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Performance Evaluation OF DV-CAST Protocol Over Vehicular Ad Hoc Networks for Highway Scenario During Late Night or Early Morning Hours and Rush Hours Without Obstacles Using OMNET++

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ABSTRACT
The technology of Vehicular Ad hoc Networks (VANETs) is one of solutions to improve transport activities such as traffic safety, traffic efficiency and even infotainment on wheels, where a great number of event-driven messages need to be disseminated in a timely way in a region of interest(ROI).VANET is also known as Intelligent Transportation networks. Long range communication technologies have been used for most of non-safety applications. We focus on safety applications, in which the event-driven emergency messages, e.g., traffic accident warnings, must be efficiently disseminated within a specific geographical region . In this article We study a data dissemination protocol for vehicular networking , named Distributed Vehicular broadcast protocol (DV-CAST),to disseminate efficiently warning messages from a source to vehicles for Circular Highway Road Traffic without Obstacles with one direction during late night or early morning Hours and (Morning Rush)Rush hours with taking into account the values of MDC,ODC and DFlg parameters to build neighbor tables in DV_Cast and Dyna_DVCastLayer Scenarios for the values of Cluster Radius equals to 2450 or 250 in a range of interest(ROI) and with taking into account the studied total geographical area in Flooding Scenario on specific day using OMNET++.
Keywords: Vehicular Ad hoc Networks (VANETs),DV-CAST Protocol ,Circular Highway Road Traffic without Obstacles, late night or early morning Hours and (Morning Rush)Rush hours, MDC,ODC and DFlg parameters ,OMNET++Simulator .

I. INTRODUCTION

1.1 FORMATIONS OF VANETs:

VANETs are classified into two formations, infrastructure-based and ad hoc, according to whether existing available infrastructure or not.[1]

1.1.1 Infrastructure-based Formation:

The infrastructure elements mainly include the base station of cellular network (3G/4G), road side units (RSUs) using WAVE standard or using Wi-Fi or, a few of them, using ZigBee and Bluetooth.[1].The world is divided into different cells in the cellular networks and each cell is served by a base station[1]. A cellphone, properly in a mobile vehicle, connect to the base station serving the cell where the cellphone is located in [1].There are two main types of access technologies, i.e., long range communication technologies and short range communication technologies. The first mainly refers to cellular networks and the second mainly includes Wi-Fi and IEEE 802.11p [1].Generously ,The station can transmit a frame only if the channel is clear or idle for at least one DIFS (DCF Inter Frame Space) [1] .A channel congestion control was designed according to the status of local network traffic[1].The short range communication technologies, e.g., IEEE 802.11p and Wi-Fi, can provide high data rate and low latency for safety applications[1].The following figure (1) shows the Infrastructure-based Formation [1].

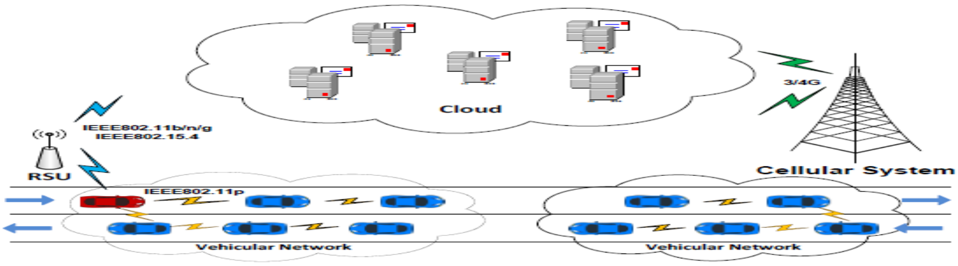


Figure (1) Infrastructure-based Formation

1.1.2 Ad Hoc Formation:

The ad hoc formation of VANETs mainly is used for safety applications using IEEE 802.11p, vehicles could cooperate together and be aware of each other in the one-hop neighborhood, so the emergency event can be informed to every vehicle involved in advance, such as intersection assistance systems, abnormal driving warming and Electronic Emergency Break (EEB).All the vehicles are equipped with dedicated short range communication (DSRC) device ,there are one control channel (CCH) reserved for carrying high priority messages known as beacons and six service channels (SCHs) for safety-related and non-safety applications[1][12][14][15][17].The biggest advantage of this formation is the real-time service[1]. There are two main problems for ad hoc formation of VANETs, i.e., broadcast storm and network partition [1].We will focus in this article on one of data dissemination protocols for ad hoc formation of VANETs using short range communication technology such as DV-CAST protocol and We will study how to handle network partition problem using Store-Carry-Forward (SCF) mechanism and broadcast storm problem but with taking into account the values of parameters (MDC=0 as default and as a fixed value because the studied Circular highway has one direction,ODC=0/1,DFlg=0/1), besides We handle these problems in WAITII ,WAITI states only as is shown in figure(19) Where We have three Scenarios (dvcastlayer , dyna-dvcastlayer ,flooding) and the default values of the parameters in our codes for two Scenarios(dvcastlayer,dyna-dvcastlayer) are (MDC=0 as default and as a fixed value, ODC=1,DFlg=0,MAXnb=5 in Target Queue) by this protocol during late Night or early Morning Hours and Rush Hours . In the Circular highway, the regime will be well-connected(dense regime), but after the intersection ,then the regime will be Sparsely-connected. It is possible that both of these two traffic conditions(dense, sparse) may coexist in the same network [2].Therefore, not every vehicle sees the same local topology; some may have very few neighbors while some have many neighbors. In this state some vehicles will have to apply broadcast suppression algorithm for solving broadcast storm problem while others will have to store-carry-forward the message in order to preserve the network connectivity and to solve network partition problem [2][13].The following figure (2) shows the Ad hoc Formation [1].

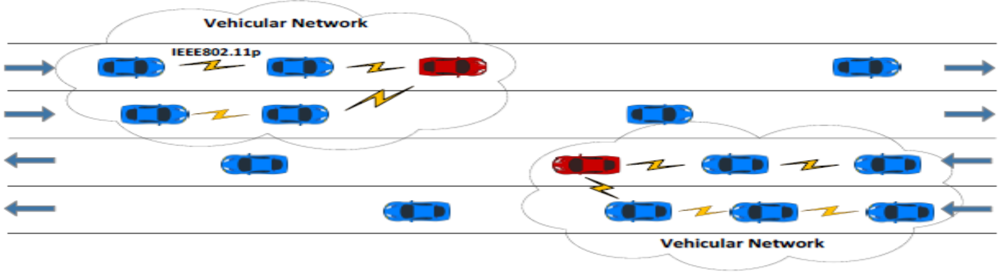


Figure (2) Ad hoc Formation

1.2.ROUTING PROTOCOLS:

VANETs can provide wireless communication technology among vehicles (V2V) or between vehicles and infrastructure (V2I) using wireless medium which form Vehicular Ad hoc Networks (VANETs) to support development of various applications concerning traffic safety, transportation efficiency and infotainment on wheels[1][9][11][12][15][16] .V2V or V2I called Inter-Vehicle Communication (IVC) [1]. V2V and V2I communication scenario with a sender and receiver vehicle is easily interrupted due to high mobility of vehicles themselves, building obstacles, interference and short range communication, RSUs act as reflectors causing path loss[1][14].Path loss is computed by considering Line-Of-Sight (LOS) and Non-Line-Of-Sight (NLOS) between vehicles and other units[14].The difference between LOS and NLOS relates to the cumulative distance between sender and receiver, including intermediate reflectors[14].There is another type of vehicular network that is for Intra-Vehicle Communication which is responsible for information exchange between sensors or nodes inside of vehicles [1][11]. However, We focus in this article on Inter-Vehicle Communication (V2V) inVANETs, using DV-CAST protocol especially for safety applications. In such applications, when an accident occurs, a safety message (event-driven message such as emergency message or warning messages) should be disseminated as fast as possible to warn nearby vehicles in a ROI about that accident in a very timely manner where the focus of routing protocols is on rushing message delivery[1][12][13].There are two extreme regimes of operation in VANETs: dense traffic and sparse traffic [2][9][13].The network is fully connected when traffic density is above a certain value [2]. DV-CAST protocol uses connectivity of vehicles on a road to determine if the neighborhood is well connected , sparsely connected, or totally disconnected[10].Broadcasting is regarded as the most suitable mechanism to disseminate safety messages ,but may lead to frequent contention and collisions and this happens in dense traffic regime while flooding is not suitable mechanism[2][9][13][12][15]. if the flooding is not controlled properly in dense networks , then a great number of vehicles would reply a data simultaneously and enormous amount of collisions will occur, that is called "broadcast storm", This means that broadcast storm occurs when multiple nodes attempt to transmit at the same time, thereby causing several packet collisions and extra delay at the medium access control (MAC) layer [2][1][9][13][15].There are many critical challenges in V2V or V2I Communication to be solved, The first challenge is broadcast storm problem in well-connected networks; IVC (V2V or V2I) protocol first should mitigate broadcast storm problem, and then find a way out to transmit efficiently messages to vehicles in a range of interest, but also handle the transient disconnected network[1].For broadcast suppression technique , a vehicular cluster classification and a sorting technique were designed to improve reliability of broadcast transmissions and suppress or mitigate the former issue (broadcast storm problem) and mobile node performs a broadcast suppression when it is in a dense traffic regime with at least one neighbor in the broadcast direction[1][2][9][16].We propose three lightweight broadcast techniques (i.e., weighted p-persistence, slotted 1-persistence, and slotted p-persistence),that will explain them in details later and these techniques based on distance and the other proposed techniques based on received signal strength when the vehicle can't get GPS signal , yet do not require former information about network topology[2][8][9][13][15].

The second challenge is the disconnected network (network link reliability) or network partition problem[2][9][13].In this problem, distribution of vehicles suffers a large deviation due to high mobility of vehicles and Moreover, the line-of-sight signal would be blocked because of existence of buildings or other objects , network links are not reliable in urban scenarios which are not our field of study and this means that the disconnected network problem, which occurs when the number of nodes in the area to help disseminate the broadcast message is not sufficient[2][1][13]. In addition, low proportion of Dedicated Short Range Communication (DSRC)-equipped vehicles in the initial market penetration phase is another reason that leads to the above issue[1][8].There are also many disconnections between vehicular clusters on highway and Consequently, the disconnected network problem is ubiquitous[1][13].There are very few vehicles on the road. For instance, the traffic density might be so low at certain times of the day (e.g., late night or early morning) that multi hop relaying from a source (the car trying to broadcast) to cars coming from behind might not be plausible because the target node might be out of the source’s transmission range[2].To make the situation worse, there might be no cars within the transmission range of source in the opposite lane either and this happens in sparse traffic regime[2]. The most commonly used method is Store-Carry-Forward (SCF) mechanism , specific vehicles were selected to be data-ferries so as to exchange information between different disconnected networks, then this mechanism is responsible for filling the gap between disconnected networks [1][2][9][13].SCF mechanism also helps the vehicle going out of ROI transmit its stored data to the vehicle coming into ROI, so that valid data can be maintained in ROI. Consequently, this mechanism not only needs to organize packets to be exchanged by an end-to-end paradigm in one-hop range, but also to discover opportunities to start a new dissemination process in a further vehicular network [1][2][13].That is, if a vehicle cannot find any neighbor to transmit messages, these messages can be stored and carried by the vehicle until meet a new opportunity to forward and this sort of operation is very useful for many scenarios in VANETs[1][2][9][13].For DV-CAST protocol, it can recognize two types of vehicles to be selected as SCF-agent in highway scenario. One is the last vehicle of a cluster driving in the same direction as the source vehicle, the other is the first vehicle of a cluster moving against the source vehicle and it uses message list to find which stored data needed to be sent [1][2].It is possible that both of these two traffic conditions(dense, sparse) may coexist in the same network [2].

1.3. BROADCAST SCHEMES:

The aim of broadcast schemes is to reduce the road accidents and alert the drivers about any emergency event in a particular area, thereby securing the safety in road transport [16]. There are three lightweight broadcast schemes (i.e., weighted p-persistence, slotted 1-persistence, and slotted p-persistence) and these schemes use a contention mechanism to disseminate warning messages based on the distance between a receiver and a source node. An example of this scheme is the timer-and probability-based protocols which aim to suppress the broadcast storm and does not create any overhead and solve the issues of redundant re-broadcasting but has the risk of missing some messages[1][8][10][15][16]. Based on its respective distance to the sender of a warning message, each vehicle is assigned with a wait time or a probability of transmission. Being given the shortest wait time or the highest probability of transmission, the vehicle located furthest in the range of the sender rebroadcasts the warning message[10].The timer and probability based protocols suffer from packet collisions due to nodes selecting the same probability or wait time for transmission, causing redundant transmissions [10].There is also Counter based Broadcasting, Area based Broadcasting is divided to Location Based Broadcasting and Distance and Hop based Broadcasting, Neighbor-

Knowledge-based Broadcasting is divided to Cluster based and Traffic based Broadcasting [1][15][16]. The proposed DV-CAST scheme in this article employs the distance (between a receiver and a source node) based Broadcasting in Dyna_DVCastLayer Scenario to suppress broadcast storm and also adopts the store-carry forward mechanism for disconnected networks as is shown in figure(19) and this Scenario is studied for Region of interest /ROI=250 and ROI=2450. Whereas in DV_Cast Scenario employs hello transmission with 1 Hz Frequency to suppress broadcast storm and also adopts the store-carry forward mechanism for disconnected networks as is shown in figure(19) and this Scenario is also studied for Region of interest / ROI=250 and ROI=2450 . Finally, in Flooding Scenario, Data is sent when accident happens or when the vehicle has to change the route and this Scenario is studied for total geographical area taken for studying and is not for only circular highway, therefore this Scenario includes all the streets found in the studied geographical area .It then specifies routing rules to disseminate multi-hop message in each of the traffic density scenarios.

For Weighted p-Persistence Broadcasting: Upon receiving a packet from node i, node j checks the packet ID and rebroadcasts with probability pij if it receives the packet for the first time; otherwise, it discards the packet[8]. Denoting the relative distance between nodes i and j by Dij and the average transmission range by R, the forwarding probability, pij, can be calculated on a per packet using the following simple expression: **pij = Dij/R Eq. 1** [8][16]. Note that if node j receives duplicate packets from multiple sources within the waiting period of **WAIT_TIME** (e.g., 2 ms) before retransmission, it selects the smallest pij value as its re forwarding probability; that is, each node should use the relative distance to the nearest broadcaster in order to ensure that nodes who are farther away transmit with higher probability. If node j decides not to rebroadcast, it should buffer the message for an additional **WAIT_TIME + □** ms, where □ is the one-hop transmission and propagation delay, which is typically less than **WAIT_TIME** [8]. In order to prevent message die out and guarantee 100 percent reachability, node j should rebroadcast the message with probability 1 after **WAIT_TIME + □** ms if it does not hear the retransmission from its neighbors. Unlike the p-persistence or gossip-based scheme, weighted p-persistence assigns higher probability to nodes that are located farther away from the broadcaster given that GPS information is available and accessible from the packet header[8]. As is illustrated in figure(3a).

For Slotted 1-Persistence Broadcasting: Upon receiving a packet, a node checks the packet ID and rebroadcasts with probability 1 at the assigned time slot TSij if it receives the packet for the first time and has not received any duplicates before its assigned time slot; otherwise, it discards the packet [8]. It suffers from a synchronization problem that can occur when multiple vehicles are assigned to a single time slot and start their transmissions simultaneously [10][13].Given the relative distance between nodes i and j, Dij, the average transmission range, R, and the predetermined number of slots Ns, TSij can be calculated as **TSij = Sij × τ Eq. 2** where τ is the estimated one-hop delay, which includes the medium access delay and propagation delay, and Sij is the assigned slot number [8],which can be expressed as : **Sij=Ns(1-[min(Dij,R)/R]) Eq. 3** [8].The time slot approach follows the same logic as the weighted p-persistence scheme ,but instead of calculating the reforwarding probability, each node uses the GPS information to calculate the waiting time to retransmit. For example, in figure (3b) the broadcast coverage is spatially divided into four regions, and a shorter waiting time will be assigned to the nodes located in the farthest region[8]. Hence, when a node receives duplicate packets from more than one sender, it takes on the smallest Dij value (the nodes are close to each other). Similar to the p-persistence scheme, this approach requires transmission range information in order to agree on a certain value of slot size or number of slots[8]. Note that Ns is a design parameter that should be carefully chosen. Although Ns should theoretically be a function of the traffic density (i.e., the denser the traffic, the smaller the slot size and the larger the number of slots), it is very hard for each vehicle to predict what the traffic density is and to arrive at a single value of Ns in practice. Hence, network designers can, at best, fix this value or adaptively change this value over time; for example, the protocol should use five slots during morning and evening rush hours, and three slots during non-rush hours [8].

For Slotted p-Persistence Broadcasting: Upon receiving a packet, a node checks the packet ID and rebroadcasts with the pre-determined probability p at the assigned time slot TSij, as expressed by Eq. 2, if it receives the packet for the first time and has not received any duplicates before its assigned time slot; otherwise, it discards the packet [8].Each node in this scheme should also buffer the message for a certain period of time (e.g.,**[Ns – 1] × WAIT_TIME + □ ms**) and retransmits with probability 1 if nobody in the neighborhood rebroadcasts in order to prevent the message's dying out . Figure (3c) illustrates the concept of slotted p-persistence with four slots. Similar to the p-persistence state, the performance of this scheme also depends on the value chosen for the reforwarding probability p[8].The proposed schemes are distributed and rely on GPS information, but do not require any other prior knowledge about network topology[2][8].

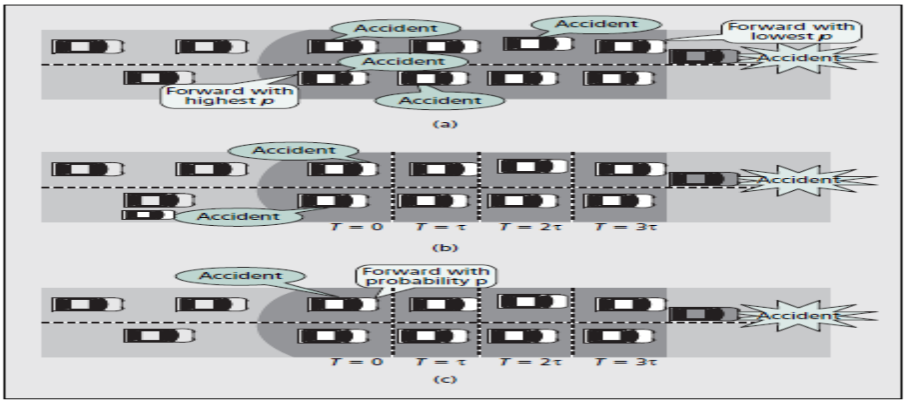


Figure (3)Broadcast suppression techniques: a) weighted p-persistence; b) slotted 1-persistence; c) slotted p-persistence.

For Counter based Broadcasting: In the counter-based scheme, the basic idea is that for a node hearing the same message an increasing number of times from the neighboring nodes decreases the additional coverage benefit from having the node to rebroadcast. Therefore, when a node hears the same message a given amount of times, indicated by threshold CTH , the node is prohibited from rebroadcasting the message[15].

For Neighbor-Knowledge-based Broadcasting: The messages are broadcast based on the knowledge of the neighboring nodes. In this method the vehicle needs to share 1-hop or 2-hop neighborhood information with other nodes via periodic exchange of hello messages to decide on the next forwarding node[16]. However, this method is not suitable for vehicular environments since messages become outdated due to the high mobility and high speed of vehicles [15][16]. It is further divided into the following: Cluster based and Traffic based broadcasting As is illustrated in figure(4). For Cluster based Broadcasting, The cluster based protocols, which broadcast messages to a group of vehicles, for example, to a fleet of vehicles with common paths[15].As is illustrated in figure(5).For Traffic based Broadcasting , a source node broadcasts a packet to all its neighbors and each of those neighbors, in turn, re-broadcast the packet exactly one time. This process continues until all the reachable network nodes have received the packet[15]. The DV-CAST protocol uses local one- hop neighbor topology to make routing decisions[15]. The protocol adjusts the back-off timer based on the local traffic density, and computes connectivity in forward and opposite direction with periodic heartbeat messages[15].This protocol divides the driving environment into three types of regions depending on the local connectivity as well-connected, sparsely connected and totally disconnected neighborhood[15]. In well-connected network, it applies any one of the broadcast suppression schemes using probability: weighted p-persistence or slotted 1-persistence or slotted p-persistence[15]. In sparsely connected neighborhood after receiving the broadcast message, vehicles immediately rebroadcast it to vehicles moving in the same direction [15]. In totally disconnected neighborhood, vehicles are used to store the message until another vehicle enters into transmission range, otherwise if the time expires it will discard the packet[15]. DV-CAST addresses how to deal with extreme situations such as dense traffic conditions during rush hours and sparse traffic during certain hours of the day[15].

