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Converging VANET with Vehicular Cloud Networks to reduce the Traffic Congestions: A review

Mohammed Saad Talib
Faculty of Information and Communication Technology
Universiti Teknikal Malaysia Melaka (UTeM) – Malaysia.
College of Administration and Economics, University of Babylon – Iraq.
Orcid: 0000-0002-2316-9242

Prof. Dr. Burairah Hussin
Faculty of Information and Communication Technology,
Universiti Teknikal Malaysia Melaka (UTeM) – Malaysia.

Dr. Aslinda Hassan
Faculty of Information and Communication Technology,
Universiti Teknikal Malaysia Melaka (UTeM) – Malaysia.

Abstract

Optimizing the traffic management operations represent an urgent issue in this era due to the massive increasing in number of circulating vehicles, traffic congestions and road accidents. Street congestions can have significant negative impact on the life quality, passenger's safety, daily activities, economic and environmental for citizens and organizations. Current progresses in communication and computing paradigms fetched the improvement of inclusive intelligent devices equipped with wireless communication capability and high efficiency processors. IoT will permit the evolution of the Internet of Vehicles (IoV) from existing Vehicular Ad hoc Networks (VANETs). In these days, cloud and fog computing approaches have been recognized for different applications of the fifth generation (5G) vehicular networks. The Software Defined Networking (SDN) has been recently considered as a flexible technique for linking wireless access networks and clouding computing (CC) centers in 5G vehicular networks. The inflexibility, short connectivity and non-intelligence shortages in VANET can be overcome now by integrating new emerging technologies. These emerging technologies are; vehicular cloud computing (VCC), IoV, Fog computing, Network Function Virtualization (NFV), Mobile Edge Computing (MEC), SDN and 5G. Integrating these technologies can create new developed technologies and services. These technologies can play a crucial role in building the Intelligent Transport System (ITS). Achieving such dream by creating novel ITS will have a significant impact on traffic management and street congestions. This paper delivers a comprehensive investigation of recent technologies and their impacts on the improvement of the ITS to manage and control the traffic congestions.

Keywords: vehicular cloud computing, fog computing, SDN, 5G, IoV, VANET, ITS, traffic congestions.

INTRODUCTION

The traffic congestion is representing a serious problem with the urbanization growth and a tangible increase in the number of circulating vehicles on roads [1]. Most of the current urban transportation systems are becoming inefficient and being exceeds their capacities due to the increase in the number of produced vehicles [2]. Citizens are suffering from the economic and social effects of traffic congestions and resulted pollution in addition to the expected increase in road accidents [3] [4]. Traffic congestion creates very hard negative effects on organizations as well as people's. It affects their daily activities, their safety and their quality of life, so it has been attracting many different scientific interests [5]. Road traffic safety (RTS) must be the essential issue in any urban environment planning [6].

The primary reason of road's congestion is that in certain epochs, the number of circulating vehicles in a specific road segment increases to there's peak level and approaches or exceeds its critical capacity. This problem may happen due to the lack of technologies that can attain well-organized network utilization [7]. Application of a computerized mechanism to distribute traffic information to drivers in a timely way can help drivers make their knowledgeable decisions [8]. In this era, travelers as well as drivers want to get the necessary assistance information in any travel mode and especially in some emergency cases. This information may contain locations, traffic congestion data, alternative roads, traffic jams and so on [9].

The traditional Intelligent Transport System (ITS) has significantly developed by utilizing the vehicular communications. Vehicular ad-hoc Networks (VANET) is a special class of Mobile ad-hoc Network (MANET). It represents an important part of the ITS. The significant grew in VANET capabilities migrate it towards emergent Internet of Vehicles (IoV), which promises innovative technical and commercial capabilities [10].

Current developments in the field of Command, Control, Communications, Computers and Intelligence (C4I) technologies have led to an extensive growth in all the intelligent devices by equipping them with wireless communication technology and embedded processors. These smart devices can be utilizes to offer an appropriate and safer environment by forming new useful generation of Internet of Things (IoT) [2].

