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Taxonomy of Intelligent Transportation Systems (VANET): A Survey

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Abstract

For last years, the evolution of new issues has incited a great development of the transportation system. In this paper, we discuss ingredients of ITS (intelligent transportation system) that are inter-vehicle communication (IVC) or what can call vehicular ad hoc networks (VANET), which are special type of MANET. We will survey the main issues relevant to VANET in detail with providing a conceptual model for the overall taxonomy. Also detail applications comparison, characteristics and properties of vanet projects and applications are given. Mobility models are benefit to research area, so their main features are discussed. The consortiums relatives of these systems are introduced. Whole protocol type's classification with their common using protocols is proposed and analysis for the main relative ones provided. Also some suggestions for routing protocols, data diffusion, mobility models, media access control protocols, and security are discussed. The investigation will try to answer to future relative attributes and limitations.

Keywords: *VANET, ITS, communication, vehicle, security, mobility*

1. Introduction

VANET is one of challenges category in mobile ad hoc networks that create an intelligent space for vehicles communications. One of the main our daily requests comprise of road and car safety capability such as traffic emergency information about accidents and providing our good times (such: using Internet, helping ours follows to each other on the road, etc).The goal of an ITS is to enhance security, efficiency, fun and pleasure in road. The goal of customary traffic control systems is based on concentrate foundations such sensors and monitors performed along the road for collecting information in congestions and traffic state for relative processing and send notice massages. Here, we speaking about architecture based on a distributed and independent system which consists of the vehicles with no relativity to any centralized system, and data routing and especially a VANET [1] as shown in Figure 1.

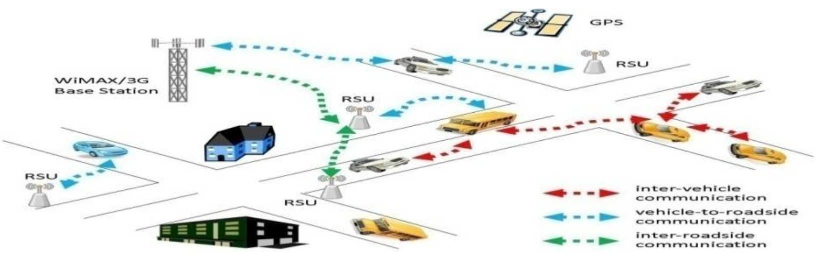

Figure 1. Example of VANET network

In this paper, we study the components in VANET that is an ITS system for inter-vehicle communication (IVC) and its relative provisions (Figure 2).

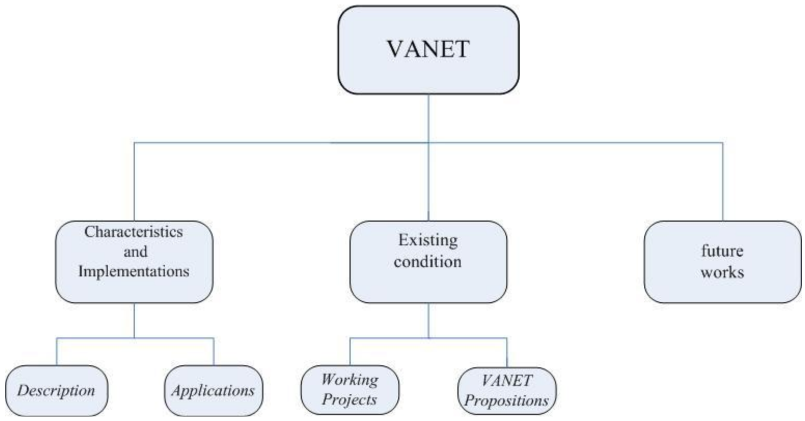

Figure 2. VANET relative provisions

The rest of the paper is organized as follows. Section 2 gives the VANET characteristics, Section 3 reviews the relative history, Section 4 describes the main idea and Section 5 concludes the paper.

2. Characteristics

The capabilities of VANET for intelligently controlling traffic and providing safety, based on its properties that provide a vast number of relevant applications.
In a VANET we have not MANET relevant restrictions. In this network, power device, processing ability and memory facilities are desired and in good condition. The network can adopted for using in real-time WANs based on GPS system.
Because of VANET characteristics and fast topological changes, mainly due to high velocities [2, 3], they can also exhibit limited temporal and functional network redundancy, in addition to frequent fragmentation of the network topology [4]. The VANET itself can modify its own topology, for instance through the way drivers respond to messages sent out by the VANET.
A VANET also involves occasional communication to roadside infrastructure (known as Roadside Units or RSUs [5]). In civilian applications, roadside communication may

be to a roadside network carrying accident or traffic black spot alerts. Because of accident avoidance and safety, all communications will concentrate on information transmission from a node to other destination nodes. However the vehicle nodes involved in similar transmission, upon their degree of implication in the activated contest, are nodes with one way solution.