For Area based Broadcasting: The messages are broadcast based on the ROI of the transmitting and receiving vehicle locations. In this method, distance information is used to decide which nodes should rebroadcast[16]. Area based broadcasting uses the concept of coverage area to adjust the rebroadcast region within the specified geographical area[15]. In this scheme, every vehicle receives multiple packets which may contain overlapping information[15]. Scrutinizing these messages provides additional coverage area[15]. The node that is farther away from the source is preferred for re-broadcast to widen the coverage area [15].It is further divided into two types: Location-based broadcasting and Distance and Hop based broadcasting [15]. For Location-based broadcasting, messages are broadcast based on the geographic area of the vehicles. Each node adds its own location in the header of the message, which is used by the receiving node to calculate the additional coverage area to re-broadcast[15]. The main problem with this approach is the cost of calculating additional coverage areas [15]. As is illustrated in figure(6). For Distance and Hop based broadcasting, messages are broadcast by considering the neighboring distances and hop count from the transmitting node[15].The distance between the source and destination is the criteria for deciding whether to re-broadcast to destination or drop the message [15].The distance-based scheme allows the receiving nodes located at a distance greater than a given threshold (DTH) to rebroadcast the message and prevents the others from rebroadcasting [15].

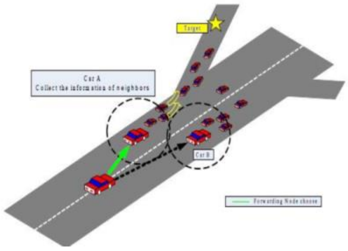


Figure (4) Neighbor Knowledge Based broadcasting

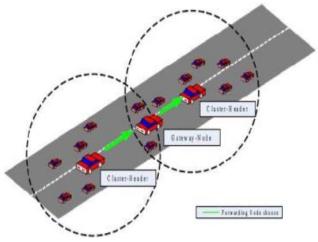
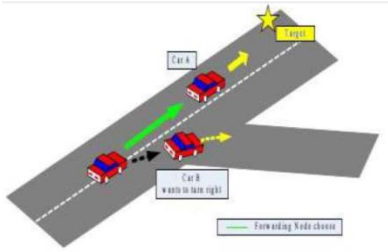


Figure (5) Cluster based broadcasting



Figure(6)Area Based broadcasting

1.4. RESEARCH PROBLEM AND OBJECTIVES:

VANETs offers characteristics that are highly dynamic and data-intensive, spatially and temporally localized[1].These characteristics are challenges facing VANETs networks, in addition to short-range communication issues in highway scenarios that We studied them in this article and in urban scenarios that We will studied them later[1]. To solve these problems, in general a broadcast communication technique is often used to disseminate data packets because it is flexible enough to spread messages to vehicles with high dynamics in a region of interest(ROI)[1].Pure or Blind flooding routing scheme, is a basic routing for broadcasts which, although it can disseminate data to a wide area with low delay, but if flooding is not properly controlled, it causes a "broadcast storm" in dense networks and may lead to redundant rebroadcasts, medium contention and packet collision [1][15].And therefore there are a number of challenges when designing routing protocols under broadcast communication paradigm [1].To overcome the problem of flooding ,there are relaying schemes that We explained them in Paragraph 1.3 that aim to selecting appropriate forwarders to mitigate this problem on highway or urban scenario [1][15][16].Also , the density of VANET varies frequently according to events or day time, which requires data dissemination protocol to well handle the scalability. This requirement is more critical in traffic safety considering human life [1]. In this paper ,We studied and evaluated the performance of DV-CAST protocol over VANETs /V2V communication for Circular highway Traffic without Obstacles in DV_Cast and Dyna_DVCastLayer Scenarios and for the studied total geographical area in Flooding Scenario during (Morning Rush) Rush hour(16:07:24 PM in our time ,but 10:07:24 AM in Chicago ,USA time) and during Late night or early morning hour (10:45:09AM in our time ,but 4:45:09 AM in Chicago, USA time) on Monday day (October 10) using OMNET++,various experiments were designed to analyze the impact of different network densities on Interstate 90 (I-90) highway map(intersection between I-90/94 and I-290 in Chicago,Illinois,USA) is circular highway using DV-CAST protocol . As We know in highway scenario, the roads are wider, like freeways, and buildings are rarely present. The geographic data of my map were exported from Open Street Map (OSM) database(Latitude and Longitude of (South-West, North-East))[6].My map files were related to Network ,e.g. I90.net.xml , I90.poly.xml and related to Traffic Demand(VehiclesTypes,Flows,Trips,Routes),e.g.I90.rou.xml and related to my Map(Nodes,Edges,Routes),e.g.I90.osm.xml and related to OMNET++ (Radio propagation model , Module Type, use Obstacles),e.g.config.xml,I90.Launchd.xml, I90.sumo.xml,and omnetpp.ini were set using the SUMO tool chain binaries path and GatcomSUMO tool with using coordinates/Latitude and Longitude of (South-West, North-East) of my map [4][7],Our free simulation framework Veins (veins/modules/mac/ieee802.11p/Mac1609_4.cc,veins/modules/traci/TRACIMobility.cc) is able to measure and to analyze several metrics related to Received Broadcasts(receptions in our code),RXTX Lost Packets ,SNIR Lost Packets ,Sent Packets ,Slots Back off ,Times Into Back off, total Busy Time(MAC),Busy Time(PHY),Total Lost Packets ,Total Distance ,MAX Speed ,Min Speed and also related to the environmental impact including the gas consumption and resulting CO2 emissions as total CO2 Emission metric (veins/modules/traci/TRACIMobility.cc) depending on the programmed code in DV_Cast and Dyna_DVCastLayer Scenarios for the Circular highway and the programmed code in Flooding Scenario for the studied Total geographical area including all the streets in the studied area .We found Packet Delivery Ratio from Received Broadcasts(receptions in our code) and Sent Packets metrics according of **Eq. 4** and Packet Loss Ratio from Total Lost Packets and Received Broadcasts (receptions in our code) metrics according of **Eq. 5**. The goal of this work is to study a distributed broadcast protocol called DV-CAST protocol in highway map without Obstacles for three scenarios (DV_Cast, Dyna_DVCastLayer, Flooding) .We solved broadcast storm problem and network partition problem depending on the programmed code in DV_Cast and Dyna_DVCastLayer Scenarios for the Circular highway in WAITII,WAITI states as is shown in figure (19) with taking into account three parameters (MDC=0 as fixed value and as default value because the highway has one direction, ODC=0/1 is the choosed direction of the highway , Dflg=0/1) using one of broadcast suppression techniques and store-carry forward mechanisms respectively and in Flooding Scenario for the studied total geographical area ,but without taking into account three parameters in this Scenario and Sending Data that belong to changing the Route and accidents to mitigate broadcast storm that may lead to redundant rebroadcasts, medium contention and packet collision, then We found Slots Back off ,Times Into Back off metrics are related to number of slots and waiting period and as they express how often a channel sensed busy in WAITII,WAITI states as is shown in figure (19) that are calculated by Veins depending on the programmed code in DV_Cast ,Dyna_DVCastLayer and Flooding Scenarios, this means that We studied Well-connected regime or Sparsely-connected regime (MDC=0 as fixed and as default value because the Circular highway has one direction, ODC=1, DfLg=0/1) and totally-disconnected regime(MDC=0 as fixed and as default value,ODC=0).

For DV_Cast scenario with Cluster Radius=2450 or =250,and ROI(Region of interest)=2*Cluster Radius,then Hello message (dv_wsm) is sent at 1 Hz frequency according of programmed instruction(simTime()-lastDroveat>1) as is shown in figure (7) and then Data(wsm) is sent and Push_back() function is applied When (!MDC=not true and ODC=true) ,after that the value of DfLg parameter is tested Whether !Dflg equals to (not true or not),this means that When (MDC=not true,ODC=true and DfLg=not true(not target/relay vehicle)),wait(WAITII) until sending message from neighbor in same Traffic direction(ODC in my code) as delayedRB/delayed Rebroadcast,and When(MDC=not true and ODC= false),wait(WAITI) until sending message from neighbor in same Traffic direction(ODC in my code) as delayedRB as is shown in figure (10).We supposed that MDC=false as fixed and as default value ,ODC=true as default value, DfLg=false as default and all that based on the diagram shown in figure (19), which will be explained later.

For Dyna_DVCastLayer scenario with Cluster Radius=2450 or =250, and ROI=2*Cluster Radius, then Hello message (dv_wsm) is sent based on the difference between the location of the current vehicle (x,y) and the location of the farthest vehicle (lastx,lasty) as absolute value within ROI with adding the old value of dlastx, dlasty (dlastx=0,dlasty=0 as default) each time and testing whether the value of dlastx and dlasty or one of them is greater or equal to the value of cluster Radius/2 , then Hello message (dv_wsm) is sent and dlastx, dlasty values are zero if the value of both are greater than the value of Cluster Radius/2, otherwise the last value of dlastx and dlasty is assigned to dlastx and dlasty as new values respectively as is shown in figure (8), and then Data(wsm) is sent and Push_back() function is applied When (!MDC=not true and ODC=true) ,after that the value of DfLg parameter is tested whether !Dflg value equals to (not true or not) , this means that When (MDC=not true ,ODC=true and DfLg=not true(not target/relay vehicle)),wait(WAITII) until sending message from neighbor in same Traffic direction(ODC in my code) as delayedRB),and When(MDC=not true and ODC= false ,wait(WAITI) until sending message from neighbor in same Traffic direction(ODC in my code) as delayedRB) as is shown in figure (10). We supposed that MDC=false as fixed value and as default ,ODC=true, DfLg=false as default and all that based on the diagram shown in figure (19), which will be explained later. As soon as a Hello message is received from one of the possible neighbors in DV_Cast and Dyna_DVCastLayer Scenarios as is shown in figure (9) , then the neighbors table is built. This table is updated with the current position of the vehicle such as (My Position x,My Position y,My Position z, My Id, angleRad) and information about the sender such as (Sender's Position x,Sender's Position y,Sender's Position z, Sender id,angle) Where the current position of the vehicle (My Position x, My Position y) is compared with x,y values of Roi_up(getCurrentPosition().x<getRoi_up().x&& getCurrentPosition().y<getRoi_up().y) and also the current position of the vehicle (My Position x, My Position y) is compared with x,y values of Roi_down (getCurrentPosition().x>getRoi_down().x && getCurrentPosition().y>getRoi_down().y) and if the conditions are met, then the neigbors_tables function is called for sender parameters (Sender Position, Sender Address, Angle) for DV_Cast and Dyna_DVCastLayer Scenarios as is shown in figures (12),(11)and this table contains three Queues(NB_BACK, NB_FRONT, NB_OPPOSITE) and based on parameters are: angleDiff which is the difference between the angle of the Sender and the angle of the current vehicle as absolute value, besides to the angle of the Sender , Position of the Sender (x,y),Current Position of the vehicle , then add_to_queue() function with Sender Id is executed for NB_Back and NB_FRONT for neighbor 'vehicles of Sender are located in the North, South, East and West directions with the same direction Traffic and also add_to_queue()

function is executed for NB_OPPOSITE for neighbor ‘vehicles of Sender are located in the opposite direction Traffic.

```
// Send hello in 1Hz frequency
if (simTime() - lastDroveAt > 1) {
    DVCast* wsm = prepareHello("hello", beaconLengthBits, type_CCH,
            beaconPriority, -1, 72);
    sendHello(wsm);
}
```

Figure(7) sending Hello For DV_Cast scenario

```
dlastx += std::abs(mobility->getCurrentPosition().x - lastx);
dlasty += std::abs(mobility->getCurrentPosition().y - lasty);

if ((dlastx >= clusterRadius / 2) || (dlasty >= clusterRadius / 2)) {
    DVCast* wsm = prepareHello("hello", beaconLengthBits, type_CCH,
            beaconPriority, -1, 72);
    sendHello(wsm);
    dlastx = (dlastx > clusterRadius / 2) ? 0 : dlastx;
    dlasty = (dlasty > clusterRadius / 2) ? 0 : dlasty;
}
    lastx = mobility->getCurrentPosition().x;
    lasty = mobility->getCurrentPosition().y;
}
```

Figure(8) sending Hello For Dyna_DVCastLayer scenario

```
if (MDC) {
    findHost()->getDisplayString().updateWith("r=16,yellow");
} else if (ODC) {
    findHost()->getDisplayString().updateWith("r=16,purple");
}

EV << "****onHello" << endl;
EV << "My Position x:" << mobility->getCurrentPosition().x
        << " My Position y:" << mobility->getCurrentPosition().y
        << " My Position z:" << mobility->getCurrentPosition().z
        << " My Id: " << getParentModule()->getIndex() << " angle: "
        << to_positive_angle(mobility->getAngleRad()) << endl;
EV << "Sender Position x:" << wsm->getSenderPos().x << " Sender Position y:"
        << wsm->getSenderPos().y << " Sender Position z:"
        << wsm->getSenderPos().z << " Sender id: "
        << wsm->getSenderAddress() << " angle: "
        << to_positive_angle(wsm->getAngle()) << endl;
if (mobility->getCurrentPosition().x < wsm->getRoi_up().x
        && mobility->getCurrentPosition().y < wsm->getRoi_up().y
        && mobility->getCurrentPosition().x > wsm->getRoi_down().x
        && mobility->getCurrentPosition().y > wsm->getRoi_down().y) {
    neigbors_tables(wsm->getSenderPos(), wsm->getSenderAddress(),
            to_positive_angle(wsm->getAngle()));
}
}
```

Figure(9) Received periodic Hello from possible neighbors For DV_Cast , Dyna_DVCastLayer scenarios

```
int to_positive_angle(double angle) {
    angle = (180 / 3.14) * angle;
    angle = fmod(angle, 360);
    if (angle < 0)
        angle += 360;
    return (int) angle;
}
```

Figure(11) Convert an Angle to a positive Angle For DV_Cast and Dyna_DVCastLayer scenarios.

```
findHost()->getDisplayString().updateWith("r=16,green");
// ignore messages that I sent out
if (contains(&sentMessages, wsm->getSerial())) {
    return;
}
if (!contains(&rcvdMessages, wsm->getSerial())) {
    // this is a new message, add to received message queue
    rcvdMessages.push_back(wsm->getSerial());
    if (!NB_OPPOSITE.empty()) {
        if (NB_OPPOSITE.size() == 1
                && (NB_OPPOSITE.front() == wsm->getSenderAddress())) {
            ODC = false;
        }
        ODC = true;
    } else {
        ODC = false;
    }

    Dflg = (wsm->getRecipientAddress() == getParentModule()->getIndex()) ?
            true : false;
    MDC = (NB_FRONT.empty() || NB_BACK.empty()) ? false : true;

    EV << "MDC:" << MDC << " ODC:" << ODC << " Dflg:" << Dflg << endl;

    if (!MDC) {
        // no broadcast suppression yet
        if (ODC) {
            sendMessage(wsm->getWsmData(), -1, wsm->getSerial());
            sentMessages.push_back(wsm->getSerial());
            if (!Dflg) {
                findHost()->getDisplayString().updateWith("r=16,pink");
                if (!contains(delayedRB, wsm->getSerial())) {
                    delayedRB.insert(
                            std::pair<int, std::string>(wsm->getSerial(),
                                    wsm->getWsmData()));
                }
            }
        } else {
            findHost()->getDisplayString().updateWith("r=16,blue");
            delayedRB.insert(
                    std::pair<int, std::string>(wsm->getSerial(),
                            wsm->getWsmData()));
        }
```

Figure(10) Received accident Data For DV_Cast and Dyna_DVCastLayer scenarios

```
EV << "**********neigbors_tables Message has arrived MyId:"
        << getParentModule()->getIndex() << " SenderId:" << senderId
        << endl;

int myAngle = to_positive_angle(mobility->getAngleRad());
int angleDiff = std::abs(senderAngle - myAngle);
if (angleDiff > 180)
    angleDiff = 360 - angleDiff;
EV << "My angle is:" << myAngle << " Neighbor's Angle is:" << senderAngle
        << endl;
if (angleDiff <= 45) {
    // same direction, calculate front and back
    if ((senderAngle >= 0 && senderAngle < 45)
            || (senderAngle >= 315 && senderAngle < 360)) {
        //east
        if (senderPosition.x > mobility->getCurrentPosition().x) {
            add_to_queue(&NB_FRONT, &NB_BACK, &NB_OPPOSITE, senderId);
        } else {
            add_to_queue(&NB_BACK, &NB_FRONT, &NB_OPPOSITE, senderId);
        }
    } else if ((senderAngle >= 45 && senderAngle < 90)
            || (senderAngle >= 90 && senderAngle < 135)) {
        //north
        if (senderPosition.y > mobility->getCurrentPosition().y) {
            add_to_queue(&NB_FRONT, &NB_BACK, &NB_OPPOSITE, senderId);
        } else {
            add_to_queue(&NB_BACK, &NB_FRONT, &NB_OPPOSITE, senderId);
        }
    } else if ((senderAngle >= 135 && senderAngle < 180)
            || (senderAngle >= 180 && senderAngle < 225)) {
        // west
        if (senderPosition.x < mobility->getCurrentPosition().x) {
            add_to_queue(&NB_FRONT, &NB_BACK, &NB_OPPOSITE, senderId);
        } else {
            add_to_queue(&NB_BACK, &NB_FRONT, &NB_OPPOSITE, senderId);
        }
    } else if ((senderAngle >= 225 && senderAngle < 270)
            || (senderAngle >= 270 && senderAngle < 315)) {
        // south
        if (senderPosition.y < mobility->getCurrentPosition().y) {
            add_to_queue(&NB_FRONT, &NB_BACK, &NB_OPPOSITE, senderId);
        } else {
            add_to_queue(&NB_BACK, &NB_FRONT, &NB_OPPOSITE, senderId);
        }
    }

} else if (angleDiff > 90 && angleDiff <= 180) {
    // opposite direction
    NB_OPPOSITE.push_back(senderId);
    add_to_queue(&NB_OPPOSITE, &NB_FRONT, &NB_BACK, senderId);
}
    MDC = (NB_FRONT.empty() || NB_BACK.empty()) ? false : true;

    if (!NB_OPPOSITE.empty()) {
        ODC = true;
    } else {
        ODC = false;
    }
```

Figure(12) neighbors table Message to decide MDC,ODC ,DfLg For DV_Cast and Dyna_DVCastLayer scenarios

For Flooding scenario, Hello message(dv_wsm) is not sent and the neighbors table is not built, but only the data (wsm) is sent for all vehicles in the total geographical area When the vehicle wants to change its route with a condition (mobility->getRoadId()!=:), after that SendMessage() function is called and push_back() function is executed for sentMessages as is shown in figure (14).Generally, Hello messages are used in DV_Cast and Dyna_DVCastLayer Scenarios For Circular highway to exchange GPS information for each vehicle and to know whether the neighbor ‘s vehicle is in front of or behind of the vehicle (North, South, East and West) in the same direction Traffic (ODC in my code) or in the opposite direction Traffic , and after knowing that information, data(wsm) is sent,which represents warning messages when changing the route or accident messages in DV_Cast , Dyna_DVCastLayer and Flooding Scenarios as is shown in figure (13) .with accident messages, they are sent when a vehicle is involved in an accident, so a message is sent based on the three conditions

SentAccidentMessage=false
in initialize () function

according to the code in DV_Cast, Dyna_DVCastLayer and Flooding Scenarios as is shown in figure (13) .

```
// stopped for for at least 10s?
if (mobility->getSpeed() < 1) {
    if (simTime() - lastDroveAt >= 10) {
        findHost()->getDisplayString().updateWith("r=16,red");
        if (!sentAccidentMessage) {
            int serial = rand() % 101;
            sendMessage(mobility->getRoadId(), -1, serial);
            sentMessages.push_back(serial);
            sentAccidentMessage = true;
        }
    }
} else {
    lastDroveAt = simTime();
}
```

Figure(13) sending accident Data For DV_Cast , Dyna_DVCastLayer and Flooding scenarios

```
findHost()->getDisplayString().updateWith("r=16,green");
// ignore messages that I sent out
if (contains(&sentMessages, wsm->getSerial())) {
    return;
}
if (!contains(&rcvdMessages, wsm->getSerial())) {
    // this is a new message, add to received message queue
    rcvdMessages.push_back(wsm->getSerial());


if (mobility->getRoadId()[0] != ':')
    traciVehicle->changeRoute(wsm->getWsmData(), 9999);
//if (!sentMessage) sendMessage(wsm->getWsmData());

sendMessage(wsm->getWsmData(), -1, wsm->getSerial());
sentMessages.push_back(wsm->getSerial());
```

Figure(14) sending Route Changing Data of the vehicle in Flooding scenario

For three Scenarios, push_back() function is executed when Data(wsm) messages and Accident messages are sent and received for adding them from back to sentMessages, rcvdMessages queues respectivity . sentMessages queue is queue of sent Messages and it is checked from its beginning to its ending. If the message is not sent before, then the message is added to queue from back and if the message is sent before ,then the message is ignored and discarded. rcvdMessages queue is queue of received Messages and it is checked from its beginning to its ending. If the message is not received before, then the message is added to queue from back and if the message is received before ,then the message is ignored and discarded .We must mention that add-to-queue() function includes three queues: tarqet queue, other queue, and other queue2. For removing redundant nodes, then remove() function is executed for three queues. Target queue includes five vehicles. To add new neighbor from back to this queue, then push_back() function is executed depending on the key of the neighbor. To pull a neighbor of this queue from front, then pop_front() function is executed depending on the key of the neighbor.

