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# *Recent study of Routing protocols in VANET : Survey and Taxonomy*

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**Abstract**— *Vehicular Ad Hoc Network (VANET) is a technology that integrates Ad Hoc network, cellular technology and wireless-LAN to achieve vehicle to vehicle and vehicle to infrastructure communication for intelligent transportation systems (ITS). The paper provides a survey of routing protocols in vehicular ad hoc networks, it fall into six categories: Topology-based, Position-based, Cluster-based, Geocast-based, Broadcast-based and Infrastructure-based. In this paper we present recent and new routing protocols focusing on the period between the years 2011 and 2013. We discuss the advantages and disadvantages of these routing protocols and propose new classification named prediction-based to estimates density of vehicles, node life time or link lifetime to improve routing in VANET.*

**Keywords**— *Vehicular Ad Hoc Networks (VANET), Routing Protocols, Survey, Intelligent Transportation System (ITS), inter-vehicle communications (IVC), vehicle to vehicle (V2V), vehicles and fixed roadside equipment (V2R)*

## I. INTRODUCTION

VANET is a novel class of Mobile Ad-Hoc Network (MANET) and an important component of Intelligent Transportation System (ITS). VANET is an emerging technology to achieve intelligent inter-vehicle communications (IVC), it aimed to support [1]:

- essential emergency alerts
- road safety
- accessing comforts & entertainments
- Platooning

- information service
- traffic monitoring and management
- prevention of collision & blind crossing

It includes a wide range of technologies such as vehicle communication system, Global Positioning System (GPS), digital mapping, video cameras, together with advanced information processing tools. It provides relevant information to users and traffic management systems to improve traffic efficiency, reduce traffic congestion avoid collisions and improve road safety. 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 that includes wireless technologies like IEEE 802.11, WiFi, WIMAX, IEEE 802.15 and Bluetooth. The remainder of this paper is organized as follows. In Section II some background is given on routing protocols in VANET then we give our conclusions.

## II. ROUTING PROTOCOLS IN VANETS

Routing tasks in VANETS are very challenging due to the high speed of vehicles making topology of the network highly dynamic and causing frequent links disconnections. Routing protocols in VANETS are classified into six categories considering the routing technique aspects: Topology-based, Position-based, Cluster-based, Geocast-based, Broadcast-based and Infrastructure-based (*Fig. 2*).

