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Vehicular Ad Hoc Networks

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ABSTRACT

Vehicular Ad Hoc Network (VANET) is an emerging new technology integrating Ad Hoc network, cellular technology and wireless LAN (WLAN) to achieve vehicle to vehicle and vehicle to infrastructure communication for intelligent transportation systems (ITS). VANETs are distinguished from other kinds of Ad Hoc networks by node movement characteristics, their hybrid network architectures and new application scenarios. The vehicular network provides wide variety of services, ranging from safety-related warning systems to improved navigation mechanisms as well as information and entertainment applications. Therefore, VANETs pose many unique networking research challenges, and the design of efficient routing protocols that not only forward packets with good end to end delay but also take into consideration the reliability and progress in data packets forwarding.

In this paper, we provide a review of VANETs architecture, its characteristics, applications various routing protocols and challenges.

Keywords : DSRC, ITS, VANET, WLAN

1.INTRODUCTION

VANET is an emerging technology to achieve intelligent inter-vehicle communications(IVC), seamless internet connectivity resulting in improved road safety, essential emergency alerts and accessing comforts & entertainments with increased efficiency of the transportation systems [1]. It includes a wide range of technologies such as vehicle communication system, Global Positioning System (GPS), video cameras, digital mapping, sensing technologies together with advanced information processing tools. It provides relevant and timely information to users and traffic management systems to improve traffic efficiency, reduce traffic congestion and improve road safety. VANET is a novel class of Mobile Ad-Hoc Network (MANET) & an important component of Intelligent Transportation System (ITS) [3],[4].

VANET is used for the exchange of messages between vehicle to vehicle (V2V) and also between vehicles and fixed roadside equipment (V2R) as shown in fig.1. Vehicles communicate using Dedicated Short Range Communications (DSRC) that includes wireless technologies like WiFi, IEEE 802.11, WIMAX, IEEE 802.15, Bluetooth, IRA and Zig Bee [5],[6]. The Federal Communication Commission (FCC) has allocated 75 MHz of the frequency spectrum in the range 5.850 to 5.925 GHz band for Dedicated Short Range Communication (DSRC) and is based on a variant of 802.11a. Seven channels each of 10 MHz make up the DSRC, with six channels being used for services and one channel for control [7]. Throughout the world, there are many national and international projects in governments, Industry, and academia devoted to the development of VANET protocols. These projects include Vehicle-Infrastructure Integration Program (VII) in North America, Vehicle Information and Communication System(VICS) & Intelligent Transportation System (ITS) in Japan, The FleetNet & Network-on-Wheels (NoW) in Germany, Intelligent Transport System in India and Cooperative Vehicle Infrastructure Systems(CVIS), Co-operative Systems for Intelligent Road Safety (COOPERS), Global Systems for Telematics(GST), COMCAR[8], DRIVE[9], COMeSafety, PREVeNT, CarTALK2000 in various European countries, the consortia like Vehicle Safety Consortium (US), Car-2-Car Communication Consortium (Europe) and Advanced Safety Vehicle Program (Japan) and standardization efforts like the IEEE 802.11p, 'Wireless Access in Vehicular Environment' (WAVE), ISO TC204 WG16 and SAE[3]. The ultimate goal of these projects is to create new network algorithms or modify the existing one for use in a vehicular environment.

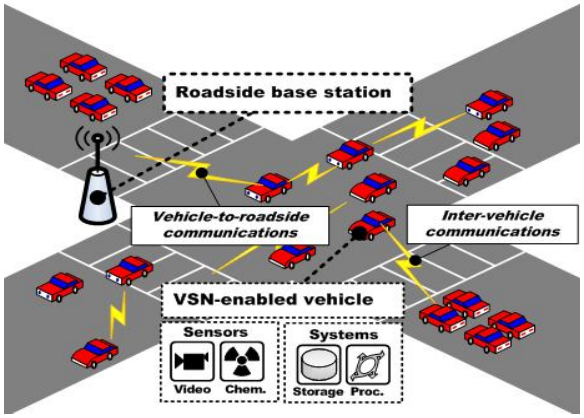

Figure 1: VANET and some possible applications[2]

In the future vehicular networks will assist the drivers of vehicles and help to create safer roads by reducing the number of vehicle accidents. Car manufactures like BMW, Mercedes, Fiat, Ford, Toyota, Nissan [10], [11] are currently prototyping vehicles equipped with WiFi (802.11a/b/g) and DSRC (802.11p) and vehicles with such facility are expected to be on the road within the next 2-4 years.

