Survey of Hybrid VANET Design for Provisioning Infotainment Application

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***Abstract*—This paper presents a survey of various existing VANET model for provisioning real-time (i.e. safety critical application) and non-real smart infotainment application for user on the go. Further, it carries out survey of various existing hybrid VANET for provisioning QoS (Quality of services), increase network density using SDN (software defined network), fog computing and cloud computing framework, and future generation high speed wireless network such as LTE (Long term evolution), 5G (Fifth generation), CRAN (Cloud based Radio area network). However, from extensive analysis carried out it can be seen existing hybrid model do not consider feature of each framework/architecture such as VANET communication (i.e. among V2I and V2V), QoS controlling mechanism in SDN for provisioning data from cloud to VANET user and also do not provide efficient resource allocation technique in cloud computing environment to minimize computation cost. This paper shows meeting aforementioned feature in designing hybrid VANET model will aid in offering scalable and flexible smart infotainment application to VANET user. Further, the survey show how propagation model is affected due to environmental factor and presence of obstacle in LOS. Further, discusses about the need for new MAC (Medium access model). Then, discusses about selecting simulation environment/tool to evaluate performance of Hybrid VANET model. Lastly, a novel possible solution is described to overcome research problem which will be the future research direction of this survey. The proposed envisioned model will aid in offering superior performance than existing models.**

Keywords*—Cloud computing, IEEE 802.11p, MAC, MIMO, Radio propagation, Software defined network, QoS,VANET.

I. INTRODUCTION WITH PROBLEM IDENTIFICATION

Rapid growth of wireless technology and increased usage of smart device has led to vehicular adhoc network technology to meet user demand for enhancing safety and efficiency. Along with, increase demand from user on the go through IP-enabled smart device in last few years has enabled infotainment applications service (i.e. both real-time and non-real-time services) to have a major role. Several design and architecture have been presented and explored in recent times. It has been very challenging to synchronize vehicular adhoc networks to proficiently enable applications with dynamic QoS requirements.

Vehicular Cloud computing (VCC), is one of the emerging fields in computing. A collection of heterogeneous and distributed systems are interconnected to provide a virtual environment to run many complex applications. VCC explained in simple context is extension and virtualization of existing web application architecture. Unlike the concept of distributed computing that provides services on onetime payment for unlimited usage, VCC based services are determined by cloud consumer request, empowered by self-catering catalogues of cloud computing loads (jobs), and jobs are accomplished across the virtual computing platform in a transparent and self-composed manner. Intelligent transport systems (ITS) is a very important investigation field due to its precise characteristic and application requirement such as regulation, road safety information and good traffic managing mechanism. VCC in a new hybrid technology makes use of vehicle assets such as storage, processing capability, and computing over wireless network. However, the vehicle are manufactured by various vendor or manufacture and thus have characteristically diverse processing capability devices. Therefore, there are lots of issues and challenges in offering flexibility in vehicular cloud computing networking (VCCN) needed to be solved [1].

In recent times SDN has emerged has effective solution to regulate traffic in wireless network in a efficient (organized) manner. The flexible and programmability nature of SDN, which is not offered in present high speed wireless infrastructure, that aid in provisioning quality of service prerequisite of VANET infotainment application, at the same time eases managing resource in VANET's. Subsequently, research are required to standardize and overcomes research problems in integrating SDN with VANET.

Recently, the future generation low energy and high speed mobile communication environment such as LTE, 5G, and CRAN have been developed by industrial researchers. With usage of massive Multi-Input Multi-Output (MIMO) and millimeter wave (mmwave) technologies, the energy and spectrum efficacy are improved [2], [3]. Recent induction of autonomous vehicle, dynamic service (strict QoS) requirement, example, for provisioning intelligent transportation systems (ITSs) in VANET the communication latency must be less than one milliseconds [4]. Thus, to meet these strict QoS requirement, future generation network, SDN and cloud computing framework are expected to be integrated into future VANET as shown in Fig. 1. Therefore, it is important to model novel network design for future generation vehicular adhoc networks.

