# AUGMENTING THE QUALITY OF EXPERIENCE IN 5G NEXT-GEN VANET ARCHITECTURE IN IOV FRAMEWORK

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## *Abstract*
*Quality of Experience is one of the core structures of the transport system. With the aid of emerging of the Fifth Generation (5G) Mobile Communication Systems and software well-defined networks, the recital of Vehicular Networks could be heightened and fresh applications of vehicular networks obligatory by upcoming vehicles can also be realized such as video sharing of road condition through internet, watching the speed and position of vehicles, applications like infotainment and so on. In order to encounter the requirements of intelligent transportation systems, new vehicular network architecture shared with 5G mobile communication technologies, software defined network and Internet of Vehicles is proposed in this paper. Moreover, Internet of Vehicles based fog cells have been projected for dispensing the complex processing of cloud data center down to the edge of the network. This permits the flexibly in covering vehicles and avoids regularly delivery between vehicles and Road Side Units (RSUs). Based on the wished-for 5G software definite vehicular networks, the transmission deferral and throughput are analyzed and likened. Replication results specify that there happens a smallest transmission delay of 5G software well-defined vehicular networks considering diverse vehicle densities. Moreover, the throughput of fog cells in 5G software clear vehicular networks is healthier than the quantity of traditional transportation management systems.*

***Keywords:***
**5G, Edge Computing, Fog Computing, Internet of Vehicles, Software Defined Network, VANET.**

## 1. INTRODUCTION

Vehicular Adhoc Network (VANET) is flattering an authorizing technology of following generation Intelligent Transport System (ITS), that is intended to offer a wide range of services to public, ranging from safe travelling to infotainment tenders such as surfing the internet, audio and video downloading and file downloading etc. [1]. In future it is expected to be a connected society. The emergent Internet of Things (IoT) technology combined with intelligent and integrated sensor network systems and domestic sensor networks are expected to potentiality employ impact on people's daily lives and are anticipated to motivate huge market in near future. VANET becomes an vital component of ITS and rapidly evolving. The number of inter connected vehicles world-wide is foretold to reach 300 million by 2025 [2]. Moreover, by 2025, secure and smarter ITS are predictable to be functioning as a VANET cloud [3]. In VANET, a vehicle becomes a Smart Vehicle (SV) once it is connected to the internet and delivers facilities to the passengers for several types of communication.

There are four types of communications recognized in VANET namely (i) In-Vehicle (InV) communication (ii) Vehicle-to-Vehicle (V2V) communication (iii) Vehicle-to-road Infrastructure (V2I) communication (iv) Vehicle-to-Broadband cloud (V2B) communication [4].

***In-vehicle* (InV) *communication*** refers to the communication system tailored inside a vehicle. It is most important and necessary in VANETs research since this domain can sense the performance a vehicle and body condition of the driver such as drowsiness or tiredness of the driver which is hazardous for the vehicle, driver and public.

**Vehicle-to-vehicle (V2V) communication** refers to the system for the drivers to exchange information and alerts, in order to benefit themselves at the occurrences of traffic jam or accidents etc.

**Vehicle-to-road infrastructure (V2I) communication** provides the efficient real-time traffic/weather conditions and allows environmental monitoring for drivers.

***Vehicle-to-broadband cloud (V2B) communication*** represents the system by which vehicles may intersect via wireless broadband technology like 4G / 5G. The ITS linked with cloud will provide monitoring data, traffic material and accomplishment. This V2B system can act as effective vehicle tracking and driver support.

However, the current VANET architectures are not enabled to fulfill the necessities of upcoming ITS applications due to the tremendously jammed traffic and mobile scenarios. The approaching trend of SVs causes the present VANET architectures; widen their bounds with hard real-time requirements. Moreover, the development of cloud computing has corrected the appearance of vehicular network with cloud-based services. In order to deliver a capable communication and collaboration for VANETs in large scale, millions of vehicles are connected with the Internet of Vehicles (IoV), in which drivers and passengers can experience all ITS services through Internet [5]. Software Defined Networking (SDN) and Cloud Radio Access Network (CRAN) are the two greatest vital and talented technologies for 5G Next generation VANETs. SDN is becoming a radical technology which controls the network in a centralized system by programming the purposes of data plane and network controls (control plane). Moreover, it eases flexible network management and control on large scale by flexible programming interface, [5,6,7]. Nowadays SDN has involved researchers towards the mobile communication and VANETs. SDN can also be careful for the dynamic and crowded VANET scenarios, with less expenditures [8, 9].

