# Performance Comparison of V2V and V2I Communication in VANET through Qualnet Simulator

[1]Rani Singh, [2]Anand Rajavat

Shri Vaishnav Institute of Information Technology
Shri Vaishnav Vidyapeeth Vishwavidyalaya, Indore, India

***Abstract-*** **VANET (vehicular ad-hoc network) is the core of intelligent vehicles. VANETs communicate in two modes V2V (vehicle to vehicle) and V2I (vehicle to infrastructure). The communication network formed in VANET ensures accuracy and security while the vehicles are moving on the road to increase road safety and decrease traffic congestion. This research aim is to analyze the two types of communication in VANET i.e. V2V and V2I. The simulations are performed using the network simulator, Qualnet. Based on the simulation result, the performance comparison of V2V and V2I is analyzed on the metrics like throughput, jitter, and end-to-end delay. According to the analyzed metrics, V2V communication shows a higher data rate compared to V2I communication. V2V provides another level of safety among the moving vehicles by allowing the vehicles to electronically communicate with each other while moving up to the range of 300 meters, even if the different objects are blocking the line-of-sight. The capability to see around all corners in V2V can enhance the safety features in various driving scenarios for VANET. Therefore V2V communication can be more preferable then V2I communication.**

***Index Terms-*** **VANET, Throughput, End-to-End Delay, Jitter, V2V, V2I**

## I. INTRODUCTION

In VANET, the environment changes constantly. VANET is the core of Intelligent Smart vehicles which will be part of IoT in the coming future. VANET is used to yield suitable wireless network services [1]. The evaluation and deployment of wireless communication systems have completely altered the life of common people by offering internet services and their various applications that ultimately made human life easy and flexible while travelling. In recent times, vehicles are not simply a vehicle which is used for transportation. VANET or Intelligent vehicles of today have On board Unit (OBU) as a wireless communication device installed in the vehicle as well as vehicles are also equipped with smart technologies that gives more sensing, processing, and communicating capabilities [2] in VANET. VANET ensures accuracy and security for communication in vehicle-to-vehicle (V2V) and vehicle-to-infrastructure (V2I) modes.

In VANETs mostly two types of communication take place, vehicle to vehicle (V2V) communication and vehicle to infrastructure (V2I) communication [4]. V2I is the communication between vehicles and RSUs (Road-Side Units). RSUs are strong computing device that are placed at several locations [3]. An RSU acts as a router in VANETs. RSUs are the backbones of this network for providing several services like it collects traffic data from the nearby road or static sensing area and forwarding those collected data to the traffic management centre. So it always causes too much traffic congestion in RSUs and base stations. RSUs are situated at a minimum distance of 2 to 5 km [4].

In VANET, the vehicle communicates with other vehicular user on road while travelling either for sharing safety or any urgent information. All information communicated in between the vehicles is stored in cloud server (traffic management system) through RSUs and base station. This information can be useful for other vehicles travelling with the same route. The RSUs can broadcast the information from cloud server through base station to all the vehicles within the range and the vehicles can further communicated it to those vehicles that are in its range. So this V2V and V2I communication is a good support for broadcasting the information's to the different vehicular user.

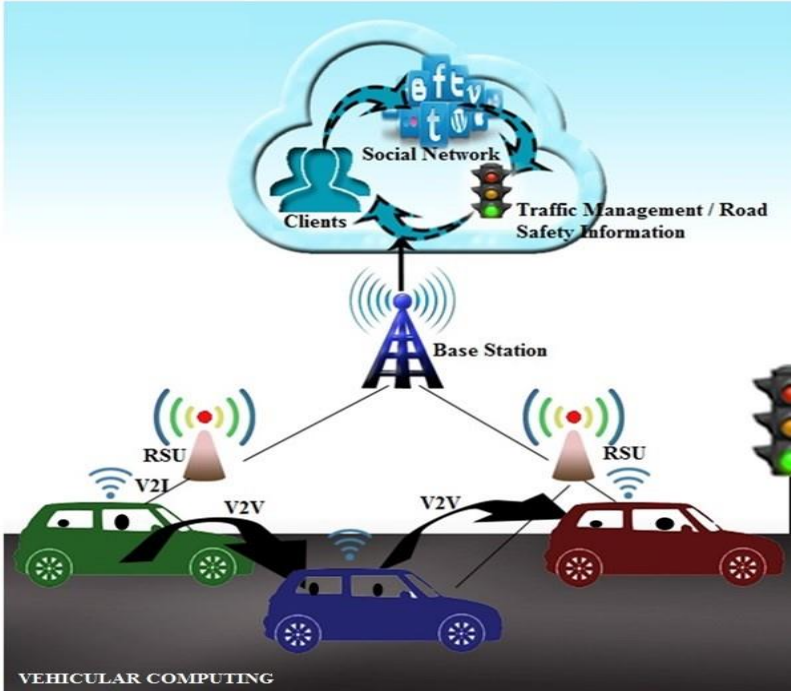

Fig 1: VANET Scenario

The objective of this research is to compare V2V and V2I communication on the parameters like throughput, jitter and end to end delay. This will make easier to decide, while the vehicles are communicating on road which communication mode to be used respective of the given parameter. As of today the biggest challenges in VANET is getting the safety and security messages as fast as possible. As in VANETs the mobile nodes (vehicles) are moving, so sending and receiving messages at right time and right place is very important.