The parked vehicles (sendWhileParking equals to false as fixed and as default value and isParking equals to true)are not involved in the simulation process .Only moving/operating vehicles (sendWhileParking equals to false as fixed and as default value and isParking equals to false, this means the vehicles whose state: green, pink, blue, yellow, purple, red is special state(accident) in DV_Cast and Dyna_DVCastLayer Scenarios, while the vehicles whose state: green, red is special state(accident) in Flooding Scenario) according to traffic rules that are involved in the simulation as is shown in figure (15).

```
isParking = mobility->getParkingState();
if (sendWhileParking == false) {
    if (isParking == true) {
        (FindModule<BaseConnectionManager*>::findGlobalModule())->unregisterNic(
                this->getParentModule()->getSubmodule("nic"));
    } else {
        Coord pos = mobility->getCurrentPosition();
        (FindModule<BaseConnectionManager*>::findGlobalModule())->registerNic(
                this->getParentModule()->getSubmodule("nic"),
                (ChannelAccess*) this->getParentModule()->getSubmodule(
                        "nic")->getSubmodule("phy80211p"), &pos);
    }
}
```

SendWhileParking=false as fixed and as default value

Figure(15) Vehicle participating conditions in the Simulation using handleParkingUpdate() Function For DV_Cast , Dyna_DVCastLayer and Flooding scenarios

We can briefly summarize a definition of some performance metrics used in the simulation process.

☒ **Received Broadcasts**: There are Received WSM, BSM, and WSA .Received WSM is a metric for how frequently vehicles change their states. Received BSM measures how often vehicles are informed of a critical situation(s)[18]. Received WSA presents the summation of informing requests about services[18]. However, these broadcast messages strongly affect back off and channel activity[18].In our code we have Received WSM and BSM which send information about the accident including Road ID and a random serial is given of accident based on the instruction: rand()%101.On reception, push_back() function is executed in order to add the received messages from the back to the rcvdMessages queue .

☒ **Sent Packets (SP):** include packets sent during message dissemination, generated WSMs, WSAs, and BSMs[18]. Wave Short Message (WSM) is a periodic message created by the vehicle to its neighbors with its current state[18]. A basic safety message (BSM) is a non-periodic broadcast message that is triggered by a vehicle to alert dangerous traffic circumstances (intersection collisions)[18]. BSM should be delivered to the nearest vehicle(s) of the situation (accident or road collision)[18]. A Wave short advertisement message (WSA) is a non-periodic broadcast message that is created by a vehicle to inform infotainment services[18].In our code we have generated WSM and BSM which send information about the accident including Road ID and a random serial is given of accident based on the instruction: rand()%101.On sending , push_back() function is executed in order to add the sent messages from the back to the sentMessages queue .

☒ **Total Lost Packets:** Total lost packets and generated/received beacon messages (WSM, BSM, WSA) are measures of how many times a vehicle can send/receive packets on its channel with no packet repetition [18] . Total lost packets were the summation of lost packets when the interference occurred, either bit error or collision[18].Total lost packets is the sum of both RXTX(receive/transmit) and SNIR(signal to noise plus interference ratio) lost packets; the first one occurs due to the busy communication channel, whereas the second one occurs due to bit errors in received packets [18]; Total Lost Packets is indicated below for the simulations performed below:

Total Lost Packets = RXTX Lost Packets+ SNIR Lost Packets [18].

☒ **Packet Delivery Ratio (PDR):** It represents total number of data messages received by vehicles in ROI as a percentage of total number of data messages sent by source node and it also can be called coverage of data dissemination [1][9][17]. The packet delivery ratio (PDR) is indicated below for the simulations performed below:

Packet Delivery Ratio(%)=∑Total Packets Sent /∑Total Packets Received *100 or
∑Total Packets Received /∑Total Packets Sent *100 [19]. **Eq. 4**

☒ **Packet Loss Ratio (PLR)**: The packet loss ratio (PDR) is indicated below for the simulations performed below:

Packet Loss Ratio(%)=∑Total Lost Packets/(∑Total Lost Packets+∑Total Packets Received) *100. **Eq. 5**

☒ **Times Into Back off**: is the number of times the vehicle is in backoff[18].

☒ **Slots Back off**: is the number of slots due to back off[18].

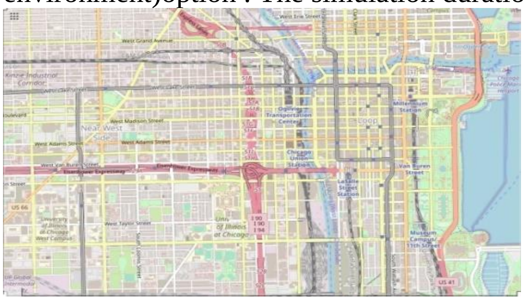
Time into back off and slots back off has a strong positive correlation with CSMA/CA MAC protocol as they express how often a channel sensed busy[18].Slots back off and times into backoff , which are measures of how many times a vehicle invoked Contention Windows 18] .

☒ **Total MAC Busy Time , PHY Busy Time**: Physical layer busy time and MAC busy time represent each vehicle channel busy time [18]. A vehicle considers a channel idle if the summation of MAC busy time and PHY busy time is idle. The total busy time measures how many seconds the MAC layer treated the channel as busy, while busy time is a PHY layer measure that increases for each frame received above a sensitivity threshold [18].

☒ **Total CO2 Emission (g or kg/km)** : Our free simulation framework Veins is able to measure and to analyze several metrics related to the environmental impact including the gas consumption and resulting CO2 emissions , along with more traditional ITS metrics[20]. We will show the values of this metric for different vehicle densities in three previous mentioned scenarios during Rush Hours and late night or early morning Hours.

1.5. STUDY METHODOLOGY AND TOOLS:

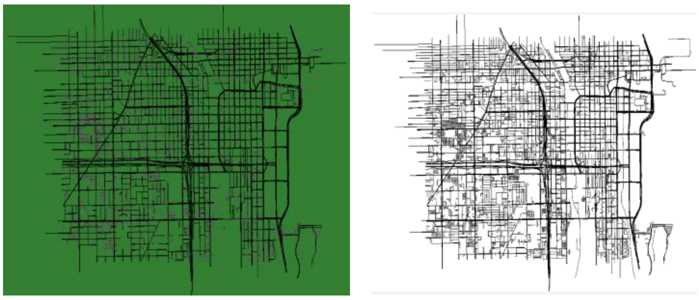
We used network simulator with powerful result analysis tools called OMNeT++ version 5.0 with road traffic simulator SUMO (Simulation of Urban Mobility) version 0.24 on Windows10 64 bit Operating System that has 2 Slots for RAM Memories (Total :8 GB /4GB:4GB) for evaluating performance of DV-CAST protocol [3][4] .We also used a specific simulation framework with high quality of source code developed for OMNeT++ designed especially for VANETs, called Veins version 4.4, that dedicates itself to simulate the WAVE protocol stack [5]. with additional tools such as java virtual machine (JVM),and Python, Code Blocks and Visual Studio Community 2019 applications .We also created highway scenario selected from Interstate 90 (I-90) Circular Highway of USA without Obstacles and with one direction (ODC) as shown in figure (16a,b), figure (17a,b), figure (18), and table(1) (MDC=false as fixed value and as default ,ODC=true or false, DfLg=false or true).We set four levels of traffic flows that include 100vph, 150vph, 200vph, and 250vph, which increase linearly during (Morning rush) rush hours that were extracted from a sample of 300 vehicles taken at Morning rush hour in Chicago,USA timing and We set five levels of traffic flows that include 20vph, 40vph, 60vph, 80vph, and 100vph during late night or early morning hours that were extracted from a sample of 180 vehicles taken during late night or early morning hours in Chicago,USA timing [For Highway environments, during Rush/peak hours, the regime will be well-connected, therefore the number of parked cars (sendWhileParking equals to false as fixed and as default value and isParking equals to true) will be small that are not involved in the simulation process, therefore it will be the number of moving/operating cars (sendWhileParking equals to false as fixed and as default value and isParking equals to false) will be big that are involved in the simulation., so the number of the samples will be few, and the difference between the samples should be large(100vph,150vph,200vph,250vph), besides one of broadcast suppression techniques will be applied . while during the early morning or late night hours , the regime will be Sparsely-connected or totally-disconnected , therefore the number of the parked cars will be big, therefore it will be the number of moving/operating cars will be small, so the number of the samples will be more, and the difference between the samples should be small (20vph,40vph,60vph,80vph,100vph), besides store-carry forward mechanisms will be applied] and We used these levels of traffic flows in _maps folder found in Simulations folder for DV_Cast Scenario with Cluster Radius=2450 or 250 and Dyna_DVCastLayer Scenario with Cluster Radius=2450 or 250 and Flooding_DV_Cast Scenario for late night or early morning hours and (Morning rush) rush hours in Simulations folder of every Project(DV_Cast, Dyna_DVCastLayer, Flooding_DV_Cast) and We executed the programmed Code in Source folder that includes (application and messages folders) using omnetpp_with_Radius250.ini (X=7942m,Y=4901m,Z=4900m) and omnetpp_with_Radius2450.ini (X=7942m, Y=4901m , Z=4900m) files in Simulations folder for DV_Cast Scenarios in DV_Cast Project and besides using omnetpp_with_Radius250.ini(X=7942m, Y=4901m , Z=4900m) and omnetpp_with_Radius2450.ini (X=7942m, Y=4901m , Z=4900m) files in Simulations folder for Dyna_DVCastLayer Scenarios in Dyna_DVCastLayer Project, and We also executed the programmed Code in Source folder that includes only application folder using omnetpp.ini file(X=7942m, Y=4901m , Z=4900m) in Simulations folder for Flooding_DV_Cast Scenario in Flooding_DV_Cast Project .Doing that , We first made a comparison of evaluating the performance of DV-CAT protocol in three Scenarios (DV_Cast and Dyna_DVCastLayer With Cluster Radius=2450 or Cluster Radius=250, Flooding_DV_Cast) in VANET Network during the early morning or late night hours or Rush Hours using (I-90) Highway without Obstacles for previous Metrics with different vehicular Densities. Second,We also made a comparison of evaluating the performance of DV-CAT protocol for previous Metrics in DV_Cast Scenario With Cluster Radius=2450 or Cluster Radius=250 between the early morning or late night hours and Rush Hours for 100vph vehicular Density in VANET Network using (I-90) Highway without Obstacles.Third,We made a comparison of evaluating the performance of DV-CAT protocol for previous Metrics in Dyna_DVCastLayer Scenario With Cluster Radius=2450 or Cluster Radius=250 between the early morning or late night hours and Rush Hours for 100vph vehicular Density in VANET Network using (I-90) Highway without Obstacles. Finally,We made a comparison of evaluating the performance of DV-CAT protocol for previous Metrics in Flooding_DV_Cast Scenario between the early morning or late night hours and Rush Hours for 100vph vehicular Density in VANET Network using (I-90) Highway without Obstacles. The results in the figures were obtained through the excel files of each metric obtained as a result of implementing Simulation.We choosed the simulation execution with Cmdenv (Command environment)option . The simulation duration of each traffic flow is 86400s(one full day).



(a)

(b)

Figure (16) Open Street Map of Interstate 90 (I-90 Highway of USA(used Circular highway scenario for simulations)



(a) (b)

Figure (17) Highway Scenario and road network in SUMO-GUI

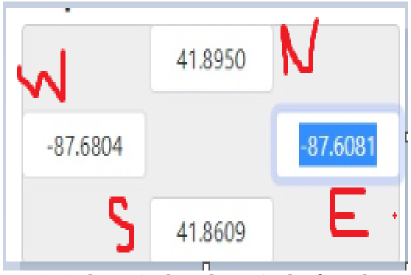


Figure (18) The Latitude and Longitude of South-West , North-East

Table (1) Scenario parameters /Rush Hours and late night or early morning Hours

Scenario	Latitude		Longitude	
	Min	**Max**	**Min**	**Max**
Highway without Obstacles	41.8609	41.8950	-87.6804	-87.6081

1.6 BROADCAST BASED ON ROUTING PROTOCOLS:

Broadcast Routing Techniques are based on flooding and are considered as traditional techniques that are used to route information in VANETs[11][15].These protocols are used when there is a need to share information with vehicles that are outside the source node range when exchanging information regarding road conditions and in emergency situations. In all states packets are sent and forwarded to all the nodes in the network[11].For example:DV-CAST, BROADCOMM, HYDI, NPPB[11]. We will study DV-CAST protocol in this article .

1.6.1 Distributed Vehicular Broad-CAST (DV-CAST) Protocol:

DV-CAST is a distributed geo-casting broadcast protocol for highway scenarios with zero infrastructure support and relies only on local topology information (list of one-hop neighbors) observed by each node (car) via use of periodic hello messages to handle data dissemination (broadcast messages) in VANETs in highway scenarios [2][1][12]. Periodic hello messages that usually can be called beacon are used to detect local topology information in one-hop neighborhood, which provides geographic position of neighbors for geographic routing[1]. Normally, vehicles in VANETs are organized by ad-hoc mode, every vehicle can be thought of "Coordinator" even if they are not the case actually[1][12]. beaconing also dedicates itself to the cooperative awareness that is the essential safety application. Finally, from the perspective of network load, adaptive beaconing can mitigate the channel congestion[1].Therefore, the key technique of beaconing is to design a strategy that can achieve a fairness of bandwidth utility (local and global) and also satisfy the requirement of safety applications[1].DV-CAST is one of early works that can mitigate both broadcast storm and disconnected network problem in dense and sparse vehicular networks. Besides, DV-CAST does not have the rescue mechanism for failed transmissions [2][1][9]. Indeed, the transmitter vehicles forward the data message only once, i.e., one-shot deal. Theoretically, the operation principle of DV-CAST guarantees a high data coverage on the highway[1].However, if a transmission fails, there is no mechanism to trigger the retransmission again. It is possible that the consecutive transmissions would fail due to fading or collisions. Therefore, if a transmission is broken at the middle forwarder, the vehicles in the rear of this forwarder cannot receive the data message[1].This protocol consists of three major components: neighbor detection ,broadcast suppression ,and store-carry forward mechanisms [2][13].

The protocol resorts to neighbor detection to distinguish between vehicles Vs. driving in the same direction with respect to the source vehicle and those Vo driving in the opposite direction[1][2][12].The neighbor detection mechanism estimates the local topology by monitoring periodic hello updates received from one hop neighbors[2][12]. The local topology is an important piece of information as it is used to assist DV-CAST in determining the relevance of the broadcast message (i.e., whether it is an intended recipient of the message or not/to be ignored, or to be rebroadcast) and whether there is any neighbor in the broadcast direction or in the opposite direction[1][2][12].In case it decides to broadcast it, the node replaces the sender's ID and position information by its own data in the message header and then rebroadcasts the message[12]. The message continues hoping until reaching the boundary of the ROI specified in the message[12].General, the message would be beneficial to vehicles following the source vehicle or vehicles moving toward the RSU (roadside unit), while the message will most likely be irrelevant to vehicles moving in the opposite direction [2]. If vehicles Vs. are connected to each other, broadcast suppression technique will be used in multi-hop broadcasts[2][1][9][13]. However, if there are gaps between clusters, the store-carry-forward mechanism will be performed to select some of vehicles Vo to be SCF-agents[2][1][9][13].

In dense networks, DV-CAST uses a broadcast suppression technique, i.e., slotted 1-persistence,published by the same research group and that explained them early [9][2][1][13].Specially, in sparse networks, DV-CAST only resort to three flags that can provide the necessary knowledge about the local topology information to handle different scenarios of disconnected network problem and to identify the vehicles in well-connected networks which is sufficient for DV-CAST to determine how to handle the broadcast packets and achieve acceptable performance [2][1].Each vehicle must have the most up-to-date local topology information and to achieve this, each vehicle is required to periodically broadcast its GPS information <latitude, longitude, heading>, which can easily be done by adding an extra field in the hello packet and data packet headers [2]. In our implementation, the original scheme can handle most of highway scenarios with special road topologies, e.g., curve road with angle more than 90 degrees, the entrance or exit of the highway. Hello broadcast frequency is set to 1 Hz in DV_Cast Scenario , and the hello packet content is kept at a minimum. periodic hello beaconing is also a requirement in many other VANET safety applications. DV-CAST maintains three separate neighbor tables ,NB_FRONT, NB_BACK ,and NB_OPPOSITE, which contains the list of neighbors who are leading, following, or moving in the opposite direction, respectively. These neighbor tables along with the information from the broadcast packet header can be used to determine the three binary flags. Each table is a priority queue, in which up to a MAXNB is number of neighbors are ordered according to the time of the neighbors' most recent GPS updates[2].Hence, MAXNB does not need to be a large value [2]. We set MAXNB to 5 in our implementation. Upon receiving the hello or data packet from the neighbor, each vehicle has to compare its GPS information against the neighbor's GPS information and determine whether the neighbor is moving in the same direction or in the opposite direction and each vehicle should be able to determine the three pieces of information that are the main input parameters to DV-CAST protocol[2]:

- **Destination Flag (DFlg),** which determines whether a car or vehicle is the intended recipient of the Message [2].If DFlg is set to 1, the vehicle should ignore any duplicate broadcast or follow the diagram in figure (19) if the message is received for the first time [2].and If DFlg is set to 0,the vehicle is a relay node and should follow routing diagram shown in figure (19)[2].This is because in a very sparse network environment, a certain relay vehicle may have to help store-carry-forward the same message more than once [2]. The diagram in the figure(19) explains the main idea of code that We depended on it in programming DV-CAST protocol in highway scenario with one direction for neighborhood table building, but The diagram in the figure(19) assumes that the highway has two directions, so it discusses the MDC value of vehicle Whether is set to 1 or 0 and the ODC value of vehicle Whether is set to 1 or 0 .
- **Message Direction Connectivity (MDC),** which determines whether a car or vehicle is the last vehicle in the group/cluster (or whether there is any next-hop neighbor moving in the same direction who will be responsible for reforwarding the message)[2] .
- **Opposite Direction Connectivity (ODC),** which determines whether a car or vehicle is connected to at least one vehicle in the opposite direction[2].in our Scenarios (DV_Cast, Dyna_DVCastLayer),the default values of these parameters are (**DFlg=false, MDC= false as fixed and as default value, ODC=true**).the following figure(19) shows the flowchart used for writing the code of DV-CAST protocol .

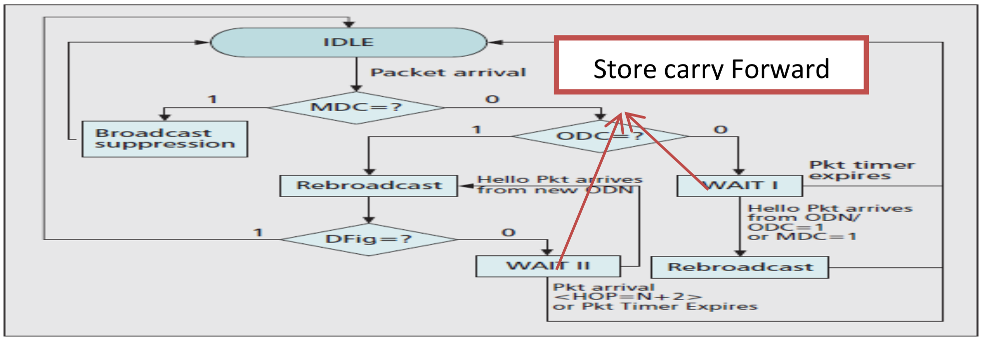


Figure (19) Decision tree for DV-CAST protocol (ODN; opposite direction neighbor).

- The flow chart begins by testing whether the MDC value of the vehicle is set to one or zero. If the MDC value of vehicle is set to 1, the regime is well-connected because this means that there is a neighbor of vehicle in the message forwarding direction that is in front of it or behind it, or it has a neighbor that is in front of it and a neighbor that is in the back in the message forwarding direction .Thus, one of the Broadcast suppression techniques should be applied and go back (transition) to the IDLE state .

- If the MDC value of the vehicle is set to 0, then the ODC value of the vehicle should be tested whether it is set to one or zero. If the ODC value of the vehicle is set to 1, then this means that there is a neighbor of vehicle in the opposite direction and a rebroadcast operation of data should be performed for the neighbor who is in the opposite direction and this neighbor is checked whether is the target or not (whose Dflq is set to 0 or 1). If the neighbor whose DFlg is set to 1(target), then it can go back to an IDLE state after the rebroadcast and If the neighbor whose DFlg is set to 0 (not target), then this neighbor is a relay vehicle, and therefore we have two states: The first state: this neighbor should wait (WAIT II state) until Hello message arrives from a neighbor (ODC) in a group, then a rebroadcast operation of data should be performed for the neighbor who is in the message forwarding direction and this neighbor delegates rebroadcast responsibility to its neighbors in the group a number of times greater than the number of hops, then go back (transition) to IDLE state .The second state : this neighbor should wait (WAIT II state) until Hello message arrives from a neighbor (ODC), then a rebroadcast operation of data should be performed for the neighbor who is in the message forwarding direction. If this neighbor whose DFlg is set to 1(target) after rebroadcast operation , then it can go back(transition) to an IDLE state after the rebroadcast and if this neighbor whose DFlg is se to 0(not target), so two states mentioned above are discussed with the final state. The final state : it waits until the packet timer expires If Hello message does not arrive,then data that we wanted to rebroadcast is discarded and can go back (transition) to an IDLE state . Hence, the packet expiration time is typically on the order of several seconds to a few minutes [2].We have Sparse-connected regime (MDC=0, ODC=1, Dflq=0 or 1).