ITS (in sometimes called "Smart Traffic System") have an ability to predict, observer, and manage traffic flows. It represents the crucial factor in a smart city idea philosophy. An optimal traffic management system would lead to a save fuel consumption and emission gasses [11]. Such system is heavily depends on traffic information and vehicles mobility data. Spread sensors such as smart meters, GPS devices and vehicular traffic flow sensors, will have serious social and technical effects [12].

IoV is a global network of vehicles supported by "Wireless Access Technologies" (WAT). Its principal domain is the vehicles driving, traffic management, vehicles safety, road infrastructures and logistics. IoV can be integrated with other developed technologies like "Vehicular Cloud Computing" (VCC) techniques, Fog computing, "Software Defined Networking" (SDN) ,"Network Function Virtualization" (NFV) and 5G [10]. The current progress in vehicles technology and related lane infrastructures can be utilized with these developed technologies to build safe, efficient and comfortable driving system with in time supported information under the era of internet and 5G. These 5G Vehicular Cloud Computing techniques can heavily contribute in handling and exceeding most of the challenges threatening the current ITS, IoV and VANET.

VEHICULAR CLOUD COMPUTING

"Cloud computing" (CC), is a technology that provides "on-demand" and scalable access to a pool of configurable assets to share information. Its advantages in mobile cellular communication can be carried out to the communication systems domain [13]. Cloud in general has two main characteristics; a "Centralized paradigm" and Pooling with scalability and Efficiency of resource utilization.

"Vehicular Cloud Computing" (VCC) is a new technique which make use of the cloud computing advantages to assist VANETs with various computational facilities. Such facilities can improve the traffic control by decreasing the roads accidents, traffic congestion and the travel time. VCC aims to deliver on demand solutions for most of the unpredictable traffic activities in a dynamic environment. It can effectively form a cloud within the produced, maintained, and consumed services to provide a self-organized model of vehicular environments. Node in a cloud can be any Vehicle on the road with sensing abilities, permanent Internet access and on-board computational. Figure 1, shows a vehicular cloud computing architecture [14][15] [16].

A considerable modification can be expected in the future transportation system due to the developed equipment's in new vehicles, drivers and travelers beside the new techniques such as Cloud computing and IoT among others. The target aim is how to make integrated decision by fusing different schemes and techniques such as Cloud computing, Wireless Sensor Network (WSN), Big data, etc. [2].

The "Network Function Virtualization" (NFV) can helps in developing some of the cloud computing interests like the rapid deployment of services, scalability and cloud environments to get a carrier class behavior that fits the requirements of the *Internet service provider* (ISP) [17].

New and significant technologies, such as CC and Big Data can be utilized in the field of traffic flow forecasting [11].