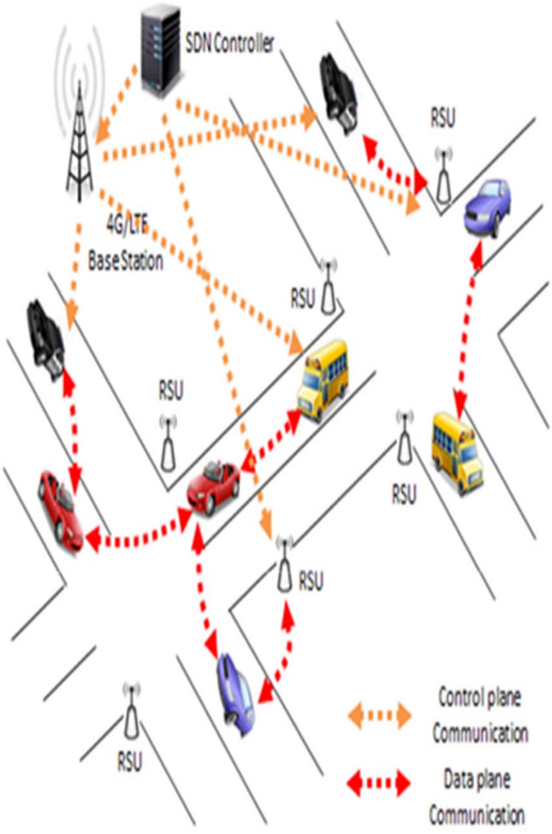

Fig. 1.VANET component and communication using Future generation mobile network and SDN.

In [5], [6], [7], and [8] have examined some basic issues pertaining to VANET.As IEEE 802.11p networks offers low capacity, irregular connectivity, and poor scalability, the LTE is introduced to provision VANET application [5]. Besides, the open issues and challenges of LTE based VANET were also examined to endorse or support possible strategy for future VANETs. In [6], introduced the simple feature of vehicular adhoc network and along with discussed the challenges associated in provisioning VANET ITS applications. In [7], presented a mathematical model to compute uplink and downlink connectivity probabilities to provide multi-hop based data transmission framework for VANET. The experiment outcome shows it failed to bring trade-offs among sink devices and network density, radio coverage of network and the maximal amount of relay devices in a routing path comprises. Further, using LTE communication for VANET affected the performance vehicular adhoc network (i.e. induce higher packet collision) due to interference [8]. For overcoming interference issues, the mmwave communication medium was used to connect vehicle users. Similarly, SDN was used an efficient network communication medium to support dynamic varying VANET ITS application function while meeting cost-effective solution through simplified software, hardware and management [9]. Subsequently, some approaches have integrated SDN with VANET [10], [11]. For provisioning QoS with VANET environment [9] employed fuzzy weighted queuing (FWQ) and regressive admission control (RAC) solution using SDN. Further, [11] presented a cooperative data scheduling (CDA) method on road side unit (RSU) to improve data propagation performance by employing cooperation among vehicle-to-vehicle (V2V) and vehicle-to-infrastructure (V2I) using SDN. However, SDN is only employed to cater workload of RSUs. When network density increases with each RSU will result in frequent handover problem. Thus, will affect the performance of SDN at the RSU of VANET [12]. Further, VANET MAC scheduling performance are severely affected on kind of radio propagating environment it operates. Thus, efficient radio propagation model is required for efficient MAC schedule design for VANET. For overcoming research challenges, this work first evaluate the factor affecting VANET performance in section II. Then, study and identifies challenges in integrating VANET with SDN, Cloud and future generation wireless network in section III. Then, this work show the future trends of hybrid model to enhance VANET performance in section IV. Then, this paper present a solution to obtain an efficient Hybrid model for provisioning infotainment application in VANET in section V. Lastly, the conclusion and future work is described.

II. FACTOR AFFECTING VEHICULAR ADHOC NETWORK PERFORMANCE

Vehicular adhoc network in recent time have attained wide attention across various industries and government organization which is generally classified into V2I and V2V and. The recent growth in communication technology advancement has to development of ITS [13]. ITS offers both safety-critical (i.e. traffic management, collision detection etc.) and non-safety (i.e. Infotainment, MP3, Video etc.) applications. As V2I induces high deployment cost, V2V is the most preferred communication method for increasing coverage range across urban, rural and highway. Modeling radio propagation model considering different environment is challenging and is very important to enhance performance of VANET [14], [15].

For modeling accurate and efficient radio propagation channel model it is important to consider the random and time varying feature aspect of different environment [16]. In V2V environment modeling radio propagation model is very important due to its characteristic challenges [17], [18] (i.e. both transmitter and receiver are mobile in nature). Further, DSRC (Dedicated Short-Range Communications) [19] and IEEE 802.11p [20] operational frequency and low antenna elevation makes VANET communication even more challenging and is different from mobile network.

The existing radio propagation presented are designed considering mean additional attenuation sophisticated obstacle fading model such as Log normal, and Nakagami [21] for cellular network. Further, these model has not considered factors (such as reflection or diffraction) affecting performance due to presence of vehicle (obstacle) in line of sight (LOS) among sending and receiving vehicle considering varied environment [22]. Thus, a new radio propagation path loss model is required for different environment condition considering presence of obstacle in LOS among transmitting and receiving vehicle.