The characteristics of VANET, particularly size condition, need making corrections.

There are three major categories: safety and efficiency in road, driver convenience and commercial issues. For improving safety and efficiency in travel and managing road accidents, IVCs suggest the feasibility of avert collisions with monitoring surrounding road, avert all obstacles and atmospheric conditions. Convenience applications make easy independency and help specially to the driver, principally for managing traffic and for case of consuming decreasing. Commercial applications will provide the entertainment such as web access, streaming audio and video, inter-vehicle chat, network games, etc.

Here, we identify the description of a few application services of V2V (Vehicle-to-Vehicle) communication system.

- *Abnormally Traffic Signals*

Safety applications would be Slow/Stop Vehicle Advisor (SVA) in which a slow or motionless vehicle will broadcast alert message to its neighborhood. Congested Road Notification (CRN) detects and notifies about road congestions which can be used for route and journey planning [6]. The toll collection without stopping is another use of this type.

- *Environmental Conditions*

Vehicle nodes intended for send and receive information about weather, intersection collision warning, parking, obstacles, emergency message etc. In case this information must be small and transmitted quickly.

- *Driving Assistance*

Providing the information that drivers have missed or might not yet is able to see. Driving cooperative [7] is a case that improves transport safety also to decreasing injury in accidents. This practice support transmitting between nodes provided with tools such as sensory devices, so detecting environment situation and then forming dynamic clusters. Vision enhancement, information about weather and parking availability information are other applications.

- *Roadside Locations and Entertainment*

Helping to find the shopping centre, hotels, and gas stations, accessing the internet are example applications. Also people can use games from other place, multimedia files, and so on. According to the description, comparisons of vanet applications are shown in Table 1.

Table 1: comparisons between vanet applications

Application	Categories	Traffic Type	Project Examples
Abnormally Traffic Signals	Category 1	event	C2C-CC
Environmental Conditions	Category 2	periodic	FleetNet
Driving Assistance	Category 2	event	PReVENT
Roadside Locations and Entertainment	Category 3	event	Car Talk

3. History

Based on the previous research papers, in this section we have reviewed fundamental projects and propositions.
Many projects and trials have been invested in the field of V2V communications. In [8] a brief summary of VANET trials supported by consortia in the USA, European Union, and Japan are discussed. Here some of known activity and relative partnerships are discussed.

- FleetNet (2000–2003): Fleetnet [9] supported by some manufacturers and academic centres in Europe, concentrated on various research areas. The consortium include exploratory character description of VANETs, suggesting the new routing and MAC protocols, with the exploring other technologies in wireless and AdHoc.
- VII (Vehicle Infrastructure Integration) (2004–2009): This consortium provides collaboration between manufactures, IT suppliers and other relative associations. The aim of the VII program is to deploy an enabling communications infrastructure that supports vehicle-to-infrastructure, as well as vehicle-to-vehicle communications, for a variety of vehicle safety applications and transportation operations. In addition, VII will enable deployment of different applications which support encourages interests, involving vehicle manufacturers [10]. Principal applications are under development such [11] notice drivers for: unsafe situations and collisions and should they be around to run off the road, supplying real-time information for congestion concerning operators, weather situations, and other events, also supplying operators the corridor capacity information.
- VSC (Vehicle Safety Communications (2002–2004), (VSC-2) (2006–2009): This consortium [12] has run many experiments over the last four years in coordination with the NHTSA (National Highway Traffic and Safety Administration). In particular its objectives of the trials being to : improving past safety scenarios by the use of DSRC(Dedicated Short Range Communication) along with positioning systems, defining requirements and parameters for safety oriented applications, traveler information, on board entertainment, fuel efficiency, pollution control etc.
- IVI (Intelligent Vehicle Initiative) (1998–2004): The IVI goal was decreasing the severity of crashes through avoiding driver mistakes.

