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REVIEW ARTICLE

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An Effectual Review on Vehicular Ad-Hoc Networks

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Abstract: **Vehicular ad hoc network (VANET) is a hot research area since few years. Due to their unique characteristicssuch as high dynamic topology and predictable mobility, VANETs attract so much attention of both academia and industry. Inthis paper, we provide an overview of the main aspects of VANETs from a research perspective. This paper starts with the basicintroduction, architecture of VANET and discusses general research methodologies and ends up with the analysison challenges and pros & cons of VANETs.**

Keywords:-VANET, Ad-hoc wireless network, computer network, Inter-vehicle, Intra-vehicle

I. INTRODUCTION

Vehicular Ad-hoc network (VANET) is emerging globally as a communication mechanism [1]. A VANET is generallydefined as a network that has many free or autonomous vehicles often composed of mobile devices or other mobile piecesthat can arrange themselves in various ways and operate without strict top-down network administration[3]. VehicularAd-Hoc Networks is integrated with wireless nodes that cancommunicate anywhere. VANET is categorized intothree types: WSN, MANET and VANET.Vehicular Ad Hoc Networks (VANETs) is technology that integrates the capabilities of new generation wirelessnetworks to vehicles. VANET builds a robust Ad-Hoc network between mobile vehicles and roadside units. It is a formof MANET that establishes communication among nearby vehicles and adjacent fixed apparatus, usually described asroadside apparatus. VANET can achieve affective communication between moving node by using different ad-hocnetworking tools such as Wife IEEE 802.11 b/g, WiMAX IEEE 802.10, Bluetooth, IRA, [4].

VANET is mainly aimed at providing safety related information and traffic management. Safety and trafficmanagement entails real time information and directly affect lives of people travelling on the road. Simplicity andsecurity of VANET mechanism ensures greater efficiency. Safety is realized as prime attribute of Vehicular Ad HocNetwork (VANET) system. The majority of all nodes in VANET are vehicles that are able to form self-organizingnetworks without prior knowledge of each other. VANET with low security level are more vulnerable to frequentattacks. There are wide ranges of applications like commercial establishments, consumers, entertainment where VANETare deployed and it is very necessary to add security to these networks so that damage to life and property could notoccur [5].

VANET inculcate sufficient potential in vehicles to transmit warnings about environmental hazards, traffic and roadconditions and regional information to other vehicles. The major intend of VANETs is to absolute theroad and build their drive safe and snug. Vehicles move at such a high speed that it is harder to maintain a seamlesshandoff and a steady connectivity to the Internet.

VANETs consist of following entities:

a) *Access point:* The access points are fixed and commonly connected to the internet. Vehicle to vehiclecommunication has two types of communication single hop and multi hop.
b) *Vehicle**:*** Vehicle is nodes of vehicular network. VANET addresses the wireless communication between vehicles (V2V) and between vehicles and infrastructure access point (V2I) [2].

TYPES OF VANET

Generally, Vehicular communication in VANET can be of two types:

- Inter-vehicle communication
- Intra-vehicle communication

The intra-vehicle communication is usedto describe communications within a vehicle,whereastheterminter-vehiclecommunication [6] represents communications between vehiclesor vehicles and sensors placed in or on variouslocations, such as roadways, signs, parkingareas, and even the home garage. Inter-vehiclecommunications can be considered to be moretechnically challenging because in this case thevehicle communications need to be supportedboth when vehicles are stationary and when theyare moving.

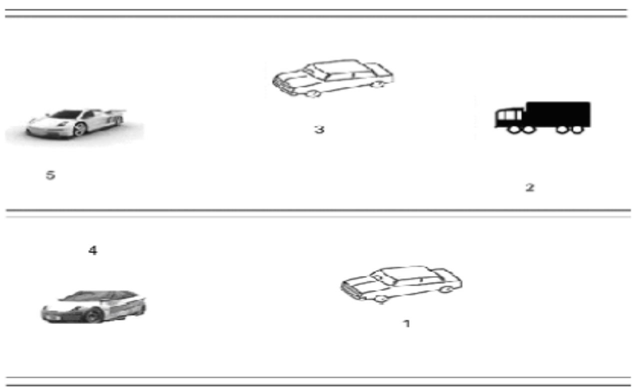

Figure 1: Example of a Vehicular Ad Hoc Network

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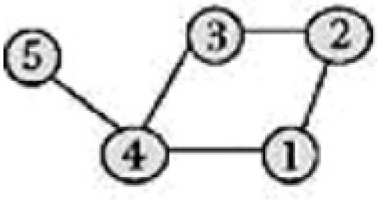

