ISSN(Online): 2320-9801
ISSN (Print): 2320-9798

International Journal of Innovative Research in Computer and Communication Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 3, Issue 12, December 2015

A Survey on Routing Protocols in Vehicular Ad Hoc Networks

[1]Viswacheda Duduku, V[2]Ali Chekima, [3]Farrah Wong, [4]Jamal Ahmad Dargham

[1]PhD Scholar, Computer Engineering Program, FKJ, Universiti Malaysia Sabah, Kota Kinabalu, Sabah, Malaysia

[2]Professor, Computer Engineering Program, FKJ, Universiti Malaysia Sabah, Kota Kinabalu, Sabah, Malaysia

[3,4]Assoc. Professor, Computer Engineering Program, FKJ,Universiti Malaysia Sabah, Kota Kinabalu, Sabah, Malaysia

ABSTRACT: Recently vehicular ad hoc networks is getting more interest in the industry and academic research field due to promisingdedicated short range communications operating in 5.9GHz band. Vanet is a special class of mobile ad hoc networks which provides communication between vehicles to vehicles and vehicles to road side unit forming an Intelligent Transport System (ITS). Routing plays an important role in communication between mobile nodes such as vehicles or cars to broadcast the information in the form of data packets to the receiver nodes successfully without errors. There are various routing protocols presently exist in vanet based on topology, position,broadcast, clustering, geocast. This paper discusses the performance of those protocols in different road scenarios and list the merits and demerits and conclude the challenges facing in the present day research of VANET.

KEYWORDS: Vehicular Ad Hoc Networks, V2V, V2I, Routing protocols.

I. INTRODUCTION

Globally there are 1.3 million people die in road accidents every year averaging nearly 3,287 deaths per day. Road crashes cost USD 518 billion costing individual countries from 1-2% of their annual GDP [1]. One of the reasons is due to the lack of intelligent transportation system ITS. This ITS promises the safety of passengers by incorporating various technologies such as cellular, wifi and ad hoc networks. Among them VANET is a technology that can provide seamless connectivity between vehicle to vehicle and vehicle to roadside unit as shown in figure 1.

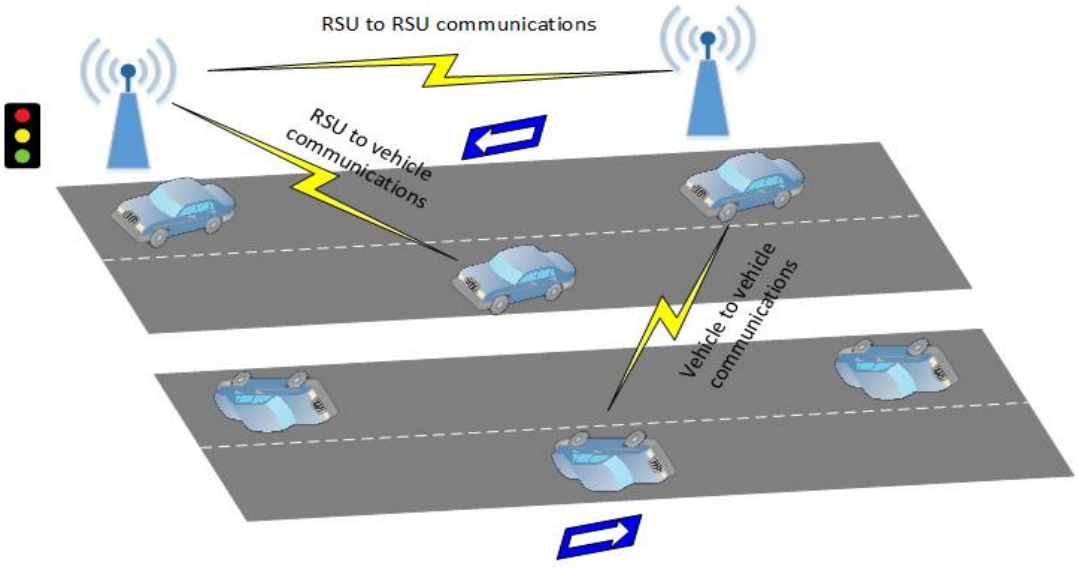

Figure 1: A Typical VANET

ISSN(Online): 2320-9801
ISSN (Print): 2320-9798

International Journal of Innovative Research in Computer and Communication Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 3, Issue 12, December 2015