On the other hand, Cloud (or centralized) Radio Access Network (C-RAN) projected by China Mobile [10], is an attractive and open cloud-based infrastructure which includes Baseband Units (BBUs), Remote Radio Units (RRUs), and antennas. The spectrum competence of the wireless network can be effectively better by the centralized control of BBUs and the cooperation among RRUs and antennas through open cloud based infrastructure. Additionally, the sharing different resources worked by BBUs can be effectively handled by the virtualization techniques, hence reducing the power consumption and operational cost [9]. Besides, fog computing can be employed in IoT [11,12] plays an important role in real time service demands of ITS by offloading techniques.

In this paper, we have wished-for a new ranked fog computing enabled 5G VANET architecture, reinforced by SDN and C-RAN with IoV technologies. We have shaped a Fog Computing (FC) framework at the edge of the network to support vehicles and people with prompt response. The purposes of the centralized controller are alienated and disseminated hierarchically. We have studied the many network restrictions like transmission delay, throughput and control overhead and likened with the other architectures. The tests are steered by using CloudSim simulator and the results showed the best recital of our approach.

We have prepared this paper in the following manner. We have assumed the contextual and related works in section II. In Section III, the architecture of the planned system is clarified. The simulation setup and the research setup are designated in the section IV and finally, we have settled the paper in section V with some imminent research guidelines.

## 2. RELATED WORKS

In this section, we deliberated numerous related works concerning the empowering technologies obtainable by 5G networks and the pertinent research steered in the domains of 5G-VANETs. Mobile Edge Computing (MEC) offers a platform for bringing services to the nearest location such as the mobile vehicles on roads in a vehicular environment. MEC is responsible for the discovering, accessing and advertising of MEC services [13] with sufficient computing resources. Since the distance between MEC resources and vehicles becomes shorter than the distance between vehicles and servers, MEC considerably outperforms cloud servers in terms of transmission latency. The impression of vehicular fog computing is proposed in [14] which employs under-used vehicles as the infrastructure for task computation and communication. A real-time traffic management key in a MEC-enabled vehicular network is proposed in [15] with the aim to minimize the average reply time of the reported events by the vehicles.

IoV provides all Internet services to drivers, passengers and vehicles. When IoV is integrated with 5G, brings the need for innovation to support

IoV communications, services, and applications. In [16] Chen, J *et al.* presented the challenges such as high efficiency in resources use, capacity increase, management, and control in a scalable and flexible way, as well the QoS (Quality of Service) in vehicular communication networks.

When SDN is applied in IoV by disassociating the control and data planes, the controller simply manages the network and can shape the data traffic for the specific application. In [17] Ghafoor, K.Z *et al.* have explained the SDIoV and the packet routing, which make IoV applications feasible while connected vehicles relay the messages received from other vehicles and/or Road Side Unit (RSU). In addition the centralized controller has a global view of the entire network, the route selection becomes easier.

Khattak *et al*. [18] proposed a vehicular fog computing architecture for infotainment applications and evaluates in terms of cache size, cache hit ratio and energy of the vehicular fog nodes. Rosário *et al.* [19] describe the operational impacts and advantages regarding video content migration in a multi-tier architecture with QoE support. Iotti *et al*. [20] analyze the effect of proactive cache into fog nodes on the network edge to avoid redundant traffic. They classify and identify the manageable traffic based on DNS queries and replies.

Xiao *et al.* [21] formulate geo-distributed and cloud-based dynamic content orchestrator redirection and resource provisioning as a stochastic optimization problem reducing costs for renting cloud resources to improve QoE by correlating with QoS metric of delay. Zhang *et al*. [22] propose content placement and request dispatching for cloud-based video distribution services with Markov decision process aiming to maximize profits of the video service provider considering cost and also correlating QoS with QoE.

In [23], Ammara Khan proposed a hierarchical 5G Next- generation VANET architecture by employing the concepts of SDN, C-RAN and fog computing. In [24] Xiaohu Ge *et al.* have proposed a new vehicular network architecture integrated with 5G mobile communication technologies and software defined network in order to meet the requirements of an intelligent transportation systems

## 3. PROPOSED SYSTEM

**(A) Topology Structure of 5G Software Defined Vehicular Networks:** There are two main technologies which enhances the efficiency of VANET. First one is the cloud computing and the second one is the fog computing. These two emergent technologies enhance the Quality of user Experience (QoE) for applications of 5G enabled vehicular networks. Furthermore, the SDN is becoming a supple method to connect wireless networks and cloud computing centers for 5G vehicular networks.