- C2C (Car-to-Car Communications Consortium): The Car2Car [13] started project in 2001 and its main objectives are development and release of an open European standard for cooperative ITS and associated validation process with focus on IVC systems, to push the harmonization of Car-2-Car communication standards worldwide, driver assistance with new technologies, development of active safety applications, contributing to the EU standardization bodies.
- NOW (Network-on-Wheels) [14] (2004-2008): A German government supported project, established by vehicle manufactories and academic centres. Its goal was performing optimum protocols for transferring messages (for network and transport layer for IEEE 802.11 and ad hoc) in addition methods for secure data transfer that used in C2C communication consortium and the EU standardization body ETSI .In addition a flexible IEEE 802.11a hardware platform, which manages in an efficient way the low level wireless communication interface has been developed and is used by the partners.
- CVIS (Cooperative Vehicles and Infrastructure Systems): An EU project that commenced in 2006 to design, develop and test the technologies to allow cars to communicate with each other (C2C) and with the nearby roadside infrastructure (C2I) with goal of road safety and efficiency [15]. The project also work on traffic and network monitoring define an architecture and system for applications, and develop common core components to support cooperation models in real-life applications and services for drivers, operators, industry and other key stakeholders, to address other issues relative to user, privacy and security, system openness and interoperability, risk and liability, public policy needs, cost/benefit and business models, and so on. Further, it will develop a mobile router using a wide range of communication media, including mobile cellular and wireless local area networks, short-range microwave (DSRC) or infrared, to link vehicles continuously with roadside equipment and servers.
- EVITA (E-safety vehicle intrusion protected applications) (2008-2011): A project funded by the EU Commission [16] within the 7th framework programme for research and technological development. The main objective of EVITA is to design, verify, and prototype an architecture for automotive networks with security components protecting and sensitive data protecting against compromise when transferred inside a vehicle. In addition, it also focuses on the protection of the intra-vehicle communication EVITA complements other e-safety related projects that focus on the protection of the vehicle-to-X (V2V, VI, and so on) communication. Based on our considerations from above projects, comparison of main properties is shown in Table 2.

Table 2: main properties of vanet projects

project	Main Objective	commenced	architecture	Type of Communication
FleetNet	driver assistance & security	Germany	Hybrid(cellular/ WLAN and ad hoc)	V2V and V2I
VII	safety applications	USA	Hybrid	V2V and V2I
VSC	safety applications	USA	cellular/ WLAN	V2V and V2I
IVI	driver distraction & crash avoidance	USA	ad hoc	V2V
C2C	driver assistance & safety applications	europ	ad hoc	V2V
NOW	protocols & security	german	ad hoc	V2V
CVIS	standards for V2V and V2I	europ	Hybrid	V2V and V2I
EVITA	security	europ	Hybrid	V2V and V2I

Some of other trials that are based on consortiums and projects include the following projects:

ADASE II, AKTIV, ANEMONE, ARTIC, ATESST2, ASV, CALM, CarTALK 2000, COVER, COOPERS,CONVERGE, COMeSafety, COM2REACT, CODIA, CFVD, CVHS, CVPC, CVTA, CYBERCARS-2, DAIDALOS, Demo 2000, DIVAS, e-FRAME, EcoMove, eIMPACT, EMMA, eSafety Support, FESTA, FIDEUS, , FOT-Net, FRAME, FREILOT, FRICTI@N, GST, GOODROUTE, GeoNET, HeavyRoute, HIGHWAY, I-WAY, i2010, INFONEBBIA, IntelliDriveSM, INTERSAFE 2, INTRO, INVENT, iTETRIS, IVSS, JARI, KAREN,Mediamobile, MITRA, MobiVip,MORYNE, NEARCTIS, OmniAir, OPTIS, P3ITS, PRE-DRIVE C2X, PRECIOSA, PReVENT, PROMETHEUS, REACT, ROADSENSE, RTMS, SAFESPOT, SAFETY TECHNOPRO, SATIN, SeVeCom, SIM-TD, SISCOGA, SISTER, SMARTFREIGHT, PREDIT, SPITS, SUMMITS, TRACE, TRACKSS, Traffimatics, V2X, VAS, WATCH-OVER, XFCD.

4. Idea

In this section we classify and describe some propositions for VANET that still need more investigation.

4.1 Routing

The routing protocols in vehicle networks are based on principles of routing in mobile ad hoc networks (MANET). There are two categories of MANET routing protocols – the flat and the large-scale protocols. The flat one includes two different subsets: Proactive protocols (DFR, IARP, CGSR, FSLS,OLSR,TBRF,…), that update network routing information to all nodes at all times even if those paths are not currently being used, Reactive protocols (SENCAST, DYMO, RAODV, ACOR, AODV, BSR, DSR, ….), that maintain and update only the routes which are currently in use. Communications between vehicles in VANET only use few numbers of routes; due to vanet characteristics, reactive protocols are suitable for them. The large-scale one includes two subsets: Geographical protocols (AGSG, GGAR, DREAM, LAR, GPSR, GRP, GeoTORA …) and Hierarchical protocols (HSR, ZRP, CGSR, LANMAR …).