- If ODC value of the vehicle is set to 0 (MDC=0,ODC=0) (the regime is Totally Disconnected) , the vehicle should wait (WAIT I state) until Hello message arrives from MDC neighbor or from ODC neighbor (MDC=0 as fixed and as default value as in DV_Cast and Dyna_DVCastLayer Scenarios), and when Hello message arrives from neighbor (MDC or ODC), a rebroadcast operation of data should be performed for ODC neighbor (as in DV_Cast and Dyna_DVCastLayer Scenarios) or for MDC neighbor (in the opposite direction or in the message forwarding direction) and can go back (transition) to IDLE state or it waits until the packet timer expires If Hello message does not arrive, then data that we wanted to rebroadcast is discarded and can go back (transition) to an IDLE state .(it had no neighbors (MDC), (ODC)).

-The **WAITII** State (a **Sparse-Connected Regime**) is discussed in the code for DV_Cast and Dyna_DVCastLayer scenarios as is shown in figure (20).

Figure (20) WAITII state for DV_Cast and Dyna_DVCastLayer scenarios

- findHost() is executed When the regime is sparse-connected (MDC=0,ODC=1,Dflq=0) , after that delayedRB is checked from its beginning to its ending. If Data message(wsm) is found or not based on serial. if Data message(wsm) is not found, then the message is added to delayedRB using insert() function .

-Within neigbors_tables() function ,then SendMessage() function is also executed for Data messages(wsm)which are found within DelayedRB and resulting from WAITII state .if DelayedRB is not empty and the value of ODC became not false(ODC!),this means that the vehicle(relay vehicle because !Dflg is not true in the code) has a neighbor in ODC direction. We executed (for) loop with DelayedRB programmly and executed SendMessage() function of vehicles whose MDC is set to not true (MDC!) as fixed value, this means that We sent Data messages (wsm) of all vehicles that have a neighbor in ODC direction. We have sparse-connected regime (MDC=0,ODC=1).After that all messages in DelayedRB is erased using erase() function and a (while) loop and the value of true is assigned to ODC.

-The **WAITI** State (**Totally Disconnected Regime**) is discussed in the code for DV_Cast and Dyna_DVCastLayer scenarios as is shown in figure (21).

```
    if (!MDC) {
        // no broadcast suppression yet
        if (ODC) {
            sendMessage(wsm->getWsmData(), -1, wsm->getSerial());
            sentMessages.push_back(wsm->getSerial());
            if (!Dflg) {
                findHost()->getDisplayString().updateWith("r=16,pink");
                if (!contains(delayedRB, wsm->getSerial())) {
                    delayedRB.insert(
                            std::pair<int, std::string>(wsm->getSerial(),
                                    wsm->getWsmData()));
                }
            }
        }else {
            findHost()->getDisplayString().updateWith("r=16,blue");
            delayedRB.insert(
                    std::pair<int, std::string>(wsm->getSerial(),
                            wsm->getWsmData()));
        }
    }
}
}
```

Figure (21) WAITI state for DV_Cast and Dyna_DVCastLayer scenarios

- For delayedRB in **WAITII, WAITI States :**

```
    if (!delayedRB.empty() && !ODC) {
        for (auto const& x : delayedRB) {
            if (!MDC) { //verify MDC is still false
                sendMessage(x.second, -1, x.first);
            }

        }
        while (!delayedRB.empty())
          {
            delayedRB.erase(delayedRB.begin());
          }
        ODC
    }
}
```

Broadcast Suppression When ODC=true after waiting in WAITII,WAITI .

Figure (22) delayedRB For WAITII &&WAITI states

-findHost() is executed When the regime is Totally Disconnected (MDC=0,ODC=0) , knowing that delayedRB is not checked from its beginning to its ending in this state If Data message(wsm) is found or not based on serial and it should execute insert() function for Data message (wsm) directly ,this means that the message is added to delayedRB .because there is no neighbors of vehicle neither in the ODC direction(as in DV_Cast and Dyna_DVCastLayer Scenarios because MDC=0 as fixd value) nor in the MDC direction.

-Within neigbors_tables() function , SendMessage() function is also executed for Data messages(wsm)which are found within DelayedRB and resulting from WAITI state .if DelayedRB is not empty and the value of ODC became not false(ODC!),this means that the vehicle has a neighbor in the ODC direction. We executed (for) loop with DelayedRB programmly and executed SendMessage() function of vehicles whose MDC is not true (MDC!), this means that We sent Data messages (wsm) of all vehicles that have a neighbor in the ODC direction . We have Totally Disconnected regime (MDC=0,ODC=0). After that all messages in DelayedRB is erased using erase() function and a (while) loop and the value of true is assigned to ODC.

II. SIMULATION ENVIRONMENT PARAMETERS

We evaluated the performance of DV_CAST protocol in three Scenarios with highway map without Obstacles that handles network partition problem using store carry-forward mechanism, besides broadcast storm problem but not at initial development phase of DSRC (because MDC=0 as default and as a fixed value, Number of Neighbors (MAXNB) =5 in Target Queue/ a small fraction of the vehicles on the road will be new and DSRC-equipped, this means the regime will be disconnected as disconnected network problem will persist until the DSRC penetration rate reaches a certain threshold),then handles it in WAITII ,WAITI states. The simulation parameters are shown in Table(2). The experiment of each vehicular density is performed for 86400s.The parked cars can improve cooperative awareness and mitigate signal attenuation in VANETs,but in our simulation SendWhileParking parameter takes false as fixed value by default. Therefore ,The parked vehicles (SendWhileParking=false, isParking=true) are not involved in the simulation process.Only moving/operating cars (SendWhileParking=false, isParking=false) according to traffic rules that are involved in the simulation . In general, a lower network density leads to more disconnected networks, which decreases the overall performance of DV-CAST protocol:Low PDR, and high number of transmissions (network overhead).On the contrary, a higher network density enables DV-CAST protocol to achieve better overall performance . We depended on the Veins framework for Times Into Back off, Slots Back off parameters that belong to the slotted 1-persistence or slotted p-persistence broadcast suppression techniques .

Table (2) Simulation Parameters

Density of vehicles /Rush hours	100 vph,150vph, 200vph, 250vph	
Density of vehicles /late Night or early Morning hours	20vph ,40vph,60vph ,80vph ,100vph	
Routing Protocol	DV-CAST	
Simulation time	86400s	
Propagation model	Free space path loss	
Metrics For late Night or early Morning hours and Rush hours	Packet Loss Ratio(%),Packet Delivery Ratio(%),Average Times Into Back off , Average total CO2 Emission , Average Slots Back off , Average total MAC Busy Time, Average PHY Busy Time.	
Physical Layer	Frequency band	5.89GHZ
	TX Power	20 mW
	Receiver sensitivity	-89 dBm
	FSPL exponent α	2.0
	Thermal noise	-110 dBm
	Radio range (Friis)	~508 m
Link Layer	Bit rate	18Mbps
	CW/Contention Windows (min, max)	[15,1023]
Wave App Layer	Header Length	256 bit
	Beacon Interval	1 s
	Max Offset	0.005s
	Data Priority	2
	Beacon Priority	3

Scenarios	Data Size	166 bytes
	Number of Neighbors (MAXNB)	5 in Target Queue
	SendWhileParking	False
	Hello size	70 bytes
	Hello Frequency	1 Hz For DV_Cast Scenario only
Mobility	Interstate_90(intersection between I-90/94 and I-290) Circular Highway	
Area	7942*4901 m	

III. SIMULATION ENVIRONMENT

3.1 Topology Of VANET Network Consists OF 20 vehicles And Used Protocol was DV-Cast with three Scenarios During late Night or early Morning Hours For (I-90) Highway without Obstacles Using Sumo Tool in OMNET++:

Figure (23) shows topology of VANET network consists of 20 vehicles and used protocol was DV-Cast with three Scenarios during late Night or early Morning Hours for (I-90) Highway without Obstacles using Sumo Tool in OMNET++. Also We can represent the topology of a VANET network consists of (40,60,80,100vehicles) with the Same tool using OMNET++.

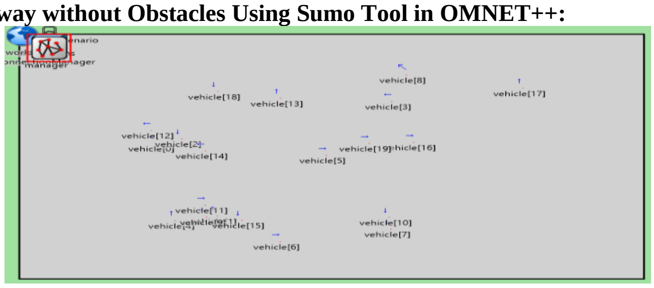


Figure (23) Topology OF VANET Network Consists OF 20 vehicles And used protocol was DV-Cast with three Scenarios during late Night or early Morning Hours For (I-90) Highway without Obstacles Using Sumo Tool in OMNET++.

3.2 Topology Of VANET Network Consists OF 100 vehicles And Used Protocol was DV-Cast with three Scenarios during (Morning Rush)Rush Hours For (I-90) Highway without Obstacles Using Sumo Tool in OMNET++:

Figure (24) shows topology of VANET network consists of 100 vehicles and used protocol was DV-Cast with three Scenarios during (Morning Rush) Rush Hours for (I-90) Highway without Obstacles using Sumo Tool in OMNET++. Also We can represent the topology of a VANET network consists of (150,200,250vehicles) with the Same tool using OMNET++.

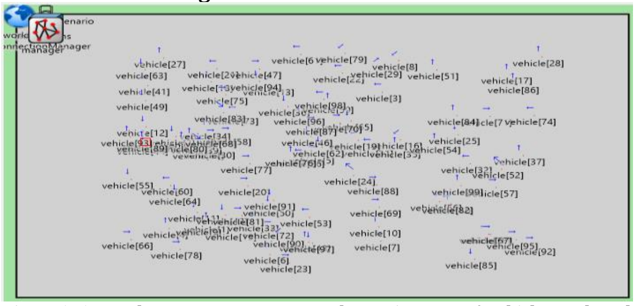


Figure (24) Topology OF VANET Network Consists OF 100 vehicles And used Protocol was DV-Cast with three Scenarios during Rush Hours For (I-90) Highway without Obstacles Using Sumo Tool in OMNET++.

4. RESULTS And DISCUSSION:

4.1 Performance Evaluation of DV-CAST Protocol for DV_Cast && Dyna_DVCastLayer With Cluster Radius=2450 applied on the axis Y &&Flooding_DV_Cast Scenarios in VANET Network consists of (20,40,60,80,100vehicles) During Early Morning or Late Night Hours using (I-90) Highway without Obstacles for previous Metrics:

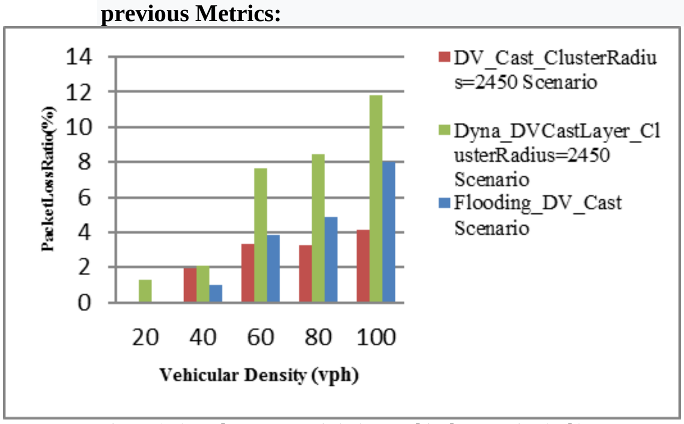


Figure (25) Packet Loss Ratio(%) V. Vehicular Density (vph)

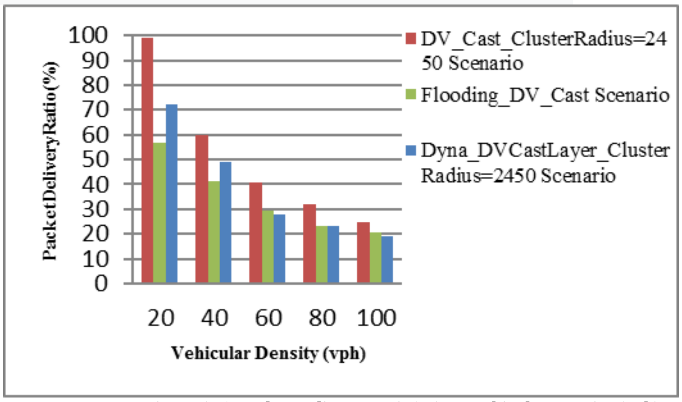


Figure (26) Packet Delivery Ratio(%) V. Vehicular Density (vph)

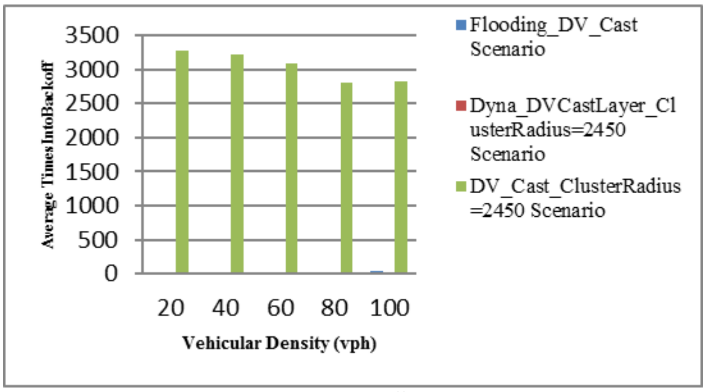


Figure (27) Average Times Into Back off V. Vehicular Density (vph)

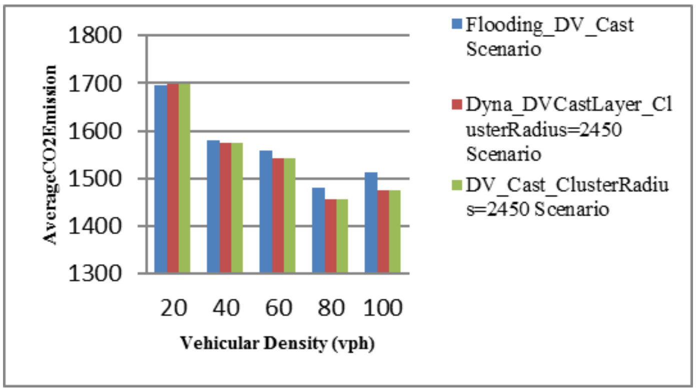


Figure (28) Average CO2 Emission V. Vehicular Density (vph)

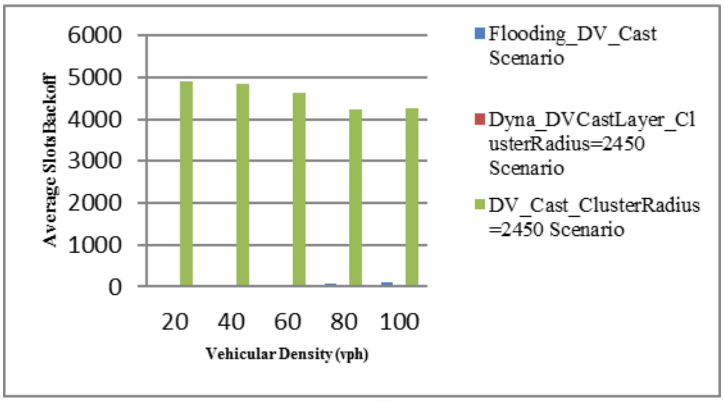


Figure (29) Average Slots Back off V. Vehicular Density (vph)

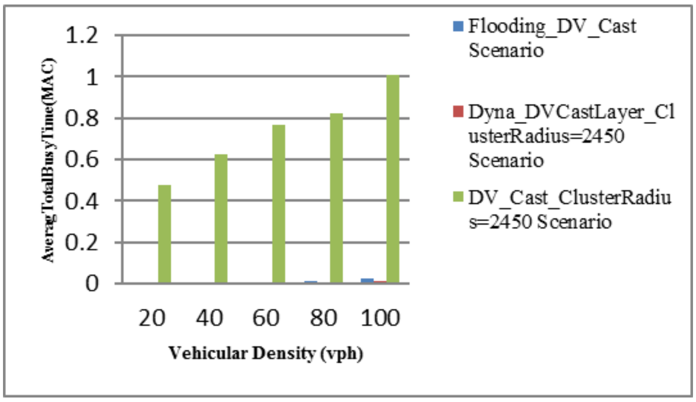


Figure (30) Average Total Busy Time(MAC) V. Vehicular Density (vph)

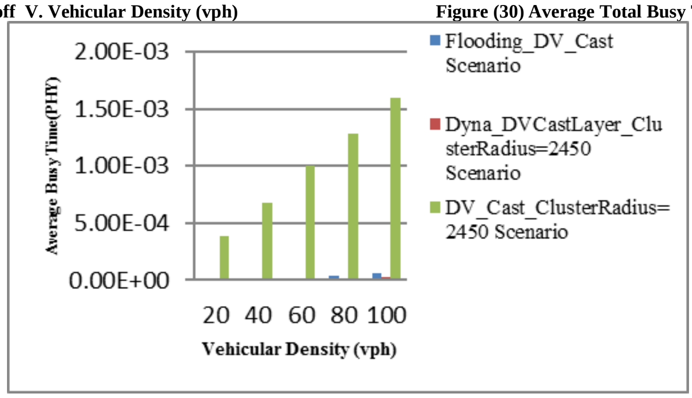


Figure (31) Average Busy Time(PHY) V. Vehicular Density (vph)

Figures(25),(26),(27),(28),(29),(30),(31) show Packet Loss Ratio(%),Packet Delivery Ratio(%),Average Times Into Back off ,Average CO2 Emission, Average Slots Back off, Average Total Busy Time(MAC),Average Busy Time(PHY) V. vehicle density(vph) respectively used in the simulation for DV_Cast and Dyna_DVCastLayer Scenarios with Cluster Radius=2450 and Flooding_DV_Cast Scenario during the early morning or late night hours. The figure (25) shows that Packet Loss Ratio(%) in Dyna_DVCastLayer scenario is higher than Packet Loss Ratio(%) in two scenarios (flooding and DV_Cast) for any of vehicle densities during the early morning or late night hours. The Packet Loss Ratio(%) in DV_Cast scenario is lower than Packet Loss Ratio(%) in flooding scenario for all vehicle densities, and When the density of the vehicles increases, then Packet Loss Ratio(%) increases for all scenarios .The figure (26) shows that Packet Delivery Ratio(%) in DV_Cast scenario is higher than Packet Delivery Ratio(%) in two scenarios (Dyna_DVCastLayer and Flooding) for any of vehicle densities during the early morning or late night hours, where Packet Delivery Ratio(%) in Dyna_DVCastLayer scenario is higher than Packet Delivery Ratio(%) in flooding scenario and When the density of the vehicles increases, then Packet Delivery Ratio(%) decreases for all scenarios. The figure (27) shows that average Times Into Back off value in DV_Cast scenario is significantly higher than average Times Into Back off value in two scenarios (Dyna_DVCastLayer and Flooding) for any of vehicle densities during the early morning or late night hours .The figure (28) shows that average CO2 Emission value in Flooding scenario is higher than average CO2 Emission value in two scenarios (Dyna_DVCastLayer and DV_Cast) for the same Cluster Radius, which equals to 2450 and the same ROI during the early morning or late night hours because in Flooding Scenario , the vehicles are not confined within the ROI because We studied the total geographical area (X=7942m, Y=4901m , Z=4900m) for any of vehicle densities Where average CO2 Emission value for

DV_Cast scenario equals to average CO2 Emission value in Dyna_DVCastLayer scenario for any of vehicle densities within the same ROI.The figure (29) shows that average Slots Back off value in DV_Cast scenario is significantly higher than average Slots Back off value in two scenarios (Dyna_DVCastLayer and Flooding) for any of vehicle densities during the early morning or late night hours for the same Cluster Radius, which equals to 2450 and the same ROI for two scenarios (DV_Cast and Dyna_DVCastLayer). The average Slots Back off value in Flooding scenario is almost higher than average Slots Back off value in Dyna_DVCastLayer scenario for any of the vehicle densities.The figure (30) shows that average Total Busy Time(MAC) value in DV_Cast scenario is significantly higher than average Total Busy Time(MAC) value in two scenarios (Dyna_DVCastLayer and Flooding) for any of the vehicle densities during the early morning or late night hours for the same Cluster Radius Which equals to 2450 and the same ROI for two scenarios (DV_Cast and Dyna_DVCastLayer) because the channel is very busy for MAC Layer in this scenario .The figure (31) shows that average Busy Time(PHY) value in DV_Cast scenario is significantly higher than average Busy Time(PHY) value in two scenarios (Dyna_DVCastLayer and Flooding) for any of the vehicle densities during the early morning or late night hours for the same Cluster Radius which equals to 2450 and the same ROI in two scenarios DV_Cast and Dyna_DVCastLayer because the channel is very busy for physical layer in this scenario.