The architectural assembly of 5G enable SDN for VANET is shown in Figure 1. This architecture consists of the following components: Cloud Computing Data Centers, SDN controllers (SDNCs), Road Side Unit Controllers (RSUCs), Road Side Units (RSUs), Base Stations, Fog Computing Clusters (FCC), vehicles and users. These infrastructures support the above mentioned four types of communications in the VANET zone.

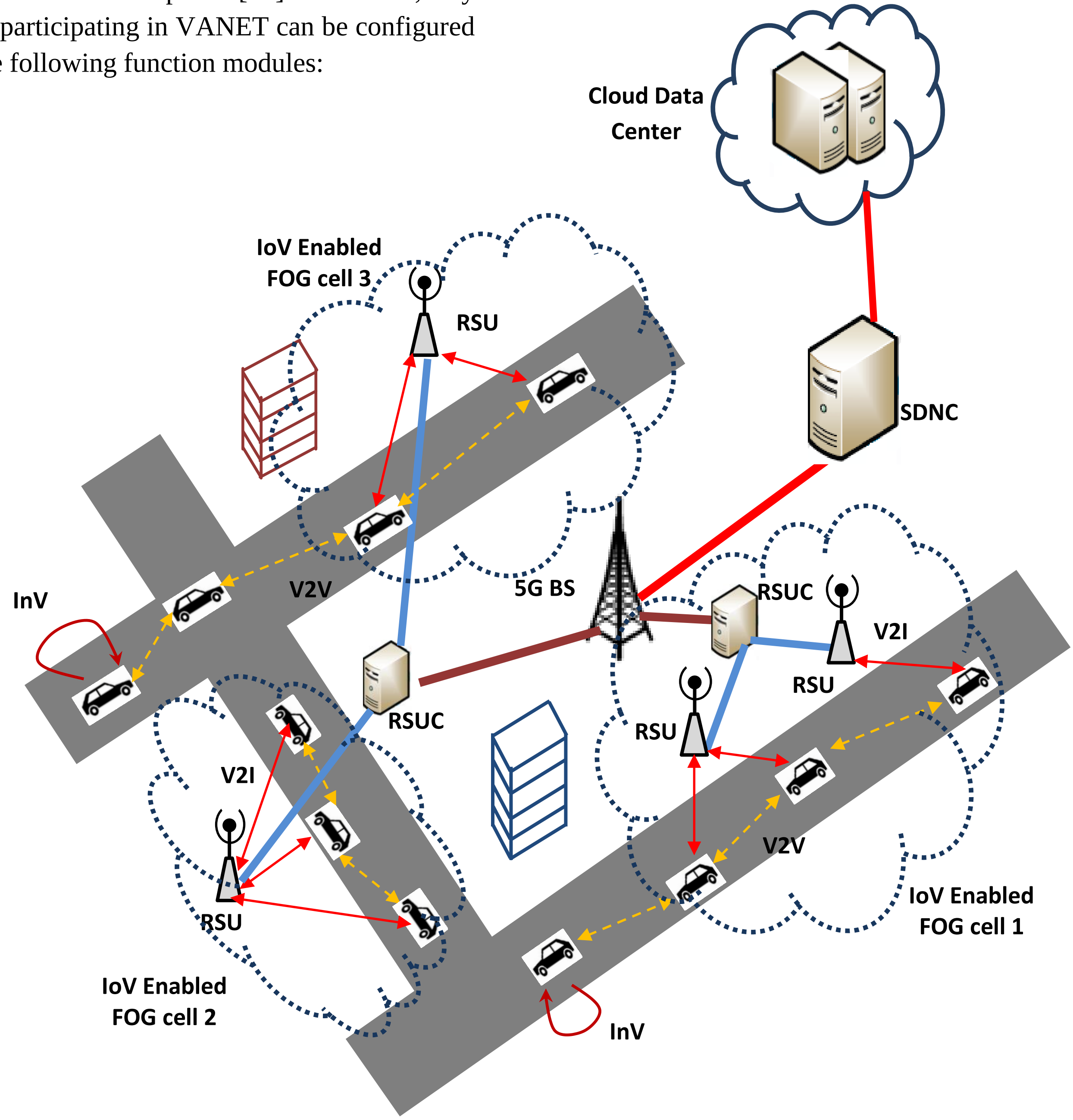
Based on 5G SDN, the data can be communal between vehicles and users under the control of the fog computing clusters. To enable the prompt communication among vehicles and users, FCC is configured in the edge of 5G SDN vehicular networks.