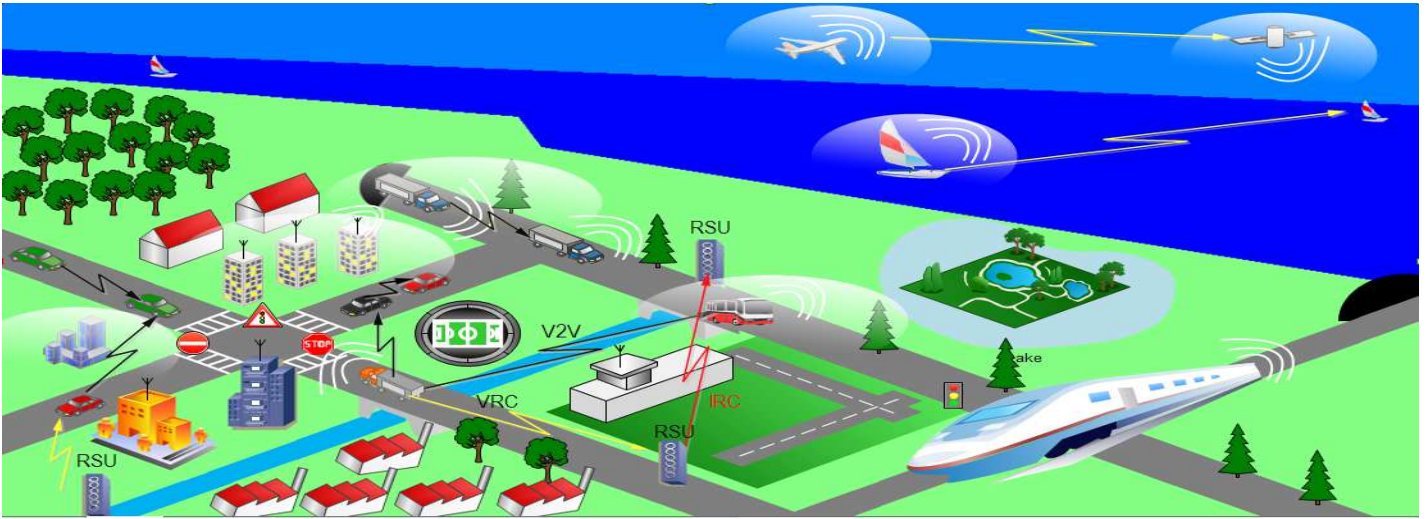


Fig. 1 : VANET scenario

### A. Topology-Based Protocols

These routing protocols use links' information that exists in the network to perform packet forwarding. They can further be divided into proactive (table-driven), reactive (on-demand), prediction and hybrid routing.

- Destination Sequence Distance Vector (DSDV) [2]

DSDV is a table driven algorithm based on Bellman-ford routing mechanism. In this protocol, every mobile node maintains a routing table in which all of the possible destinations within the network and the number of hops to each destination are recorded. Each entry is assigned a sequence number by the destination node.

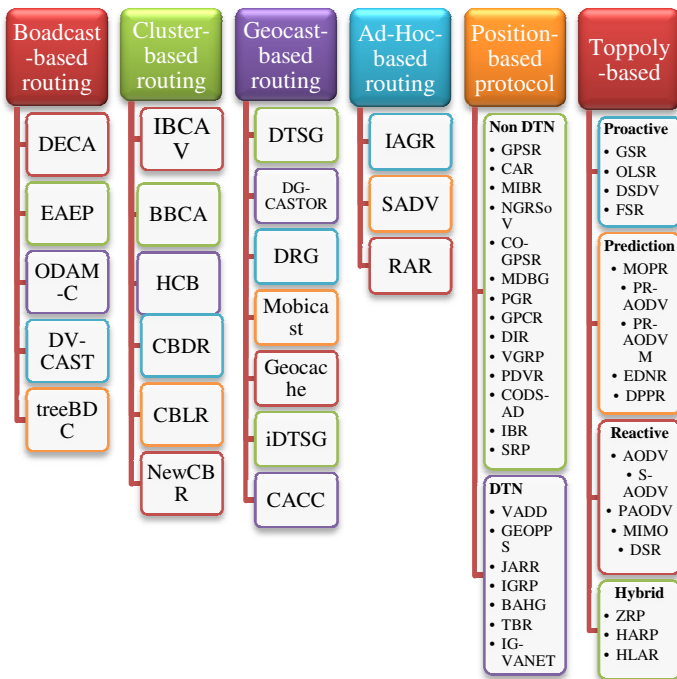


Fig. 2 : Taxonomy of Various Routing Protocols in VANET

#### 1) Proactive protocols

Proactive routing protocols try to update routing information periodically. The advantage of proactive routing protocols is that there is no route discovery since the destination route is stored in the background, but the disadvantage of this kind of protocols is that it provides low latency for real time application, poor scaling system and Unused paths occupy a significant part of the available bandwidth.

#### 2) Prediction-based

- Exploring dynamic nature routing (EDNR)[3]
- Some protocols discussed earlier already use the lifetime of nodes to improve the performance of routing protocols. EDNR refines the lifetime prediction by using the residual battery and past activity of a given node. It thus looks at the battery drain rate of a node to predict its lifetime.

- Driving Path Prediction Based Routing Protocol in Vehicular Ad hoc Networks (DPPR) [4]

DPPR is a new driving path prediction based routing protocol aims to improve the performance of data delivery in VANETs, it can observably increase the ratio to find the proper next hop vehicles that move toward the optimal expected road in intersection areas. Authors compare DRPP with other protocols like GPRS and epidemic so they conclude that the protocol can reach high data delivery performance in VANETs.