4.2 Performance Evaluation of DV-CAST Protocol for DV_Cast && Dyna_DVCastLayer With Cluster Radius=2450 applied on the axis Y &&Flooding_DV_Cast Scenarios in VANET network consists of (100 ,150,200,250vehicles) During Rush Hours using (I-90) Highway without Obstacles for previous Metrics:

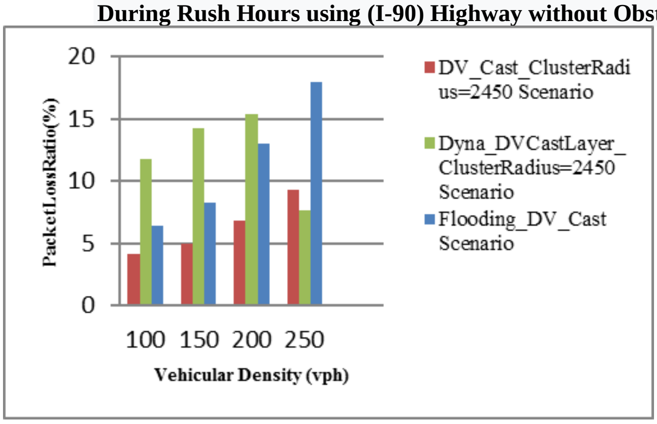


Figure (32) Packet Loss Ratio(%)V. Vehicular Density (vph)

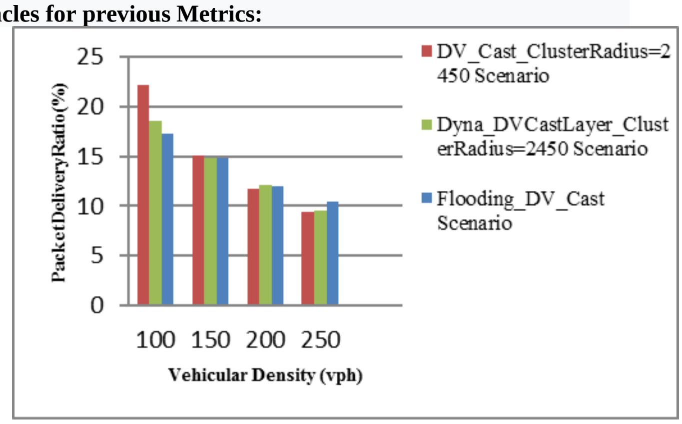


Figure (33) Packet Delivery Ratio(%)V. Vehicular Density (vph)

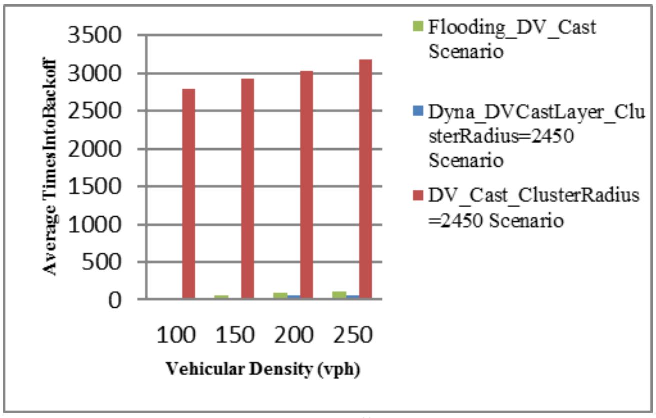


Figure (34) Average Times Into Back off V. Vehicular Density (vph)

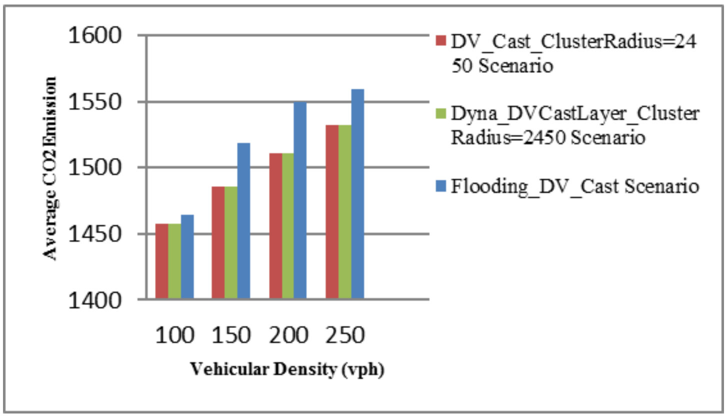
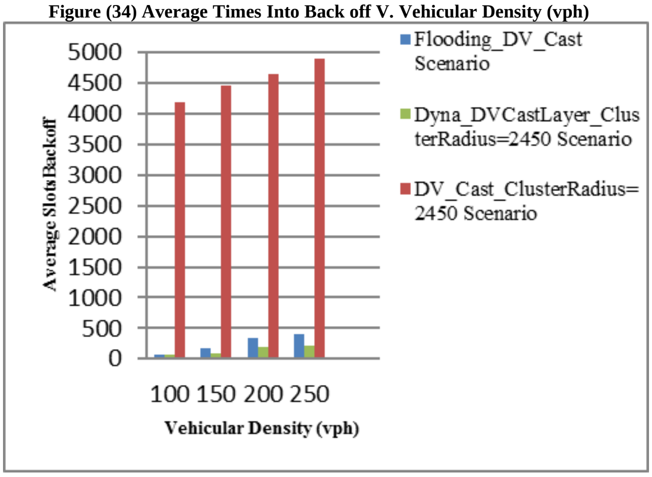


Figure (35) Average CO2 Emission V. Vehicular Density (vph)



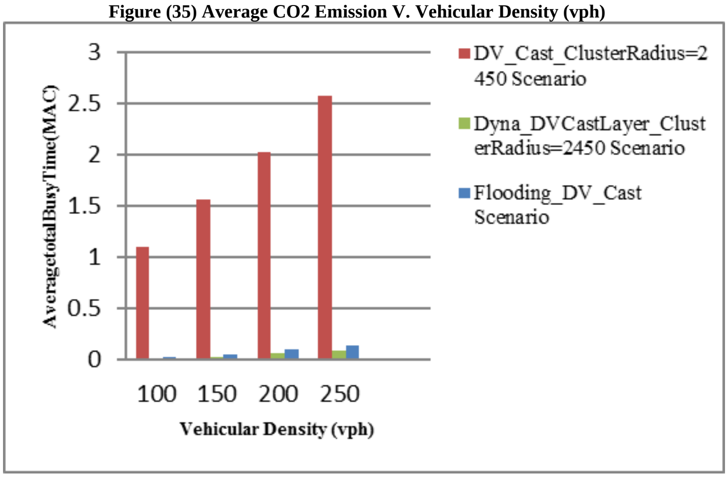


Figure (36) Average Slots Back off V. Vehicular Density (vph) **Figure (37) Average Total Busy Time(MAC)V. Vehicular Density (vph)**

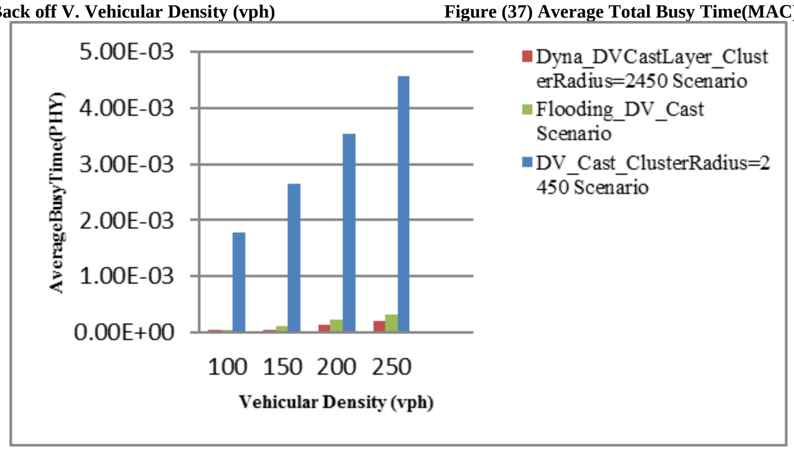


Figure (38) Average Busy Time(PHY) V. Vehicular Density (vph)

Figures(32),(33),(34),(35),(36),(37),(38) show Packet Loss Ratio(%),Packet Delivery Ratio(%), Average Times Into Back off ,Average CO2 Emission, Average Slots Back off, Average Total Busy Time(MAC),Average Busy Time(PHY) V. vehicle density(vph) respectively used in the simulation for DV_Cast and Dyna_DVCastLayer Scenarios with Cluster Radius=2450 and Flooding_DV_Cast Scenario during Rush hours.The figure(32)shows that Packet Loss Ratio(%) for Dyna_DVCastLayer scenario is higher than Packet Loss Ratio(%) for two scenarios (flooding and DV_Cast) for any of vehicle densities during Rush hours until the vehicle density reaches to 250vph , then Packet Loss Ratio(%) for Flooding Scenario is higher than Packet Loss Ratio(%) for two scenarios (Dyna_DVCastLayer and DV_Cast), but Packet Loss Ratio(%) for DVCast remains the lowest for any of vehicle densities .The figure (33) shows that Packet Delivery Ratio(%) for DV_Cast scenario is higher than Packet Delivery Ratio(%) for two scenarios (Dyna_DVCastLayer and Flooding),but with increasing in the density of the vehicles ,then Packet Delivery Ratio(%) is equal for all Scenarios, until the vehicle density reaches to 250vph, then Packet Delivery Ratio(%) for flooding Scenario is almost higher than Packet Delivery Ratio(%) for two scenarios (Dyna_DVCastLayer and DV_Cast) during Rush Hours. The figure (34) shows that average Times Into Back off value for DV_Cast scenario is significantly higher than average Times Into Back off value for two scenarios (Dyna_DVCastLayer and Flooding) for any of vehicle densities during Rush hours . The average Times Into Back off value for Flooding scenario is higher than average Times Into Back off value for Dyna_DVCastLayer scenario. The figure (35) shows that average CO2 Emission value for Flooding scenario is higher than average CO2Emission value for two scenarios (Dyna_DVCastLayer and DV_Cast) for the same Cluster Radius, which equals to 2450 and the same ROI during Rush hours because in Flooding Scenario ,the vehicles are not confined within ROI because We studied the total geographical area (X=7942m, Y=4901m , Z=4900m) for any of vehicle densities,but average CO2 Emission value increases with increasing the density of the vehicles for all Scenarios Where average CO2 Emission value for DV_Cast scenario equals to average CO2 Emission value for Dyna_DVCastLayer scenario for any of vehicle densities within the same ROI.The figure (36) shows that average Slots Back off value for DV_Cast scenario is significantly higher than average Slots Back off value for two scenarios (Dyna_DVCastLayer and Flooding) for any of vehicle densities during Rush hours, for the same Cluster Radius, which equals to 2450 and the same ROI for two scenarios (DV_Cast and Dyna_DVCastLayer). The average Slots Back off value for Flooding scenario is almost higher than average Slots Back off value for Dyna_DVCastLayer scenario for any of the vehicle densities.The figure (37) shows that average Total Busy Time(MAC) value for DV_Cast scenario is significantly higher than average Total Busy Time(MAC) value for two scenarios (Dyna_DVCastLayer and Flooding) for any of the vehicle densities during Rush hours for the same Cluster Radius which equals to 2450 and the same ROI for two scenarios (DV_Cast and Dyna_DVCastLayer) because the channel is very busy for MAC Layer in this scenario .The figure (38) shows that average Busy Time(PHY) value for DV_Cast scenario is significantly higher than the average Busy Time(PHY) value for two scenarios (Dyna_DVCastLayer and Flooding) for any of the vehicle densities during Rush hours for the same Cluster Radius which equals to 2450 and the same ROI for two scenarios DV_Cast and Dyna_DVCastLayer because the channel is very busy for physical layer in this scenario.

4.3 Performance Evaluation of DV-CAST Protocol for DV_Cast && Dyna_DVCastLayer With Cluster Radius=250 applied on the axis X &&Flooding_DV_Cast Scenarios in VANET Network consists of (20,40,60,80,100vehicles) During Early Morning or Late Night Hours using (I-90) Highway without Obstacles for previous Metrics:

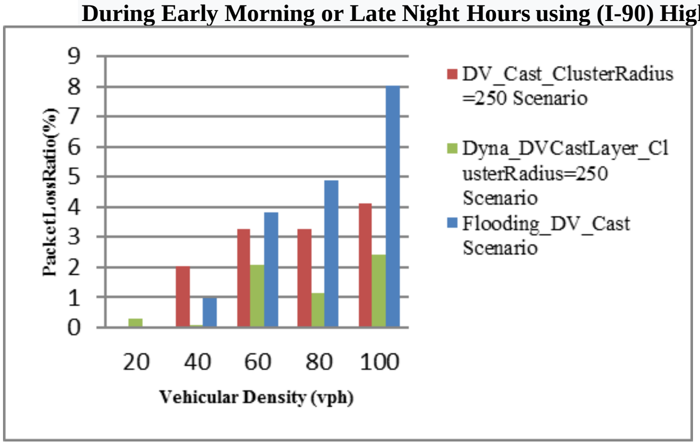


Figure (39) Packet Loss Ratio(%)V. Vehicular Density (vph)

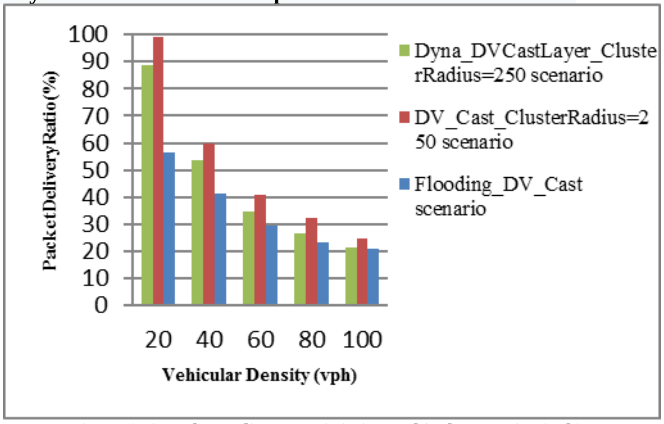


Figure (40) Packet Delivery Ratio(%)V. Vehicular Density (vph)

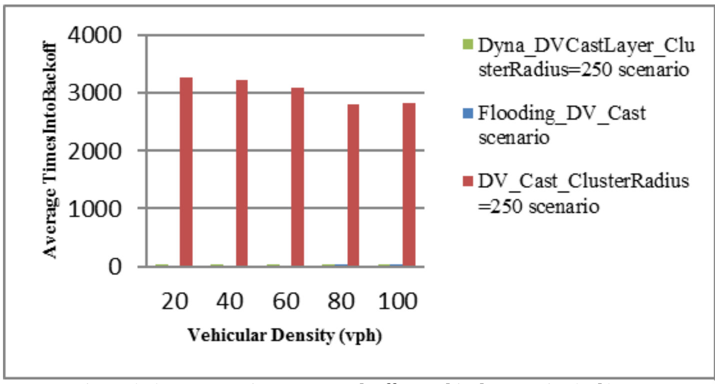


Figure (41) Average Times Into Back off V. Vehicular Density (vph)

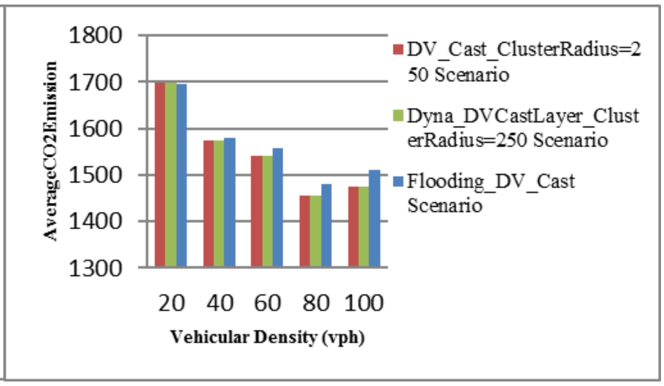


Figure (42) Average CO2 Emission V. Vehicular Density (vph)

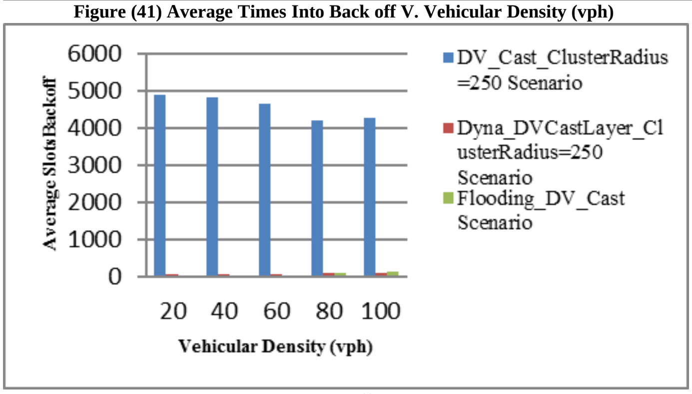


Figure (43) Average Slots Back off V. Vehicular Density (vph)

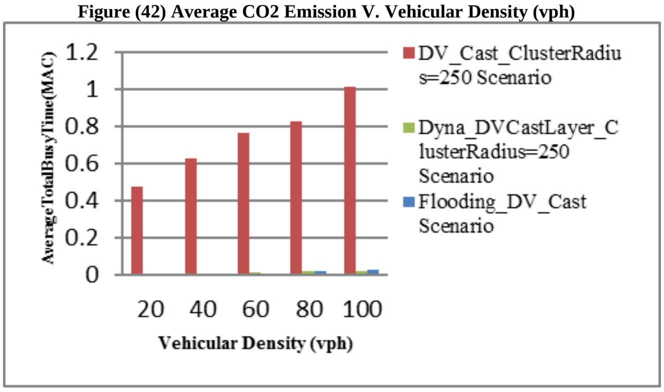


Figure (44) Average Total Busy Time(MAC)V. Vehicular Density (vph)

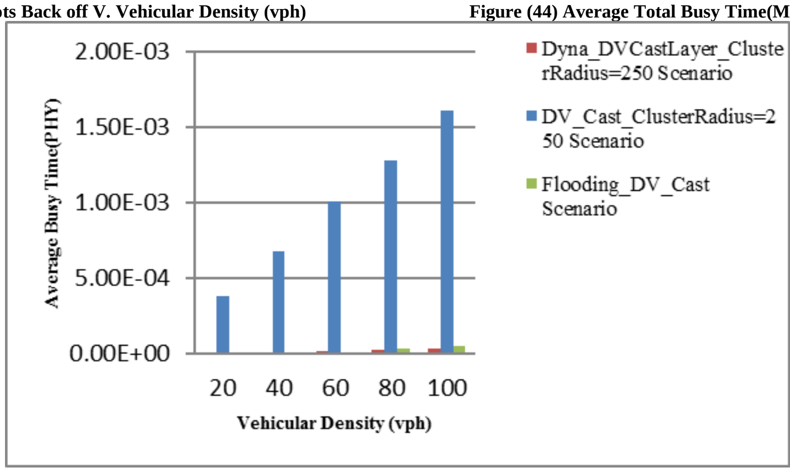


Figure (45) Average Busy Time(PHY) V. Vehicular Density (vph)

Figures(39),(40),(41),(42),(43),(44),(45) show Packet Loss Ratio(%),Packet Delivery Ratio(%), Average Times Into Back off, Average CO2 Emission, Average Slots Back off, Average Total Busy Time(MAC),Average Busy Time(PHY) V. vehicle density(vph) respectively used in the simulation for DV_Cast and Dyna_DVCastLayer with Cluster Radius=250 and Flooding_DV_Cast Scenarios during the early morning or late night hours. The figure(39) shows that Packet Loss Ratio(%) for Flooding scenario is higher than Packet Loss Ratio(%) for two scenarios (DV_Cast and Dyna_DVCastLayer with Cluster Radius=250) for any of vehicle densities during the late night or early morning hours, since the total lost packets in this scenario (SNIR Lost Packets + RXTX Lost Packets) is the highest for any of vehicle densities except for 40vph vehicle density where the Packet Loss Ratio(%) for DV_Cast scenario is the highest and Packet Loss Ratio(%) remains the lowest for Dyna_DVCastLayer scenario for any of vehicle densities .The figure(40) shows that Packet Delivery Ratio(%) for DV_Cast scenario is higher than Packet Delivery Ratio(%) for two scenarios (Dyna_DVCastLayer and Flooding) for any of vehicle densities during the early morning or late night hours .While Packet Delivery Ratio(%) for Flooding scenario remains the lowest for any of vehicle densities during the early morning or late night hours .The figure(41) shows that average Times Into Back off value for DV_Cast scenario is higher than average Times Into Back off value for two scenarios (Dyna_DVCastLayer and Flooding) for any of vehicle densities during the early morning or late night hours and this value gradually decreases with the increasing in the density of the vehicles because it should wait for sending Hello messages that are sent every 1Hz and therefore the waiting period is long, therefore number of times a vehicle invoked Contention Windows will be big ,so average Times Into Back off value for DV_Cast scenario is the highest while sending Hello messages in Dyna_DVCastLayer scenario depends on the issue of distance, and therefore the waiting period is short, and then data is sent (broadcasted) within ROI depending on the flow chart shown in figure(19) for DV_Cast and Dyna_DVCastLayer scenarios. As for Flooding scenario, there are no Hello messages to send, and there is no waiting period but only data is sent to Total geographical area When the vehicle wants to change the route or when the vehicle is in the accident state, and the process of sending it does not depend on the flowchart shown in figure(19).The figure(42) shows that average CO2 Emission value in Flooding scenario is higher than average CO2 Emission value in two scenarios (Dyna_DVCastLayer and DV_Cast with Cluster Radius=250) for any of vehicle densities during the early morning or late night hours because in Flooding Scenario , the vehicles are not confined within the ROI because We studied the total geographical area (X=7942m, Y=4901m , Z=4900m) for any of vehicle densities.Where average CO2 Emission value for DV_Cast scenario equals to average CO2 Emission value for Dyna_DVCastLayer scenario for any of vehicle densities within the same ROI. The figure(43) shows that average Slots Back off value for DV_Cast scenario is significantly higher than average Slots Back off value for two scenarios (Dyna_DVCastLayer and Flooding) for any of vehicle densities during the early morning or late night hours because it should wait for sending Hello messages that are sent every 1Hz and therefore the waiting period is long, therefore number of times a vehicle invoked Contention Windows will be big and this scenario needs more Slots Back off than Dyna_DVCastLayer and Flooding Scenarios .The figure(44) shows that average Total Busy Time(MAC) value in DV_Cast scenario is significantly higher than average Total Busy Time(MAC) value in two scenarios (Dyna_DVCastLayer and Flooding) for any of the vehicle densities during the early morning or late night hours because the channel is very busy for MAC Layer in this Scenario. The figure(45) shows that average Busy Time(PHY) value in DV_Cast scenario is significantly higher than average Busy Time(PHY) value in two scenarios (Dyna_DVCastLayer and Flooding) for any of the vehicle densities during the early morning or late night hours because the channel is very busy for physical Layer in this Scenario .