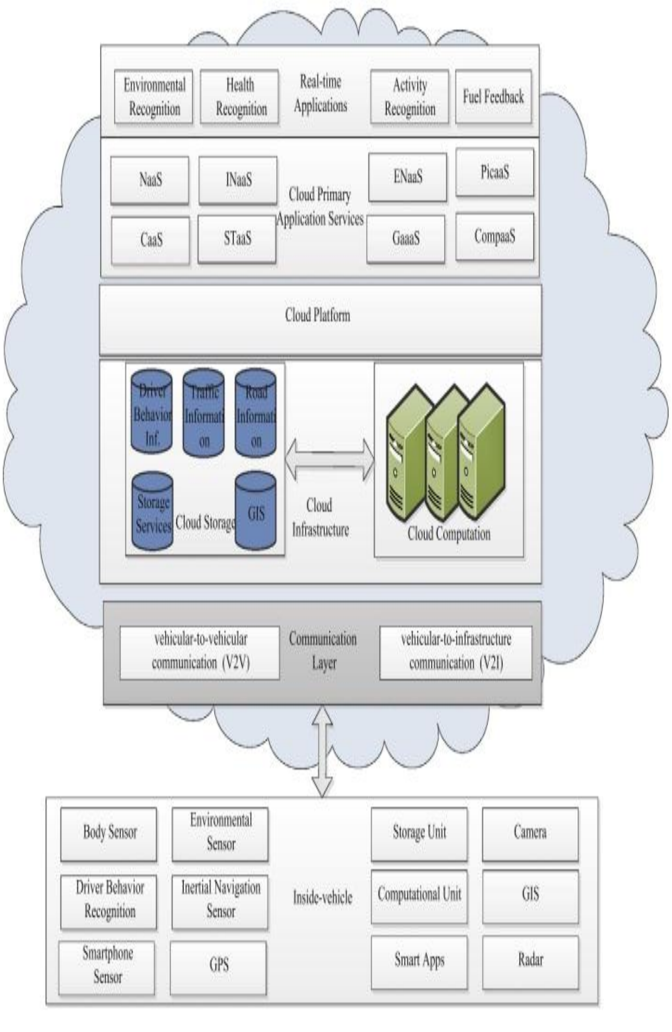
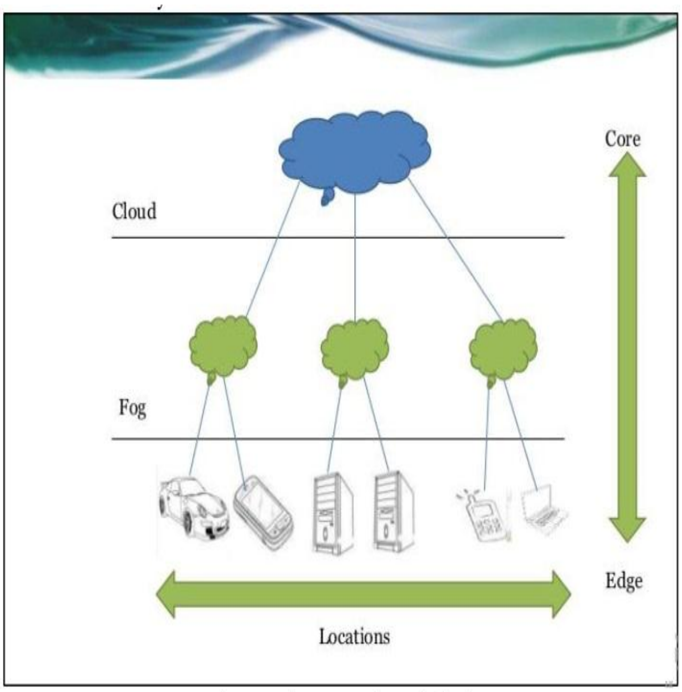


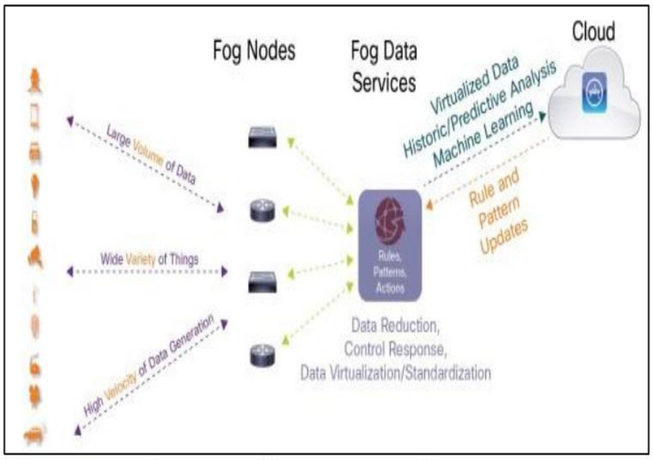
Figure 1: Vehicular Cloud Computing Architecture [16][15].