Further, due to high and dynamic mobility nature of VANET periodic beaconing is required for obtaining real-time network information in a cooperative means under shared medium/channel access model. Thus, it is difficult and interesting to model MAC model under such environment. Along with, addressing congestion in network is challenging due to dynamic traffic load generated by high density of VANET users. Each VANET user communicate their network information (packet) to nearby by device within their communication range. Thus, induces packet transmission latencies and packet collision overhead. As described in [23], 100 ms is the maximal latency requirement for offering real-time service provisioning. Along with, successful packet transmission must be lesser than 90% as described in [24]. Further, simulation result carried out in [25] demonstrates that how successful packet transmission and latency is affected due high vehicular density and mobility. Therefore, if medium access control model is not designed in a scalable manner, the QoS cannot be assured. Thus, a new MAC based scheduling model is required that meets QoS of application considering different radio propagating environment under shared channel access environment.

III. CLOUD AND SDN TOOL FOR PROVISIOING REAL-TIME SCALABLE SMART INTELIGENT SYSTEM FOR VANET

Cloud computing (CC) framework [26] offers cost-effective, scalable and elastic services to its end user. Cloud service provider (CSP) use its features such as scalability, elasticity and pay-as-you-use to enhance QoS and minimize its operational cost. In CC environment the feature such as scalability and elasticity can be attained by dynamically decreasing or increasing virtual computing resources such as hardware, virtual machine (VM) etc. Usage of virtualization concept has aided in increasing the efficiency and capacity of CC data center (DC) to a level where a state-of-art network architecture cannot offer.

The increase in demand of cost-effective and scalable computer network architecture with provisioning of multi-tenancy has led to growth of SDN. SDN offers a novel way of managing network switches with capability of fine-grained traffic management in a centralized manner. SDN facilitates network module to dynamically design and control traffic through centralized controller. This aided SDN by separating data control plane from data forwarding plane. SDN offers dynamic traffic management, bandwidth allocation as per QoS requirement of traffic flow, and faster recovery. Thus, SDN aid in improving energy efficiency and QoS [27], [28]. Along with, OpenFlow [29] was presented to accelerate network design, virtualization and traffic management. OpenFlow allow dynamic optimization to the network by communicating with controller. Meeting real-time traffic demand of user is an effective feature to cope with the dynamic requirement of CCDC. Thus, to further enhance performance, we need tool that provide a setup for conducting test case study with SDN and OpenFlow within CCDC. Mininet [30] was designed to emulate similar network architecture of OpenFlow switches. Thus, it provide a testbed to test varied SDN based traffic rules/strategy in controller. Mininet emulates thousands of computing nodes with network topologies in a Linux based machine using virtualization concepts. It offers more accurate performance evaluation of congestion and delay at the OS level. However, Mininet, is similar to NS-3 [31] (i.e., it does not offer testing cloud centric features such as workload schedulers, virtual machine placement policies, etc. Along with, Mininet does not offers any environment to evaluate other cloud resource management and predominantly focuses on network resources.

For overcoming research issues, [32] introduced CloudSimSDN. CloudSimSDN offers testbed for joint allocation of network and compute resources. CloudSimSDN is built on top of CloudSim [33] and has been concisely discussed with respect to software defined clouds [34] where resource are managed and configured dynamically in a DC through centralized controller. CloudSimSDN is built in a manner to evaluate resource management strategy applicable to software defined network enabled CDC. It can experiment CDC, switches, network links, physical machine (PM), virtual topologies to quantify (measure) performance to assure energy consumption minimization, cost reduction and QoS. However, it does not provide integration mobility enable network (mobile nodes) such as MANET and VANET. From survey it can be seen integrating SDN with cloud is challenging and very limited tool provides such feature. Further, no prior work considered building a simulation integrating VANET with SDN and cloud. This work aims to build such hybrid model to provision real-time and scalable smart intelligent transport system for VANET.