The vehicles mobility attributes and their replacing topology results in conventional MANET protocols being insufficient for efficiently deal with VANET as intermediate nodes cannot always be found between source and destination nodes and complete connectivity cannot always be performed. This influenced the investigators to find dynamic routing protocols that are strong enough for the common path distributions caused by vehicle mobility [17, 18, 19], new approaches that can deliver enhanced throughput and better packet delivery ratio [20, 21], thereupon protocols investigation, they are classified into two major categories: topology-based and position-based. These routing protocols shown in Figure 3.

• *Position based (Geographic) Protocols*

These protocols [22] use the information regarding physical location of the involved nodes that are available to the straight neighbors in a manner that transmit beacons periodically. Determination of routing in all nodes is based on the destination's location included in their packets and the location of the neighbors of forwarding nodes. Examples of position based protocols include:

A-STAR (Anchor-based Street and Traffic Aware Routing) [23] was a protocol for a urban IVC condition. This protocol is based on buses route for recognizing anchor-based routing to sending or receiving packets.

CAR (Connectivity-Aware Routing) [13], main property of CAR is its capability to maintain a cache of achieved routes between sources and destinations. This property was inspired by supervision of other position-based protocols and their lack for utilizing information gathering about detached routes, after detecting those disconnections.

GSR (Geographic Source Routing) proposed for VANET in city environments [24]. It joins position-based routing protocol with topological information by calculating the junctions arrangement that must be pass overed by packets to reach their destination; then this information are contained in the packets in the form of GSR.

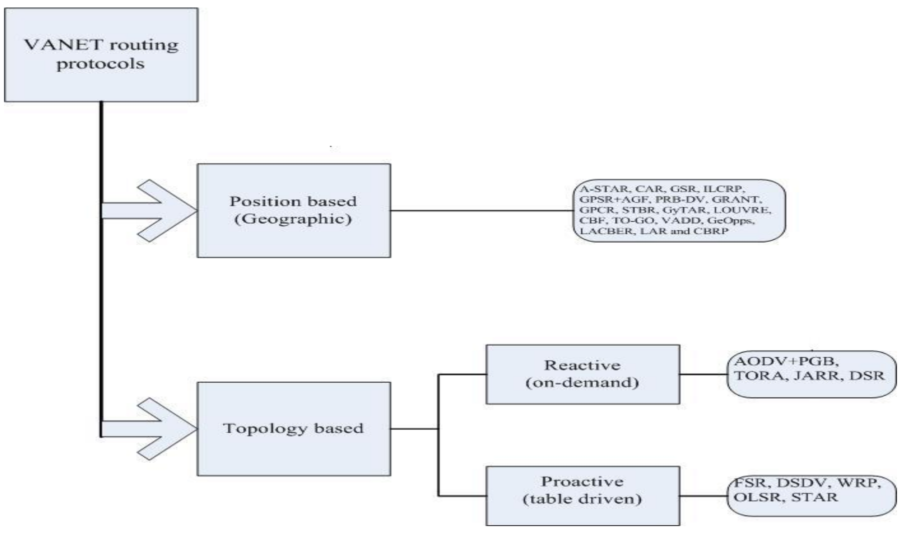

Figure3. Routing Protocols in VANET

ILCRP (Improved Location aided Cluster based Routing Protocol) for GPS enabled MANETs hoped that the geographic routing based clustering scheme presented would form the foundation for the possibility of reliable data sharing and communication between highly mobile vehicles i.e., VANETs for the present and in the future [18].

Many other protocols have been proposed include: GPSR+AGF, PRB-DV, GRANT, GPCR, STBR, GyTAR, LOUVRE, CBF, TO-GO, VADD, GeOpps, LACBER, LAR and CBRP.

- *Topology based Protocols*

These routing protocols use network links data. These protocols categorized in two divisions, the first is Reactive and the second is Proactive. Example of proactive (table driven) routing protocol is FSR (Fisheye State Routing) (Iwata, 1999; Pei, 2000) which is based on link state protocols. Each of network node works with a network state diagram and send this information to their near nodes. Examples of reactive (on-demand) routing protocols are: AODV+PGB(Distance Vector+ Preferred Group Broadcasting) [25]. Its main goal is reducing the network bandwidth consumption in distance vector protocols for discovery manner. Other property is stable routing for vehicle nodes. Drawbacks are the taking longer route discovery and broadcast can discontinue if the group is found to be empty. TORA(Temporally Ordered Routing Algorithm), main property of protocol is giving route to entire nodes, so the route stability needed for vanet is in desired level and network control packets reach to farthest nodes rapidly.

