12th International Conference on Recent Innovations in Science, Engineering and Management
Sri Venkateswara College of Engineering & Technology,Etcherla, Srikakulam (ICRISEM'18)
17th February 2018 www.conferenceworld.in ISBN: 978-93-87793-01-9

ROUTING TECHNIQUES ON INTERVEHICULAR COMMMMUNICATION SYSTEM

Smita Rani Sahu[1], Uriti Archana[2]

[1,2]Computer Science & Engineering Department,
Sri Venkateswara college of Engineering & Technology, (India)

ABSTRACT

In past few years, VANET (Vehicular Ad-hoc Network) has become a remarkable area for research analysis and development. VANET is a subgroup of MANET (Mobile Ad-hoc Network). VANET and MANET both are wireless networks which are characterized as self-configured and autonomous ad-hoc networks. VANETs differ from MANETs in terms of dynamic topology and high mobility. Due to unstable connectivity, high mobility and network partitioning, information routing in VANETs becomes difficult and challenging, thus creating a need for efficient VANET routing protocols. This work aims to develop and evaluate routing protocols which focus on vehicle to vehicle i.e. V2V communication.

Keywords: Ad-hoc Network, MANET, VANET

I. INTRODUCTION

1.1VANET

Vehicular Ad hoc networks (VANETs) are a special type of mobile ad hoc networks; where vehicles are simulated as mobile nodes. VANET contains two entities: access points and vehicles, the access points are fixed and usually connected to the internet, and they could participate as a distribution point for vehicles. VANET addresses the wireless communication between vehicles (V2V), and between vehicles and infrastructure access point (V2I). Vehicle to vehicle communication (V2V) has two types of communication: one hop communication (direct vehicle to vehicle communication), and multi hop communication (vehicle relies on other vehicles to retransmit) [1]. VANET implements intelligent transportation system (ITS) and aims to optimize traffic flow, improve road safety and reduce congestion. The communication depends on routing. The sporadic connectivity and sudden changes in network topology are the characteristics of VANET that make routing a challenging task. This paper gives a brief overview of routing protocols in VANET, their issues which are under research. VANET also has special characteristics that distinguish it from other mobile ad hoc networks; the most important characteristics are: high mobility, self-organization, distributed communication, road pattern restrictions, and no restrictions of network size, all these characteristics made VANETs environment a challenging for developing efficient routing protocols. Recent improvements in mobile ad-hoc network

(MANET) technology and ever-increasing safety requirements as well as consumer interest in Internet access have made VANETs an important research topic. Vehicle to vehicle and vehicle to roadside communications have become important components of vehicle infrastructure integration. Most of the VANET research has focused on urban and suburban roadway conditions, where the numbers of vehicles are large, the inter-vehicle spacing is small, terrain is not a significant factor and fixed communication infrastructure is available. In rural and sparse areas, the conditions and constraints are significantly different. Node densities are low, inter-vehicle spacing can be large, terrain effects may be significant and there is very little or no fixed communication infrastructure available.

Vehicular ad-hoc networks are responsible for the communication between moving vehicles in a certain environment. A vehicle can communicate with another vehicle directly which is called Vehicle to Vehicle (V2V) communication, or a vehicle can communicate to an infrastructure such as a Road Side Unit (RSU), known as Vehicle-to-Infrastructure (V2I). Figure 1 shows a typical VANET scenario.