IV. FUTURE TRENDS AND DIRECTION

This section discusses about the future trends and direction for provisioning efficient infotainment application service considering both real-time and non-real-time application in VANET.

a) Architecture/framework modeling:

A set of future pattern is to give an increasingly adaptable, dependable reliable, scalable, flexible and robust software defined network SDN design for vehicular adhoc networks. To start with, the most critical element of planning a software defined vehicular network's system is to accomplish pedestrian (walker) safety and driver safety. Realistic outcomes demonstrate that the smart device user proportion in 56 noteworthy nations has accomplished 60%. In the event that all vehicles can be associated with all person on smart device in the software defined vehicular network design, failure in recognizing picture for security could be kept away from, and the entire associated system can be expanded. What's more, more superior correspondence capacities among road side units can accelerate the software defined vehicular network framework.

b) Conventions, guidelines, and standards:

A great deal of methods and conventions for software defined vehicular networks are needed to be modeled for standardizing for effective operation. For example, open channels and direction forecast could prompt dangers of wellbeing, security and privacy of users. The intruder could communicate false (intruding) packet, modify packet to escape duty of some vehicle accident, and spying of user or vehicles. Along these lines, cryptography, replacing certificates of user in periodic manner or different methodologies are needed. Furthermore, more upgrades can be established for the systems under dedicated short range communication (DSRC), on the grounds that the DSRC is a radio frequency procedure, which is effectively obstructed due to presence of obstacle in LOS and can be diffracted.

c) Self-Organizing system/network:

System knowledge is significant to software defined vehicular networks. Energy consumption overhead could be minimized through self-association of software defined vehicular networks. For example, in the data channel, since the terrain condition varies a great deal, it is critical to explore how bandwidth of road side units are balanced independently by examining quality of service and successful packet transmission rates. Along these lines, the software defined network controller must examine the information gathered from the data channel to accomplish self-association of this system. Furthermore, dynamic traffic stream and climate or environmental factor cause different self-association outcomes, and additionally impact resource allocation process and direction forecasting. However, an excessive amount of programmed adaptation could be not controllable, and subsequently the robust performance and security must be considered.

d) Device to device (D2D) associations:

There shows up a tradeoff among distributed and centralized vehicular adhoc network, and the ideal tradeoff has been generally examined. This examination uncovers that static system models may solidify the execution and adaptability, which therefore propelled the SDN and "OpenFlow" to progressively enhance the system performance features, which is known as a cloud-down model.

e) Vehicular cloud computing network (VCCN):

As processing and correspondence advancements (design) have been quickly built up, the vehicles with potentprocessing capacities are upheld to be viewed as service provisionary as opposed to being just administration/service buyers. Accordingly, the idea of VCCNarepresented, that mutually makes utilization of processing, correspondence and capacity assets in vehicular devices. Overall, administrations in the VCCN framework can be partitioned into four sorts as indicated by the capacity/operation of the assets, such as Software, Computing, Sensing, and Network as a Service. Differently from the conventional distributed computing framework, the vehicular cloud computingnetwork framework has its remarkable highlights [1]. For instance, one such things is the fluctuation of the accessible virtual computing assets in VCCNs. Because of the vulnerability of the vehicle characteristic, i.e., vehicles may arbitrarily leave or associate VCCN's, the assets in VCCNs varies with respect to time. Another undeniable component is the heterogeneity of VCCNs assets. Vehicles are delivered by various merchants and therefore have intrinsically unique computing assets. Consequently, there are cluster of issues in VCCNs should have been comprehended [1].

f) Heterogeneity of road side units:

Based on environmental conditions, heterogeneity of road side unit's prompts different plans of software defined vehicular adhoc networks. For example, in the urban environment, dynamic traffic perquisite continuous adaption of the system topography. Consequently, the capacity of processing topography in road side units ought to be upgraded. In the application in expressway and highways, vehicle path does not change much, and consequently, path forecasting in road side units would not be pivotal. In the rural environment, the amount of vehicular user is very less, and consequently, the capacity of processing multihop communication in road side unit could be decreased.

g) Fog computing (FC):

Some past works have combined the fog computing method with software defined network so that road side unit can have a certain operation (capacity) of the software defined network controller to accomplish faster computing meeting application real time QoS demands. Further work is carried out on characterizing this coordinated method in various application situations could be carried out. For example, the need of messages for provisioning safety application ought to be considered in improving execution of FC. Or on the other hand, geological data of road side units could aid software defined network FC give increasingly confined unsafety applications.

h) Latency regulation in software defined vehicular adhoc network:

Latency regulation in software defined vehicular adhoc network:In vehicular adhoc network, there is no assurance that a specific remote administration of all vehicular user can effectively obtain on time. In spite of the fact that the general system execution can be upgraded in any ideal viewpoints through the all-inclusive asset improvement in distributed computing environment such as cloud computing framework. In any case, the expense of using distributed computing in vehicular adhoc network is getting to be exorbitant as the quantity of augmented vehicles vigorouslyincreases. Such expense incorporates gathering client data such as QoS prerequisite, tracking location, passing client data to central units in the cloud, distributing ideal resource to vehicles, channel conditions, and in particular, latency of every single activity/functions. Consequently, latency regulation in vehicular adhoc network could be a vital issue in future vehicular adhoc networks [35].