Figure 2: Vehicular Mesh structure

II. RELATED WORK

Josefa Z. Hernandez [7] is a decision support framework proposed for VANET. Comparison between combinedTRYS and TRYS autonomous agents has been presented in this paper. This framework was agent-based architecturesfor intelligent traffic management systems. Marc Torrent Moreno [8] presented mechanism that was aimed atinvestigating broadcasted messages to a neighbor by another neighbor node in VANETs. Saschaet. al.[9]presented Modern decision support systems (DSS) for transportation management that store huge amounts ofdecision-relevant data, as well as intend at assisting decision-makers to explore the meaning of that particular data,and to obtain decisions based on understanding this architecture. NabeelAkhtar [10] has presented realistic analysis ofthe VANET topology characteristics over time and space for highway. In this analysis, Author integrate real –worldroad topology and real-time data extracted from the Freeway Performance Measurement System (PeMS) database intoa microscopic mobility model to generate realistic traffic flows along the highway. Umar FarooqMinhas [11]introduced multi-faced trust model that is an intelligent agent based scheme for vehicular Ad-hoc network. In thisscheme, drivers exchangeinformation with other drivers regarding road and traffic conditions. Christian Adler et. Al[12] presented the concept of self-organized and context-adaptive information diffusion in VANETs. Christian Lochertet. al [13] presents information dissemination in vehicular ad-hoc networks (VANETs) in city scenarios. Zhou Wang et.al [14] examined the cooperative packet forwarding schemes in VANETs. VANET insists cooperative communicationwith peer nodes below its operation environment of high mobility, quickly changing topology and low associativelyredundancy. Mingliu Zhang et. al [15] reviewed the routing protocols for VANETS. Imran Khan et. al [16] evaluatedthe performance of AODV and OLSR routing protocols under realistic radio channel characteristics using NS-2 with Nakagami fading model.Haidar N. AL-Hashimi et. al [17] presented an inter-domain PMIPv6 handover scheme forvehicular environment. The proposed PMIPv6 handover system is based on MIIS information function.Francesco Lupiet. al [18] evaluate the performance of broadcast routing protocol in a VANET presented and also presented theemployment of RSUs inside the vehicular network. AbderrahimBenslimane [19] introduced a novel architecture thatcombines 3G/UMTS networks with VANET networks. Muhammad NadeemMajeed [20] review the necessaryprocesses twisted in a VANET handoff process. P. Suresh [21] proposed an analytical model for warning messagesthrough collision avoidance (CA) system.

III. ARCHITECTURE OF VANET

The architecture of VANET is described as follows:-

*A. Main Components:*According to the IEEE 1471-2000 [24, 25] and ISO/IEC 42010 architecture standard guidelines,we are able to achieve the VANETs system by entities whichcan be divided into three domains: the mobile domain, theinfrastructure domain, and the generic domain [23].

As shown in Figure 3, the mobile domain consists oftwo parts: the vehicle domain and the mobile device domain.The vehicle domain comprises all kinds of vehicles such ascars and buses. The mobile device domain comprises allkinds of portable devices like personal navigation devices andsmartphones.