This paper is organized as: section 2 discusses the related works; section 3 discuss the VANET scenario ; section 4 explains the performance comparison based on vehicular movement, section 5 gives the implementation results and section 6 concludes the paper with future scope.

## II. LITERATURE OF REVIEW

In [5] authors have compared AODV and DSR protocols on MANET Scenarios, under different performance metrics like throughput , packet drop rate and end to end delay.

In[6] authors investigated the connection between network algorithm and social behaviour in respect of VSNs (Vehicular Social Networks). Centrality concept has been introduced for Dynamic Bandwidth Allocation (DBA) in this paper. Simulation results have measured the performance in terms of throughput and average queuing delay based on the proposed Quality of Service (QoS)-aware DBA algorithm. In [7] authors have discussed the security issues for real time Vehicular Cloud Service (VCS) which combines the security issues of Body Area Sensor Network (BASN), smart phones, and V2V authentication and authorization. Three-Tier Vehicular Cloud architecture has been proposed in this paper. This paper has also introduced special concept of real time VCS like health care, resource sharing, parking, dinning etc. For the purpose of improvement in public safety and road traffic optimization, an authentication protocol is proposed in [8] based on one-way hash chain. This scheme is applicable for both V2V and V2I communications to achieve security and privacy. In [9] the paper focuses on the performance analysis of VANET in different Traffic scenarios, different routing protocols are used for comparative analysis like AODV, DSR, OLSR and AODVUU. A reverse back-off strategy is proposed in [10] for enhancing road safety in VANET. A vehicle in a network generates messages of various priorities. To deal with this problem, a prioritized gossip algorithm is developed in [11].

Vehicles of today are not simply a vehicle which is used for transportation form one place to another rather vehicles are equipped with smartphones that have more sensing, processing, and communicating capabilities [12]. In [13] the mapping scheme for the V-track system is based on the Markov model and Viterbi decoding scheme is used for estimating travel time. In [13] researchers have investigated the performance analysis of different protocols for V2V and V2I communication, The DSR routing protocol performs better than the FSR routing protocols in both V2V and V2I network models for throughput and end-to-end delays in all scenarios.

In [14] researchers have done a comparative analysis on vehicular safety on two network simulation tool NS3 and Vein. For comparative analysis three metrics was considered like packet inter-reception time, packet delivery rate, and maximum communication range. In [15] researchers have presented a short summary for all the routing protocol (proactive, reactive and hybrid routing protocols) which is used in VANETs, with their merits and demerits. Firstly, a Homogeneous Continuous-Time Markov Chain (HCTMC)-based security state model is designed for VANET. The value of each state of the HCTMC is determined with a value function that incorporates the security strength of transmitted data, dynamic and randomness of the vehicular channel, and transmission delay of the current situated environment of VANETs [16]. L. Xie [17] investigated the security and privacy issue in the transportation system and the vehicular IoT environment in SDN-enabled 5G-VANET.