II. ARCHITECTURE AND APPLICATIONS OF VANET

Vehicular Ad hoc network is a subclass of mobile ad hoc network which has got its own importance in providing infrastructure to users. The main features of VANET are the nodes participating in VANET are moving at very high speed which makes prediction of node's position difficult for network topology. The position of node changes regularly as network topology changes in VANET. It can be implemented anywhere and anytime having minimum infrastructure in vehicles. The nodes in VANET move freely that means there is no restriction unless they are in the radio propagation range to receive or transmit information to other vehicles or road side units. Time factor is available for nodes to share information and respond accordingly. The battery power is not a constraint for VANET since all vehicles have abundant battery power to transmit information to other vehicles [2].

The architectural categories of Vehicular ad hoc network are spread into three types such as

A. Pure Adhoc mode
B. Pure cellular/wlan mode
C. Hybrid networks.

A. Pure Adhoc mode

In vehicular ad hoc network when there arises a situation of emergency then pure ad hoc mode is used by vehicles or nodes. In vehicle to vehicle communication and vehicle to roadside unit it is possible for pure ad hoc mode where information is transmitted and received with in the radio propagation range of nodes in accordance with the protocol type used for information broadcasting in the network as shown in figure 2.

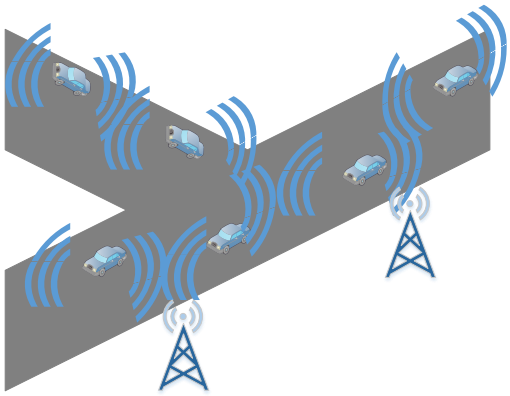

Figure 2: Pure Ad hoc mode

B. Pure cellular.wlan mode

In vehicular ad hoc network mainly in city environments where there is a facility of cellular towers and WLAN access points the nodes or vehicles can get access to the infrastructure and can download the information regarding traffic conditions, weather conditions, parking information, web browsing and GPS data. The cellular communication lacks the coverage are when it reaches the city outskirts then VANET has to depend on DSRC through pure ad hoc mode or WLAN mode as shown in figure 3.

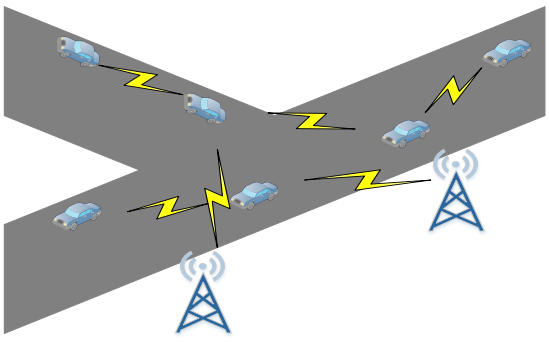

Figure 3: Pure cellular/WLAN

ISSN(Online): 2320-9801
ISSN (Print): 2320-9798

International Journal of Innovative Research in Computer and Communication Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 3, Issue 12, December 2015

C. Hybrid Networks

A hybrid network is a combination of both cellular technology and ad hoc mode. The vehicles or nodes equip with WLAN and cellular technology form as clusters. The node can use either cellular or ad hoc mode to transmit and receive information with in the radio propagation range of ad hoc mode. This traffic scenario occurs in city environments depending on infrastructure and sometimes ad hoc mode as shown in figure 4.