4.2 Dissemination and Diffusion of data

Information diffusion is data forwarding from a source node to other destination nodes, with guarantee a finite delay, effective reliability and better resource use with regard to Road Safety and Commercial Applications. Receiving nodes in diffusion method may be known with their IP and conditions or other identification. The following are some relative methods.

VADD (Vehicle-Assisted Data Delivery) use predictable traffic model and vehicle mobility to assist effective data delivery [26]. Its main goal is identifying paths with minimum delay that is essential for wireless disseminations. For rapid packet transmission, high speed road must be selected. The selection may be changed based on intersections condition.

MDDV (Mobility-Centric Data Dissemination Algorithm for Vehicular Networks) [27]. For reflecting relative traffic density and distance, a weight assigned to each connection. This solution uses a forwarding path indicated as the smallest weight route to destination domain in the lead graph.

UMB is an IEEE 802.11 based Urban Multi-hop Broadcast protocol [28] for IVC. The protocol works on two relevant issues, in directions and junctions. In directional dissemination, information sending is based on furthest distance vehicle node. In junction dissemination, information sends to all road sections.

SODAD is a method for scalable information dissemination in highly mobile VANETs [29]. This protocol’s main goal is for driver convenience and helping them. In SODAD, information about traffic conditions, weather, accidents and other comfort related data such as parking lots are stored and disseminated to all neighbors and updated periodically.

TRADE (Track Detection) [30], purpose is promise good reliability and restricted number of rebroadcasts so every vehicle must indicate in relative near nodes which their motions assurance guaranteed.

DDT (Distance Defer Time) [30], uses a delay period for receiving packet previously and meanwhile if it gets that same packet from other node, it doesn't transmit it to others.

IVG (inter- vehicle geocast) [31] is other dissemination method which makes general the last methods (TRADE and DDT) for overcoming network segmentation and trustworthy. Dynamic retransmits are initiated for periodically retransmit alarm notices that are selected according to their distance with source node. The IVG have better performance and reliability than TRADE and DDT.

4.3 Mobility models

The complexity of VANET environment makes it difficult and expensive to implement and evaluate them before any new issues. A mobility model defines the set of rules that defines the movement model of nodes used by network simulators to create random topologies based on nodes position and perform some tasks between them.
The UDel mobility model version 1.0[32] is a simulating tool for urban mesh networks that contains interference in mobile nodes and produces corresponding urban area graph. The behavior of mobile nodes will be observed. Other simulators such as TRANSIM [33], VISIM [34], CORSIM [35] and Vanet MobiSim [36] are able to generate the traces for movement of vehicles and their behaviors traffic in urban.
In the STRAW (STreet RAndom Waypoint) [38] model, node motion is limited to road areas and specified with true classified information which mobility is restricted to road congestion. MOVE tool on the basis of SUMO (Simulation of Urban Mobility) was developed [37] for producing data files for movability used with NS-2 and Qualnet simulators in [39], GrooveSim simulation tool was improved that merges path models with a set of mobility, communication and traffic. The Features of the major vehicular mobility models are shown in Table 3.

Table 3: mobility models features

mobility model	Input	Output	Graph	Platform	Velocity	Human Patterns
MobiSim	GDF, AWL	ns-2, glomoSim, QualNet	User Defined	java	uniform	IDM
STRAW	TIGER	Swans	Geographical	Swans	smooth	CFM
MOVE	TIGER db	ns-2, QualNet	User Defined, Random	C++	uniform	CFM
SUMO	TIGER db	ns-2, glomoSim, QualNet	Grid Based, UserDefined	C++	Road Dependent, Smooth	CFM
Groove Sim	TIGER db	none	Geographical	C++	uniform	no

4.4 Media Access Control (MAC)

Currently, there are two types of approaches in developing MAC for IVC: contention-based and schedule-based (contention-free) protocols [40]. The main advantage of contention-based approaches is that no reconfiguration needing during operation however, due to the random access they cannot guarantee a bounded access delay. Thus, the main challenge for this kind of protocols is to find a way that limits the access delay (with high probability). Contrary, schedule-based protocols can provide a bounded access delay. But reconfiguration needed due to time slots, which takes time and needs messages to be exchanged. Now we discuss some propositions which attempt to enhance specific aspects of existing rules:

D-FPAV (Distributed Fair Transmit Power Adjustment for VANET) is a Contention-based protocol [41], the main purpose is limit transmit power of periodic status messages (prioritization), keep overall network load under specific threshold (maximum beaconing load: MBL) always reserve some bandwidth for safety messages.