Recent research work areas in VANET emphasizes on design of protocol or modify the existing one, data sharing, security and privacy, network formation etc. This Paper is organized as follows: Section-2 gives the idea about VANET architecture and its characteristics. Section-3 describe the different application. Section-4 presents the overview of the routing protocols used in VANET. In Section-5 the mobility models: RWP & STRAW described. Section-6 concludes the different challenges of VANET Communication.

2. NETWORK ARCHITECTURE AND ITS CHARACTERISTICS

VANET is an autonomous & self-organizing wireless communication network that operate without any fixed infrastructure and access point for communication and dissemination of information. In VANET nodes themselves acts as servers and/or clients for exchanging & sharing information.

The network architecture of VANET can be classified into following three categories: pure cellular/WLAN, pure Ad Hoc and hybrid [13]. If VANET uses fixed cellular gateways and 'Continuous Air-interface for Long & Medium range telecommunications' (CALM) selected IETF working groups WLAN/WiMax access points at traffic intersections to connect to the internet, gather traffic information for routing purposes then this network architecture is pure cellular or WLAN as shown in fig.2(a). VANET can combine both cellular network and WLAN to form such a network. The connectivity can be provided by stationery or fixed gateways around the road side units to vehicles as shown in fig2(b). Hybrid architecture combines the Ad-Hoc networks and infrastructure networks together[14] as given in fig.2(c).

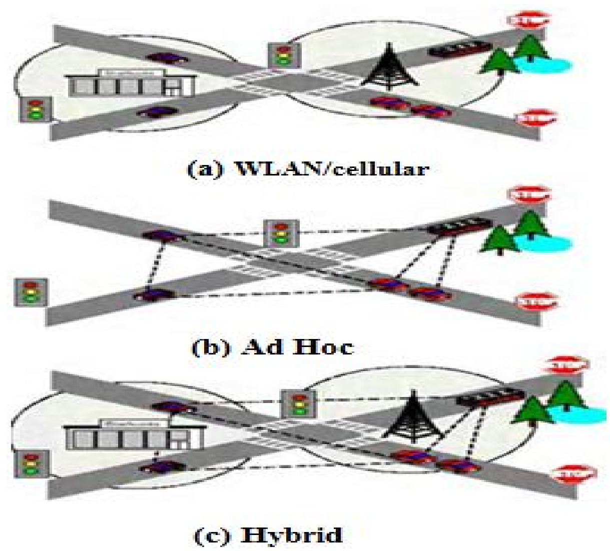

Figure.2: Three categories of VANET[12]

VANET have unique characteristics that impact the design of communication system and its protocol security. These characteristics include[15],[16]:

Self-Organization : VANET is self organizing and self managing type network. So a network in VANET may be formed or deformed automatically anywhere, at any time and the nodes transmit packets with or without the need of any fixed infrastructure in the network.

Large number of nodes : VANET is the technical basis for envisioned ITS & hence it is expected that a large portion of vehicles will be equipped with communication capabilities like GPS for vehicular communication along with fixed road-side infrastructure units (RSUs).

Highly Dynamic Network Topology : In vehicular communication networks(VCNs), nodes are moving and changing their position constantly. Hence the network topology changes frequently as the links between nodes connects and disconnects and the duration of time that remains for exchange of data packets is small. Each pair of nodes can communicate directly when they have a line of sight to each other within the radio range.

Frequent disconnected network (Intermittent connectivity) Highly dynamic topology results in frequent disconnection between two vehicles when they are exchanging information. Such disconnection between nodes mostly occurs in sparse network.

Unlimited transmission power & computational capability : Since nodes in VANET are vehicles instead of small handheld devices so they can provide continuous power to their computing and communication devices. As a result, we need not have to account for methodologies that try to prolong the battery life.

Mobility modeling and predictability : The mobility pattern of vehicles depends on traffic conditions, roads structure, the speed of vehicles, driver's driving behavior etc**.** Due to high movement of nodes, there is high degree of change in the number and distribution of the nodes in the network at any given time instant. Vehicular nodes are mostly controlled by pre-built roads, highway and streets. So for the given street map, current speed and average speed, the future position of the vehicle can easily be predicted.

