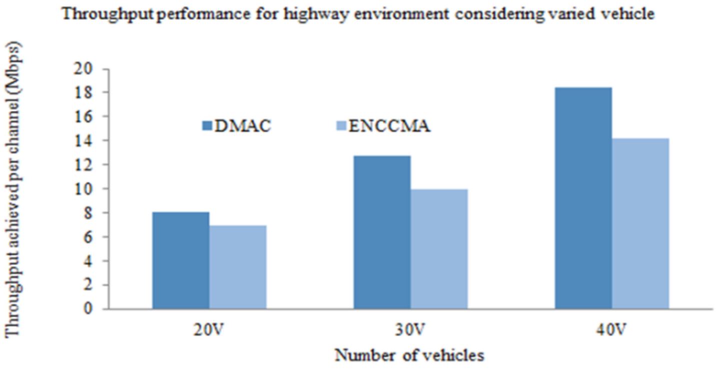


Figure 8. Throughput performance for highway environment considering varied vehicle

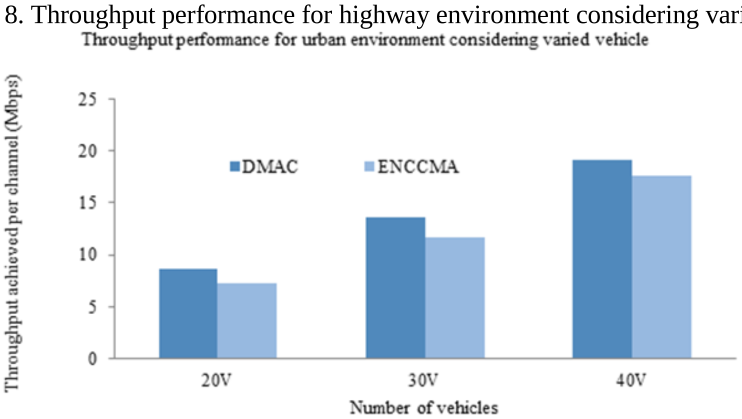


Figure 9. Throughput performance for urban environment considering varied vehicle

5. CONCLUSION

This work presented an efficient distribute MAC design to maximize system throughput and minimize collision. The $DMAC$ aims to reduce the cost of data access .i.e. utilizing bandwidth more efficiently) for subscriber. Our model achieves an optimal solution for the research objectives. Experiment are conducted to evaluate $DMAC$ performance over $ENCCMA$ in term of collision, successful packet transmission and throughput achieved. The outcome shows, $DMAC$ reduces collision by 37.29%, 35.26% and 41.53% for rural, highway and urban environment respectively, over $ENCCMA$. $DMAC$ improves packet transmission by 25.23%, 28.83% and 19.07% for rural, highway and urban environment respectively, over $ENCCMA$. $DMAC$ improves throughput by 24.71%, 19.87% and 13.5% for rural, highway and urban environment respectively, over $ENCCMA$. The overall result achieved show that the proposed $DMAC$ model is scalable irrespective of network density and environmental condition. The future work would consider evaluation under varied mobility speed and network size.

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