#### 3) Reactive protocols

Reactive routing protocol is called on demand routing because it starts route discovery when a node needs to communicate with another node thus it reduces network traffic. The advantage of Reactive routing is to update routing table not require periodic flooding the network. Flooding requires when it is demanded and Beaconless so it saves the bandwidth but for route finding latency is high and Excessive flooding of the network causes disruption of nodes communication.

- MIMO Distance Vector Protocol (MIMO) [5]

Minimum Interference MINimuM hop-cOunt aODV (MIMO-DV) is a version of AODV, which has the basis of the traditional AODV, from which it inherits control packets and packet exchange procedures. MIMO is dedicated to the optimization of path-length and interference level, it takes advantage of a dynamic allocation of the DSRC spectrum, in

order to reduce interference levels among nearby mobile nodes. MIMO aims to find the best path in terms of interference and hop-count, basing on the choice of next-hops on a new defined metric.

- hybrid location-based protocol (HLAR) [6]

HLAR was proposed because in all scenarios no single routing protocol will excel in VANETs, it combine features of reactive routing AODV (that has the best performance and lowest routing overhead among all topology based routing protocols) with geographic routing. The main point of the protocol is not to compete or replace current AODV type protocols but to enhance and complement existing AODV protocols as location information is made available to the nodes.

### B. Position-Based Protocols

They are also called Geographic-based protocols. This class uses geographical information of vehicles in the relay selection process assuming that each vehicle has the mean to know its geographical position [7]. The advantage of this categorie is :

- Route discovery and management is not required
- Scalability
- appropriate for high node mobility pattern

But it requires position determining services, GPS device doesn't work in tunnel because satellite signal is absent there.

#### 1) Protocols that not be applicable in DTN

- Cross Layer Optimization of VANET Routing (CO-GPSR)[8]

CO-GPSR is an extension of the traditional GPSR (Greedy Perimeter Stateless Routing) that use relay nodes which exploit radio path diversity in a vehicular network to increase routing performance.

#### 2) Protocol that be applicable in DTN

Delay Tolerant Network (DTN) uses carry & forward strategy to overcome frequent disconnection of nodes in the network [9]. In carry & forward strategy when a node can't contact with other nodes it stores the packet and forwarding is done based on some metric of nodes neighbors (Fig. 3).

- Intersection-Based Geographical Routing Protocol\_(IGRP) [10]

IGRP is another protocol that performs a selection of road intersections through which a packet must pass to reach the gateway to the Internet. This selection must guarantees network connectivity among the road intersections while satisfying quality of service constraints on error rate, tolerable delay and bandwidth usage.

- Back-Bone-Assisted Hop Greedy Routing (BAHG)[11]

To reduce the hop count, and thus the reduction of the end to-end delay, another protocol called BAHG. This protocol tries to find a routing path consisting of the minimum of intermediate intersections. It is designed considering certain features in a city map, such as intersections and road segments.

- Trajectory-based Routing Protocol (TBR) [12]

TBR is designed specifically for vehicle-to-vehicle communications in rural networks, each vehicle utilizes a future knowledge of the trajectories of the other vehicles in the network to identify a suitable inter-vehicle route over which to deliver its packets to the destination, the vehicles download the trajectories of all the other vehicles in the network from a nearby RSU but the disadvantage of TBR is that may not be easily implemented in real-world rural VANET since RSUs are not always available.

- intersection graph-based vehicular ad hoc network (IG-VANET) [13]

Intersection graph-based vehicular ad hoc network (VANET) is a novel architecture that uses available electronic MAP and historical traffic statistics from public traffic databases for improving unicast routing performance. IG-VANET based on three roles : vehicles (each vehicle is equipped with the GPS device and the on board unit), road side units RSU (there may be an RSU to monitor traffic statistics) and the traffic control center (can preprocess static traffic information, augment historical traffic statistics with monitored traffic statistics and collect dynamic traffic events).