Hard Delay Constraints : Some of VANET applications does not require high data rates but requires on time delivery of message to relevant nodes (e.g. accidents, brake event). The ITS safety applications have high requirements w.r.t. real time and reliability. In such applications maximum delay will be crucial instead of average delay, an end-to-end delay of even single second can render a safety information meaningless.

Fragmented network : Because of different traffic densities, in some areas, perhaps there may be no vehicle that can forward the packets to the destination i.e. the network is fragmented into several isolated clusters of nodes. Such a scenario is mostly common in sparsely populated areas.

Network connectivity : The degree to which the network is connected is highly dependent on two factors: the range of wireless links and the fraction of participant nodes (vehicles), where only a fraction of vehicles on the road could be equipped with wireless interfaces.

Communication environment : The vehicles experiences different communication environment in sparse networks and dense networks. In dense network building, trees & other objects behave as obstacles while in sparse networks like high-ways, the effect of such obstacles is less prone. So the routing approach of sparse & dense network will be different.

Interaction with onboard sensors : The current position & the direction, moving speed of nodes can easily be sensed by onboard sensors like GPS device & this information can help for effective communication & routing decisions.

Privacy : The communication capabilities in vehicles might reveal all information about the driver / user, such as identifier, position speed and mobility pattern. Although there is need of message authentication of safety messages, but privacy of users/drivers should be respected in particular location privacy and anonymity.

3. APPLICATIONS

Vehicular network applications requires wireless communication network which may be cellular, ad hoc, WLAN or Info stations[17] . The choice of technology depends on the type of application that the network is intended to support. Advanced research work has enabled VANET communication (V2V and V2I) to be used for numerous potential applications with highly diverse requirements. Generally, from the connectivity point of view the VANETs application can be divided into four main groups: vehicle to infrastructure (V-2-I), vehicle to vehicle (V-2-V), vehicle to home and routing based applications. These applications are either ITS services or passengers oriented non-ITS services[17]. ITS services targets to minimize accidents and improve traffic scenario by providing the drivers and passengers with useful information. ITS applications can be divided into three main classes: assistance (navigation, cooperative collision avoidance, and lane-changing), information (speed limit or work zone info) and warning (post crash, rollover warning, obstacle or road condition warnings). These application demands timely dissemination of safety alerts to nearby vehicles due to their delay-critical nature (e.g. emergency braking alarms) and mostly use broadcast or geocast based routing schemes.

The passengers oriented non-ITS services aims for providing commercial and leisure Services to passengers & drivers with internet connectivity, multi-media access, interactive communication facilities by exploiting available infrastructure in an "on-demand" fashion. Web browsing, accessing emails, audio and video streaming are some of the connectivity related applications where the emphasis is on the availability of high bandwidth stable internet connectivity. Another non-ITS application is reception of data from commercial vehicles and roadside infrastructures like shopping malls, fast foods, gas stations, motels, they can set up stationary gateways to transmit marketing data to the potential customers passing nearby. Furthermore, these services could be integrated with electronic payments. Such applications primarily use unicast routing protocols. The communicating vehicles should follow the low latency in order to guarantee: i) services reliability, taking into account the minimum time delay, for ITS applications, and ii) the quality and continuity of service for passenger oriented non-ITS applications.

4. OVERVIEW OF ROUTING PROTOCOLS

A routing protocol governs the way through which two communication entities exchange information; it includes the procedure of establishing a route, decision in forwarding information and action in maintaining the route and/or recovering from the routing failure. In VANETs, the routing protocols can be divided into five categories [18] : (i) Topology based, (ii) Position based, (iii) Cluster based, (iv) Geocast and (v) Broadcast based as shown in fig.3computing time in forwarding a packet in network and making the balance between potential routes. Topology based routing approach can be further subdivided into proactive (table-driven) and reactive (on-demand) & hybrid routing protocols.