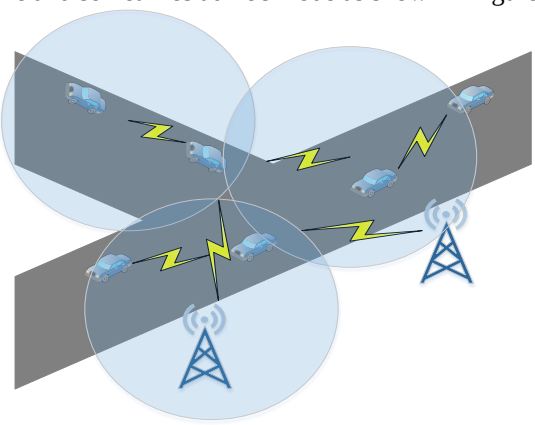

Figure4: Hybrid network

Applications of VANET can be classified into safety oriented applications, value added applications and comfort applications. The safety oriented applications consists of emergency warning stopped vehicle warning and road condition warning. The value added services comprises mobile commerce, entertainment multimedia streaming. The comfort applications constitute passenger's comfort and traffic efficiency like weather information and traffic information [3].

III. ROUTING PROTOCOLS IN VANET

Routing protocolis an important aspect in communication between networks. It is a set of rules that are framed for exchanging the information in a network from one node to another node as specified in the routing protocol. The main difference between the MANET and VANET routing is network topology, mobility patterns, demographics, density of vehicles at different timings, rapid changes in vehicles arriving and leaving the VANET. The routing protocols are classified into five types as shown in figure 5, summary of VANET protocols in Table 1 and they are

A. Topology based protocols
B. Position based protocols
C. Geocast based protocols
D. Cluster based protocols
E. Broadcast based protocols

A. TOPOLOGY BASED PROTOCOLS

In computer networks the term topology is defined as "the way in which constituent parts are interrelated or arranged". In vehicular ad hoc networks the topology based routing protocols try to find the shortest path from source to destination. All the information about the routing is stored in the form of routing table. There are three type of topology based routing protocols. They are

A. Proactive routing protocols
B. Reactive routing protocols
C. Hybrid routing protocols

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ISSN (Print): 2320-9798

International Journal of Innovative Research in Computer and Communication Engineering