Most of data in the edge of 5G SDN is saved and processed by fog computing clusters which include the RSUC, RSUs, BSs, vehicles and users. The SDNCs gather and forward the data from the FCCs into the CDC. Furthermore, the control data is replied by SDNCs to FCCs. The detailed logical structure of 5G SDN based VANET is depicted in Figure 2.

**(B) Logical Structure of 5G Software Defined Vehicular Networks**

The logical structure of 5G SDN based VANET in Figure 2. It consists of three major modules called the data plane, the control plane and the application plane.

a) The data plane consists of vehicles, BSs and RSUs. The major functions of the data plane are data collection, quantization and then forwarding data into the control plane [25]. In detail, any vehicle participating in VANET can be configured with the following function modules:

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|---|---|
| SDNC – SDN Controller | RSU – Road Side unit |
| 5G BS – 5G Base Station | RSUC- RSU Controller |

**Fig.1. Architecture of the 5G enabled SDN based VANET**

- Data Collection Module: This module uses different sensors to read information related to position, speed and direction of vehicles and CCTVs, network cameras, lane checking cameras, etc.

- Communication Module: This module includes the various types of communication as mentioned earlier which include InV, V2B, V2I and V2V.

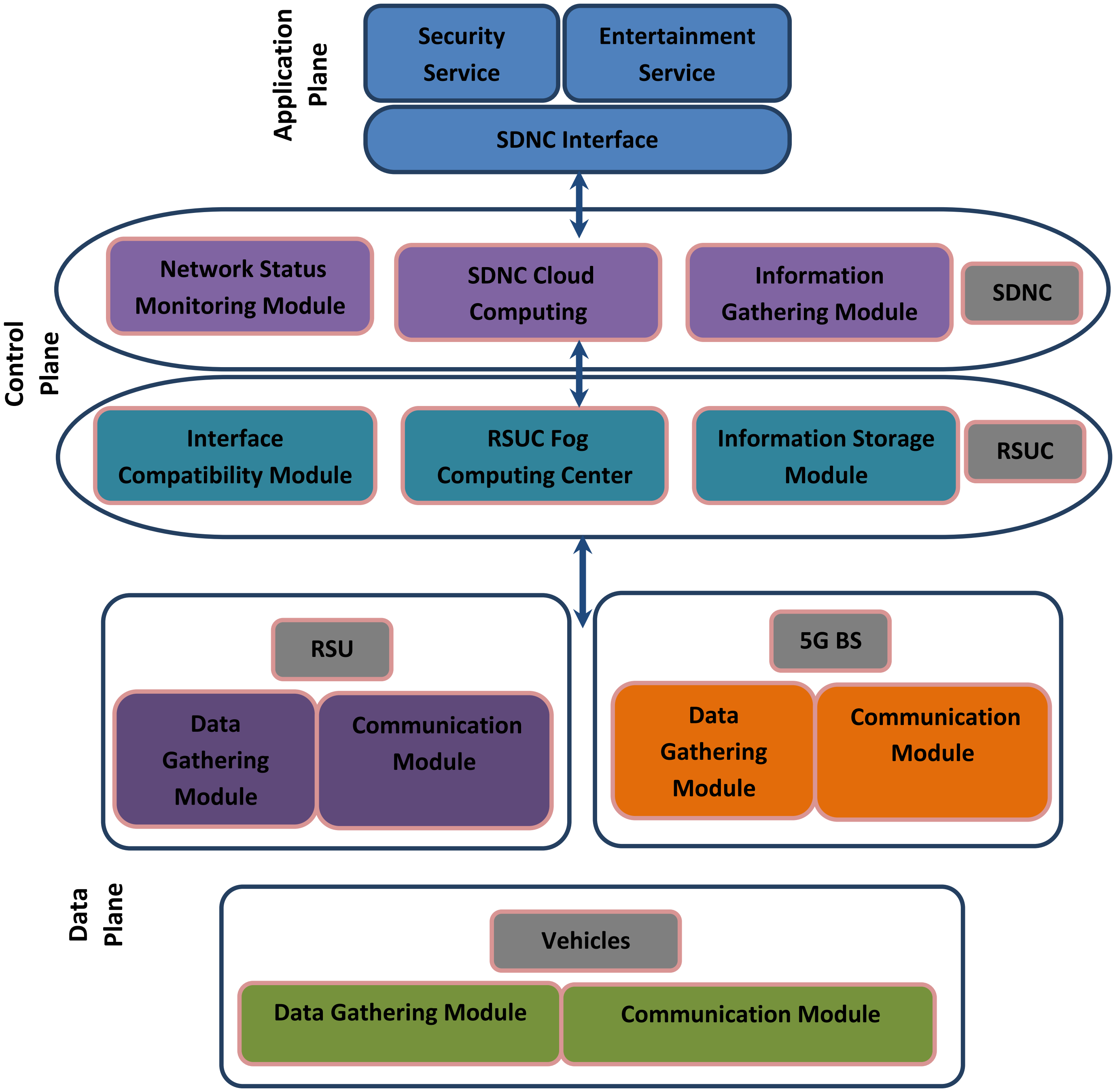


**Fig.2. Logical structure of the SDN based VANET**

b) There are two important components in the he control plane: RSUCs and SDNC. A fog cell is created by having the RSUC as the control center. In VANET frequent handover will take place due to the quick mobility of the vehicles and the congested wireless traffic between the vehicles and the RSU. This kind of frequent handovers should be avoided to maintain the seamless communications between the RSU and vehicles. To address this issue, we have proposed the fog cell for 5G SDN. A fog cell consists of vehicles and a RSU. The wireless relay Communications among vehicles is enabled by millimeter wave links and the total bandwidth of millimeter wave is shared by all vehicles in a fog cell. Further, every fog cell is powered by IoV, a sensor network which is responsible for the different types of VANET communications. IoV consists of different sensors, in a vehicle as said earlier, to sense and control the status and position of a vehicle on road. Hence, the data about a vehicle is made available through the internet, and will be communicated to the people who have the interest on it. This makes the people to have good and pleasant experience in travelling and feel the Quality of Experience (QoE) on sharing data.