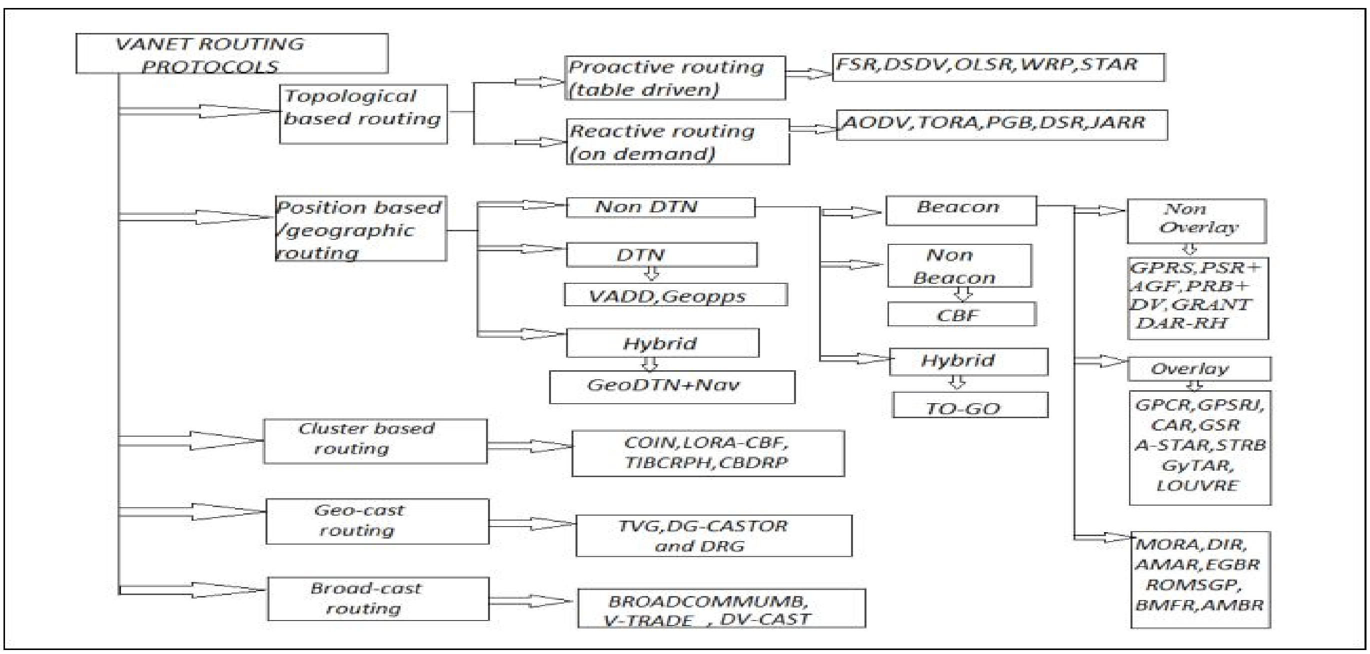

Figure 3: Computing time in forwarding a packet in network

4.1.1 Proactive Routing Protocol[19]

Proactive routing or table driven routing is similar to the connectionless datagram networks. Proactive routing approaches are based on shortest path algorithms. The mobile nodes in the network continuously evaluates routes to all reachable nodes and maintains up-to-date routing information in the form of table. The updated information is also shared by nodes with their neighbors. Whenever any change occurs in the network topology, every node updates its routing table. The advantage of the proactive routing protocols is that no route discovery is required since route to the destination is maintained in its background and is always available upon lookup. Although for real time applications it provides low latency, the maintenance of unused paths uses a significant part of the given bandwidth. The various types of proactive routing protocols are : FSR, DSDV, OLSR, CGSR, WRP and TBRPF.

4.1.2 Reactive Routing Protocol[19]

Reactive (on-demand) routing protocols employs a lazy approach where by mobile nodes only initiates route discovery on-demand. In route discovery process, the query packets are flooded into the network for the path search. The route discovery phase completes when a route has been found or no route is available after the examination of all route permutations. These protocols maintain only the routes that are currently in use, hence reduces the burden on the network when only a few of all available routes is in use at any time. Reactive protocols consume less bandwidth than proactive protocols, but the delay associated with route determination may be large. In reactive protocols, since routes are only maintained while in use, it is always required to perform a route discovery process before packets can be exchanged between nodes. Therefore, this leads to a delay for the first packet to be transmitted. One more limitation is that, although route maintenance is limited to the routes currently in use, yet it may generate a significant the routes currently in use, yet it may generate a significant amount of network traffic when the network topology changes frequently i.e. route finding latency may be high. Finally, packets transmitted to the destination are likely to be lost if the route to the destination changes. The various types of reactive routing protocols are AODV, TORA, PGB, DSR and JARR.