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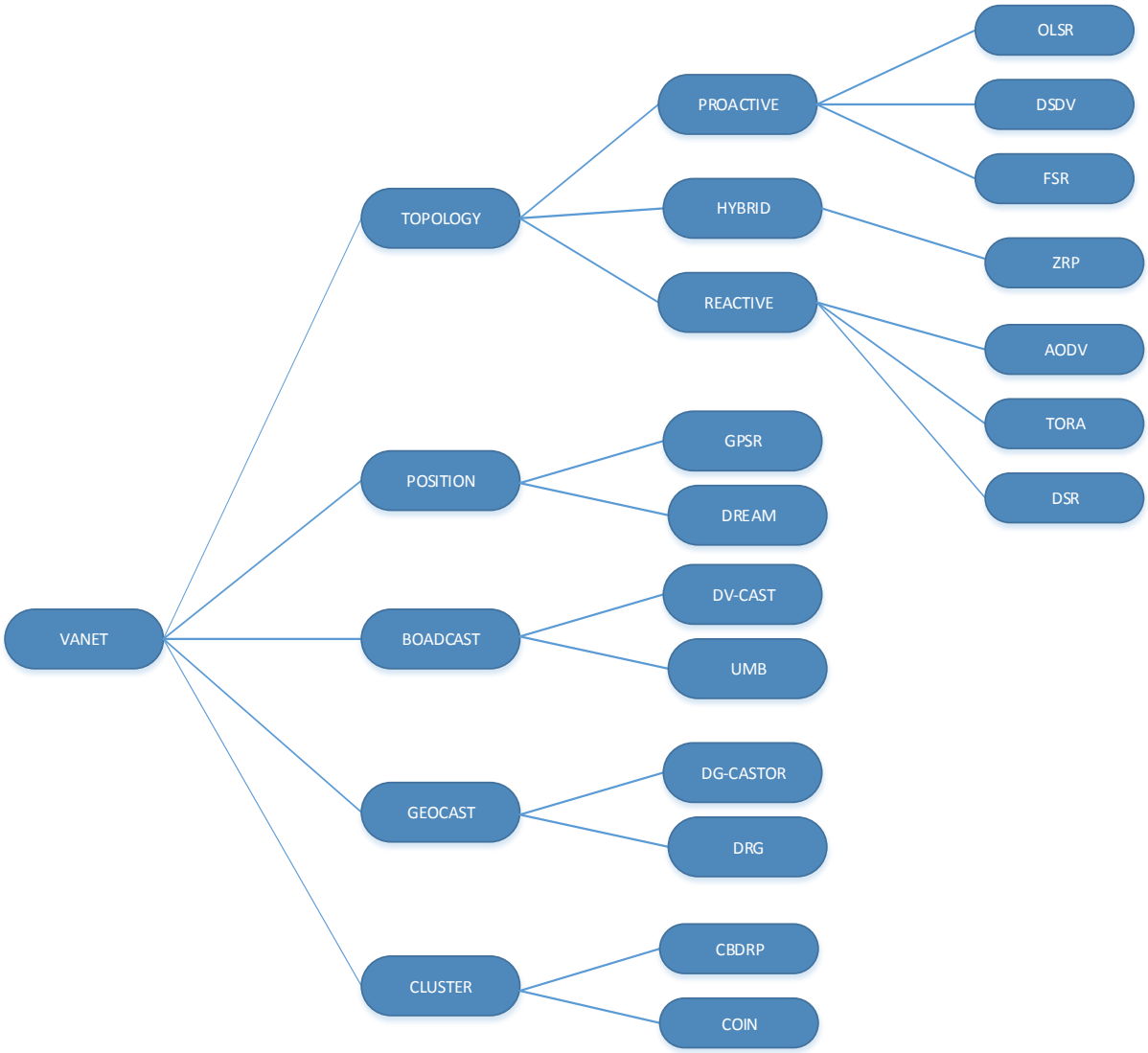

Figure 5: VANET Routing Protocol Hierarchy

A. **Proactive routing protocols**: In proactive routing protocols the entire topology of the nodes in the network is maintained in the form of tables. The routing entries of the nodes entering or leaving the network are maintained up to date in the network. Due to this there will be additional overhead cost affecting the throughput of the network. The main types of proactive routing protocols are destination sequence distance vector (DSDV), optimized link state routing (OLSR) and Fisheye state routing (FSR).

a. Destination Sequence Distance Vector routing(DSDV) -DSDV is a table driven proactive routing protocol based on classical distributed Bellman-Ford routing mechanism. Each node maintains routing table of all other nodes. A sequence numbering system is given to distinguish old routes from new ones and assign by destination node. Routing table updates are sent periodically. High volumes of control traffic meaning an inefficient utilization of network

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ISSN (Print): 2320-9798

International Journal of Innovative Research in Computer and Communication Engineering

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resources. To alleviate this problem, the protocol uses two types of route update packets they are Full dump which carries all available routing info and can require multiple network protocol data units. Infrequently transmitted while there is not much movement. Incremental packets.These smaller packets are for relaying only the information that was updated since the last full dump [4].

b. Optimized Link State Routing (OLSR) -TheOptimized Link State Routing Protocol(OLSR) is a proactive routing protocol optimized for mobile ad hoc networks and can be applicable for vehicular ad hoc networks. OLSR is a proactive routing protocol meaning it will exchange the topology information with other nodes in the network in a regular manner. Due to the proactive nature of the OLSR the protocol acquired the firmness of the link state algorithm so that the routes will be available immediately when needed. The control messages are informed periodically by nodes which are selected as multi point relay. The node selected as multi point relay calculates the route from the give node to any destination. The flooding of control messages is done by the mobile node designated as the multi point relay in the network. In VANET scenario in the traffic congestion this protocol can be useful for forwarding and relay the messages to the vehicles. [5].