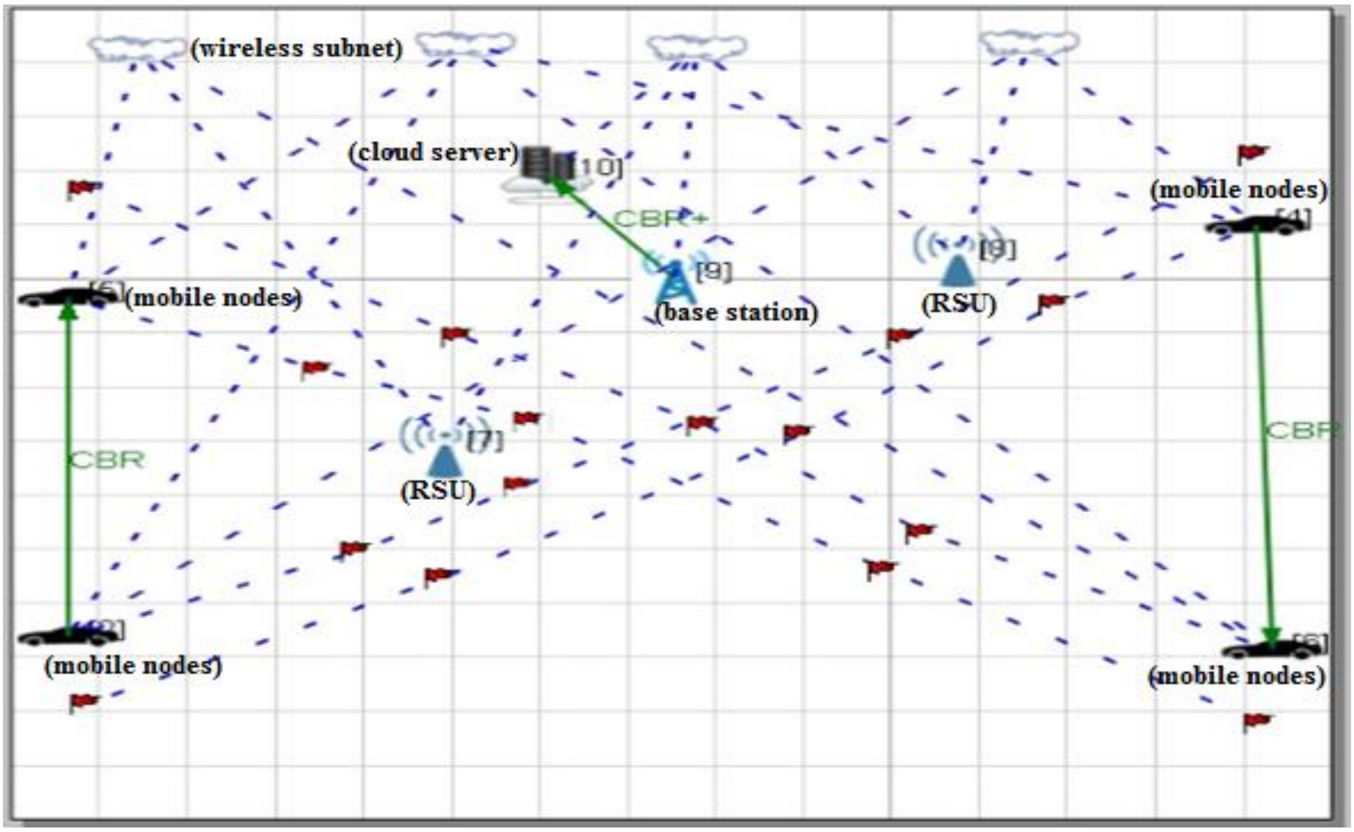


Fig 2. Architect module of QualNet showing the simulation scenario including 4 vehicle nodes, 1 base station, 2 RSUs, and 1 cloud server.

## III. VANET SCENARIO

According to the scenario presented in Fig 2, the vehicles are connected to form a network for sharing data. The movements of the vehicles are shown using mobility waypoints. There are RSUs at regular intervals. The RSUs are connected to WiMAX base station. The vehicles are connected to the cloud via the RSUs and base station. CBR (Constant Bit Rate) links has been defined between the vehicles. The vehicles connect with other vehicles wirelessly when they are in signal range of each other. When the vehicles come within the signal range of the RSUs, they can connect to the internet via the base station.

The parameters which have been used in QualNet while simulating VANET scenario are given in Table 1

| | |
|---|---|
| **Network Simulator** | **Qualnet 7.1** |
| **Dimension of space** | **1500m ✕ 1500m** |
| **Simulation Time** | **1000 sec** |
| **Item Size** | **512 bytes** |
| **Number Of Channels** | **3** |
| **Routing Protocol** | **AODV** |
| **MAC Protocol for RSUs** | **802.11** |
| **MAC protocol For Base Station** | **802.16** |
| **Application Used** | **CBR** |

Table 1: Scenario Parameter Values

In Fig.2, four vehicles move according to the mobility waypoints. The routing protocol used is AODV because on-demand paths are established between the vehicles. Fig.3 shows the simulation of VANET where nodes 2,5,6,4 are the vehicles, nodes 7,8 are the RSUs, node 9 is the WiMAX base station and node 10 is the cloud server can be considered as a Traffic Management system[20].

Constant Bit Rate (CBR) is a traffic generator which is a UDP-based client-server application that sends data from client to server at a constant bit. CBR links have been defined between the vehicles. Here the client may be vehicles and servers may be the vehicle itself or RSUs or base stations.

Two different scenarios have been considered here, in the first scenario the vehicles are kept closer to each other by adjusting the mobility way point. For vehicular node 4, 2 (CBR client node) and vehicular node 5,6 (CBR server node)), the mobility way point is adjusted in such a manner that these vehicle communicate with each other in V2V communication mode and in the next scenario the mobility way points of the vehicles are adjusted in such a way that it communicate with RSUs (V2I ).V2V or V2I communication takes place with the help of a special device, installed in vehicles i.e. OBU.