4.1.3 Hybrid Routing Protocols[19]

Hybrid routing protocol combines both the proactive and the reactive routing approaches in order to achieve a higher level of efficiency and scalability. The hybrid protocols reduces the control overhead of proactive routing protocols and decrease the initial route discovery delay i.e. the latency caused by route search operations in reactive routing approaches. The hybrid protocols are ZRP, HARP.

4.2 Position Based Routing Protocol[20]

The position based protocols uses each nodes its own and neighbors location information instead of links information in order to select the next forwarding hops while routing. The packet is send without any map knowledge to that one hop neighbor which is closest to the destination node. The advantage of this routing protocol is that no route discovery is required and doesn't maintain any routing table or exchange any links state information with neighbor nodes. It is suitable for high node mobility scenario. This protocol requires position determining services like GPS. Position based routing can be divided into : Position based greedy V2V protocols & Delay Tolerant Protocols.

4.3 Cluster based protocols[21]:

In Cluster-based routing protocols vehicles nearby each other forms a cluster and each cluster has its own cluster-head, which is responsible for all intra and inter-cluster management functions. Intra- cluster nodes communicate with each other through direct links, whereas in inter-cluster communication occurs via cluster heads. In cluster based routing protocols, the formation of the clusters and the selection of the cluster-head is an issue of importance. In VANET due to high mobility dynamic cluster formation is a towering process. The various Cluster based routing protocols are COIN, TIBCRPH, LORA-CBF and CBDRP.

4.4 Geocast based protocols[22]

Geocast routingis basically a location based multicast routing used to send a message to all vehicles in a pre-defined geographical region. Its main objective is to deliver the packets from the source node to all other nodes within a specified geographical region (Zone of Relevance : ZOR).

In Geocast routing vehicles outside the zone of relevance are not alerted as the information (e.g. related to accident, important alerts) would have least importance to distant nodes. It defines a forwarding zone in which it directs the flooding of packets so that message overhead and network congestion caused by simply flooding packets everywhere gets reduced. In the destination zone, unicast routing strategy can be used for forwarding the packets. The network partitioning and unfavorable neighbors may hinder the proper forwarding of messages in case of Geocast routing. The various Geocast based routing protocols are IVG, DRG and DG-CASTOR.

4.5 Broadcast based protocols[23]

Broadcast is based on hierarchical structure for the highway networks. In broadcast the highway is divided into virtual cells which move like that of vehicles. The moving nodes in the highway are organized into two level of hierarchy : the first level hierarchy includes all the nodes in a cell, the second level of hierarchy is represented by the cell reflectors, which are those nodes located closed to geographical centre of cell. Some cell reflectors behaves as cluster head for certain interval of time and handles the emergency messages coming from members of the same cell or nearby neighbor. Broadcast can be used in unicast routing protocols in routing discovery phase to find an efficient route to the destination. When the message has to be disseminated to the vehicles beyond the transmission range then multi-hop is used. This protocol performs similar to flooding based routing protocols for message broadcasting. Moreover, it only works well with lesser number of nodes in the network. With a larger density of nodes, there is exponential increase in message transmission leading to collisions, higher bandwidth consumption and hence drop in overall performance. Broadcast based protocols are used for sharing weather, traffic, emergency, road condition among the vehicles, and delivering announcements and advertisements. The various Broadcast routing protocols are BROADCOMM, V-TRADE, UMB and DV-CAST.