c. Fisheye State Routing (FSR)–FSRprotocol is considered as proactive protocol and is a link state based routing protocol that has been adapted to the wireless adhoc network. It relays on link state protocol as a base, and it has the ability to provide route information instantly by maintaining a topology map at each node. The updated information of the neighbouring node will be available in link state table. In every node the full topology map is stored and utilized. FSR uses the fish eye technique meaning it will reduce the size of information required to represent graphical data. In routing the fish eye approach translate to maintaining accurate distance and path quality information about the immediate neighbourhood of a node with progressively less detail as the distance increases [6]

B. **Reactive routing protocol:** In reactive routing protocol works on the principle of on demand acquisition. In this protocol the mobile nodes transmit packets from source to destination by finding route using route discovery and route maintenance functions, few of the reactive protocols are AODV, DSR, TORA.

a. Adhoc On demand Distance Vector (AODV) -AODV is a reactive routing protocol in the sense whenever any node wants to send data packet to another node at that time the node will be searching for the path on demand or needed and send the data packet from source to destination, this is called as pure on demand route acquisition system. In order to discover a route, first it will broadcast a RREQ (Route REQuest) to find a route and when destination receive that packet it will send a RREP (Route REPly) to the source. AODV maintains all the route information in the form of routing table. If routing table entry of the node is expired if it is not used recently will be notified. The destination sequence number is used for prevention of routing loops and avoidance of old and broken routes. In VANET traffic scenario this protocol is helpful in broadcasting the messages on demand when needed [7].

b. Dynamic Source Routing-Dynamic Source Routing(DSR) is a reactive routingprotocol. If a node wants to send data packet to another node in the network then it will go for route searching when needed and send the data from source to destination. First the node go for route discovery by broadcasting RREQ (Route REQuest) with a unique ID from source and when the packet is received by the nodes in the network it will find where the data packet need to be sent in the network and broadcast until it is received at correct destination. The destination node receives the data packet and broadcast a RREP (Route Reply) packet back to source with unique ID. This protocol maintains route information. If there is any broken link or unused route then the information is processed by route maintenance, if there is any route error then the nodes will send a RERR (Route ERRor) message to the network. In VANET traffic this protocol can be useful in maintaining network information and send to roadside unit about the density of traffic [8].

ISSN(Online): 2320-9801
ISSN (Print): 2320-9798

International Journal of Innovative Research in Computer and Communication Engineering

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Vol. 3, Issue 12, December 2015

S. NO	PROTOCOL	TYPE	DIGITAL MAP	ROUTING	PROPOSED BY AUTHOR, YEAR	OVER HEAD	SCENARIO
1	DSDV	Topology	No	Proactive	C.E. Perkins *et al*, 1994	Ad hoc	urban
2	OLSR	Topology	No	Proactive	T. Clausen *et al*, 2003	Link state	urban
3	FSR	Topology	No	Proactive	G. Pei *et al*, 2000	Link state	urban
4	AODV	Topology	No	Proactive	C.E. Perkins *et al*, 2003	Path state	urban
5	DSR	Topology	No	Reactive	D.B. Johnson *et al*, 1996	Multi hop	urban
6	TORA	Topology	No	Reactive	V.Park*et al*, 1998	Multi hop	urban
7	ZRP	Topology	No	Hybrid	Z. J. Haas, 1997	Multi hop	urban
8	GPSR	Position	Yes	Reactive	B.Karp*et al*, 2000	Beacon	urban
9	DREAM	Position	Yes	Reactive	S. Basagni*et al*, 1999	Beacon	urban
10	DV-CAST	Broadcast	Yes	Reactive	Tonguz O. K, 2010	Multi hop	urban
11	UMB	Broadcast	Yes	Reactive	G.Korkmaz*et al*, 2004	Multi hop	urban
12	DG CASTOR	Geocast	Yes	Reactive	Atechian T., *et al*, 2008	Multi hop	urban
13	DRG	Geocast	Yes	Reactive	H.P.Joshi., *et al*, 2007	Multi hop	urban
14	CBDRP	Cluster	Yes	Reactive	Tan Song, 2010	Multi hop	urban
15	COIN	Cluster	Yes	Reactive	Blum *et al*, 2003	Multi hop	urban