4.4 Performance Evaluation of DV-CAST Protocol for DV_Cast && Dyna_DVCastLayer With Cluster Radius=250 applied on the axis X &&Flooding_DV_Cast Scenarios in VANET Network consists of (100,150,200,250vehicles) During Rush Hours using (I-90) Highway without Obstacles for previous Metrics:

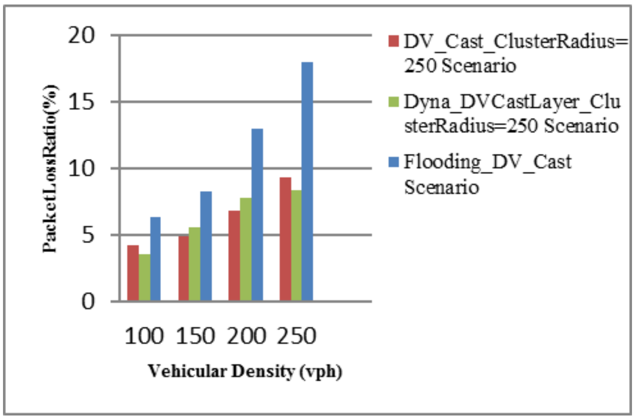


Figure (46) Packet Loss Ratio(%)V. Vehicular Density (vph)

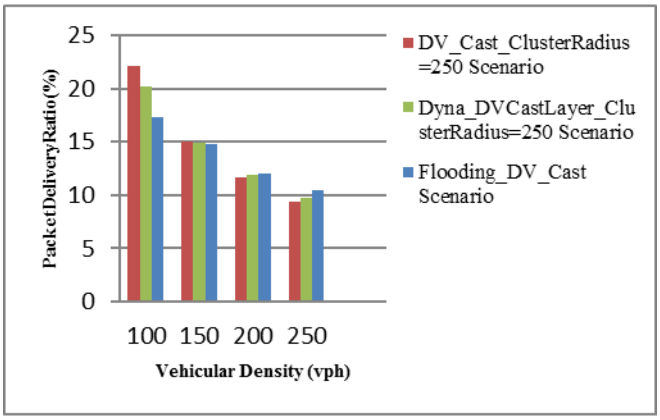


Figure (47) Packet Delivery Ratio(%)V. Vehicular Density (vph)

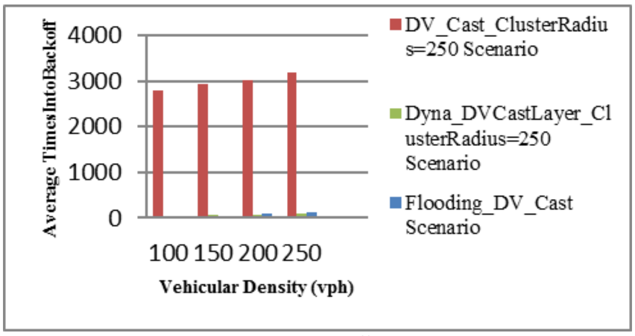


Figure (48) Average Times Into Back off V. Vehicular Density (vph)

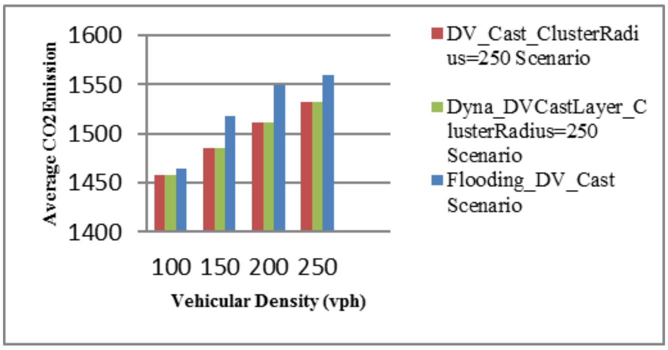


Figure (49) Average CO2 Emission V. Vehicular Density (vph)

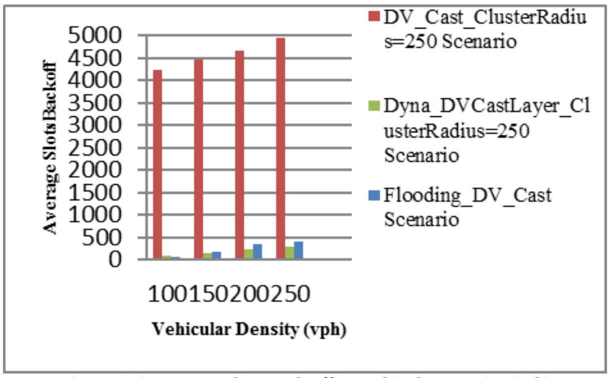


Figure (50) Average Slots Back off V. Vehicular Density (vph)

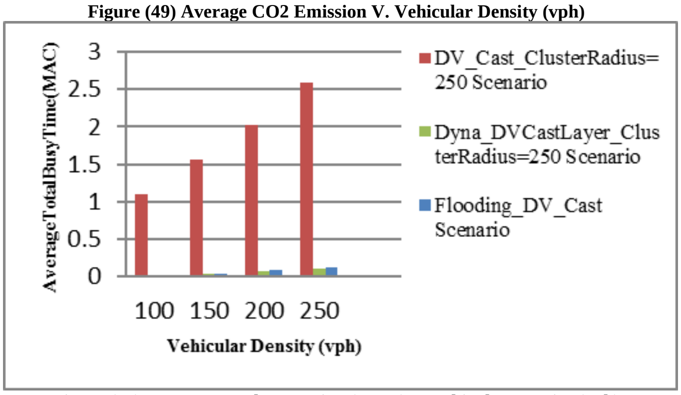


Figure (51) Average Total Busy Time(MAC)V. Vehicular Density (vph)

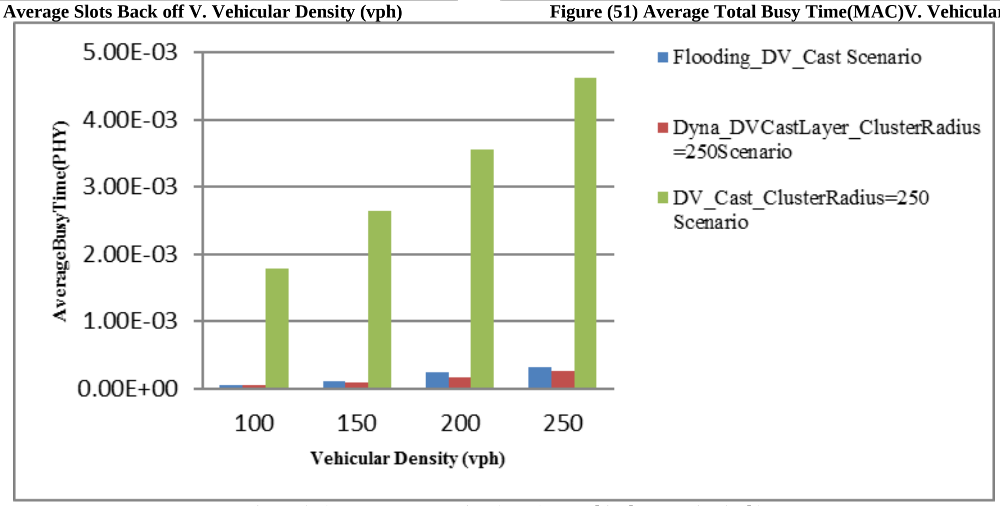


Figure (52) Average Busy Time(PHY) V. Vehicular Density (vph)

Figures(46),(47),(48),(49),(50),(51),(52) show Packet Loss Ratio(%),Packet Delivery Ratio(%), Average Times Into Back off ,Average CO2 Emission, Average Slots Back off, Average Total Busy Time(MAC),Average Busy Time(PHY) V. vehicle density(vph) respectively used in the simulation for DV_Cast and Dyna_DVCastLayer with Cluster Radius=250 and Flooding_DV_Cast Scenarios during Rush hours.The figure (46) shows that Packet Loss Ratio(%) is higher for Flooding scenario than Packet Loss Ratio(%) for two scenarios (Dyna_DVCastLayer and DV_Cast) for any of vehicle densities during Rush hour .The figure (47) shows that Packet Delivery Ratio(%) in DV_Cast scenario is higher than Packet Delivery Ratio(%) for two scenarios (Dyna_DVCastLayer and Flooding),but with increasing in the density of the vehicles ,then Packet Delivery Ratio(%) is equal for all Scenarios, until the vehicle density reaches to 250vph, then Packet Delivery Ratio(%) is higher for flooding Scenario than Packet Delivery Ratio(%) for two scenarios (Dyna_DVCastLayer and DV_Cast) during Rush Hours. The figure (48) shows that average Times Into Back off value for DV_Cast scenario is significantly higher than average Times Into Back off value for two scenarios (Dyna_DVCastLayer and Flooding) for any of vehicle densities during Rush hours because in DV_Cast scenario should wait for sending Hello messages that are sent every 1Hz and therefore the waiting period is long, therefore number of times a vehicle invoked Contention Windows will be big ,so average Times Into Back off value for DV_Cast scenario is the highest . The figure (49) shows that average CO2 Emission value for Flooding scenario is higher than average CO2 Emission value for two scenarios (Dyna_DVCastLayer and DV_Cast) for the same Cluster Radius, which equals to 250 and the same ROI during Rush hours because in Flooding Scenario , the vehicles are not confined within the ROI because We studied the total geographical area (X=7942m, Y=4901m , Z=4900m) for any of vehicle densities Where average CO2 Emission value for DV_Cast scenario equals to average CO2 Emission value for Dyna_DVCastLayer scenario for any of vehicle densities within the same ROI,but average CO2 Emission value increases with increasing the density of the vehicles for all Scenarios.The figure (50) shows that average Slots Back off value for DV_Cast scenario is significantly higher than average Slots Back off value for two scenarios (Dyna_DVCastLayer and Flooding) for any of vehicle densities during Rush hours, for the same Cluster Radius, which equals to 250 and the same ROI for two scenarios (DV_Cast and Dyna_DVCastLayer) because in DV_Cast scenario should wait for sending Hello messages that are sent every 1Hz and therefore the waiting period is long, therefore number of times a vehicle invoked Contention Windows will be big and this scenario needs more Slots Back off than Dyna_DVCastLayer and Flooding Scenarios.The figure (51) shows that average Total Busy Time(MAC) value for DV_Cast scenario is significantly higher than average Total Busy Time(MAC) value for two scenarios (Dyna_DVCastLayer and Flooding) for any of the vehicle densities during Rush hours for the same Cluster Radius Which equals to 250 and the same ROI for the two scenarios DV_Cast and Dyna_DVCastLayer because the channel is very busy for MAC Layer in this scenario. The figure (52) shows that average Busy Time(PHY) value for DV_Cast scenario is significantly higher than average Busy Time(PHY) value for two scenarios (Dyna_DVCastLayer and Flooding) for any of the vehicle densities during Rush hours for the same Cluster Radius which equals to 250 and the same ROI for two scenarios (DV_Cast and Dyna_DVCastLayer) because the channel is very busy for physical layer in this scenario.

4.5 Comparison and Performance Evaluation of DV-CAST Protocol for DV_Cast Scenario With Cluster Radius=2450 applied on the axis Y between Early Morning or Late Night Hours and Rush Hours in VANET network consists of 100 vehicles using (I-90) Highway without Obstacles for previous Metrics:

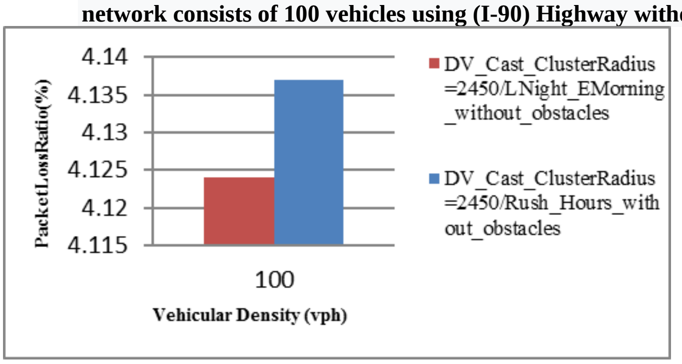


Figure (53) Packet Loss Ratio(%)V. Vehicular Density (vph)

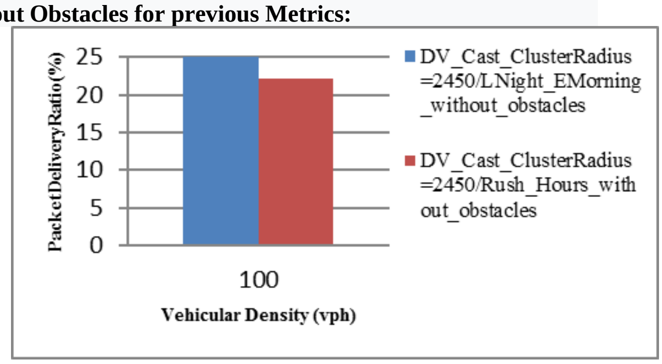


Figure (54) Packet Delivery Ratio(%)V. Vehicular Density (vph)

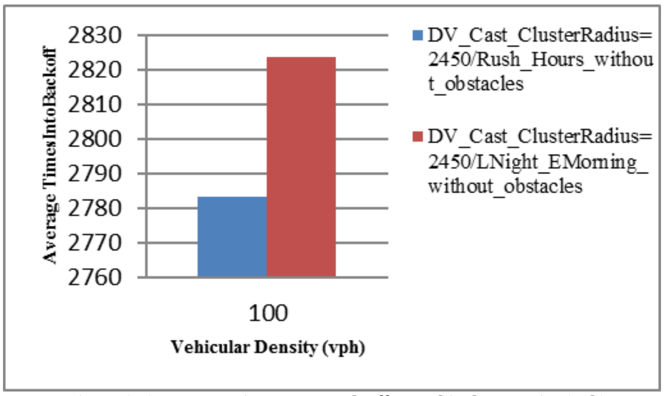


Figure (55) Average Times Into Back off V. Vehicular Density (vph)

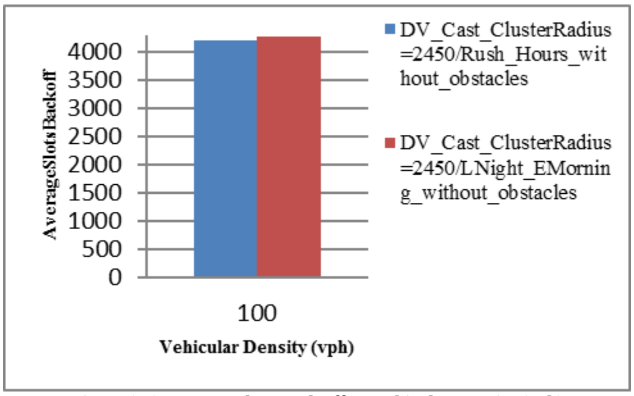


Figure (56) Average Slots Back off V. Vehicular Density (vph)

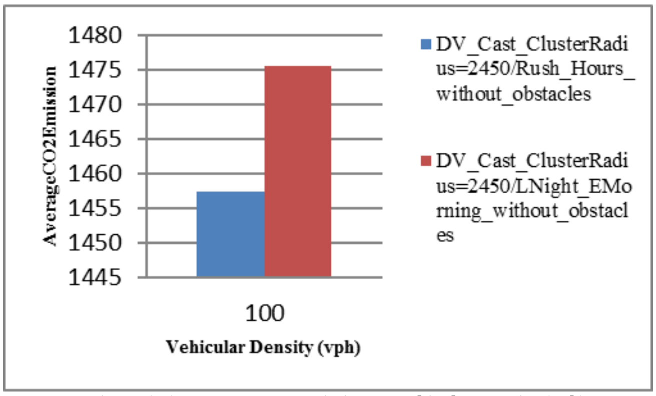


Figure (57) Average CO2 Emission V. Vehicular Density (vph)

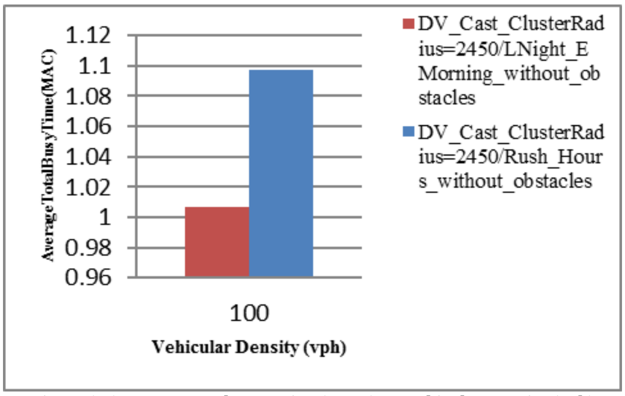


Figure (58) Averag Total Busy Time(MAC) V. Vehicular Density (vph)

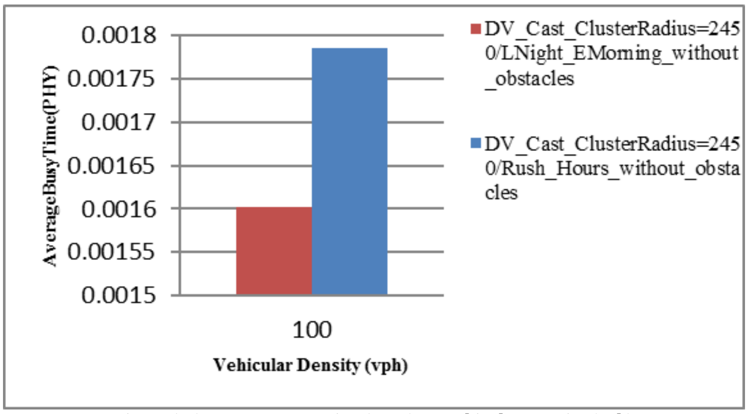


Figure (59) Average Busy Time(PHY) V. Vehicular Density (vph)

Figures(53),(54),(55),(56),(57),(58),(59) show Packet Loss Ratio(%),Packet Delivery Ratio(%), Average Times Into Back off, Average Slots Back off, Average CO2 Emission, Average Total Busy Time(MAC),Average Busy Time(PHY) V. vehicle density(vph) respectively used in the simulation during the early morning or late night hours or Rush hours for DV_Cast Scenario with Cluster Radius=2450 for 100vph vehicle density. The figure(53) shows that Packet Loss Ratio(%) in DV_Cast scenario with Cluster Radius=2450 at peak hours is higher than Packet Loss Ratio(%) for the same scenario during the early morning or late night hours for 100vph vehicle density . The figure(54) shows that Packet Delivery Ratio(%) in DV_Cast scenario with Cluster Radius=2450 during the early morning or late night hours is higher than Packet Delivery Ratio(%) for the same scenario at peak hours(Morning Rush) for 100vph vehicle density . The figure(55) shows that Average Times Into Back off value in DV_Cast scenario with Cluster Radius=2450 during the early morning or late night hours is higher than Average Times Into Back off value for the same scenario at peak hours(Morning Rush) for 100vph vehicle density .The figure(56) shows that Average Slots Back off value in DV_Cast scenario with Cluster Radius=2450 during the early morning or late night hours is higher than Average Slots Back off value for the same scenario at peak hours(Morning Rush) for 100vph vehicle density . The figure(57) shows that Average CO2 Emission value in DV_Cast scenario with Cluster Radius=2450 during the early morning or late night hours is higher than Average CO2 Emission value for the same scenario at peak hours(Morning Rush) for 100vph vehicle density . The figure(58) shows that Average Total Busy Time(MAC) value in DV_Cast scenario with Cluster Radius=2450 at peak hours(Morning Rush) is higher than Average Total Busy Time(MAC) value for the same scenario during the early morning or late night hours for 100vph vehicle density . The figure(59) shows that Average Busy Time(PHY) value in DV_Cast scenario with Cluster Radius=2450 at peak hours(Morning Rush) is higher than Average Busy Time(PHY) value for the same scenario during the early morning or late night hours for 100vph vehicle density .