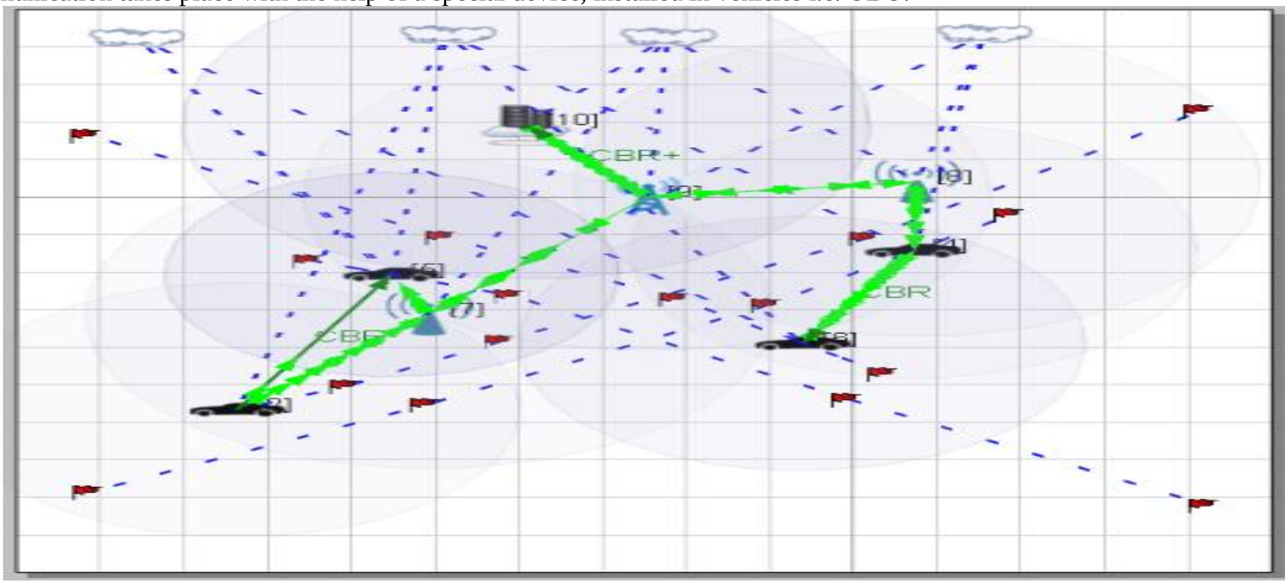


Fig.3 Architect module of QualNet showing the simulation scenario of VANET communication

To study the performance of VANET, depending on parameters like throughput, end-to-end delay, and jitter, a network simulation is performed using QualNet network simulator. After the simulation, performance analysis of the CBR clients and the servers has been performed. The values of the Quality of Service (QoS) parameters: throughput, average jitter and average delay have been observed from the statistics generated after the simulation.

## IV. PERFORMANCE COMPARISON BASED ON VEHICULAR MOVEMENT

In this paper a performance comparison based on vehicle movements by changing the waypoint arrival time of the vehicles is done, by adjusting the waypoint arrival time of the vehicles which leads to a variation in the time duration for which the vehicles are in the signal range of each other. This in turn affects the data received by the CBR server.

In the first case, the waypoint arrival time of all the vehicles 2,4,6 and 5 is set as 0, 100,300,500 and 800 seconds. Due to closer waypoints or arrival time of the vehicles, all the vehicles arrive at their waypoints at the same instant. When the way point arrival time set for the vehicles are less, then mostly vehicle to vehicle communication takes place i.e. vehicles moves within their ranges. In the second case, when the waypoint arrival time of vehicles 2 is set as 0, 100, 500, 1000 and 1500 seconds. The waypoint arrival time of the vehicle 5 ,2,4 is kept the same. Due to this the vehicles 2(CBR client) and 5(CBR server) moves at different instant at the waypoints. In such case, vehicles are not in range of each other. Vehicle communicates mostly via base stations and RSUs. So here V2I communication takes place.

Fig. 4 and Fig. 5 show the CBR data sent and received in the first case. Fig. 6 and Fig. 7 show the CBR data sent and received in the second case. In Fig.8 and Fig. 9 the graphs show the comparison between the data sent and received for the first and second cases respectively.