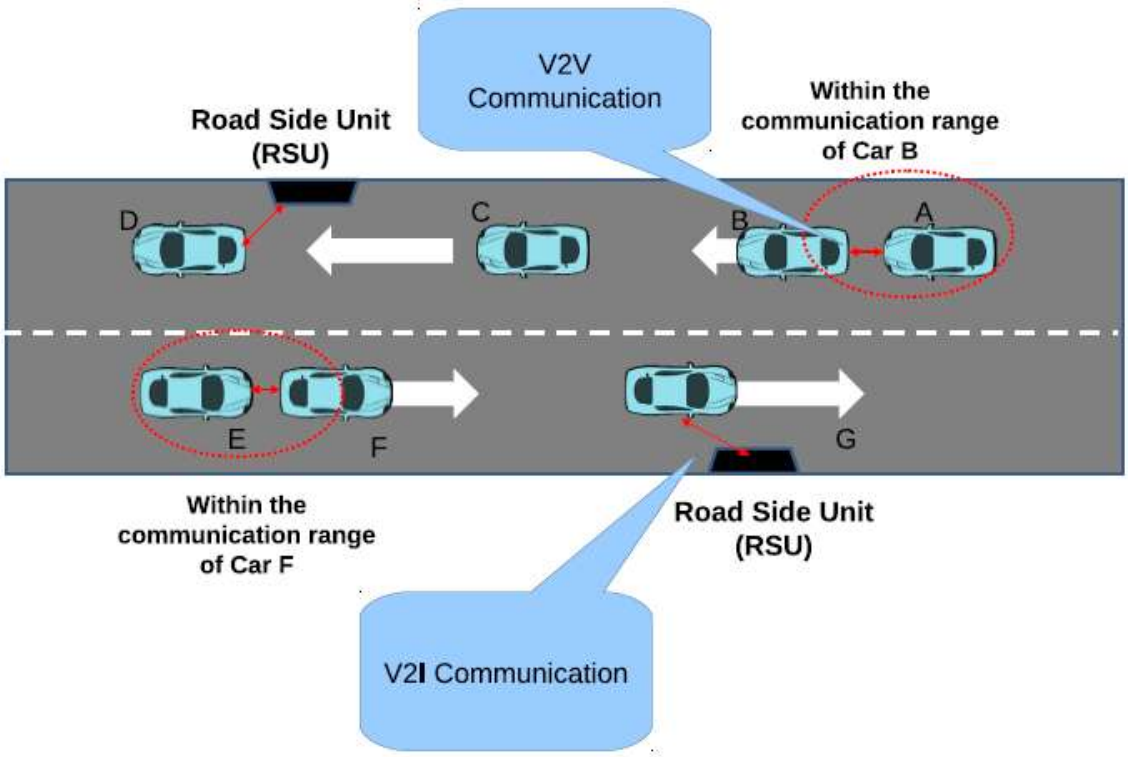

Fig 1. Ad-hoc Network using Vehicles (VANETs) [1]

VANET is a subclass of mobile ad-hoc networks (MANETs). It is a self-organizing network without any physical infrastructure. VANET allows the fast moving vehicles to exchange real-time information that can assist the drivers to avoid any situation like-accidents, traffic jams, etc. With the rapid increase in the vehicular traffic on roads, the corresponding increase in accidents created a security issue that drew the attention of

researchers towards VANET. Dedicated short range communication (DSRC) facilitates the wireless communication in VANET. DSRC is IEEE 802.11p standard and is a MAC protocol operating at 5.9 GHz [2]. IEEE has standardized the whole communication stack that is referred to as wireless access in vehicular environments (WAVE). VANET provides a wide variety of applications for both safety and non-safety purposes. The major application of VANET is ITS [3].

In addition several value added services such as enhanced navigation; automated toll payment, internet access, and location based services are also provided. In VANET, each vehicle is equipped with devices that allow it to send, receive and exchange information with other vehicles or road side units.[4] Facilitating communication among the vehicles and developing an efficient routing protocol in VANET is a challenging task due to the following reasons: signal fading due to the presence of obstacles (buildings etc.), bandwidth constraints, high mobility of the vehicles and the speed depends on the traffic signs and signals. High mobility results in frequent fragmentation in the network [5].

1.2 Importance of Routing in VANET

Wireless communication, particularly real-time communication is highly unreliable. In addition, VANET has certain unique issues that make it different from other wireless networks. Because no central coordination can be assumed, a sole shared control channel is required at the MAC layer (the so-called one channel paradigm). Mobility movements of vehicular networks are also very specific, e.g. vehicles move along the roads, in predefined directions, and this requires new specific mobility models to be devised. Normal mobility models could not address the requirements of VANET. Moreover, now a day's cars are having very high mobility rates and so change the topology in an in-deterministic fashion that makes wireless transmission very challenging. The applications of vehicular networks should also fulfil a number of non-functional requirements, such as potentially very high reliability, but also security to ensure that safety-critical applications cannot be tempered with. Vehicles range over very large geographical areas (cities or countries), and therefore require potentially large-scale networks, and especially a very extensive deployment of equipment if infrastructure-based networks are used. Many VANET applications have either delay constraints or other QoS requirements. Efficient broadcasting of safety messages for getting full coverage and low latency to provide QoS and reliability in VANET routing is still a challenging problem[6].