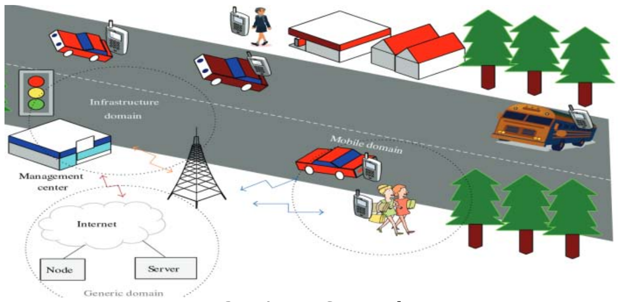

Figure 3: VANET System domain

Within the infrastructure domain, there are two domains:the roadside infrastructure domain and the central infrastructure domain. The roadside infrastructure domain contains roadside unit entities like traffic lights. The centralinfrastructure domain contains infrastructure management centers such as traffic management centers (TMCs) andvehicle management centers [23].

However, the development of VANETs architecture variesfrom region to region. In the CAR-2-X communicationsystem which is pursued by the CAR-2-CAR communicationconsortium, the reference architecture is a little different.

CAR-2CAR communication consortium (C2CCC) is themajor driving force for vehicular communication in Europeand published its "manifesto" in 2007. This system architecture comprises three domains: in vehicle, ad hoc, andinfrastructure domain.

As shown in Figure 3, the in-vehicle domain is composedof an on-board unit (OBU) and one or multiple applicationunits (AUs). The connections between them are usually wiredand sometimes wireless. However, the ad hoc domain iscomposed of vehicles equipped with OBUs and roadside units(RSUs). An OBU can be seen as a mobile node of an adhoc network and RSU is a static node likewise. An RSUcan be connected to the Internet via the gateway; RSUs cancommunicate with each other directly or via multi-hop as well.

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There are two types of infrastructure domain access, RSUsand hot spots (HSs). OBUs may communicate with Internetvia RSUs or HSs. In the absence of RSUs and HSs, OBUscan also communicate with each other by using cellular radionetworks (GSM, GPRS, UMTS, WiMAX, and 4G) [22].

B. *Communication Architecture:* Communication types inVANETs can be categorized into four types. The category isclosely related to VANETs components as described above.Figure 3 describes the key functions of each communicationtype [26].

a) *In-vehicle communication*, which is more and more necessary and important in VANETs research, refers to the invehicle domain. In-vehicle communication system can detecta vehicles performance and especially drivers fatigue anddrowsiness, which is critical for driver and public safety.

b) Vehicle-to-'vehicle (V2V) communication can provide adata exchange platform for the drivers to share informationand warning messages, so as to expand driver assistance.

c) *Vehicle-to-road infrastructure (V2I)* communication isanother useful research field in VANETs. V2I communicationenables real-time traffic/weather updates for drivers andprovides environmental sensing and monitoring.

d) *Vehicle-to-broadband cloud (V2B)* communication meansthat vehicles may communicate via wireless broadbandmechanisms such as 3G/4G. As the broadband cloud mayinclude more traffic information and monitoring data as wellas infotainment, so this type of communication will be useful foractive driver assistance and vehicle tracking.

C. *Layered Architecture for VANET:* The open system interconnection (OSI) model group similar communication functions into one ofthe seven logical layers [27]

Generally, the architecture of VANETs may differ fromregion to region, and thus the protocols and interfaces arealso different among them. DSRC is specifically designed for automotive use and a corresponding set of protocols and standards[28]. The US FCC has allocated 75 MHz of spectrum forDSRC communication, from 5.850 GHz to 5.925 GHz [28].

Different protocols are designed to use at the various layers;some of them are still under active development now. TheIEEE 802.Ilp, an approved amendment to the IEEE 802.11standard to add wireless access in vehicular environments(WAVE), is focused primarily on the PHY layer and MAC

D. *Sub-layer of the stack:* IEEE 1609 is a higher layer standardbased on the IEEE 802.Ilp. IEEE 1609 represents a family ofstandards that function in the middle layers of the protocolstack to flexibly support safety applications in VANETs, whilenon-safety applications are supported through another set ofprotocols. In particular, network layer services and transportlayer services for non-safety applications are provided by threequite stable protocols: IPv6, TCP, and UDP [24, 28, 29].