4.6 Comparison and Performance Evaluation of DV-CAST Protocol for DV_Cast Scenario With Cluster Radius=250 applied on the axis X between Early Morning or Late Night Hours and Rush Hours in VANET network consists of 100 vehicles using (I-90) Highway without Obstacles for previous Metrics:

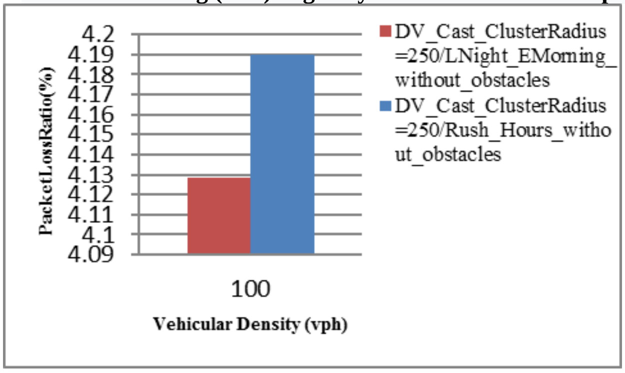


Figure (60) Packet Loss Ratio(%)V. Vehicular Density (vph)

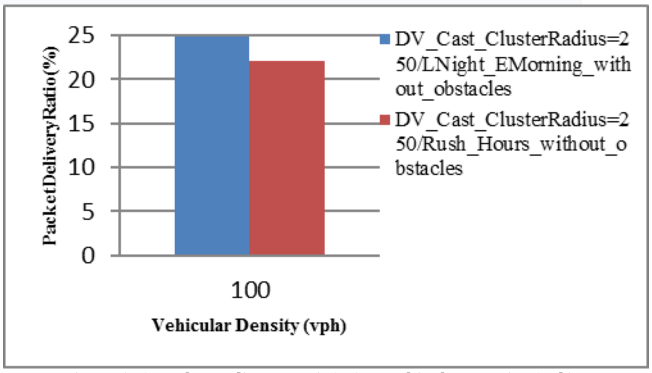


Figure (61) Packet Delivery Ratio(%)V. Vehicular Density (vph)

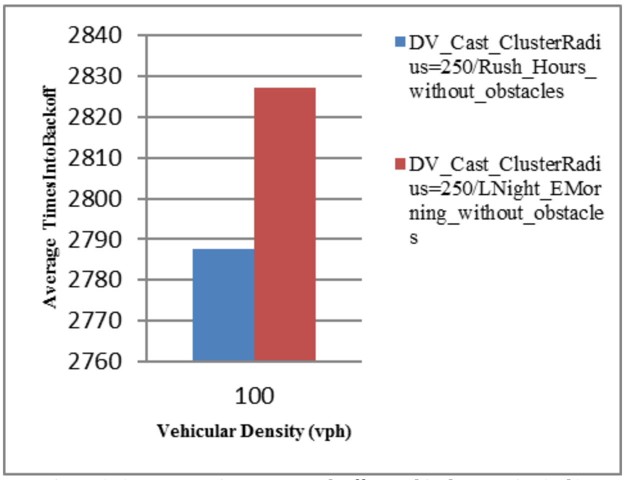


Figure (62) Average Times Into Back off V. Vehicular Density (vph)

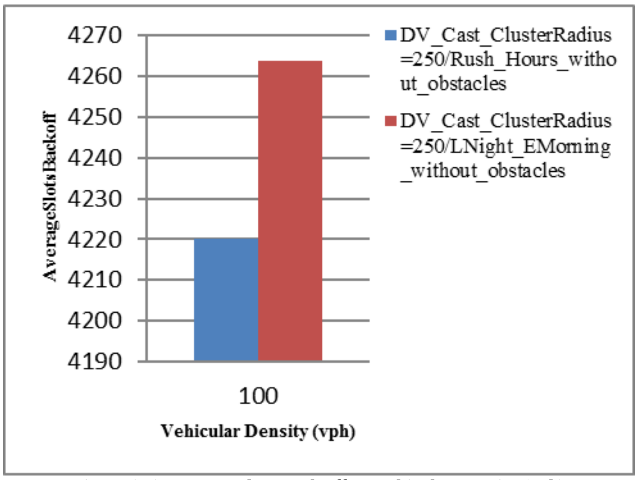


Figure (63) Average Slots Back off V. Vehicular Density (vph)

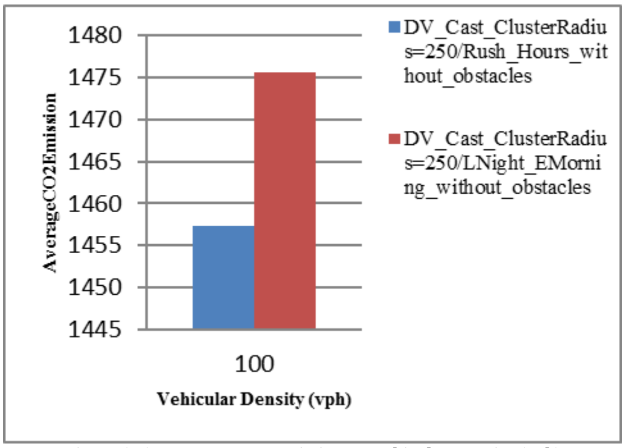


Figure (64) Average CO2 Emission V. Vehicular Density (vph)

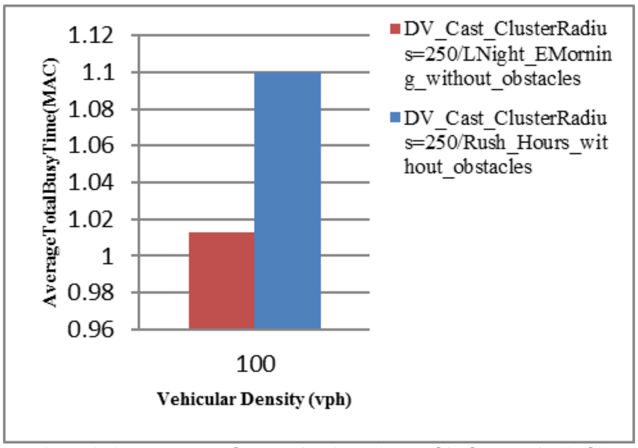


Figure (65) Average Total Busy Time(MAC) V. Vehicular Density (vph)

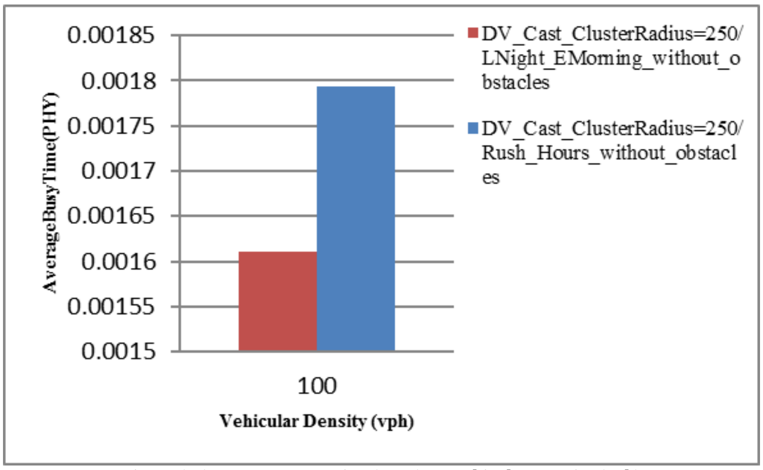


Figure (66) Average Busy Time(PHY) V. Vehicular Density (vph)

Figures(60),(61),(62),(63),(64),(65),(66) show Packet Loss Ratio(%),Packet Delivery Ratio(%), Average Times Into Back off, Average Slots Back off, Average CO2 Emission, Average Total Busy Time(MAC),Average Busy Time(PHY) V. vehicle density(vph) respectively used in the simulation during the early morning or late night hours or Rush hours for DV_Cast Scenario with Cluster Radius=250 for 100vph vehicle density. The figure(60) shows that Packet Loss Ratio(%) in DV_Cast scenario with Cluster Radius=250 at peak hours is higher than Packet Loss Ratio(%) for the same scenario during the early morning or late night hours for 100vph vehicle density . The figure(61) shows that Packet Delivery Ratio(%) in DV_Cast scenario with Cluster Radius=250 during the early morning or late night hours is higher than Packet Delivery Ratio(%) for the same scenario at peak hours(Morning Rush) for 100vph vehicle density . The figure(62) shows that Average Times Into Back off value in DV_Cast scenario with Cluster Radius=250 during the early morning or late night hours is higher than Average Times Into Back off value for the same scenario at peak hours(Morning Rush) for 100vph vehicle density .The figure(63) shows that Average Slots Back off value in DV_Cast scenario with Cluster Radius=250 during the early morning or late night hours is higher than Average Slots Back off value for the same scenario at peak hours(Morning Rush) for 100vph vehicle density.The figure(64) shows that Average CO2 Emission value in DV_Cast scenario with Cluster Radius=250 during the early morning or late night hours is higher than Average CO2 Emission value for the same scenario at peak hours(Morning Rush) for 100vph vehicle density . The figure(65) shows that Average Total Busy Time(MAC) value in DV_Cast scenario with Cluster Radius=250 at peak hours(Morning Rush) is higher than Average Total Busy Time(MAC) value for the same scenario during the early morning or late night hours for 100vph vehicle density . The figure(66) shows that Average Busy Time(PHY) value in DV_Cast scenario with Cluster Radius=250 at peak hours(Morning Rush) is higher than Average Busy Time(PHY) value for the same scenario during the early morning or late night hours for 100vph vehicle density .

4.7 Comparison and Performance Evaluation of DV-CAST Protocol for Dyna_DVCastLayer Scenario With Cluster Radius=2450 applied on the axis Y between Early Morning or Late Night Hours and Rush Hours in VANET network consists of 100 vehicles using (I-90) Highway without Obstacles for previous Metrics:

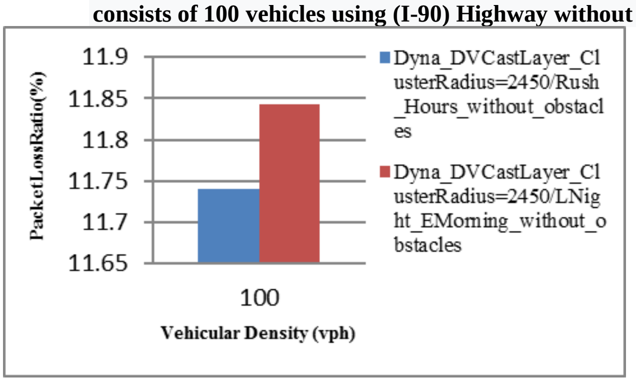


Figure (67) Packet Loss Ratio(%) V. Vehicular Density (vph)

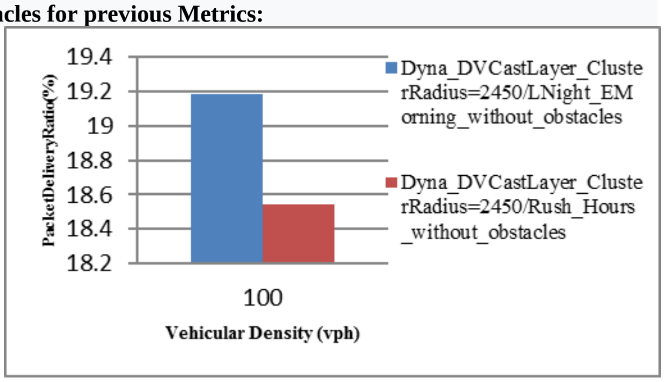


Figure (68) Packet Delivery Ratio(%) V. Vehicular Density (vph)

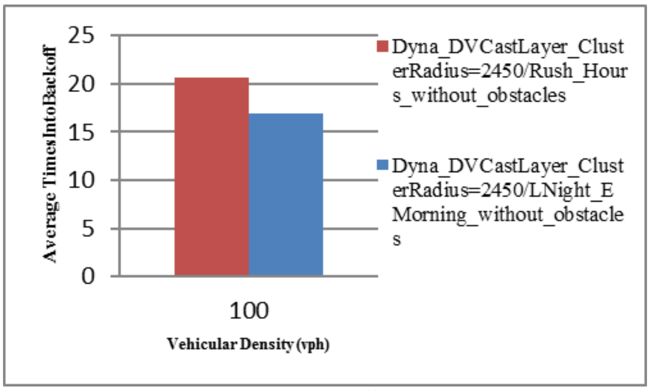


Figure (69) Average Times Into Back off V. Vehicular Density (vph)

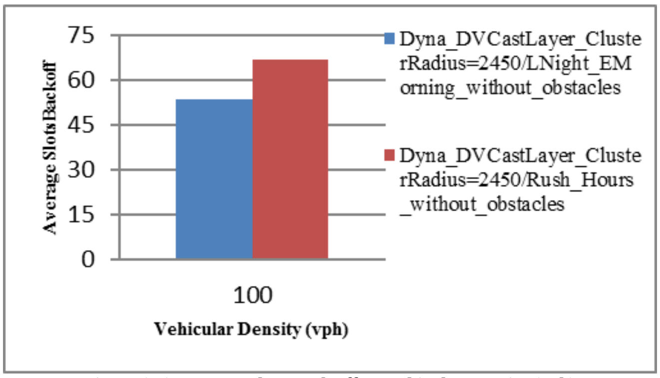


Figure (70) Average Slots Back off V. Vehicular Density (vph)

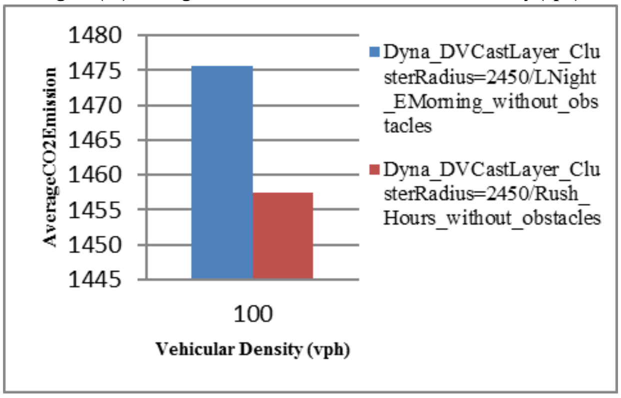


Figure (71) Average CO2 Emission V. Vehicular Density (vph)

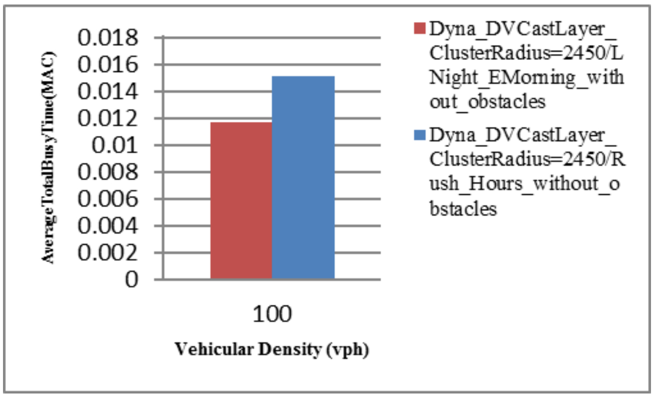


Figure (72) Average Total Busy Time(MAC) V. Vehicular Density (vph)

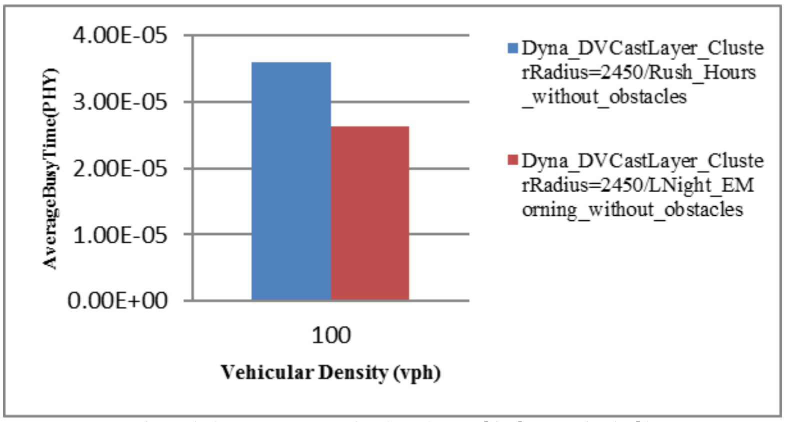


Figure (73) Average Busy Time(PHY) V. Vehicular Density (vph)

Figures(67),(68),(69),(70),(71),(72),(73) show Packet Loss Ratio(%),Packet Delivery Ratio(%), Average Times Into Back off , Average Slots Back off, Average CO2 Emission, Average Total Busy Time(MAC),Average Busy Time(PHY) V. vehicle density(vph) respectively used in the simulation during the early morning or late night hours or Rush hours for Dyna_DVCastLayer Scenario with Cluster Radius=2450 for 100vph vehicle density. The figure(67) shows that Packet Loss Ratio(%) for Dyna_DVCastLayer Scenario with Cluster Radius=2450 during the early morning or late night hours is higher with small value than Packet Loss Ratio(%) for the same scenario at peak hours for 100vph vehicle density.The figure(68) shows that Packet Delivery Ratio(%) for Dyna_DVCastLayer Scenario with Cluster Radius=2450 during the early morning or late night hours is higher than Packet Delivery Ratio(%) for the same scenario at peak hours(Morning Rush) for 100vph vehicle density . The figure(69) shows that Average Times Into Back off value for Dyna_DVCastLayer Scenario with Cluster Radius=2450 at peak hours(Morning Rush) is higher than Average Times Into Back off value for the same scenario during the early morning or late night hours for 100vph vehicle density .The figure(70) shows that Average Slots Back off value for Dyna_DVCastLayer Scenario with Cluster Radius=2450 at peak hours(Morning Rush) is higher than Average Slots Back off value for the same scenario during the early morning or late night hours for 100vph vehicle density . The figure(71) shows that Average CO2 Emission value for Dyna_DVCastLayer Scenario with Cluster Radius=2450 during the early morning or late night hours is higher than Average CO2 Emission value for the same scenario at peak hours(Morning Rush) for 100vph vehicle density . The figure(72) shows that

Average Total Busy Time(MAC) value for Dyna_DVCastLayer Scenario with Cluster Radius=2450 at peak hours(Morning Rush) is higher than Average Total Busy Time(MAC) value for the same scenario during the early morning or late night hours for 100vph vehicle density . The figure(73) shows that Average Busy Time(PHY) value for Dyna_DVCastLayer Scenario with Cluster Radius=2450 at peak hours(Morning Rush) is higher than Average Busy Time(PHY) value for the same scenario during the early morning or late night hours for 100vph vehicle density .