VeSOMAC (Vehicular Self Organising MAC protocol) is a contention-free protocol [42] using time slots, It is a distributed TDMA approach and it's able to reconfigure it's schedule very fast after topology changes. It uses an in-band network topology information exchange technique, it's necessary for every node to send at least one packet every frame, even if no application data is available for sending.

LCA (Location-based Channel Access) a distributed access protocol on the basis of position information that divides a geographical surface into several cells with an individual channel. Each can use every multiple access protocol such as CSMA or CDMA.

RR-ALOHA (Reliable R-ALOHA) protocol on the basis of UTRA TDD. In this protocol, extra information about the situation of every slot is transmitted to all nodes for avoidance of the similar reservation occurs.
Several other protocols are proposed like: MBCC, adaptive QoS, VMESH MAC, RMAC, clustering based multichannel MAC, CA-CDMA. Although many other protocols recommended, but more work need to perform in this field.

4.5 Security

Security of message content is a big issue for V2V and V2I communication. The research work is concentration on the security system of VANET with following features: Authentication, Data Integrity, Anonymity, Availability, Low Overhead, Privacy, and Real Time Constraints. A brief description of some of these propositions follows.
Within the SeVeCom project [43], having developed a security architecture that introduced a range of mechanisms, to handle identity and credential management, and to secure communication while enhancing privacy. In [44], the authors presented the ECPP protocol that characterized by the generation of on-the-fly short-time anonymous keys between On-board Units (OBUs) and Roadside Units (RSUs), which can provide fast anonymous authentication and privacy tracking while minimizing the required storage for short-time anonymous keys. The authors of [45] propose Adaptive Message Authentication (AMA), a lightweight filtering scheme that reduces the number of

cryptographic operations performed by the nodes. The authors of [46] recommended a model for evaluating validity level of data move around in the VANET. The authors of [47] describe and analyze the different attacks in vehicular networks and suggest one security design for describing and evaluating its protocols. Also they present a cryptography public key adapted for VANET networks. The authors of [48] offered the SecCar design for IVCs based on a public key infrastructure to offer security solutions. The authors of [49, 50] have discussed security requirements with using of digital signatures and public key infrastructure for a VANET environment. In NOW project [51] a construction of attack trees implemented.

5. Conclusions and future works

In this article we have explained several components of VANET. For A comparative survey in characteristics and various applications, projects, consortiums and propositions, a number of contributions are presented. Subsequently a review of previous mobility models was conducted to contributing to the researchers for future work. Due to the vast number of routing protocols, classify them into two major categories. Also there is similarity to MANET, demands and solutions need special investigate with researches. We think that Many researches fields such as special concentration must be given to mobility models for a good overall situation, allocation of a protected frequency and for road safety, possible use of the IEEE 802.11p / WAVE standard(wireless access to vehicular environment), data transport MAC protocols and cross-layer design, realistic approaches for the investigation of routing protocols, joining of wireless technologies, security, control of congestion, resource management, IP mobility and IPv6 deployment in VANET, capacity and mobility connectivity, integration of VANETs with cellular networks and data dissemination are left for future work.

6. References

[1] Arunkumar Thangavelu, Sivanandam S.N.: ‘Location Identification and Vehicular Tracking for Vehicular Ad-Hoc Wireless Networks’. IEEE Explorer, February 2007, 1 (2), pp. 112–116.

[2] Menouar H. and Filali F.: ‘A survey and qualitative analysis of MAC protocols for vehicular ad hoc networks’, IEEE Wireless Communications, October 2006.

[3] Leinmuller T., Schoch E., and Kargl F.: ‘Position verification approaches for vehicular ad hoc networks’, IEEE Wireless Communications, October 2006.

[4] Wang Z. and Chigan C.: ‘Countermeasure Uncooperative Behaviors with Dynamic Trust-Token in VANETs’, in the proceedings of ICC 2007.

[5] Zang Y., Stibor L., Walke B., Reumerman H-J. And Barroso A.: ‘Towards Broadband Vehicular Ad Hoc Networks – The Vehicular Mesh Network (VMESH) MAC Protocol’, in the Proceedings of IEEE WCNC 2007.

[6] Kamini and Rakesh Kumar: ‘VANET Parameters and Applications: A Review’,Global Journal of Computer Science and Technology,sept 2010.

[7] Houda, L.: ‘Wireless Ad Hoc and Sensor Networks’ (John Wiley, 2008).

[8] Hartenstein, H., Laberteaux, K. ‘A tutorial survey on vehicular ad hoc networks’, IEEE Communications Magazine, June 2008, pp.164–171.

[9] FleetNet project – Internet on the road, http://www.et2.tu-harburg.de/fleetnet,2000.