Since mobility of VANETs cannot be captured by general mobility models. Traffic flow (both in time and space) need to be studied and integrated in the design of reliable and high-performance mobility models. Cooperation among inter-vehicular networks and sensor networks placed within the vehicles or along the road need to be further investigated and analyzed. As the number of vehicles grows the trust between them should also be maintained for the smooth communication. In addition to technical challenges, socio-economic challenges have to be solved. The benefits of V2V communication only become significant when there are a sufficiently large number of vehicles using the technology. Vehicular applications must therefore be able to operate and be useful despite initial low penetration.

II. LITERATURE SURVEY

Routing is a process of sending data packets from source node to destination node, therefore routing in ad-hoc networks is a critical issue. There are a number of routing protocols existing in various networks; this paper focuses on the routing protocols of VANETs between vehicle to vehicle communication, the routing protocol classification and the related research open issues in VANET routing.

III.ROUTING PROTOCOLS IN VANET

In V2V communication, each vehicle is designed by using sensors, network devices, Global positioning System (GPS), computing devices and digital map which has the road segment information. The communication between V2V can be either unicast or multicast packet forwarding techniques from source vehicle to destination vehicles.

The routing protocols of VANET can be classified into five categories:

1) Topology based Routing Protocol
2) Position based Routing Protocol
3) Cluster based Routing Protocol
4) Geocast based Routing Protocol
5) Broadcast based Routing Protocol

1) Topology Based Routing Protocol

Topology based routing protocol use the link information that is available in the existing networks to perform packet forwarding [7].

This protocol is further classified into three main protocols.

a)Proactive Routing Protocols/Table-Driven routing protocol : Proactive routing protocol will store and maintain the routing information about the paths that are currently in use and also not in use [8].The main advantage is that the packets are transmitted constantly among the nodes therefore no discovery of route is required since they maintain the route information at the background. The main disadvantage is that it also maintains unused path information that will occupy the significant part of available bandwidth and causes reduction of bandwidth in the network topology.

b)Routing Protocol/On-Demand routing protocol : The routes are discovered to the destinations on-demand [9]. The routing table is maintained only for the routes that are used currently which reduces the traffic in the network. This protocol consumes less bandwidth when compared to proactive routing protocol but it takes more time to discover a route that results delay in the network. The disadvantage is that, though the routing table is maintained with currently used routes, due to changes in the network topology it will result in significant

amount of network traffic. This will also result in loss of packets to the destination. Another disadvantage is dislocation of communication nodes in the network due to excessive flooding.

c)Hybrid Routing Protocol/Zone Routing Protocol: In this routing protocol, the characteristics of both Proactive and Reactive Routing protocol is combined to make the routing process more efficient and scalable [10].This protocol is to overcome the drawbacks of Proactive and Reactive routing protocols and also it solves on-demand routing by using limited number of routes. The network overhead caused by Proactive routing and network delay caused by Reacting routing are reduced by discovering the routes efficiently. The main drawback is that, this protocol cannot withstand in some environment like VANET where the node's behaviour is highly dynamic and changes rapidly.

2) Position Based Routing Protocol

By using the property of geographic positioning information like GPS, the position based protocol will selectthe next forwarding hops. Therefore it is not necessary to create and maintain routing table or to exchange routing information with neighbour nodes. The disadvantage of position based routing protocol is, it requires position determining services. The position based routing protocol is broadly classified into the following protocols.

a) Greedy Perimeter Stateless Routing (GPSR): Greedy Perimeter Stateless Routing [11], each node finds the neighbouring nodes by using beacon signal or HELLO messages and the position of the destination with the use of location service. In GPSR, each node should be capable of finding its current position. .The advantage of GPSR is the packet forwarding decision is made dynamically and a node needs to know only one hop neighbour location to forward the packet. The disadvantage is destination node will send the information through packet header of intermediate node but it is not updated in the routing table of that node.