FOG COMPUTING

Fog computing (sometimes called edge computing) is a "paradigm that extends cloud computing and services to the edge of the network". Fog forms a mid-layer between the cloud and the other smart equipment's to process all the required connection operations. Cloud is more centralized while fog is closer to the edge with low latency. Fog computing is offer services to the widely distributed deployments. It can compute, deliver data, store and apply services to the end-users. Fog computing can meet the VANETs requirements such as reducing the cloud load, quick response to the essential devices and its ability to analyze the real-time stream data. Any device such as road infrastructure and a mobile vehicle can perform as a fog node if it equipped with network connectivity, storage and computing unit. As fog computing deals with the edge location, so it can achieve all the low latency applications. Fog computing is a new paradigm and it is still under development. By extending the cloud computing, fog computing providing virtualized assets and engaged "location-based services" to the edge of the mobile networks so it can assist mobile traffics. There are no much VANET's applications based on fog technology. The most candidate applications for fog computing are: WSN, connected vehicles, IoT and SDN. While the dynamic connectivity in VANET represents the vital success element for the fog computing Figure 2, shows a simple representation of the three level hierarchy of cloud , fog and edges in a and a cisco representation in b. [18][19].



a. Three level hierarchy.

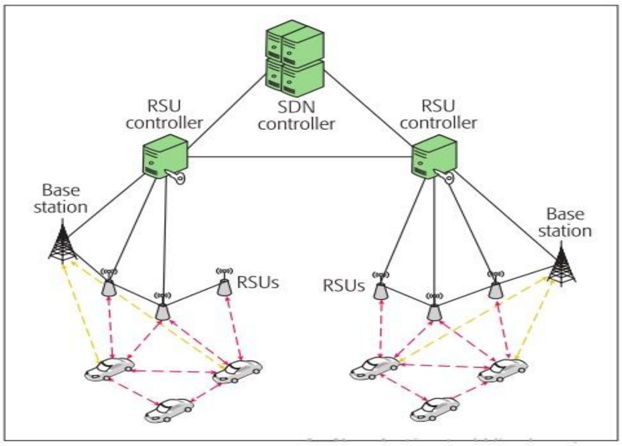


b. Cisco proposed architectures.

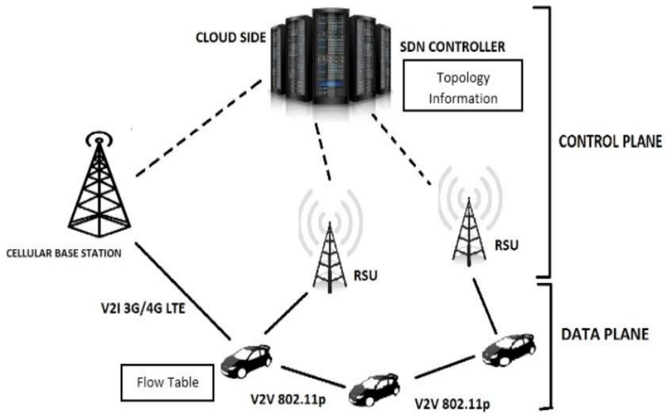
Figure 2: Fog Architectures [19].

SOFTWARE DEFINED NETWORKING

IoT, IoV, CC and VCC have become prominent major technologies in the past decade. In the current era, these technologies are pooled into each other to develop and create novel services. Software Defined Networking represents one of these new emerging programmable networking technologies. SDN was initially proposed for wired applications. It is being merged into mobile ad hoc networks (MANET) and VANETs at these present periods. SDN can enable VANETs to adjust the network topology changes. It can also assimilate programmability aspects in VANETs control plane to deliver new services. These services are virtualization of network infrastructure, safety measures and surveillance [20]. SDN can support in bringing configuration in network computing and simplicity, novelty in network management. Old networks frequently suffered from the flexibility lack to respond to the immediate changes due to the network rigidity. SDN can combine the data plane with the control plane and transferring the control logic from the node to a central controller [21]. SDN can support IoV by integrating its programmability feature into the vehicular cloud. Combining fog computing and SDN will help in overcoming the VANET challenges such as inflexibility, non-intelligence and short connectivity. SDN can allows control on the behavior of the network, while the fog computing conveys the location and times services. Integrating SDN and fog can contribute in reducing the communication delay and optimizing the resources utilization [22]. Merging SDN with IoT is valuable to vehicular networks in which SDN can offers automation and abstraction while IoT can enables the resources connection in a network. In addition, SDN offers a chance for network providers to virtually deploy their network elements**.** It can also utilizes in the virtualization process of cloud computing. Figure 3, shows a two different representation views of the SDN in a and b [20] [23].



a. Application.



b. Architecture.