[10] www.vehicle-infrastructure.org, accessed sept 2011.

[11] Zeadally S. et al., ‘Vehicular ad hoc networks (VANETS): status, results,and challenges’,Telecommunication Systems , Springer, DOI10.1007/s11235-010-9400-5,December 2010.

[12] Shulman, M., and Deering, R.: ‘Vehicle safety communications in the United States’ (2007) As sited in ‘Vehicular ad hoc networks (VANETS): status, results,and challenges’,Telecommunication Systems , Springer, DOI10.1007/s11235-010-9400-5,December 2010.

[13] Car2Car Communication Consortium, www.car-to-car.org, accessed Dec 2013.

[14] NOW (Network-On-Wheels), www.network-on-wheels.de, accessed sept 2011.

[15] CVIS (Cooperative Vehicles and Infrastructure Systems), www.cvisproject.org, accessed Sept 2011.

[16] EVITA, www.evita-project.org, accessed Sept 2011.

[17] Luo, P., Huang, H., Shu, W., Li, M., and Wu, M.: ‘Performance evaluation of vehicular dtn routing under realistic mobilitymodels’,In Proceedings of IEEE wireless communications and networking conference, April 2008, pp. 2206–2211.

[18] Velmurugan M., Angamuthu T.: ’A new approach to geographic routing for location aided cluster based MANETs’, EURASIP Journal on Wireless Communications and Networking, doi:10.1186/1687-1499-2011-18, June 2011.

[19] Chung, S.-E., Yoo, J. and Kim, C.-K.: ‘A cognitive MAC for VANET based on the WAVE systems’, In Proceedings of 11th international conference on advanced communication technology (ICACT 2009), , February 2009, Vol. 1, pp. 41–46.

[20] Choi, J.; Jung, S.: ‘A Security Framework with Strong Non-Repudiation and Privacy in VANETs’,Consumer Communications and Networking Conference, Las Vegas, NV CCNC 2009, 6th IEEE, 2009.

[21] Gerlach, M, Full paper:’ assessing and improving privacy in VANETs’,www.network-on-wheels.de/downloads/ escar2006gerlach.pdf, accessed May 2010.

[22] Füßler, H., Mauve, M., Hartenstein, H., Käsemann, M., and Vollmer, D.: ‘A comparison of routing strategies for vehicular ad hoc networks’, (Technical report, TR-02-003), Department of Computer Science, University of Mannheim, July 2002.

[23] LIM T.M,SEET B.C.,LEE B.S.,YEO C.K.,KASSLER A.: ‘Pervasive Communication for Commuters in Public Buses’,Proceedings of IEEE International Conference on Pervasive Computing and Communications Workshops (PERCOMW 05), Washington, USA, 8-12 March 2005, pp.75-79.

[24] LOCHERT C., HARTENSTEIN H., TIAN J., FLER H., HERRMANN D., MAUVE M.: ‘A Routing Strategy for Vehicular Ad Hoc Networks in City Environments’, Proceedings of IEEE Intelligent Vehicles Symposium (IV2003),Ohio, USA, June 2003.

[25] Naumov, V., Baumann, R., Gross, T. : ‘An evaluation of Inter-Vehicle Ad Hoc Networks Based on Realistic Vehicular Traces’, Proc. ACM MobiHoc’06 Conf., May 2006.

[26] Zhao J. and Cao G.: ‘VADD: Vehicle-Assisted Data Delivery in Vehicular Ad Hoc Networks’, IEEE Transactions on Vehicular Technology, Vol. 57, No. 3, May 2008.

[27] WU H., FUJIMOTO R., GUENSLER R. and HUNTER M.: ‘MDDV: a Mobility Centric Data Dissemination Algorithm for Vehicular Networks’,Proceeding of the 1st ACM InternationalWorkshop on Vehicular Ad Hoc Networks, Philadelphia, PA, USA, 2004, pp.47-56.

[28] KORKMAZ G., EKICI E., OZGUNER F. and OZGUNER U.: ‘Urban Multi-Hop Broadcast Protocol for Inter-Vehicle Communication Systems’, Proceeding of First ACM Workshop on Vehicular Ad Hoc Networks(VANET 2004), Philadelphia, PA, USA,2004, pp. 76-85.

[29] Wischhof, L., Ebner, A. and Rohling, H.: ‘Information Dissemination in Self-organizing Intervehicle Networks’, IEEE Transactions on Intelligent Transportation Systems, March 2005, 6(1), pp. 90-101.