b)Greedy Perimeter Coordinator Routing (GPCR): Greedy Perimeter Coordinator Routing will forward packets to the path that are selected previously by using greedy algorithms [12].in this protocol, the decisions are made at the junction in the road that helps to communicate by providing more number of alternate paths. The advantage is it does not require any global or external information like static maps. The disadvantage is since this protocol uses junction nodes, the first approach will fail on curve road and the second approach will fail on sparse road.

c) Connectivity-Aware Routing (CAR): CAR is designed by combining the characteristics of both Geographic routing and Ad-hoc routing protocols [13]. In this protocol, path discovery is done by using AODV and data dissemination is done by using PGB. CAR follows four main phases like path discovery, data forwarding, guard concept and error recovery. The advantage of Connectivity-Aware Routing is it does not require any digital maps and no local maximum problem. The disadvantage will be selecting unnecessary node as head node and when there is any changes in the network traffic due to environment problems, it is very difficult to adapt with the sub-paths.

d)Geographic Source Routing (GSR): GSR protocol consists of topological knowledge with the combination of position-based routing protocol. Like GPCR [14], the shortest path is preselected by using Greedy forwarding algorithm and the same path is calculated with the help of Dijkstra algorithm. The advantage of this GSR protocol, exceeds them in packet delivery ratio and average delay time. The disadvantage is it fails to have enough packets for forwarding, when there is low traffic density in sparse network.

e) Anchor-Based Street and Traffic Aware Routing (A-STAR): A-STAR [15] is designed for the purpose of inter vehicle communication system especially for city environment. For an end-to-end communication, high connectivity in packet delivery is assured with the help of city bus traffic information. This is the advantage of this routing protocol even in low traffic density. The disadvantage of A-STAR will be connectivity problem for finding a path from source to destination.

3) Cluster Based Routing Protocol

In Cluster Based Routing, a Cluster is made with group of nodes or vehicles. Every cluster has one Cluster head which will be responsible for all inter-cluster and intra cluster communication. Each node in the cluster will describe them as a part of the cluster.

There are different types of Cluster based routing protocol.

a)Hierarchical Cluster Based Routing (HCB): The HCB routing protocol is designed for MANET with the help of clustering techniques [16]. HCB have two layers communication architecture. In Layer I, the nodes will communicate with each other through multihop path and they have single radio interface whereas in Layer II, the nodes will communicate with each other through base station. Due to large number of packet loss, the number of retransmission is high.

b) Cluster-Based Directional Routing Protocol (CBDRP): This protocol [17] is designed especially for the vehicles that will move in same direction. Here, the source node will forward its packet to the cluster head and it is transmitted in the same cluster by cluster head. The advantage of this protocol is reliability and rapid data transfer. It also solves link stability problem. The disadvantage is that the number of retransmission is high and it has average control packet overhead.

c)Cluster Based Location Routing (CBLR): Though CBLR protocol is cluster based protocol, it also possess the properties of Reactive and On- Demand routing protocols [18]. Every cluster head maintains a routing table which has the information like address and location of each cluster members. The main advantage is CBLR protocol will suit for all high mobility networks and it makes use of digital maps. Here, it has low control packet overhead. Like CBDRP, it has the disadvantage of large number of retransmission.

d)Cluster Based Routing (CBR): CBR protocol is based on position and cluster protocols in which the geographic area is divided into square grids [19]. That geographic information will help to forward data packets

from every node to its neighbour node. The CBR will not find route discovery is an advantage of this protocol which results in less routing overhead. The important parameters like velocity and direction is not considered in CBR protocol is the main disadvantage.

e)Location Routing Algorithm with Cluster-Based Flooding (LORA-CBF): This protocol is similar to greedy routing protocol. The information about each and every node is maintained by the cluster head [20]. It has the advantage of packet forwarding technique. The disadvantage is it results in heterogeneous performance.

4) Broadcast Based Routing Protocol

Broadcast routing protocol is used in VANET to broadcast the information for maximum number of nodes when an unexpected event like accident, traffic jam occurs. When these packets are broadcast into the network it leads to collision, utilization of high bandwidth consumption, and reduce the overall performance. This Broadcast routing protocol is suitable for smaller network where less number of nodes are connected.