Table. 1: A Summary of routing protocols in VANET

c. Temporally Ordered Routing Algorithm (TORA) –TORA protocol works on the principle of link reversal. Tora is proposed for highly dynamic mobile, multi-hop wireless networks. The nodes in the network find multiple paths from source to destination. Since it is a source initiated on demand routing protocol. The topology of the network information is kept only by few nodes where there is a change in mobility of the network. The tora protocol uses three functionalities like route creation, route maintenance and route erasure. The nodes in the network will find a route creation in order to broadcast the information from source to destination, if there is multi path then the information will be kept by route maintenance and when there is loss of route then route erasure takes place in the network [9].

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ISSN (Print): 2320-9798

International Journal of Innovative Research in Computer and Communication Engineering

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*C.***Hybrid:** Hybrid protocol uses the combination of proactive routing protocol and reactive routing protocol anddecrease the initial route discovery delay in reactive routing protocols. The hybrid protocol discussed here is ZRP.

a. Zone Routing Protocol (ZRP)-In ZRP the proactive part of the protocol is restricted to a small neighbourhood of a node and the reactive part is used for routing across the network. This reduces the latency in route discovery and reduces the number of control messages as well. The routing is divided into two parts they are intrazone routing and interzone routing. In intrazone routing the packets are sent with in the routing zone of the source node to reach the peripheral node. In interzone routing the packet is sent from the peripheral node to the destination node[10]

B. POSITION BASED ROUTING PROTOCOL

In vehicular ad hoc network due to rapid change in topology the routing is a challenging task. As compared to topology based routing protocol position based routing protocol provides information of mobile nodes position in participating network. This helps for easy dissemination of information broadcasting if position is known in the network. The few types of position based routing protocols are greedy perimeter stateless routing (GPSR) and distance routing effect algorithm for mobility protocol (DREAM).

a. Greedy Perimeter Stateless Routing (GPSR) The GPSR uses greedy algorithm to do routing and orbits around a perimeter. The GPSR is a responsive and efficient routing protocol for vehicular ad hoc networks. GPSR allows nodes to find the closest neighbor using beacons. To calculate a path GPSR uses the greedy forwarding algorithm that will send the information to the final destination using the mostefficient path found. If greedy forwarding fails the nodes uses the perimeter forwarding in the network [11]

b. Distance routing effect algorithm for mobility (DREAM)–DREAM protocol is a restricted flooding communication protocol used in vanet where there is high mobility and unstructured network. Every node in the network maintains the location table of all the nodes participating in the network. Every node sends a control packet to all the nodes about the location in the network. Each location packet submitted by node A to other nodes to update their location tables contain A's coordinates along with its speed and the time the location packet was transmitted [12]

C. BROADCAST ROUTING PROTOCOL

In vehicular network if an emergency situation occurs then broadcast routing protocol is appropriate in sharing information among vehicles participating in the network. The nodes will send packets to all the nodes in the network. Few of the broadcast routing protocols are distribute vehicular broadcast protocol (DV-CAST) and urban multihop broadcast (UMb).

a. Distributed Vehicular Broadcast Protocol (DV-CAST) -The vehicular nodes in the DV-CAST protocol sends regular hello messages for broadcasting the information. Each node uses a flag variable to check whether the packet is applicable or not. In the vehicular ad hoc network this protocol uses three types of connectivity based on requirement in the network such as well connected, sparsely connected and totally disconnected nodes [13].

b. Urban Multihop Broadcast (UMB)-In vehicular ad hoc network when there is a problem in more densely network traffic and mobile nodes want to send packets in multi hop manner then UMB protocol helps in overcome the interference, packet collision and hidden node problem during packet delivery to destination [14].