5. MOBILITY MODEL

The formulation of algorithm applicable for VANET largely depends on a authentic mobility model and decision parameters of nodes to forward the packets to destination or other nodes. To propose a realistic mobility model, the parameters such as node density, street map structure and speed, urban or geographic conditions including obstacles such as trees and buildings need to be considered properly. Basic methodologies applied in the mobility model are explained below :

5.1 RWP (Random Way Point)

Random way point mobility model [24] is one the most simplest and oldest models used. In this a random destination point and a uniform speed is attributed to each of the node. Once destination point is reached, another arbitrary destination point is provided and so forth. RWP is widely used in ad hoc network simulation but the model as such is far from a realistic one. To modify this existing model of RWP [25], parameters such as road length, average speed, number of lanes and average separation between nodes are included to improve its reliability. Towards further up-gradation of mobility model, Saha and Johnson [26] included real road map based on TIGER (Topologically Integrated Geographic Encoding and Referencing); US road map by US Census Bureau. In their model, they converted road maps into graphs and used speed 5 mph above and below the prescribed speed limits and defined the movement of nodes based on shortest path algorithm.

5.2 STRAW (Street Random Waypoint)

In an attempt to make the above model more realistic, STRAW [27] uses a car-following model with road information to simulate the realistic traffic situation that includes traffic congestions, traffic controls, car interactions etc. In an urban or rapidly changing environment. When the simulation results of both AODV and DSR were compared under varying traffic conditions, it gave significantly different results for STRAW and RWP. In the latest technique of more realistic mobility modeling, vehicles are monitored by recording their one dimensional position and lane on the highways on every discrete time steps of 0.5 sec. Combining the valid traces, a realistic mobility scenario can be developed. The traces can also be obtained using Multiagent Microscopic Traffic Simulator (MMTS) [28], which is capable to simulating public and private traffic over real regional road maps with a high level of realism.

6. CHALLENGES OF VANET COMMUNICATION[29]

6.1 Security

Besides the introduction and management of trust also the security of message content is a big issue for vehicular communication. The contents of received messages has to be verified within a short time to be able to use the information as soon as possible.

6.2 Authentication

The authentication service is concerned with assuring that the communication is authentic within its entities. Vehicles or nodes should react to events only with disseminating messages generated by authorized senders. Every message before transmission is digitally signed and verified for the signature before taking a message under consideration. This mechanism can help to stop the replay of messages, by using an authenticated timestamp within the message.

6.3 Integrity

The integrity is a service which addresses the unauthorized alternation of information. To ensure integrity, one must have the ability to detect data manipulation by unauthorized parties. It assures that messages are received as sent, without insertion, reordering, modification or replays.

6.4 Accessibility

Different kind of attacks can result in the loss or diminution in the accessibility. Some attacks such as deny of service can bring the network down even for a robust communication channel. Therefore, availability should be always supported by alternative means.

6.5 Privacy

The scheme used to authenticate messages can be used in order to track vehicles' movements & reveal the permanent identities of vehicles. Since permitting the third parties to track users/drivers movements is a severe violation of driver privacy. A certain degree of anonymity will always be required by users.

6.6 Reliability

Because of brief communication time, it is difficult to ensure the reliable message reception & acknowledgement between communicating vehicles in opposite directions. In vehicular Ad Hoc networks a majority of the messages that are transmitted are periodic broadcast messages that announces the state of node to its neighbors. So it needs more reliability.

6.7 Media Access Control

To create wide scale vehicular Ad Hoc networks, it is desirable to make changes in media access control (MAC) layer. The MAC layer aims to access the shared medium i.e. the wireless channel. If no method is used to coordinate the transmission of messages, then a large number of collisions will occur and the data sent would be lost frequently.

6.8 Scalability

Scalability means the number of users and/or the traffic density can be increased with reasonably small performance degradation or even network outage and without changing the system components and protocols.

7. CONCLUSION

This article presents different perspectives for VANETs, illustrating deployment architectures examples together with some promising wireless technologies along with mobility modeling . An exhaustive survey and comparison of different category of VANET routing protocol has been done in Table 1. which is essential to come up with new protocol proposals for VANET. Vehicular communication security is also addressed, presenting prime security challenges, the issues in authentication, authorization and access control in such networks. Vehicular networks are promising in being one of the real applications of Mobile Ad Hoc Networks. Its opportunities and areas of applications are growing drastically and includes many kinds of services with different goals and requirements. However, it posses numerous technical challenges which can slow their development and can impact their wide-scale deployment. But consumer and corporate interests in this technology promise bright prospects. Many distinguishing qualities of this environment have not been yet explored, leaving a vast opportunities for further research in the area.