There is large number of broadcasting protocols available and they are as follows:

a)BROADCOMM: BROADCOMM [21] is designed specifically for highway network and this protocol is mainly based on hierarchical structure. The advantage is it has better outperformance for a highway network that has less number of nodes. The only disadvantage is the position information is entirely based on cell formations.

b)Edge-Aware Epidemic Protocol (EAEP): The main function of this EAEP is to transmit messages over all the vehicles [22]. This special kind of protocol will allow each vehicle to possess its own geographical position. The advantage of EAEP is, it will overcome even simple flooding problem and by rejecting hello packets, this protocol will decrease control packet overhead. The main disadvantage is it results in large number of data transmission with high delay and also the issues that caused by intermittent connectivity is not handled in this protocol.

c) Secure Ring Broadcasting (SRB): Based on the receiving power, the secure Ring Broadcasting divides the nodes into three groups such as Inner node, Outer node and Secure Ring nodes [23].The advantage of SRB is by reducing number of retransmission messages, more stable routes are gained. The disadvantage is it has more control packet overhead.

d) Preferred Group Broadcast: This protocol is specially designed to prevent the problem that is caused due to broadcast storm from transmitting route request [24]. It has the advantage of decreasing RREQ broadcasting. This PGB protocol is not a reliable broadcasting protocol.

e)Urban Multihop Broadcasting (UMB): During message transmission in multi hop broadcasting it will come across lot of problems like Collision and hidden node problem, this UMB protocol is designed to overcome this

issues [25]. The advantages are the performance is good in case of high packet loads and vehicle traffic density. It also solves collision and hidden node problems. The only disadvantage is this protocol has unused bandwidth.

5) Geocast Based Routing Protocol

The message will be sent to all vehicles in the predefined geographical area since this protocol depends on location based multicast routing protocol. The Zone of Relevance or ZOR is the place selected for the purpose of transmission.

This protocol has different routing protocols as follows:

a) Inter-Vehicle Geocast (IVG): When the vehicles are moving on highways [26], this protocol will broadcast messages to those vehicles.

b) Robust Vehicular Routing (ROVER): The ROVER protocol is especially designed for sending messages to all the vehicles that are present in a specific Zone of relevance [27]. The advantage is it depends on geographical multicast protocol. Due to redundant message, the data transfer will result in more delay is the main disadvantage of ROVER. Another disadvantage is it has more number of retransmissions and control packet overhead.

c)Dynamic Time-Stable Geocast Routing (DTSG): The DTSG protocol is used for sparse density networks and it is designed with two phases [28].The advantage of this protocol helps to align the network density and speed of the vehicles dynamically that result in better performance.

IV.CHALLENGES IN DESIGNING OF PROTOCOLS IN VANET

Various issues and challenges are defined as follows:

(a) ***Quality of Service (QoS):*** Provision of certain quality of service levels in VANET is an important task. A network with minimum delay for data delivery, less retransmissions,
and high connectivity time can provide certain QoS guaranteed to the users. Promising this kind of QoS with different user applications and dynamic network environment is an interesting and challenging task in VANET design.

(b**) *Efficient Routing Algorithms Design****:*** In order to timely and properly sending data packets from one node to another node an efficient routing algorithm is required. In VANET, efficient routing algorithm means a routing scheme with minimum delay, maximum system capacity and less computational complexity. Design such an algorithm which can be implemented in multiple topologies of the network and satisfies all of the above mentioned properties is an active area of research in VANET.

(c**) *Scalability and Robustness****:*** Designing a scalable and robust network remains an open area of research in VANET because of its challenging characteristics. Many design approaches fall short when VANETs transform

from sparse to high dense mode, or from high mobility to slow traffic scenarios. A complete VANET framework that is scalable to different network scales and robust to the topological changes is required. This is an emerging area of research for VANET environment.

(d) ***Co-operative Communication*****:** A key challenge in VANET is establishing the communication among different nodes. Different concepts of co-operative communication from wireless network theory may not be directly applied to VANET. This co-operative communication, such as up to which extent nodes should exchange information among themselves, is one of the key research areas in the VANET design.