IV. RESEARCH METHODOLOGIES

In order to evaluate the performance of different architecture approaches, protocols, algorithms, and applications, an effective research methodology is required in VANETs. Such methods enable researchers and developers to check the drawbacks as well as ensure the availability of new proposed approaches to the above-mentioned aspects. Since VANETs have a potentially large scale, the introduction of a new technology into VANETs requires long development and the experimental implement is very expensive. In general, there are two important and necessary steps before the market introduction: (1) analysis and evaluation by simulations and (2) analysis and verification by field operational testing [23].In this section, we first introduce the different models which are the essential basis for setting up respective methodologies, and then the simulations and field operational testing are discussed in the following contents.

A. *VANETs Models:* VANETs are a large and complex overall system model, which consists of four sub models for the different aspects: driver and vehicle model, traffic flow model, communication model, and application model [23].

a) *Driver and Vehicle Model:*This model aims to reflect the behavior of a single vehicle. This behavior needs to consider two main factors: different driving styles and the vehicle characteristics, such as an aggressive or passive driver and a sports car. In [23], the authors discuss the driver and vehicle model introduced by Treiber et al. or Bayliss.

b) *Traffic Flow Model*:This model aims to reflect interactions between vehicles, drivers, and infrastructures and develop an optimal road network. In [31], according to various criteria (level of detail, etc.), the authors discuss three classes of traffic flow models: microscopic and macroscopic.

c) *Communication Model:*This model is a pretty important part of research methodologies to address the data exchange among the road users. Thanks to the constraints of many factors (the performance of the different communication layers, communication environment, and the routing strategies), communication model plays an important role in the research.The authors in [28] give a detailed overview in the research field.

d) *Application Model:* This model is very useful for the market introduction because it can address the behavior and quality of cooperative VANETs applications. This kind of model is necessary for two main reasons: (1) different functionality and visualizations for cooperative applications are provided by different vehicle manufacturers and (2) a prioritization of the information and warnings is needed among the simultaneous existence of several cooperative applications [23].

B. *Simulation Methods*: Simulation is no doubt an essential step before the implement of new technologies in VANETs. The simulation of VANETs requires two different components: a traffic simulator and a network simulator.

a) Traffic Simulators: In order to analyze vehicular ad hoc network characteristics and protocol performances, traffic simulators are needed to generate position and movement information of a single vehicle in VANETs environment. In [23], the authors list some existing traffic simulators in detail, like SUMO (simulation of urban mobility) and VISSIM (simulation of the position and movement for vehicles as well as city and highway traffic).

b) Network Simulators: To model and analyze the functionality of VANETs, a good network simulator should possess some features including a comprehensive mode, efficient routing protocols like AODV (ad hoc on demand distance vector), and communication standards like IEEE 802.II[p] and IEEE 1609 specifications [23]. Martinez et al. do a comparative study of network simulators, such as GloMoSim (global mobile information simulation) and NS-2 (the most popular simulator for IP-based wired and wireless networks) [32].

V. VANET CHALLENGES

Based on the previous discussion of VANETs, we can see that VANETs are a fantastic self-organizing network for the future intelligent transportation system (ITS). Although researchers have achieved much great progress on VANETs study, there are still some challenges that need to be overcome and some issues that need to be further investigated (e.g. communication, security, applications, stimulation, verification, services, etc.) [26, 33]

Compared with MANETs, the specific features of VANETs require different communication paradigms, approaches to security and privacy, and wireless communication systems [34]. For example, network connections may not be stable for a long time period. In order to improve the performance of communication, researchers have investigated the efficient use of available infrastructure, such as roadside units and cellular networks. Although some specific challenges of VANETs have been overcome, many key research challenges have only partially been solved [34]. Thus, researchers need to do deeper work to solve these challenges. In the following discussion, we will summarize the key challenges.

a) *Fundament Limits and Opportunities:*Surprisingly little is known about the fundamental limitations and opportunities of VANETs communication from a more theoretical perspective [35]. We believe that avoiding accidents and minimizing resource usage are both important theoretical research challenges.

b) *Standards:* The original IEEE 802.11 standard cannot well meet the requirement of robust network connectivity, and the current MAC parameters of the IEEE 802.Ilp protocol are not efficiently configured for a potential large number of vehicles [26]. Thus, researchers must do more work about standards.