The SDNC is the total control center for 5G SDN and it is responsible for allocating resources among fog cells. Therefore, the control plane is responsible for creating the global information map based on the data sent from the data plane. This information map thus created will be used by the control center for generating the control information based on rules and strategies from the application plane. All these functions of the control plane are carried out by several functional modules of RSUCs and SDNC as given below:

- Information collection modules of RSUC and SDNC
- Networking status module
- Computing module
- Hot caching module

c) The application plane is responsible for various application requirements from users and vehicles. Based on the requirements from users and vehicles, rules and strategies of 5G SDN are generated by the application plane and forwarded into the control plane. Typically, the application plane includes the security service module, the service efficiency module and the entertainment service module.

## 4. EXPERIMENT AND COMPARISON OF RESULTS

We have employed our planned method using NS2 emulator and the mathematical examines are done by using MATLAB. We have cast-off a laptop having Intel Core i7 processor with 16 GB RAM for conducting all numerical experiments. The area of transportation is immovable as 1500m X 1500m. We have programmed the RSUs to act as 802.11p Access Points where 802.11p is an extension of IEEE 802.11 for Wireless Access in Vehicular Environments (WAVE). The bandwidth for RSU is set as 10 Mbps, and the bandwidth for the 5G BS is set as 1Gbps.

The presentation of our planned architecture is analyzed and associated with two architectures: (i) conventional architecture and 5G VANET architecture planned in [24], named as 5G SD VANETs for our comparison. In traditional architecture, every vehicle communicates with the RSU directly, whereas in [24], each node has to direct signaling information to a node closer to RSU.

Figure 3 shows the better throughput, as associated to throughput in [24], and throughput of old-fashioned architecture. We have analyzed and compared the transmission delay of vehicles, in our proposed IoV fog framework, considering dissimilar number of vehicle.