Figure 3: Software-Defined Networking [20] [23].

SDN has facility to permits networks configuration and management due to its separate control panel. It can also provide additional management facilities to the dynamic topology of the vehicular networks [20]. Finally we can expect as a conclusion that the integration among the developed software technologies such as SDN, VCC and NFV will being the principal approach to form and establish flexible 5G intelligent vehicular networks in order to exceed the current challenges of the current vehicle's traffic and congestion models.

COMMUNICATION TECHNOLOGIES

"Mobile communication technologies" have experienced many technology generations in the past decades. These generations are often classified in certain sequence; the first one was being the "analog mobile radio systems" known as 1G, which was launched in the period of 1980s. It was supported only "Frequency Division Duplex (FDD)" mode. 2G is the second generation which represents the first digital mobile communication systems. It was emerged in 1990s, and its main access system was based on "Code Division Multiple Access (CDMA)" or "Time Division Multiple Access (TDMA)". It was contributed in developing the system capacity and supporting the "Short Message Service (SMS)", email, voice and data rate services.The third generation was begun its implementation in the early 21st century under the organization of the "International Communication Union (ITU)". It was established in two major setting forms, "3rd Generation Partnership Project Group (3GPP) and 3rd Generation Partnership Project Group 2 (3GPP2)". 3G was based on CDMA technology. It helps in supporting high data rate, high capacity, voice, video services and larger bandwidth. 3G represents a new technology that have an ability to "handle broadband data using circuit switched data services. The fast growth of the mobile communications and the increasing demand for larger data rate applications were lead to develop the existing generations into the "Fourth Generation (4G)" technologies. "The Long-Term Evolution (LTE)" is a 4G "mobile communications standard" set by ITU. 4G-LTE is presently implemented by the most mobile operators. It helps in improving the mobile network speeds, coverage and capacity. The tangible interesting access approaches of 4G are to raise the telecommunications and video traffic under the LTE expansion. LTE improve the user capability and service scenarios by presenting multi-Mbit bandwidth, reducing the latency, improving the mobility and providing efficient use of radio networks. The "typical User Equipment (UE)" throughput is improved from "2.4 kbps of the 1 G to 30 Mbps of 4G". 4G systems are heavily based on the "Orthogonal Frequency Division Multiplexing (OFDM)" technology [24][25][26][27]. Currently the innovation technology "mobile communication systems" called 5G have been developed. It provides supreme levels of efficiency, scalability and capability. 5G technology uses the millimeters wavelength (mm-wave) and a carrier frequency spectrum of (3–300 GHz) with an unlicensed (5 GHz Wi-Fi) spectrum of adaptable traffic offloading to reach its enhanced speed [28].

5G networks will be able to provide flexible greater capacity low power requirements massive machine type communications and Enhanced mobile broadband with Ultra-reliable and low latency communications. It can include a massive multiple input and multiple output (MIMO) technique, device-to-device communications and integrated relays. Such tools can improve the performance of its services frequency bands, capacity, and cost effective scalability requirements [13] [29].

5G can make rapid and on-time information accessibility at any pace and any time. It has an ability to support services and real-time application with negligible delay. The emergency cases and data transmission delay are the essential challenges and requirements for any reliable vehicular network and ITS [30].