Table 1: Vanet Routing protocol

Protocol	Forwarding strategy	Routing Maintenance	Scenario	Recovery strategy	Infrastructure Requirement	Digital map	Control packet over-head	No. of retrans-missions
FSR	Multi-hop	Proactive	Urban	Multi hop	No	No	High	Less
OLSR	Multi-hop	Proactive	Urban	Multi hop	No	No	High	Less
TBRPF	Multi-hop	Proactive	Urban	Multi hop	No	No	High	Less
AODV	Multi-hop	Reactive	Urban	Store and forward	No	No	Low	Less
DSR	Multi-hop	Reactive	Urban	Store and forward	No	No	Low	Less
TORA	Multi-hop	Reactive	Urban	Store and forward	No	No	Low	Less
ZRP	Multi-hop	Hybrid	Urban	Multi hop	No	No	Moderate	Less
HARP	Multi-hop	Hybrid	Urban	Multi hop	No	No	Moderate	Less
GPSR	Greedy forwarding	Reactive	Urban	Store and forward	No	Yes	Moderate	Less
VGPR	Greedy forwarding	Reactive	Urban	Store and forward	No	Yes	Moderate	Less
GPCR	Greedy forwarding	Reactive	Urban	Store and forward	No	Yes	Moderate	Less
MIBR	Bus first	Reactive	Urban	Store and forward	No	Yes	Low	Moderate
GYTAR	Greedy forwarding	Reactive	Urban	Store and forward	No	Yes	Moderate	Less
ROVER	Multi-hop	Reactive	Urban	Flooding	No	No	High	High
TZDP	Multi-hop	Reactive	Urban	Flooding	No	No	low	High
DTSG	Multi-hop	Reactive	Urban	Flooding	No	No	Moderate	High
HCB	Multi-hop	Reactive	Urban	Store and forward	No	Yes	Moderate	High
CBLR	Multi-hop	Reactive	Urban	Flooding	No	Yes	Less	High
CBR	Multi-hop	Reactive	Urban	Store and forward	No	Yes	Moderate	High
CBDRP	Multi-hop	Reactive	Urban	Store and forward	No	Yes	Moderate	High
EAEP	Multi-hop	Proactive	High way	Store and forward	No	No	High	Moderate
DV-CAST	Multi-hop	Reactive	High way	Store and forward	No	No	High	Moderate

SRB	Multi-hop	Reactive	High way	Store and forward	No	No	High	Moderate
PBSM	Multi-hop	Reactive	High way	Store and forward	No	No	High	Moderate
ACK-PBSM	Multi-hop	Reactive	High way	Store and forward	No	No	High	Moderate
SADV	Store and forward	Reactive	Urban	Multi hop	Yes	No	Low	Low
RAR	Store and forward	Reactive	Urban	Multi hop	Yes	No	Low	Low

REFERENCES

1. Ministry of Transportation **, Intelligent transportation systems, 2009**. Available at http://www.mto.gov.on.ca/english/engineering/its.htm.

2. Available at http://www.moreinspiration.com/article/1629vehicular-sensor-network?t=entertainment

3. M. Kihl and M. L. Sichitiu, **Inter-vehicle communication systems: A survey**, *IEEE Communications Surveys & Tutorials*, Vol. 10, Issue 2, pp.88–105, 2008.

4. Moez Jerbi, Senouci, Yacine Ghamri-Doudane, Sidi-Mohammed and Mohamed Cherif. **Vehicular Communication Networks : Current Trends and Challenges**, *Handbook of research on Next Generation Networks and Ubiquitous Computing* , 2009.

5. Dedicated Short Range Communications (DSRC)/Homehttp://www.leearmstrong.com/Dsrc/DSRCHomeset.htm

6. Task Group p *IEEE 802.11p Wireless Access for Vehicular Environment* Draft Standard. http://grouper.ieee.org/groups/802/11/.

7. Abu-Rgheff M.A., Abdalla G.M.T. and Senouci S.M. **Current Trends in Vehicular Ad Hoc Networks**, 2008.

[8. Ericson's, **Communication and Mobility by Cellular Advanced Radio**, *Com-Car Project*, 2002. Available at : www.comcar.de.

9.Available at : http://www.ist-drive.org/index2.html.