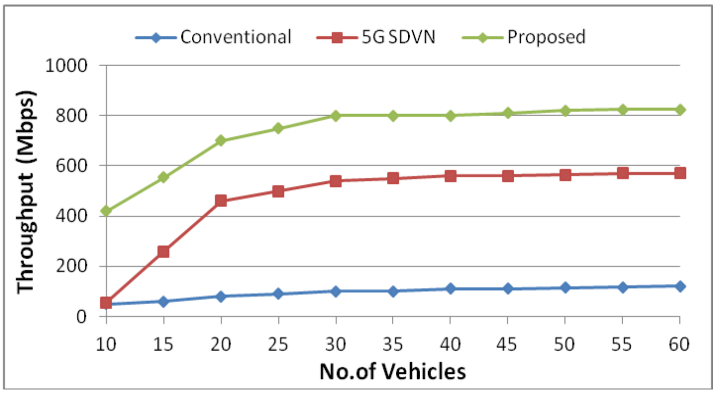


**Fig.3. Throughput comparison**

In [24], when the complexity of handovers between vehicles and RSU is increased, the propagation delay increases with an increase in multihop relay vehicles. Using the notion of zones and clusters, the quantity of multi-hop relay vehicles is abridged, thus reducing delay.

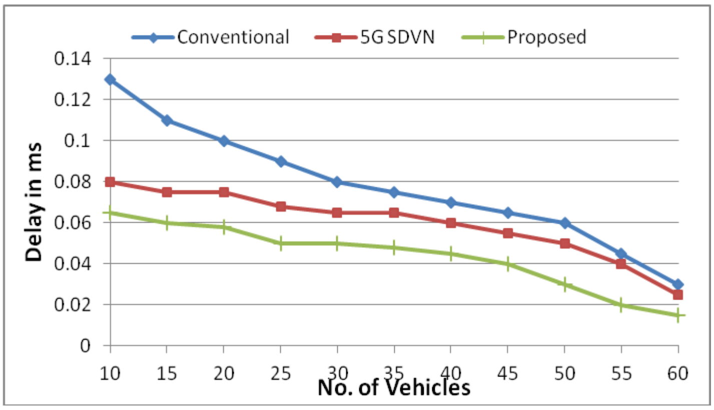


**Fig.4. Comparison of transmission delay**

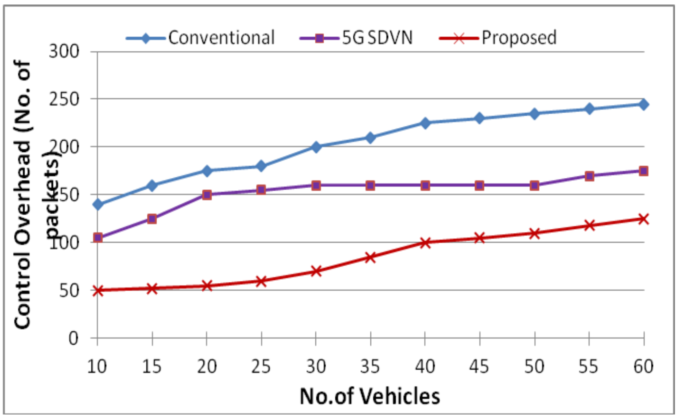


**Fig.5. Comparison of control overhead**

Figure 4 displays, there exist a smallest transmission delay of 0.06ms, as associated to transmission delay of traditional architecture and 5G SDN architecture [24]. The aim is, in our proposed IoV fog framework, we have used the sensor network and all the controlling functions are shared among various controllers. Further data, processing and applications are carried out in devices/vehicles at the edge of the network, rather than in the cloud.

The decision of control above is shown in Figure. 5 and it is seen that the control overhead is meaningfully reduced as compared to the control overhead in traditional architecture and 5G SDN architecture in [24]. This is due to hierarchical distribution of controllers in control plane with IoV fog and the employment of region based groups in our projected IoV fog framework.

## 5. CONCLUSION AND FUTURE RESEARCH DIRECTION

In this article, we have assessed a new hierarchical 5G Next generation VANET architecture, by realizing IoV as a core technology supported with the concepts of SDN, C-RAN and fog computing technologies. A pioneering architecture for VANET is shaped which assimilates 5G mobile communications, cloud computing, SDN technologies. Furthermore, IoV powered fog cells are recognized at the edge of 5G SDN which cuts the persistent handover between the RSU and vehicles by using multi-hop relay networks. Simulation outcomes display that the transmission deferral is reduced when connected with the extra prevailing approaches and the throughput of the proposed technique is improved as linked with the additional standup systems. Since IoV uses numerous sensors, in upcoming, our intentional method can be cast-off for evolving driverless vehicles, at the same time in case of universal and locality alert amenities for the commuters.

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