(e*) Security and confidentiality*: Keeping a reasonable balance between the security and privacy is one of the main challenges in VANET; the receipt of trustworthy information from its source is important for the receiver. However, this trusted information can violate the privacy needs of the sender [29].

(f)*Connectivity*: Owing to the high mobility and rapid changes of topology, which lead to a frequent fragmentation in networks, the time duration required to elongate the life of the link communication should be as long as possible. This task can be accomplished by increasing the transmission power; however, that may lead to throughput degradation. Accordingly, connectivity is considered to be an important issue in VANET.

(g*)Signal fading and distortions*: Objects placed as obstacles between two communicating vehicles are one of the challenges that can affect the efficiency of VANET; these obstacles can be other vehicles or buildings distributed along single road in the villages. Their impact is placed on preventing the signal from reaching its destination and increasing the fading in the transmitted signal.

(h) ***Bandwidth limitations***: Another key issue in the VANET is the absence of a central coordinator that controls the communications between nodes, and which has the responsibility of managing the bandwidth and contention operation. Therefore it is necessary to utilize the availability of bandwidth efficiently. There is a high probability that channel congestion can occur, Owing to the limited range of bandwidth frequency (10–20 MHz) for VANET applications, particularly in a rural environment. The fair use of bandwidth has its impact on reducing the time delay for disseminating messages; if a vehicle needs to send a message and finds there are no opportunities for transmission, it must wait for a time.

V. PROBLEM STATEMENT

Motivated by the need of routing protocols in Vehicular Ad Hoc Networks, the protocols used for routing techniques and keeping the research directions in view, it has been realized that there exists enough scope to improve the routing protocol. This work aims to analyse the routing protocols on Inter Vehicular Communication.

VI. CONCLUSION

In this work an attempt will be made to address the research issues in designing energy efficient routing protocols for VANETs i.e. vehicular ad hoc networks. A literature survey will be made on various protocols used for communication in VANET. The communication in VANET takes place in two different ways Vehicle-To-Vehicle (V2V) communication and Vehicle-To-Infrastructure (V2I) communication. The existing routing algorithms used for communication between vehicle to vehicle will be analyzed individually with their advantages and disadvantages. All these approaches tend to focus on V2V and require GPS.

REFERENCES

[1] "Survey of Routing Protocols in Vehicular Ad Hoc Networks," Kevin C. Lee, Uichin Lee, Mario Gerla, Advances in Vehicular Ad-Hoc Networks: Developments and Challenges, IGI Global, Oct, 2009."Border Node-based Routing Protocols for VANETS in Sparse and Rural Areas", Zhang and Wolff: Auto net Workshop, IEEE Globe COM, Washington DC, November 2007.

[2] Yousef-Awwad Daraghmi, Chih-Wei Yi, "Forwarding Methods in Data Dissemination and Routing Protocols for Vehicular Ad Hoc Networks", IEEE Network 2013.

[3] Fan Li , Yu Wang, "Routing in Vehicular Ad Hoc Networks: A Survey", IEEE Vehicular Technology Magazine,2007

[4] M. Durresi, "Emergency broadcast protocol for intervehicle communications," 2005.

[5] Amandeep Kaur, Issues and Challenges of Routing Protocols in VANET-Survey, National Conference on Innovations in Engineering and Technology (IEIT-2014), March 2014.

[6] "Routing Protocols for Vehicular Ad Hoc Networks in Rural Areas", Zhang and Wolff IEEE Communications Magazine, November, 2008, pp. 126-131.

[7] DongreManoj M, Bawane N G, JawadeNilima R, "Routing Protocols for V2V communications used in Urban VANET to improve ITS", *National Conference on Innovative Paradigms in Engineering & Technology (NCIPET-2012), International Journal of Computer Applications® (IJCA)* 19.

[8] Bernsen, J. Manivannan, D., "Routing Protocols for Vehicular Ad Hoc Networks That Ensure Quality of Service", In the fourth international conference on Wireless and Mobile Communications., pp.1-6, Aug. 2008.

[9] C. Lochert, H. Hartenstein, J. Tian, D. Herrmann, H. Füßler, and M. Mauve, "A routing strategy for vehicular ad hoc networks in city environments," in *Proceedings of IEEE Intelligent Vehicles Symposium (IV2003)*, pp. 156–161, June 2003.