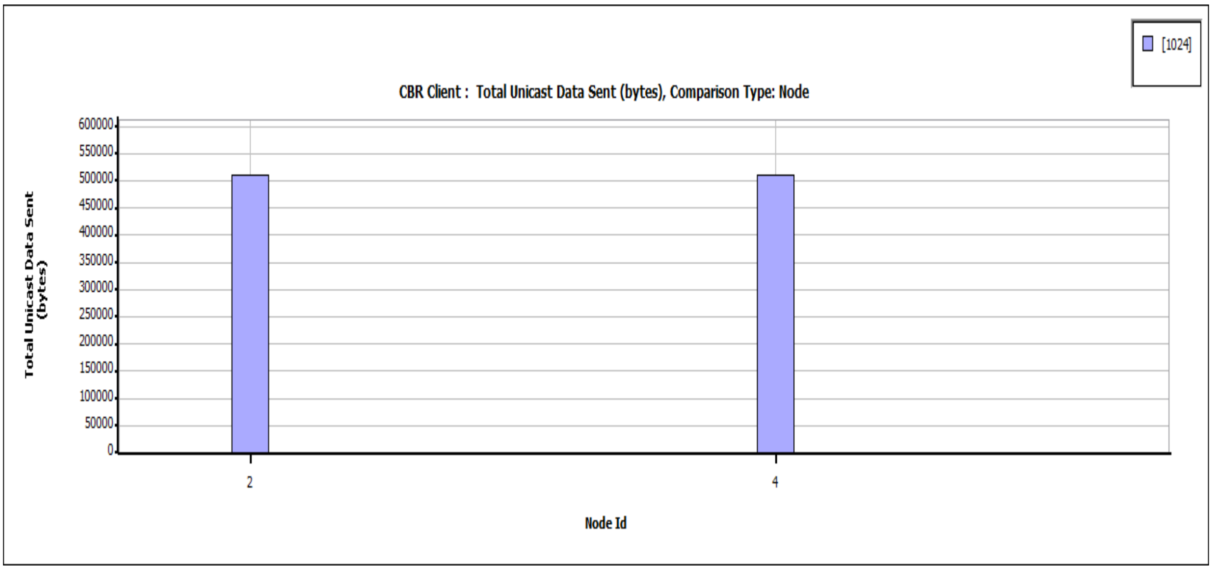


Fig.4 Total unicast data sent by the CBR client (nodes 2, 4). When the mobility waypoint is set as 0, 100,300,500, and 800 seconds.

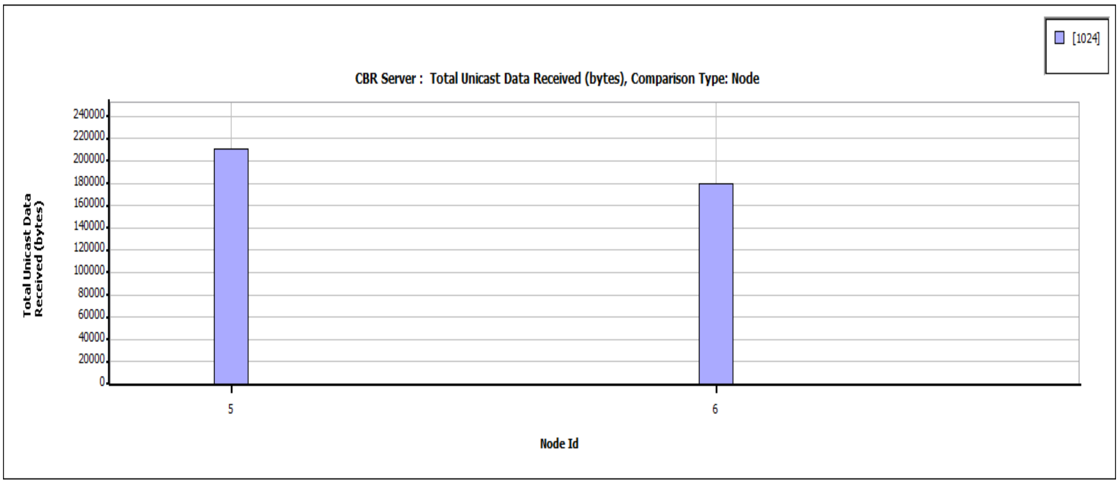


Fig.5 Total unicast data received by the CBR server (nodes 5, 6). When mobility waypoint is set as 0, 100, 300, 500, 800

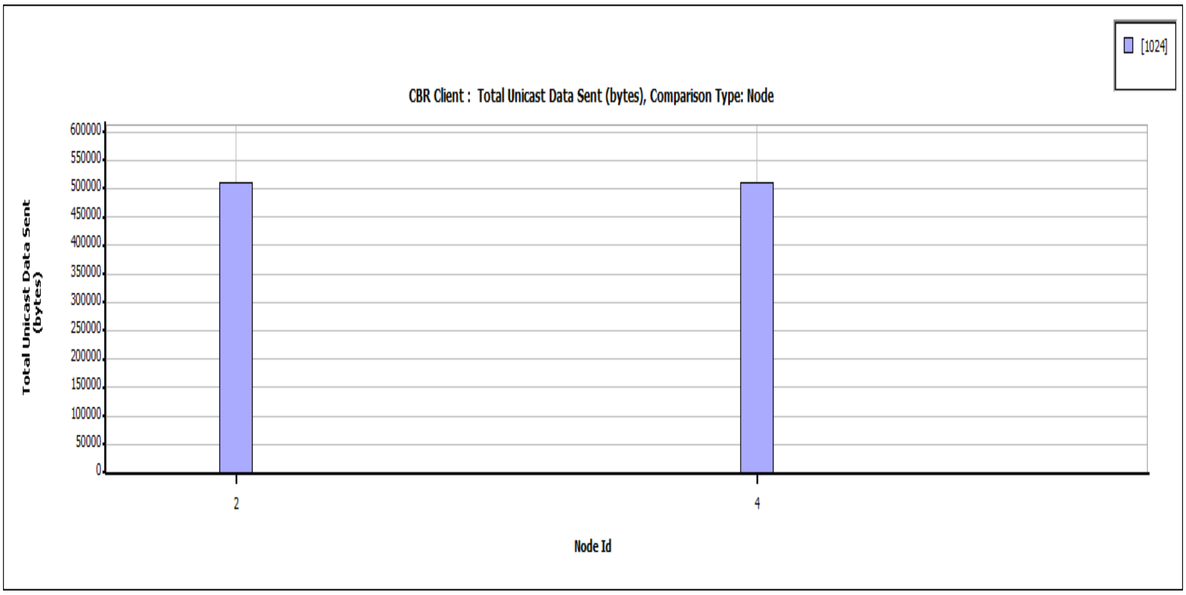


Fig. 6 Total unicast data sent by the CBR clients when the mobility waypoint is set 0, 100, 500, 1000 and 1500 seconds (for node 2).