10. C. L. Robinson, D. Caveney, L. Caminiti, and K. Laberteaux. **Efficient Coordination and Transmission of Data for Cooperative Vehicular Safety Applications** in VANET, *Proceedings of the 3rd international Workshop on Vehicular AdHoc Networks*, New York, pp. 10–19, 2006.

11. Nissan Motors Co. Ltd., **Nissan to Test Intelligent Transportation System** , Kanagawa, 2009.

12. Pooja Duddalwar1, Atul Deshmukh and S. S. Dorle. **A Comparative Study of Routing Protocol in Vehicular Ad Hoc Network,** *International Journal of Emerging Technology and Advanced Engineering,* 2012.

13. Kevin C. Lee, Mario Gerla and Uichin Lee. **Survey of Routing Protocols in Vehicular Ad Hoc Networks**, *Advances in Vehicular AdHoc Networks: Developments and Challenges, IGI Global*, 2009.

14. V. Namboodiri, L. Gao and M. Agarwal. **A study on the feasibility of mobile gateways for vehicular ad-hoc networks,** in Proceedings of the First International Workshop on Vehicular Ad Hoc Networks, pp. 66–75, 2004.

15. M. Nekovee. **Sensor networks on the road: the promises and challenges of vehicular ad hoc networks and vehicular grids,** Proc. of the Workshop on Ubiquitous Computing and e-Research, Edinburgh, U.K, 2005.

16. J. Blum, A. Eskandarian, and L. Hoffmman. **Challenges of intervehicle ad hoc networks,** IEEE Trans.Intelligent Transportation System, pp.347–351, 2004.

17. H. Moustafa and G. Bourdon. **Vehicular Networks Deployment View: Applications, Deployment Architectures and Security Means**, *Ubiquitous Computing and Communication Journal*, special issue, 2008.

18. Uma Nagaraj, M. U. Kharat and Poonam Dhamal. **Study of Various Routing Protocols in VANET**, *IJCST* , 2011.

19. Fan Li and Yu Wang. **Routing in Vehicular Ad Hoc Networks: A Survey**, *IEEE Vehicular Technology Magazine* , 2007.

20. M. Kihl, M. Sichitiu, T. Ekeroth and M. Rozenberg. **Reliable Geographical Multicast Routing in Vehicular Adhoc Networks**, Lecture Notes in Computer Science 4517 LNCS[C], pp. 315- 325, 2007.

21. J. Blum, A. Eskandarian, and L. Hoffman. **Mobility management in IVC networks**, IEEE Intelligent Vehicles Symposium , 2003.

22. Hamidreza Rahbar, Amiya Naya and Kshira Sagar Naik. **DTSG: Dynamic Time-Stable Geocast Routing in Vehicular Ad Hoc Networks**, IEEE Symposium on Computers and Communications, pp. 198–203, 2003.

23. M. Durresi, A. Durresi, and L. Barolli. **Emergecy broadcast protocol for intervehicle communications**, in ICPADS'05: Proceedings of *: InternationalConference on* Parallel and Distributed Systems Workshop, 2005.

24. J. Broch, D.B. Johnson, D.A. Maltz, Y.C. Hu, and J. Jetcheva. **A performance comparison of multi-hop wireless ad hoc network routing protocols**, *Mobile Computing and Networking*, pp. 85–97, 1998.

25. T. Nadeem, C. Liao, S. Dashtinezhad, and L.Iftode, **Traffic view: traffic data dissemination using car-to-car communication**, *Mobile Computing and Communications review*, vol. 8, no. 3, pp. 6–19, 2004.

26. A.K. Saha and D.B. Johnson. **Modeling mobility for vehicular ad-hoc networks,** ACM International Workshop on Vehicular Ad Hoc Networks, pp. 91–92, 2004.

27. D. Choffnes and F. Bustamante. **An integrated mobility and traffic model for vehicular wireless networks,** The 2nd ACM International Workshop on Vehicular Ad Hoc Networks, 2005.

28. B. Raney, N. Cetin, A. Voellmy, M. Vrtic, and K. Nagel. **Towards a microscopic traffic simulation of all of Switzerland**, International Conference on Computational Science(Part 1), pp. 371–380,2002.

29. F. Doetzer. **Privacy issues in vehicular ad hoc networks,** Privacy Enhancing Technologies, Lecture Notes in Computer Science, *Springer*, pp. 197–209, 2005.

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