c) *Routing Protocols:*Although researchers have been presenting many effective routing protocols and algorithms such as CMV (cognitive MAC for VANET) and GyTAR (greedy traffic-aware routing), the critical challenge is to design good routing protocols for VANETs communication with high mobility of vehicles and high dynamic topology [33].

d) *Connectivity:*The management and control of network connections among vehicles and between vehicles and network infrastructures is the most important issue of VANETs communication [36]. Primary challenge in designing vehicular communication is to provide good delay performance under the constraints of vehicular speeds, high dynamic topology, and channel bandwidths [37].

e) *Cross-Layer:*In order to support real-time and multimedia applications, an available solution is to design cross-layer among original layers [37]. In general, cross-layer protocols that operate in multiple layers are used to provide priorities among different flowsand applications. In [34, 38], the authors address the importance of cross layer design in VANETs after analyzing the performance metrics.

f) *Cooperative Communication:*In [36], the authors consider the VANETs as a type of cloud called mobile computing cloud (MCC), and in [26] the authors present a broadband cloud in vehicular communication. Thus, the cooperation between vehicular clouds and the Internet clouds in the context of vehicular management applications has become a critical challenge to researchers.

g) *Mobility:* Mobility that is the norm for vehicular networks makes the topology change quickly. Besides, the mobility patterns of vehicles on the same road will exhibit strong correlations [38]. In [30], the authors address the idea that mobility plays a key role in vehicular protocol design and modeling.

h) *Security and Privacy:*Reference [39] presents many solutions that come at significant drawbacks and the mainstream solution still relies on "key pair/certify catel signature." For example, key distribution is a key solution for security protocols, but key distribution poses several challenges, such as different manufacturing companies and violating driver privacy [38]. Besides, tradeoff of the security and privacy is the biggest challenge under the requirement of efficiency.

i) *Validation:*It is necessary not only to assess the performance of VANETs in a real scenario but also to discover previously unknown and critical system properties. Besides, validation has become more and more difficult under the wider range of scenarios, and Altintas et al. present can use field operational tests (FOTs) to solve this problem, but conducting meaning FOTs is a challenge like a large and complex system with technology components [36]. Thus, considering the characteristics of high mobility and high dynamic topology, researchers still need to study further and find solutions to the challenges we discussed above.

VI. PROS & CONS OF VANET

A. *Pros of VANET*

VANET offers countless benefits to organizations of any size. Automobile high speed Internet accesswould transform the vehicle's on-board computer from a nifty gadget to an essential productivity tool,making virtually any web technology available in the car. While such a network does pose certain safetyconcerns (for example, one cannot safely type an email while driving), this does not limit VANET'spotential as a productivity tool. It allows for "dead time"—time that is being wasted while waiting forsomething—to be transformed into "live time"—time that is being used to accomplish tasks. Acommuter can turn a traffic jam into a productive work time by having his email downloaded and readto him by the on-board computer, or if traffic slows to a halt, read it himself. While waiting in the car topick up a friend or relative, one can surf the Internet. Even GPS systems can benefit, as they canintegrated with traffic reports to provide the fastest route to work. Lastly, it would allow for free, VoIPservices such as GoogleTalk or Skype between employees, lowering telecommunications costs.

B. *Cons of VANET*

While the Internet can be a useful productivity tool, it can also prove to be quite distracting, resulting insafety and actually time-wasting concerns. Like cellular phones, the Internet can be tempting and candistract users from the road. Checking emails, surfing the web or even watching YouTube videos canengross drivers and lead to accidents.Similarly, while drivers may have the opportunity to do work while on the road, they also may use thisopportunity to engage in other leisurely tasks, such as VoIP with family, watch news highlights or listento podcasts.

CONCLUSION

This paper provides a detailed review on Vehicular Adhoc networks from the research perspective which covers brief introduction of VANET, architecture and research methodologies of VANET. It also covers the challenges in the establishment of VANET.We have focused on detailed study on VANET scenarios. In our next research we will implement some algorithm to establish our own VANET Adhoc Network for the secure and optimize routing.

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