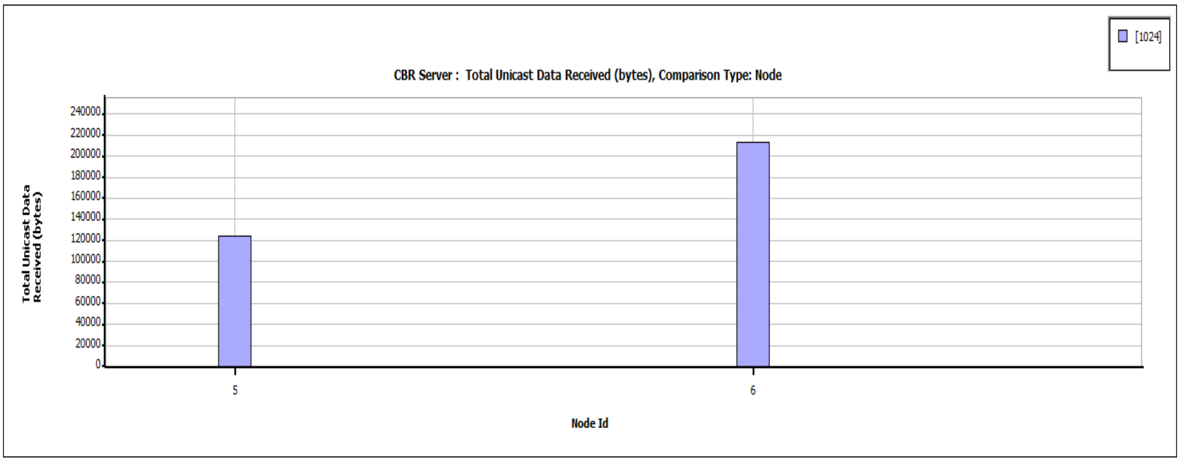


Fig.7 Total unicast data received by CBR server when the mobility is set as 0, 100, 500, 1000 and 1500 seconds.

From Fig.6 it is observed that the data received by node 5 is more when the waypoint arrival times of vehicles 2 and 5 same are. Fig. 7 depicts the second case where the arrival time at the waypoints is different for vehicles 2 and 5. It is seen that the data received by vehicle 5 is less in this case. This shows that when the vehicles are in the signal range of each other data sharing is more efficient.

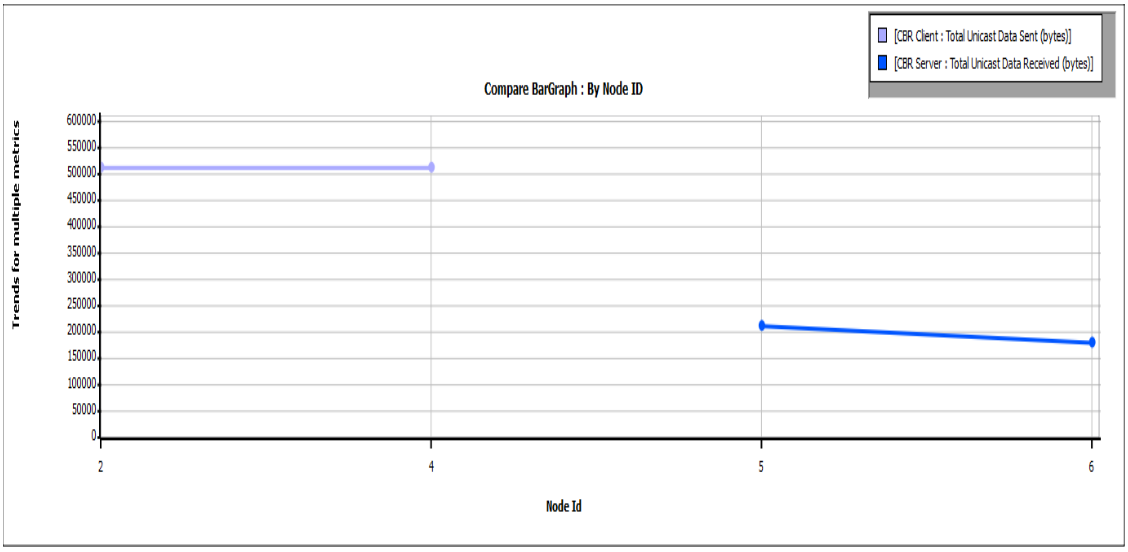


Fig.8 Comparison between data sent (node 2, 4) and received (node 5, 6) between the CBR server and client when the mobility waypoints in set as0, 100,300,500 and 800 seconds