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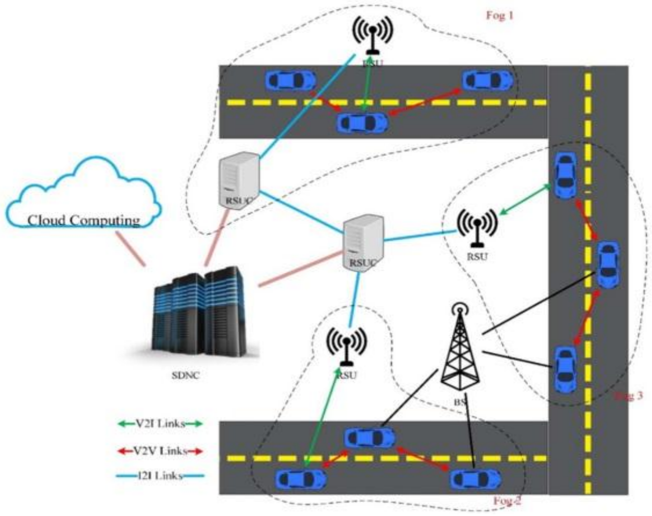
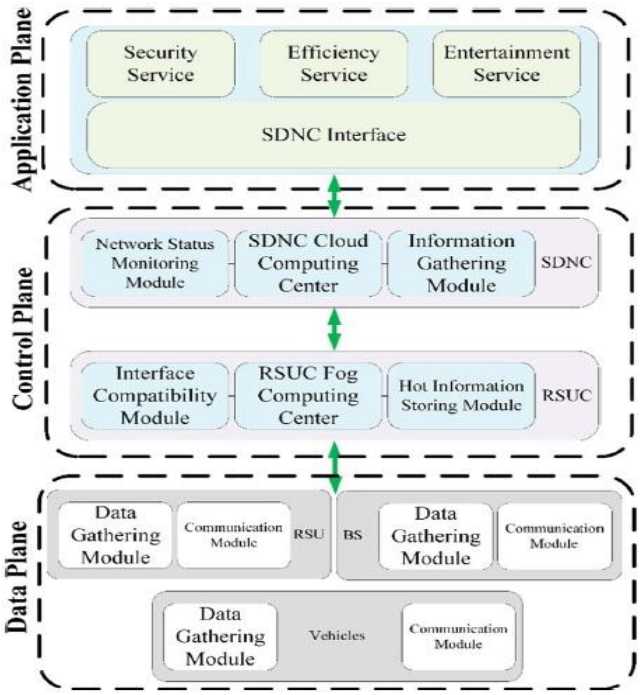
In the Current 5G vehicular networks applications, fog and cloud computing techniques have been settled and modified to suit such applications. Likewise, SDN has been lately considered as flexible tool to join CC and wireless access networks (WAN) in 5G networks. Figure 4, illustrates the topological structure of the 5G software defined vehicular networks. Such networks are including CC centers, SDN controllers (SDNCs), Fog computing, road side units (RSUs), base stations (BSs), users and vehicles. Figure 4, clarifies the topological configuration of emerging SDN in the fifth generation in part a and a framework sample in part b [13].



a. The features configuration



b. Framework sample

Figure 4: SDN Elements in 5G [13]. [21].

5G heavily considers the machine-type communication to set the essential foundations for IoT in order to achieve a completely connected word. This facility will open the door for many future useful intelligent service applications. A single service network may be able to achieve different requirements in 5G era.

INTELLIGENT TRANSPORTATION SYSTEM

Intelligent transportation system (ITS) represents a system to establish roads and to minimize their traffic congestions. It utilizes technologies to improve and control the transportation systems. ITS usually depend on distributed sensors, cameras, GPS, vehicles identifications, vehicles locaters and high quality servers. Any of its applications must use traffic management center (TMS) to control and succeed the transportation problems. TMS is to collect and analyze roads data and combined it with the other related equipment's information. The main objective of ITS is to utilize and integrate sensors information with concepts and technologies to construct an efficient vehicles traffic by saving vehicles energy, minimizing travel time, reducing emission gases, safety, comfort for drivers [31][4].

VANETs are the basis for different applications offered in ITS. ITS can offer important prospects to keep survives. Transport modeling is the process of analyzing the entities behavior to make decisions concerning the transport. ITS can be modeled and established by fusing "Machine-to-machine" (M2M) correspondence. M2M is a computerized communication between essential guiding system and several distant apparatuses to monitor real-time options. According to such technology, a "vehicle-to-vehicle" (V2V) and "vehicle-to-infrastructure" (V2I) communications can contribute in developing ITS. A video-based surveillance technology forms one of the future essential parts of the developed ITS [32][33][4].