V. RESEARCH GAP IDENTIFICATION WITH SOLUTION

From deep rooted survey, it can be seen hybrid design is required to support infotainment application considering both safety and non-safety application in VANET. For provisioning VANET model the exiting model have combined CLOUD and SDN. Further, for obtaining higher bandwidth and provide higher density (vehicle) future generation high speed wireless network such LTE, CRAN, and 5G software defined vehicular networks adapting the cloud computing and fog computing technologies has been presented. However, the drawback of existing hybrid model is they are designed to reduce transmission delay and improve throughput performance of VANET by using SDN and CLOUD technologies. However, it is important to address feature of each environment such as VANET communication (i.e. among V2I and V2V), QoS controlling mechanism in SDN for provisioning data from cloud to VANET user and efficient resource allocation technique in cloud computing environment to minimize computation cost. Meeting aforementioned feature will aid in offering scalable and flexible smart infotainment application to VANET user. For overcoming research challenges, this work present a novel VANET design using future generation (such as 4G, 5G CRAN) SDVN adopting the cloud computing and fog computing technologies.

Firstly, the future research direction of this research work is to develop a novel radio propagation model considering presence of obstacle in line of sight among transmitting and receiver vehicle considering various environment such as urban, highway, and rural. Further, this work will develop a novel MAC scheduling algorithm for VANET communication. For minimizing frequent handover among vehicle and RSU multi hop based communication is considered. Then, we will develop a novel SDN framework for QoS provisioning to obtain data or perform some computation on cloud computing environment. A basic resource allocation scheduler will be cloud. Then, this work will present a novel resource allocation algorithm for minimizing computing cost on cloud environment. Experiment will be conducted to evaluate proposed hybrid VANET design in terms of throughput, packet collision, success packet transmission etc. No open source simulator is available in market to evaluate VANET performance combining SDN and cloud computing environment. Mininet offers evaluation of SDN with static node. However, it cannot support cloud computing and VANET integration. On the other side, CloudSimSDN support SDN and cloud computing integration. However, it cannot support VANET integration. Thus, experiment for evaluating traditional VANET model will be evaluated using SimITS [36]. SimITS is designed using NS3 and SUMO which offers object oriented programing (OOP) interface with rich GUI. As the SimITS simulator is designed using OOPs concept this research combine SIMITS with CloudSimSDN. Thus, can offer reliability, flexibility and high packet delivery ratio.

VI. Conclusion

This work conducted extensive survey of various existing radio propagation model, Environment modeling, MAC scheduling, hybrid model using SDN, Cloud and future generation high speed mobile/wireless network for vehicular adhoc network. From survey, it can be seen the traditional VANET model is not efficient for provisioning safety and non-safety application considering current dynamic application requirement of VANET user. For provisioning efficient ITS, it is important to utilize the benefit of various architectural design such as SDN, cloud and high speed wireless network. Number, of hybrid approaches has been presented in recent times to enhance ITS for VANET. However, these model are not efficient as it is designed considering specific environment and QoS metrics. Further, do not considers QoS controlling mechanism in SDN for provisioning data from cloud to VANET user and also do not offer efficient resource allocation technique in cloud computing environment to minimize computation cost. This work showed how radio propagation model is affected due to environmental factor and presence of obstacle in LOS. Further, discussed about the need for new MAC scheduler.Then, discussed about selecting simulation environment/tool to evaluate performance of Hybrid VANET model. From analysis it can be seen CloudSimSDN offer superior benefit and ease of use for integrating VANET with SDN and Cloud. Lastly, a novel solution is described to overcome research problem which will be implemented in future work. The future work consider developing a propagation model considering presence of obstacle in LOS among communicating vehicle under different environment condition such as urban, rural, and highway. No prior work has considered presence of obstacle in LOS for environment modeling. Further, the future work consider developing a novel scheduling algorithm under shared multi-channel environment and model will be evaluated under different radio propagation environment. No prior work has considered such evaluation and they are designed considering single channel environment. Along with, by combining SDN and cloud computing environment will aid in offering scalable performance. However, existing model incurs computation overhead in allocating resource to user. Thus, the future work will develop a resource allocation method that minimize cost and meet QoS requirement of application. Thus, the proposed envisioned model by combining VANET, with SDN and cloud with better radio propagation model, MAC scheduling for shared multichannel network, and resource allocation model will aid in offering scalable and flexible performance.

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