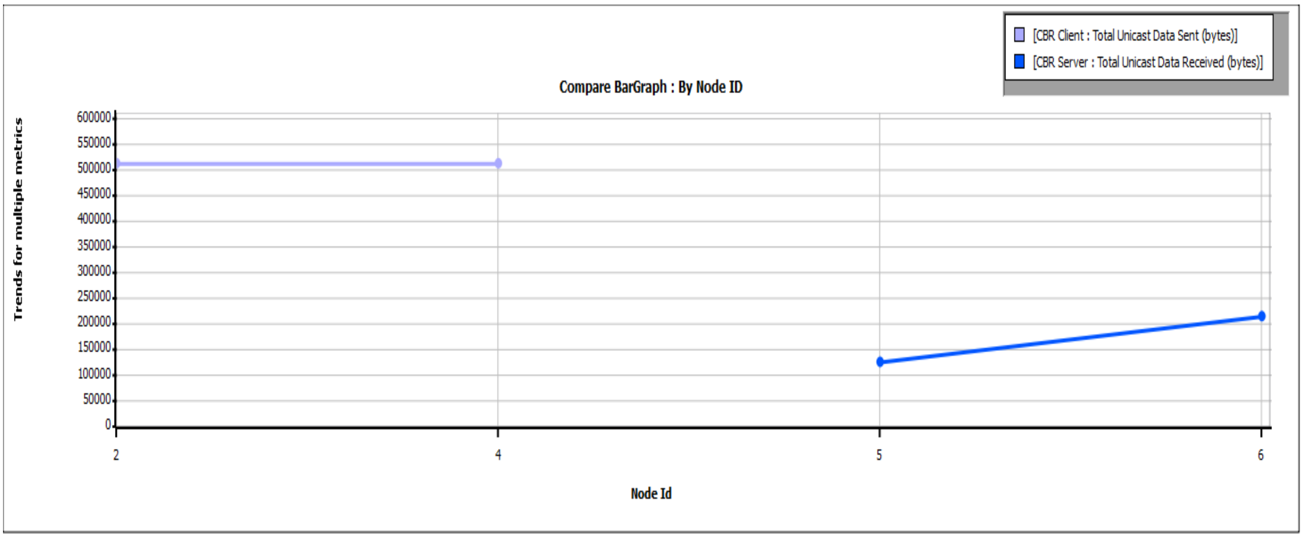


Fig.9 Comparison between data sent and received between CBR server and client when the ways points are set as 0, 100, 500, 1000 and 1500 seconds.

## V. IMPLEMENTATION RESULT

Average End-to-End Delay

The end-to-end delay gives the measure of time taken by the data packet to traverse from the CBR client to the application layer of the CBR server [21]. It includes all forms of delay like delays due to buffering, delays caused due to the discovery of routes, queuing latency at the interface, delays due to retransmission of packets, and delays involved in the transmission and propagation of the packets. The graph shown in Fig. 10 shows the end-to-end delay of the four CBR servers i.e. nodes 5, 6, 9, and 10 in our simulation. In between node 5 and node 6 which is a mobile node (vehicles) according to our scenario, the delay of node 5 is higher than that of node 6. This is because the CBR client node 4 was within the signal range of the CBR server node 6, so communication among the vehicles takes place with fewer overheads (V2V). But node 2 and node 5 were away due to the difference in their waypoint arrival time, so here V2I communication took place. Node 9 has a maximum average end-to-end delay than all the other nodes because network conjunction is highest at this node. According to the scenario node, 9 is a base station through which the vehicle communicates to cloud storage and vice versa either for storing data or fetching some data/information. A base station is the central point of vehicular communication.

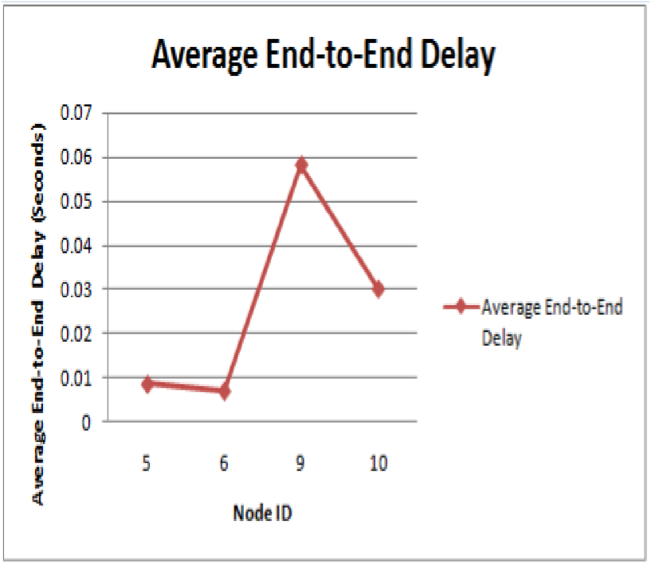


Fig.10. Average unicast end-to-end delay of CBR servers.