D. GEOCAST ROUTING PROTOCOL

The mobile nodes in geocast routing protocol uses the principle of routing data packet from one source to all mobile nodes belonging to destination called zone of relevance. Zone of forwarding is used to confine the message forwarding until it reaches ZOR through flooding. Few of the protocols are DG-CASTOR and DRG.

a. Direction based geocast routing protocol (DG-CASTOR): In vehicular ad hoc network the DG-CASTOR protocol works based on link availability estimation. The nodes in the network communicate with another nodes when there

ISSN(Online): 2320-9801
ISSN (Print): 2320-9798

International Journal of Innovative Research in Computer and Communication Engineering

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is equal proportion of similarity to communicate in a certain period of time. The rendezvous group represent the source node and destination node to meet in future if there is possibility of routing happens [15].

b. Distributed robust geocast routing protocol (DRG): In VANET the DRG routing protocol works based on the principle of forwarding algorithmstating that more distance is more favorable principle to select relays. Each node receiving a geocast message checks the relevance based on its location. If the node belongs to ZOR it reads the message and if it is in the ZOF range it forwards the message or else the packet is dropped [16].

E. CLUSTER BASED ROUTING PROTOCOLS

In vehicular ad hoc network the nodes having the same characteristics such as moving with same velocity in the network can form as cluster and share information. They elect the node as cluster head which manages the cluster in the network of inter cluster communications. Few routing protocols are CBDRP and COIN.

a. Cluster Based directional Routing protocol (CBDRP)-In vehicular ad hoc network CBDRP is used in highway traffic where there is high speed nodes are moving. The nodes will form as a network if they follow similar direction of flow. The cluster head receives the packet first from any source node if it wants to broadcast the information then cluster head forwards it to the destination node [17].

b. Clustering for open intervehicle communication network (COIN): In vehicular ad hoc network COIN protocol is used for intervehicle communication without any infrastructure.The clusters are formed on the basis of mobility, position and behavior in various traffic scenarios and receive and transmit packets accordingly [18].

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IV. CONCLUSION

In this paper we reviewed the various types of VANET routing protocols exist in different traffic scenario, different protocols have some advantage over other in terms of providing quality of service at the end. The protocols vary by topology, position, broadcast, geocast and cluster based routing protocols. The hierarchy of the routing protocols as shown in figure 5 are discussed widely based on the type of the routing protocol usedbased on topology, position,broadcast, clustering, geocast. The summary of routing protocols are discussed based on protocol type used, digital map used, routing protocol proposed by author and year, overhead used and traffic scenario as shown in table 1. In future we propose our own routing protocol which can provide the best of QOS to vehicular ad hoc network.

REFERENCES

1. http://asirt.org/initiatives/informing-road-users/road-safety-facts/road-crash-statistics
2. K. C. Lee, U. Lee and M. Gerla, "Survey of Routing Protocols in Vehicular Ad Hoc Networks," in Advances in Vehicular Ad-Hoc Networks: Developments and Challenges, IGI Global, Oct, 2009.
3. YaseerToor et al., "Vehicle Ad Hoc Networks: Applications and Related Technical issues", IEEE Communications surveys & Tutorials, 3rd quarter, vol 10, No 3,pp. 74-88, 2008.
4. Charles E. Perkins and Pravin Bhagwat, "Highly dynamic Destination Sequenced Distance Vector routing DSDV for mobile computers", SIGCOMM Comput. Commun. Rev., Vol. 24, Nr. 4 New York, NY, USA: ACM pp. 234–244, 1994.
5. T. Clausen and P. Jacquet ,"Optimized link state routing protocol (OLSR)," RFC 3626 Experimental, October 2003.
6. G. Pei, M. Gerla, and T. W. Chen, "Fisheye State Routing in Mobile Ad Hoc Networks," In Proceedings of the 2000 ICDCS workshops, Taipei, Taiwan, Apr. 2000.
7. C. E. Perkins, E. Belding-Royer, and S. R. Das, "Ad-hoc on-demand distance vector (AODV) routing," IETF RFC 3561, July 2003.
8. D.B. Johnson and D A. Maltz, "Dynamic Source Routing in Ad Hoc Wireless Networks," In Proceedings Mobile Computing, edited by T. Imielinski and H. Korth, Chapter 5, pp.153-181, 1996.
9. V. Park and S. Corson, "Temporally Ordered Routing Algorithm (TORA) Version 1, Functional specification", IETF Internet draft, 1998.
10. Z. J. Haas. "The Zone Routing Protocol (ZRP) for ad hoc networks", Internet Draft, Nov. 1997.
11. Brad Karp &H.T.Kung, "GPSR: Greedy Perimeter Stateless Routing for Wireless Networks", Proceedings of Sixth Annual International Conference on Mobile Computing &Networking, Boston, pp.243-254, 2000.
12. S. Basagni, I. Chlamtac, V.R. Syrotiuk, and B.A. Woodward, "A Distance Routing Effect Algorithm for Mobility (DREAM)", MOBICOM'9, 1999.
13. Tonguz O. K, "DV-CAST: A distributed vehicular broadcast protocol for vehicular ad hoc networks" IEEE wireless communications, vol 17, issue 2, pp:47-57, 2010.