[30] SUN M.T., FENG W.C., LAI T.H., YAMADA K. and OKADA H.: ‘GPS-based Message Broadcast for Adaptive Inter-vehicle Communications’, Proceeding of IEEE VTC Fall 2000, Boston, MA, USA, September 2000, no. 6, pp. 2685-2692.

[31] BENSLIMANE A. and BACHIR A.: ‘Réseaux Ad Hoc Mobiles: Géodiffusion InterVehicules’ , in G. Pujolle(ed), L’Internet ambient, Hermes, Paris, 2004, pp. 215-236.

[32] UDel models for simulation of urban mobile wireless networks, http://udelmodels.eecis.udel.edu, accessed Sept 2013.

[33] TRANSIMS (TRansportation ANalysis and SIMulation System), http://transims.tsasa.lanl.gov, accessed May 2011.

[34] PTV simulation—VISSIM (2010), www.english.ptv.de/cgi-bin/traffic/traf_vissim.pl, accessed Dec 2013.

[35] CORSIM:microscopic traffic simulation model,http://mctrans.ce.ufl.edu/featured/tsis/Version5/corsim.htm, accessed Sept 2013.

[36] VanetMobiSim project, home page, http://vanet.eurecom.fr, accessed Sept 2011.

[37] KARNADI F.K., MO Z.H. and LANY K.-C.: ‘Rapid Generation of Realistic Mobility Models for VANET’, Proceeding of the Eleventh Annual International Conference on Mobile Computing and Networking, Cologne, Germany, August-September 2005.

[38] CHOFFNES D.R., BUSTAMANTE F.E.: ‘An Integrated Mobility and Traffic Model for Vehicular Wireless Networks’, Proceeding of the 2nd ACM International Workshop on Vehicular Ad Hoc Networks(VANET), Cologne, Germany, September 2005.

[39] MANGHARAM R., WELLER D.S., STANCIL D.D., RAJKUMAR R. and PARIKH J.S.: ‘GrooveSim: A Topography-Accurate Simulator for Geographic Routing in Vehicular Networks’, Proceeding of the Second ACM International Workshop on Vehicular Ad Hoc Networks”, Cologne, Germany, September 2005.

[40] Raghavan V. S., Kumar S. and Deng J.: ‘ Medium access control protocols for ad-hoc wireless networks: A survey’, Elsevier Ad-Hoc Networks Journal, May 2006, 4(3), pp. 326-358.

[41] Torrent-Moreno M., Santi P., and Hartenstein H.: ‘Distributed fair transmit power adjustment for vehicular ad hoc networks’, SECON '06. 2006 3rd Annual IEEE Communications Society on Sensor and Ad Hoc Communications and Networks, Sept. 2006, 2:479-488.

[42] Fan Yu and Subir Biswas: ‘A self-organizing mac protocol for dsrc based vehicular ad hoc networks’, 2007.

[43] Papadimitratos, P., et al.: ‘Secure Vehicular Communication Systems: Design and Architecture’, Communications Magazine, IEEE, Vol. 46 Issue: 11, November 2008.

[44] Rongxing Lu et al.: ‘Efficient Conditional Privacy Preservation Protocol for Secure Vehicular Communications’, proceedings of the IEEE INFOCOM, 2008.

[45] Ristanovic, N., et al.: ‘Adaptive Message Authentication for multi-hop networks’, Eighth International Conference on Wireless On-Demand Network Systems and Services (WONS), Jan. 2011, pp. 96 – 103.

[46] Papadimitratos, P., et al.: ‘Secure Vehicular Communication Systems: Design and Architecture’, Communications Magazine, IEEE, Vol. 46 Issue: 11, November 2008.

[47] GOLLE P., GREENE D.H., STADDON J.: ‘Detecting and Correcting Malicious Data in VANET’, Proceeding of First ACM Workshop on Vehicular Ad Hoc Networks, Philadelphia, USA,October 2004, pp. 29-37.

[48] RAYA M., HUBAUX J-P.: ‘ The Security of Vehicular Ad Hoc Networks’ , Proceeding of the 3rd ACM Workshop on Security of Ad Hoc and Sensor Networks, Alexandria, USA, November 2005.

[49] BLUM J., ESKANDARIAN A.: 'The Threat of Intelligent Collisions', IT Professoinal, vol. 6, no. 1, January-February 2004, pp. 24-29.

[50] GOLLAN L., MEINEL C.: 'Digital signatures for automobiles', Systemics, Cybernetics and Informatics (SCI), 2002.

[51] ELZARKI M., MEHROTRA S., TSUDIK G., VENKATASUBRAMANIAN N.: 'Security Issues in a Future Vehicular Network', European Wireless, Florence, Italy, February 2002.