**Average Jitter**

Jitter is defined as the disparity in timing in the arrival of packets caused due to congestion of the network, time drift, or changes in the route [22]. For better performance of the routing protocol, the jitter should be less. Fig.11 shows the graph of the average jitter of nodes 5 and 6. It has been observed that the jitter in case of node 5 is higher. CBR server node 5, when not in the signal range of CBR client vehicle 2, it communicates through RSUs. Therefore delay between nodes is higher when they are communicating with RSUs and then to base stations. Base station node 9 has the highest average jitter because due to network traffic conjunction and data prioritization [20]. Node 10 which is the cloud storage according to our scenario has almost negligible jitter due to constant latency with zero variation.

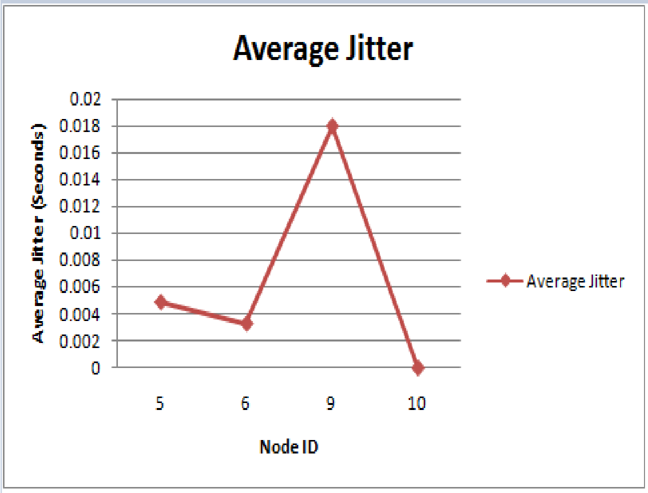


Fig 11. Average jitter of CBR servers.

**Throughput**

Throughput can be defined as the rate of data received by the CBR server from the CBR client. It is expressed in bits/seconds [22]. Fig.12 shows the throughput of the CBR servers nodes 5, 6, 9, and 10. Between node 5 and node 6, throughput is more in node 6 (because of V2V communication with node 4) than node 5 which show V2I communication with node 2. Data send and receive is the maximum for the cloud server and base station. Vehicles communicate to a cloud server through RSUs and base stations, and vice versa either for uploading important information.

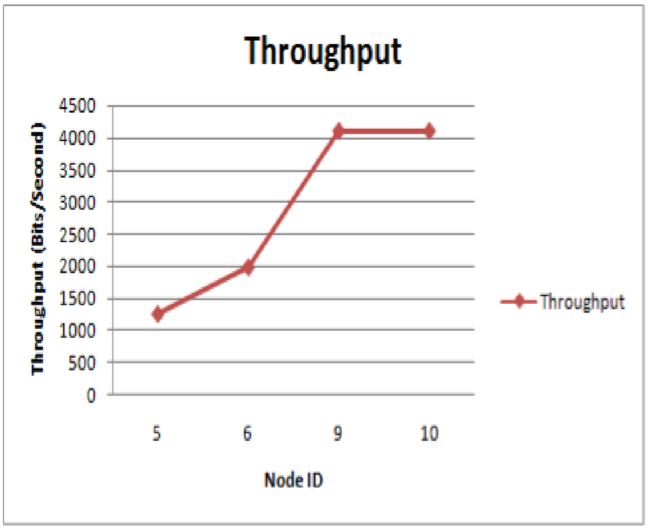


Fig.12. Through puts of CBR servers depending on the rate of data exchanged by CBR clients and servers.

## VI. Conclusion

In VANET, Vehicles are the moving nodes. Additionally, urgent information like traffic congestion, accidents, roadblocks, natural calamities, and information related to utilities like hospitals, schools, cafeterias, etc. can be shared via this network. Thus VANETs can help in mitigating several types of emergencies by providing prior information to unaware commuters. In case of natural disasters, the most used network infrastructure may collapse. In such situations, VANET can significantly contribute to disseminating information. Therefore, it is important to circulate the emergency information among the vehicles with lesser delay and jitter, so for that preferable V2V communication is better than V2I communication. V2V communication occurs when vehicles are within the range of each other. Otherwise, V2I communication occurs where the vehicles communicate with RSUs or though base stations.

In this paper performance comparison of VANET communication, V2V and V2I are done on QualNet network simulator. After simulation, it is depicted that when the vehicles are closer to each other (V2V) i.e. within the range, data exchange rate is more with lesser delay and jitter. But when the vehicles are far from each other (V2I), the communication includes more delay and jitter comparatively. Due to too much network conjunction at RSUs and Base station as large numbers of vehicles tries to get connected with RSUs and Base station for runtime message communication, therefore conjunction is more and data rate is less in V2I communication.

In the future, it is expected multi-hop vehicle to vehicle communication can be established when the vehicles are not in range of each other, so that vehicular ad-hoc networks will be supporting more services and applications for increasing road safety and efficient road transportation with a faster way of communication.

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