4.8Comparison and Performance Evaluation of DV-CAST protocol for Dyna_DVCastLayer Scenario With Cluster Radius=250 applied on the axis X between Early Morning or Late Night Hours and Rush Hours in VANET network consists of 100 vehicles using (I-90) Highway without Obstacles for previous Metrics:

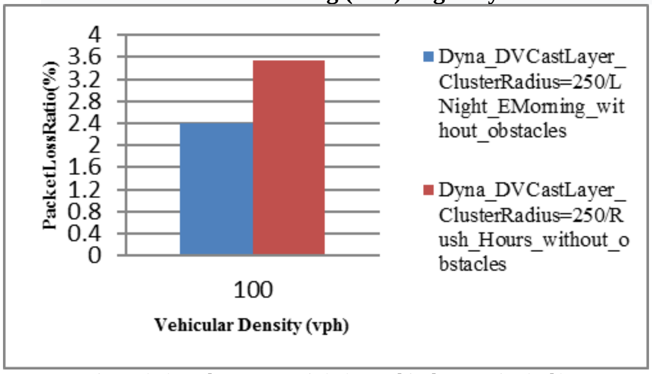


Figure (74) Packet Loss Ratio(%)V. Vehicular Density (vph)

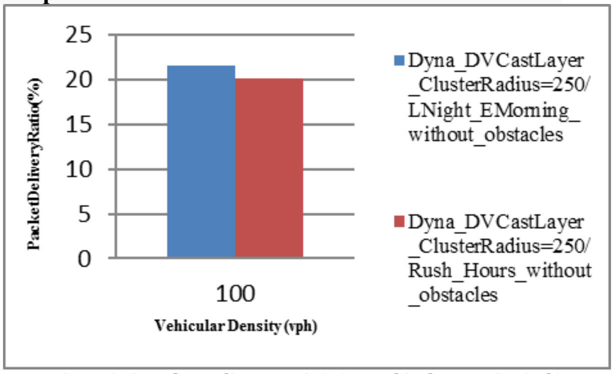


Figure (75) Packet Delivery Ratio(%)V. Vehicular Density (vph)

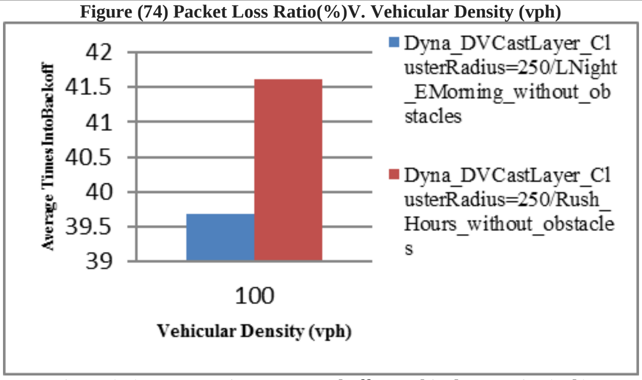


Figure (76) Average Times Into Backoff V. Vehicular Density (vph)

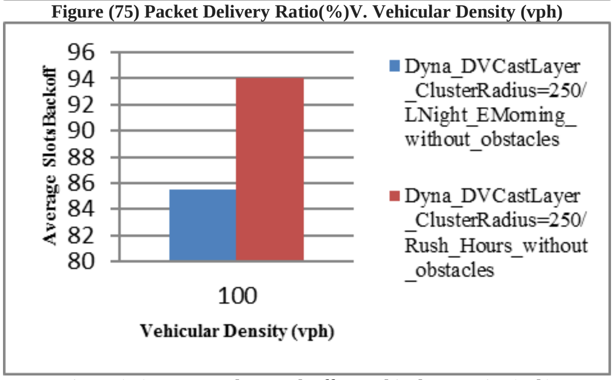


Figure (77) Average Slots Back off V. Vehicular Density (vph)

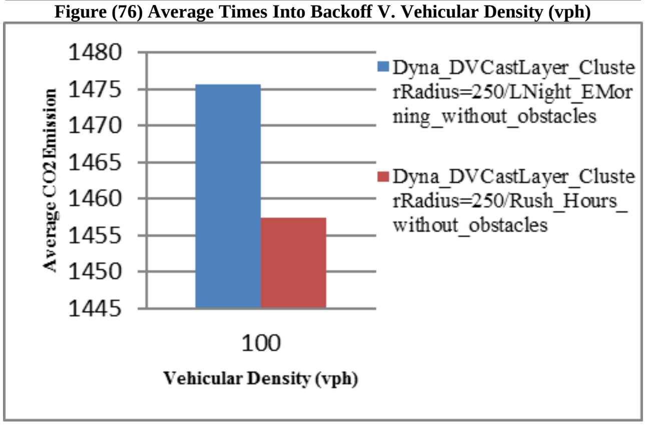


Figure (78) Average CO2 Emission V. Vehicular Density (vph)

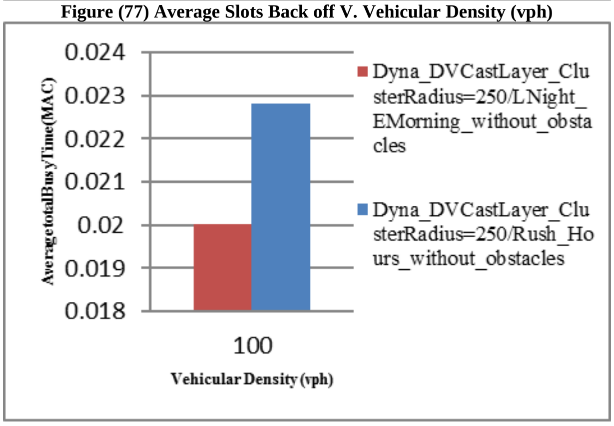


Figure (79) Average Total Busy Time(MAC)V. Vehicular Density (vph)

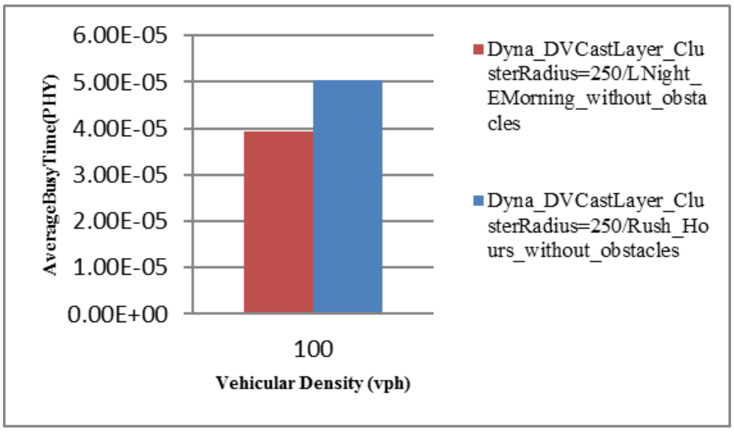


Figure (80) Average Busy Time(PHY) V. Vehicular Density (vph)

Figures(74),(75),(76),(77),(78),(79),(80) show Packet Loss Ratio(%),Packet Delivery Ratio(%), Average Times Into Back off, Average Slots Back off ,Average CO2 Emission, Average Total Busy Time(MAC),Average Busy Time(PHY) V. vehicle density(vph) respectively used in the simulation during the early morning or late night hours or Rush hours for Dyna_DVCastLayer Scenario with Cluster Radius=250 for 100vph vehicle density. The figure(74) shows that Packet Loss Ratio(%) for Dyna_DVCastLayer Scenario with Cluster Radius=250 at peak hours is higher than Packet Loss Ratio(%) for the same scenario during the early morning or late night hours for 100vph vehicle density . The figure(75) shows that Packet Delivery Ratio(%) for Dyna_DVCastLayer Scenario with Cluster Radius=250 during the early morning or late night hours is higher than Packet Delivery Ratio(%) for the same scenario at peak hours(Morning Rush) for 100vph vehicle density . The figure(76) shows that Average Times Into Back off value for Dyna_DVCastLayer Scenario with Cluster Radius=250 at peak hours(Morning Rush) is higher than Average Times Into Back off value for the same scenario during the early morning or late night hours for 100vph vehicle density . The figure(77) shows that Average Slots Back off value for Dyna_DVCastLayer Scenario with Cluster Radius=250 at peak hours(Morning Rush) is higher than Average Slots Back off value for the same scenario during the early morning or late night hours for 100vph vehicle density . The figure(78) shows that Average CO2 Emission value for Dyna_DVCastLayer Scenario with Cluster Radius=250 during the early morning or late night hours is higher than Average CO2 Emission value for the same scenario at peak hours(Morning Rush) for 100vph vehicle density . The figure(79) shows that Average Total Busy Time(MAC) value for Dyna_DVCastLayer Scenario with Cluster Radius=250 at peak hours(Morning Rush) is higher than Average Total Busy Time(MAC) value for the same scenario during the early morning or late night hours for 100vph vehicle density.The figure(80) shows that Average Busy Time(PHY) value for Dyna_DVCastLayer Scenario with Cluster Radius=250 at peak hours(Morning Rush) is higher than Average Busy Time(PHY) value for the same scenario during the early morning or late night hours for 100vph vehicle density .

4.9 Comparison and Performance Evaluation of DV-CAST Protocol for Flooding_DV_Cast Scenario between Early Morning or Late Night Hours and Rush Hours in VANET network consists of 100 vehicles using (I-90) Highway without Obstacles for previous Metrics:

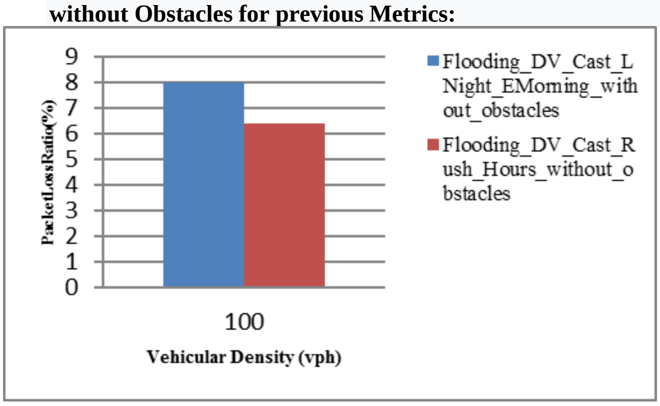


Figure (81) Packet Loss Ratio(%)V. Vehicular Density (vph)

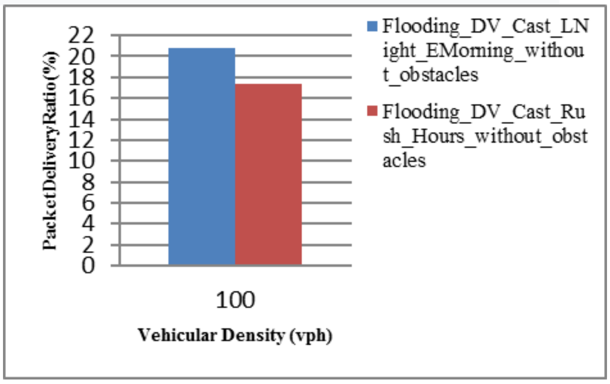


Figure (82) Packet Delivery Ratio(%)V. Vehicular Density (vph)

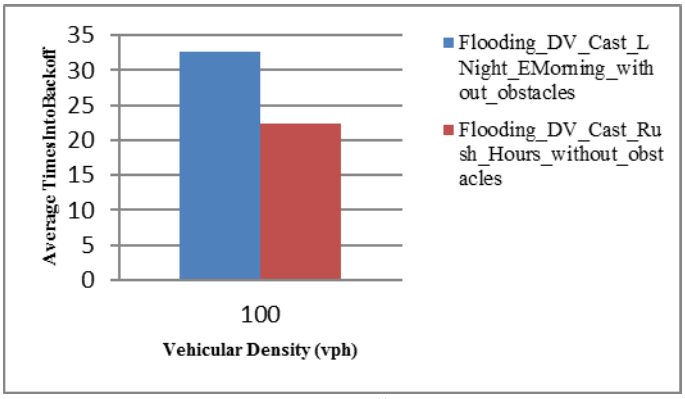


Figure (83) Average TimesIntoBackoff V. Vehicular Density (vph)

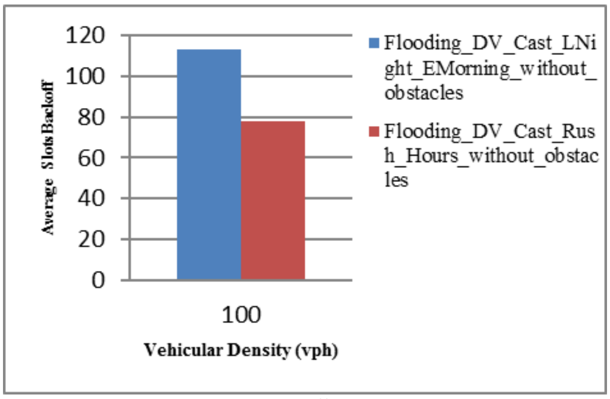


Figure (84) Average SlotsBackoff V. Vehicular Density (vph)

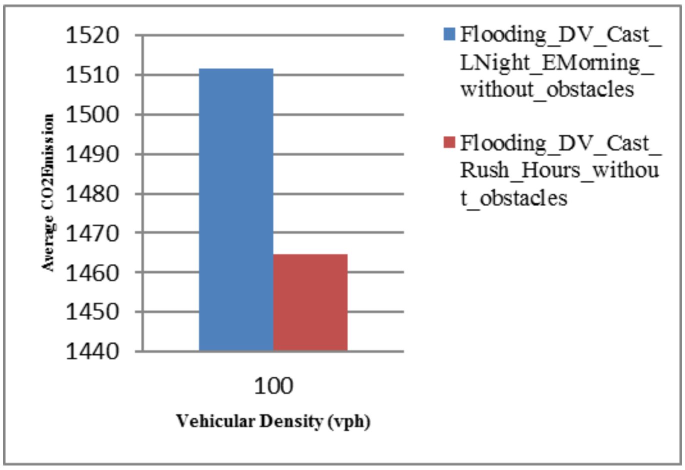


Figure (85) Average CO2 EmissionV. Vehicular Density (vph)

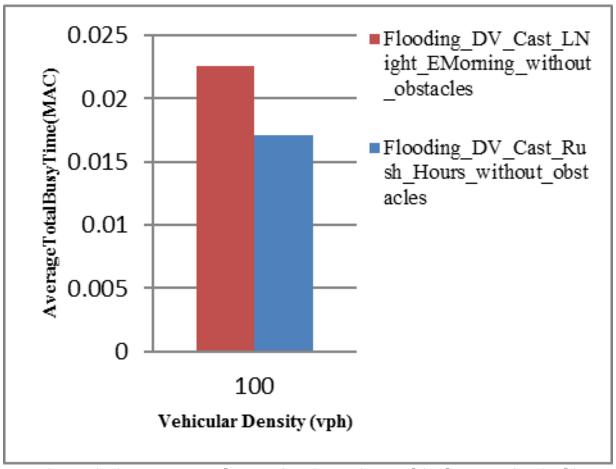


Figure (86) AveragTotalBusyTime(MAC)V. Vehicular Density (vph)

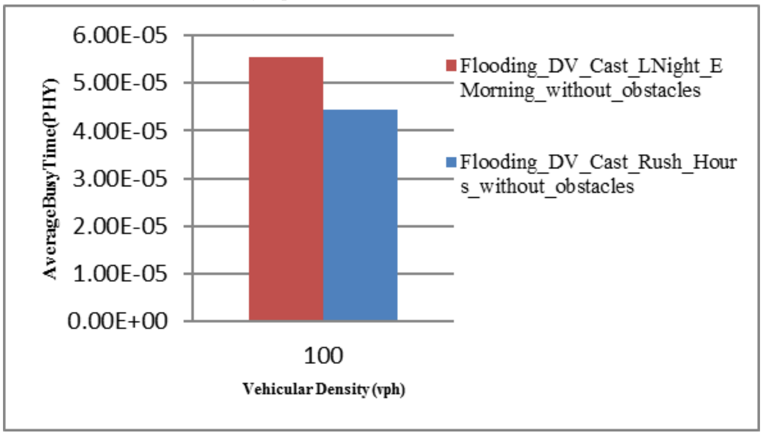


Figure (87) Average Busy Time(PHY) V. Vehicular Density (vph)

Figures(81),(82),(83),(84),(85),(86),(87) show Packet Loss Ratio(%),Packet Delivery Ratio(%), Average Times Into Back off, Average Slots Back off, Average CO2 Emission , Average Total Busy Time(MAC),Average Busy Time(PHY) V. vehicle density(vph) respectively used in the simulation for flooding Scenario during the early morning or late night hours or Rush hours for 100vph vehicle density. The figure(81) shows that Packet Loss Ratio(%) for flooding Scenario is higher during the early morning or late night hours than Packet Loss Ratio(%) for the same scenario at peak hours for 100vph vehicle density .The figure(82) shows that Packet Delivery Ratio(%) for flooding Scenario is higher during the early morning or late night hours than Packet Delivery Ratio(%) for the same scenario at peak hours(Morning Rush) for 100vph vehicle density.The figure(83) shows that Average Times Into Back off value for flooding Scenario is higher during the early morning or late night hours than Average Times Into Back off value for the same scenario at peak hours(Morning Rush) for 100vph vehicle density.The figure(84) shows that Average Slots Back off value for flooding Scenario is higher during the early morning or late night hours than Average Slots Back off value for the same scenario at peak hours(Morning Rush) for 100vph vehicle density .The figure(85) shows that Average CO2 Emission value for flooding Scenario is higher during the early morning or late night hours than Average CO2 Emission value for the same scenario at peak hours(Morning Rush) for 100vph vehicle density.The figure(86) shows that Average Total Busy Time(MAC) value for flooding Scenario is higher during the early morning or late night hours than Average Total Busy Time(MAC) value for the same scenario at peak hours(Morning Rush) for 100vph vehicle density.The figure(87) shows that Average Busy Time(PHY) value for flooding Scenario is higher during the early morning or late night hours than Average Busy Time(PHY) value for the same scenario at peak hours(Morning Rush) for 100vph vehicle density .

IV. CONCLUSION

In the first part and the second part of this article a comparison was made of evaluating the performance of DV-CAST protocol for three Scenarios (DV_Cast and Dyna_DVCastLayer with Cluster Radius=2450 or Cluster Radius=250, Flooding_DV_Cast) in VANET network during the early morning or late night hours or Rush Hours using (I-90) Highway without Obstacles for previous Metrics with different vehicular Densities as it was found that performance of DV-CAST protocol is better for DV_Cast Scenario with Cluster Radius=2450 or Cluster Radius=250 than the performance of DV-CAST protocol for Dyna_DVCastLayer Scenario with Cluster Radius=2450 or Cluster Radius=250 and Flooding_DV_Cast Scenario during the early morning or late night hours because Packet Delivery Ratio(%) in DV_Cast Scenario is the highest for different values of this metric with Cluster Radius=2450 or Cluster Radius=250 for any of vehicle densities . Whereas during Rush hours ,then Packet Delivery Ratio(%) is higher for DV_Cast scenario with Cluster Radius=2450 or Cluster Radius=250 than Packet Delivery Ratio(%) for two scenarios Dyna_DVCastLayer with Cluster Radius=2450 or Cluster Radius=250 and Flooding, but with increasing in the density of the vehicles,then Packet Delivery Ratio(%) is equal for all Scenarios, until 250vph vehicular density , then Packet Delivery Ratio(%) is higher for flooding Scenario than Packet Delivery Ratio(%) for two scenarios Dyna_DVCastLayer and DV_Cast with Cluster Radius=2450 or Cluster Radius=250).

As for the third part and the fourth part of the article , a comparison was made of evaluating the performance of DV-CAST protocol for DV_Cast Scenario with Cluster Radius=2450 or Cluster Radius=250 in VANET Network between the early morning or late night hours and Rush Hours using (I-90) Highway without Obstacles for previous Metrics with 100vph vehicular Density as it was found that performance of DV-CAST protocol is better in DV_Cast Scenario with Cluster Radius=2450 or Cluster Radius=250 for 100vph vehicular Density during the early morning or late night hours because Packet Delivery Ratio(%) in this scenario is higher than Packet Delivery Ratio(%) for the same scenario during Rush Hours with the same density.

As for the fifth part and the sixth part of the article , a comparison was made of evaluating the performance of DV-CAST protocol for Dyna_DVCastLayer Scenario with Cluster Radius=2450 or Cluster Radius=250 in VANET Network between the early morning or late night hours and Rush Hours using (I-90) Highway without Obstacles for previous Metrics with 100vph vehicular Density as it was found that performance of DV-CAST protocol is better for Dyna_DVCastLayer Scenario with Cluster Radius=2450 or Cluster Radius=250 for 100vph vehicular Density during the early morning or late night hours because Packet Delivery Ratio(%) in this scenario is higher than Packet Delivery Ratio(%) for the same scenario during Rush Hours with the same density.

As for the seventh part of the article , a comparison was made of evaluating the performance of DV-CAST protocol for Flooding_DV_Cast Scenario in VANET Network between the early morning or late night hours and Rush Hours using (I-90) Highway without Obstacles for previous Metrics with 100vph vehicular Density as it was found that performance of DV-CAST protocol is better for Flooding_DV_Cast Scenario for 100vph vehicular Density during the early morning or late night hours because Packet Delivery Ratio(%) in this scenario is higher than Packet Delivery Ratio(%) for the same scenario during Rush Hours with the same density.

FUTURE WORKS

In the future, We can think studying of evaluating the performance of DV-CAST protocol for three Scenarios : DV_Cast ,Dyna_DVCastLayer and Flooding_DV_Cast in VANET network during the early morning or late night hours and Rush Hours using Urban environments for previous Metrics with different vehicular Densities with applying specific algorithms. And We can also perform comparison of evaluating the performance of DV-CAST protocol for every Scenario in VANET network between the early morning or late night hours and Rush Hours using Urban environments for previous Metrics with specific vehicular Density .

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