Emerging network virtualization, SDN and CC in the 5G can improve ITS in meeting different necessities. Future ITS can well provide the sensing utility, controlling process, interacting and computing. Its effectiveness can be improved in minimizing the traffic congestions, infrastructures, emergencies, storages and big data processing [13].

SENSORS TECHNOLOGY

Sensor represents a small size and cheap price device used electronically to sense, respond or detect its surrounding environment phenomena and physical quantities. It can estimates certain parameters of the observed area entities and provides a proportional digital or analog signal. Sensor has an ability to translate (convert) the sensing data into an understandable form can be processed by computers. Available sensors are ranging in size from a very tiny (Nano sensors) to a relatively considerable ("surveillance camera").

Sensors are always deployed in different manners to achieve their tasks depending on the area of interest and the application type. Network connectivity, saving power, coverage and reliability are the most important factors guiding the deployment technique. Sensor can be deployed on roads sides to sense vehicles' location, humidity, identify threats, temperature, road icing, wind speed and vehicles accident [34] [35].

Usually sensor nodes deliver a fundamental association of computing, communication and distributed sensing. The developed capabilities of these sensors were utilized in the creation of useful WSNs. Sensor nodes are playing the role of being data routers and functions as data originators. Their features play the key role in suggesting and applying any new WSN [36]. WSNs combine information and equipment from networking, Control theory and wireless communications. Generally, the WSN are utilizing "Low-power" "Radio Frequency (RF)" communication techniques. After the vast technology development, WSN are being the back bone in the military (C4I) systems. New emerging technologies from the WSN in this era are the "Vehicular sensor networks", the "body sensor networks", and others. Associating WSNs with IoT represents the crucial networks to assist, monitor, track and sense different indoor or outdoor environmental activities. Current researches are focusing on the network performance, energy efficiency and scalability. IoV comprises the features of VANET and WSN is representing vehicular network tendency [37] [34]

INTERNET OF VEHICLES (IOV)

The Internet of Vehicles (IoV) is a technology that permits to share information between the vehicles and its surroundings infrastructures in a wireless communication manner [2]. IoV represents an integrated combination of road conditions and vehicular wireless network. IoT was permitting the advancement of the IoV from existing VANETs. The main IoV aspects are aimed to collect, share, convey, calculate, process and protect the arrived data to empower ITS. These technologies will create a good foundation for new developed services and supervisions to drivers by incorporating sensors, vehicles, communication centers and cell phones into the worldwide system. VANETs represent an example of an initial form of IoV. It operates coverage area range of about 300 m and 5.9 GHz frequency. Road observing systems based on VANETs analyze the roads information and gather the vehicles positions using processors and roadside access points. These systems will bring new services to drivers by incorporating sensors, vehicles, and mobile devices into the worldwide network [3] [14].

Emerging the new techniques in the fifth generation networks such as VCC, advanced signal processing, feasible solutions, NFV and SDN can providing reliable systems to achieve most of the ITS requirements. These systems will make the next ITS have an ability to well improve the sensing function, internetworking, controlling and processing. Future ITS will improve the transportation efficiencies, reducing traffic congestions and controlling the road accidents and emergencies.

The three essential IoV network elements are clients, connection and cloud. Fig 5 illustrates these elements [38].

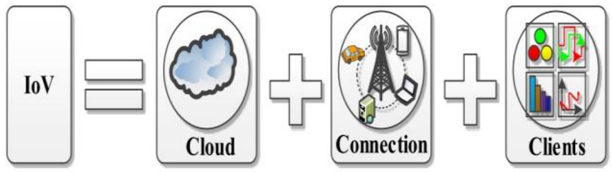


Figure 5: IoV Network Elements.