ISSN(Online): 2320-9801
ISSN (Print): 2320-9798

International Journal of Innovative Research in Computer and Communication Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 3, Issue 12, December 2015

14. Atechian T., Brunie L, "DG-CastoR for query packets dissemination in VANET ", 5th IEEE International Conference onMobile Ad Hoc and Sensor Systems, 2008. MASS 2008, pp 547-552, oct 2008
15. G. Korkmaz,E. Ekici,F. Ozguner,and U. Ozguner, "Urban Multi-Hop Broadcast Protocols for Inter-Vehicle Communication Systems, " in , Proc. of First ACM Workshop VANET 2004,pp. 76-85,Oct. 2004.
16. H. P. Joshi, M. Sichitiu, and M. Kihl, "Distributed Robust Geocast Multicast Routing for Inter-Vehicle Communication," WEIRD Workshop on WiMax, Wireless and Mobility, May 2007.
17. Tan Song, "A cluster-based directional routing protocol in VANET". In the proceedings of 12th IEEE International Conference onCommunication Technology (ICCT 2010), pp 1172 – 1175, Nov 11-14, 2010.
18. Blum, J., A. Eskandarian, and L. Hoffman. Mobility management in IVC networks. in Intelligent Vehicles Symposium, 2003. Proceedings. IEEE. 2003.

BIOGRAPHY

Viswacheda Duduku V is a PhD scholar in faculty of Engineering, Universiti Malaysia Sabah, He received Master of Communication Engineering in 2008 from Universiti Malaysia Sabah, Malaysia. His research interests are Computer Networks (wireless Networks), Vehicular ad hoc networks, security in wireless networks. He has authored 4 international journal papers and 6 IEEE conference papers so far.

Ali Chekima received his B.Eng in Electronics from the "Ecole Nationale Polytechnique", University of Algiers, in 1972. Then, he received his MSc and PhD in Telecommunications from the School of Engineering, Rensselaer Polytechnic Institute, Troy, New York in 1978 and 2004 respectively. In 1996 he joined the School of Engineering and Information Technology, University Malaysia Sabah as Associate Professor where he was promoted to full Professor in 2011. His research interest is Communication, Pattern Recognitionand Artificial Intelligence. He has published more 100 papers in referred journals, International conferences proceedings and book chapters. He has supervised more 30 Postgraduate students (Master and PhD). He has examined more 60 Master and Phd theses.

Farrah Wong received her Doctor of Philosophy in Electronic Engineering from Universiti Malaysia Sabah in 2004. She is a Senior Member of IEEE, USA. Currently, she is the Head of the Computer Engineering Programme offered under the Faculty of Engineering in Universiti Malaysia Sabah. Her area of research is in Intelligent Systems and Machine Visions.

Jamal Ahmad Dargham received his BSc in Control Systems Engineering, University of Technology, Iraq in 1984 and his MSc in Control Systems Engineering from the University of Manchester, UK, in 1987 and his PhD in Image Processing from Universiti Malaysia Sabah in 2008. Presently working as Associate professor in faculty of Engineering, UMS. His main research interests are in Image Processing specifically Biometrics as well as Engineering Education. He has published more than 75 papers in refereed journals, conferences, book chapters and research reports. He has supervised more than 10 and was the examiner or more than 10 graduates at the Master and PhD levels.