[10] Tarik Taleb,, EhssanSakhaee, *Student Member*,, Abbas Jamalipour, Kazuo Hashimoto, Nei Kato, , and Yoshiaki Nemoto, "A Stable Routing Protocol to Support ITS Services in VANET Networks" IEEE TRANSACTIONSON VEHICULAR TECHNOLOGY, VOL. 56, NO. 6, NOVEMBER 2007.

[11] Karp, B. and Kung, H. T (2000), "GPSR: greedy perimeter stateless routing for wireless networks." In Mobile Computing and Networking, pages 243-254, 2000.

[12] Lochert, C., Mauve, M., F¨ussler, H., and Hartenstein, H., "Geographic routing in city scenarios," SIGMOBILE Mob. Comput.Commun.Rev., vol. 9, no. 1, pp. 69–72, 2005

[13] Naumov, V., Gross, T.R. (2007), "Connectivity-Aware Routing (CAR) in Vehicular Ad-hoc Networks," INFOCOM 2007. 26th IEEE International Conference on Computer Communications.IEEE, vol., no., pp.1919-1927, 6-12 May, 2007.

[14] Lochert, C., Hartenstein, H., Tian, J., Fussler, H., Hermann, D., Mauve, M. (2003), "A routing strategy for vehicular ad-hoc networks in city environments," Intelligent Vehicles Symposium, 2003. Proceedings. IEEE, vol., no., pp. 156-161, 9-11 June 2003.

[15] Seet, B.-C., Liu, G., Lee, B.-S., Foh, C. H., Wong, K. J., Lee, K.-K. (2004), "A-STAR: A Mobile Ad Hoc Routing Strategy for Metropolis Vehicular Communications." NETWORKING 2004, 989-999

[16] Yang Xia," Hierarchical Cluster Based Routing for Highly Mobile Heterogeneous MANET", 2007.

[17] Tao Song, Wei Xia, Tiecheng Song, LianfengShen,"A Cluster-Based Directional Routing Protocol in VANET", International Conference on Communication and Mobile Computing, 2010.

[18] R. A. Santns, R. M. Edwards, A. Edwards and *D.* Belis, "A novel cluster-based location routing algorithm for intervehicular communication", Personal, Indoor and Mobile Radio Communications, IEEE proceedings of the 15th Annual Symposium, 2004.

[19] Yuyi Luo, Wei Zhang, YangqingHu,"A New Cluster Based Routing Protocol for VANET", IEEE Wireless Communications and Trusted Computing, 2010.

[20] R. A. Santos, "Performance evaluation of routing protocols in vehicular ad hoc networks," 2005.

[21] M. Durresi, "Emergency broadcast protocol for intervehicle communications," 2005.

[22] M. Nekovee, B. BjamiBogason, "Reliable and efficient information dissemination in intermittently connected vehicular ad hoc networks", IEEE the 65th VTC'07 spring, Dublin, Ireland, 22-25 (2007).

[23] V. Naumov, R. Baumann, and T. Gross, "An evaluation of inter-vehicle ad hoc networks based on realistic vehicular traces," Proc. ACM the 7th ACM MohiHoc'06, Florence, Italy, May 22-25 (2006).

[24] G. Korkmaz, "Urban multihop broadcast protocol for inter-vehicle communication systems".

[25] A. Bachir, "A Multicast Protocol", in Ad hoc Networks Inter-Vehicle Geocast. April 2003.

[26] M. Kihl,"Reliable Geographical Multicast Routing in Vehicular Adhoc Networks", 2007.

[27] HamidrezaRahbar, KshirasagarNaik, AmiyaNayak, "DTSG: Dynamic Time-Stable Geocast Routing in Vehicular Ad Hoc Networks", 2001.

[28] "Routing Protocols for Vehicular Ad Hoc Networks in Rural Areas", Zhang and Wolff IEEE Communications Magazine, November, 2008, pp. 126-131.

[29] Rainer Baumann, "Vehicular Ad hoc Networks", Master's Thesis in Computer Science, ETH Zurich (2004).