SUMMERY FUTURE RESEARCH DIRECTIONS

1. VANET-Cloud as a future technology must report the issues of the data aggregation, security, energy efficiency and sub-clouds organization [39]. IoV is proposed to solve many transportation issues by elevating its main goal to minimize the road accidents, offering high transport efficiency, saving fuel and reducing emissions by developing the vehicles and the ITS [40]. It can develop the information technologies (IT) and the automation process by increasing the social and economic improvement. It will have positive direct effect on user's life by creating an extra intelligent, robust and efficient ITS. The other issues are [2][40]:
   A. IoV can have economic and social impacts on the fuel consumption reduction. It can be developed to supply the drivers with an on-line unexpected safety options.
   B. Still IoV suffers from communication among equipment's with efficient and scalable matching.
   C. Data processing and transition capabilities can be improved in the presence of SDN, Fog and 5G. The developing technologies in the field of IT have been led to think about establishing smart cities which requires special ITS.
   D. There is a robust wish to deal with the security aspects in future IoV.
2. SDN and NFV are becoming exciting topics according to the 5G networks objectives and tools in a globalization era. There are various open source tasks to govern both SDN and NFV that obey the standards certificated by The "European Telecommunication Standards Institute (ETSI)". SDN and NFV are two tools each one enhances and completes the qualities of the other but they are co-dependent [41]. It can be integrated with certain Mobile Edge Computing (MEC) technologies to change the current data collection approach [1]. Merging SDN in VANETs can produced software-defined vehicular

networks (SDVNs) as different computing tools. SDVN has also faced several challenges that required attention to be solved [20]

3. In the preceding period, CC, IoT, VCC and IoV have become significant emerging technologies. SDN is also a significant programmable networking tool. At the current days, these techniques are incorporated into each other to create and improve different services [20]. Integrating IoV, 5G, CC and SDN paradigm to develop reliable ITS can overcome and exceed most of the ultimate future vehicular networks challenges [30].
4. The social graph can give near real time for the ITS if it is spread in different communication layers. The social cooperation based IoV will represent the fundamental part of the upcoming ITS [40].
5. Due to the isolation between the data and control planes in SDN (Control Plane is placed onto the central server out of the network equipment's), the process of designing a good response strategy is being possible. This strategy can create more decisions to resolve the disturbed and upset traffic flow and propose adaptable path selection policy. New vehicles are regularly prepared with various wireless components to maintain different V2V and V2I communications. SDN can offer a channel allocation and cognitive radio policy which permits high-bandwidth and low-latency communication [1].
6. Advanced vehicles technology is expected to contribute in the memory speed, in-vehicle storage capacity and computation process to enable the vehicle to achieve different computational processes. Future vehicles will be capable to state and deal with issue of traffic congestion, road safety, fuel consumption and pollution which affecting the automotive culture [42][40]. Reliable free localization GPS technology is being required in the globalization era and the 5G networks to accurately estimate the vehicle direction of arrival, time of arrival and its distance to the base stations which helps in developing the ITS requirements [1].
7. The previous traffic prediction models were dealt with a small traffic data. Enormous traffic data can be collected with the vast development in the roadside sensors and other devices deployments. So, traffic prediction models must be developed to model, mine and analyze these massive real-time data of traffic flow and helps in estimating the optimal route for drivers [1].

CONCLUSIONS

Streets traffic congestions represent an exciting challenging in the urbanized technologies, IoT and globalization era. Improving the global environment automation and building reliable ITS can add a positive significant effect toward minimizing the waiting times in street congestions. Many developed emerging technologies can contribute in facilitating the traffic congestion problems. Upcoming ITS based VCC, Fog and IoV can offer real-time required responses to vehicles drivers. SDN paradigm can deliver flexibility, low-latency and high-bandwidth communication.

Integrating VANETs, 5G, SDN, MEC and VCC are expected to create the dream future enhanced vehicular networks to optimize the street's traffic management. Merging these technologies in ITS will be the essential foundation for the change towards the global automation environment.

Deploying developed roadside sensors with cameras and making use of the revolution in information technology, real-time information regarding the vehicles direction, speed, location, road state as well as weather state can be sensed and transmit as streams of data continuously. The future aim is to process and mined these streams of data with the help of the emerging technologies to get an optimal decision with a negligible delay. So there is an ultimate necessity to suggest and design different types of the 5G vehicular cloud networks.

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