### C. Cluster-Based Protocols

Clustering techniques are usually employed in VANETs to reduce resources consumption and improve the efficiency of the network. In cluster-based routing protocols, the vehicles have similar characteristics, like performing in the same direction with more or less velocity, can form a cluster and elect a cluster-head which manages the cluster and is in charge of inter-cluster communications [14],

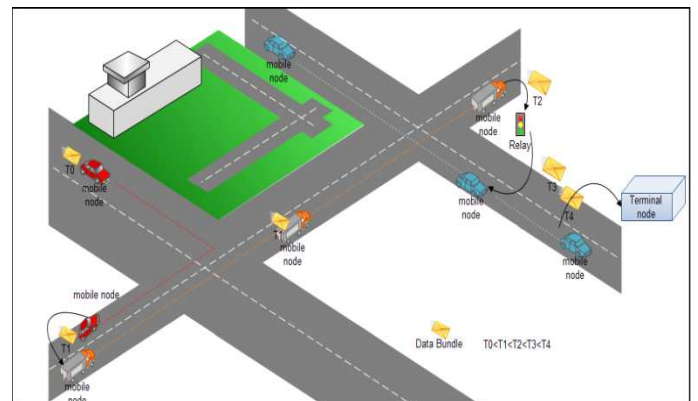


Fig. 3 : the paradigm of store-carry-and-forward

- Intelligent Based Clustering Algorithm (IBCAV) [15]
- IBCAV seeks to improve routing algorithms in VANETs by employing inter-layered methods, awareness of the existing traffic flow as well as combination of various factors on the basis of a smart method based on artificial neural network. It take into account cluster size, speed and density of nodes.

- Beacon-based clustering algorithm (BBCA) [16]
- beacon-based clustering algorithm aimed at prolonging the cluster lifetime in VANETs. New aggregate local mobility criterion is used to decide upon cluster re-organisation. The scheme incorporates a contention method to avoid triggering frequent re-organisations when two cluster heads encounter each other for a short period of time.

#### D. Broadcast –Based Protocols

This class of routing protocols uses the simple flooding on the network in order to reach all vehicles [17]. Different relay selection techniques are used to reduce the message overhead.

- Optimized Dissemination of Alarm Messages ODAM-C[18]

ODAM-C algorithm improves the packet delivery rate by two mechanisms based on the forwarding features of ODAM. The first distance-based mechanism reduces the possibility of packet loss by considering the angles between receiving nodes, source nodes and forwarding nodes. The second mechanism increases the redundancy of forwarding nodes to guarantee the packet success delivery ratio.

- A new tree based double covered broadcast protocol (treeBDC) [19]

TreeDCB use a tree structure instead a graphical representation for broadcasting the packets. The Mechanism uses fixed length packets and guarantees that each node is either a forwarding node or covered by at least two forwarding nodes. TreeDCB is based on a single source, the advantages is low control overhead but it not evaluate control traffic, and the average packet path length.

#### E. Geocast-based PROTOCOLS

Geocast routing protocols follow the principle of routing data packets from a single source vehicle to all vehicles belonging to the destination area called zone of relevance ZOR [10, 8]. However, to override the simple flooding of the geocast message from the source to the ZOR, a forwarding area called zone of forwarding ZOF is used to confine the message forwarding until it reaches the ZOR [17].

- Geocache Sharing and Exchanging Road Traffic (Geocache) [20]

Geocache is a peer-to-peer application over VANET for detecting and avoiding road traffic congestion. This application uses a simple collection and dissemination protocol for cooperatively exchanging and sharing information related to road congestion. This information is used by mobile vehicles to dynamically and proactively determine the optimal routes to their final destination based on the congestion state on the road.

- Time-Stable Geocast for Post Crashi (iDTSG) [21]

iDTSG is an improvement of the existing DTSG protocol, it consider a highway scenario where the crashed vehicle or the vehicle that has seen an accident wants to inform the other vehicles that are approaching the dangerous area. iDTSG suppresses the broadcast storm further more than DTSG and modifies the length of the extra region used in DTSG.

#### CONCLUSION

In this paper we have discussed various routing protocols of VANETs. A conception of an efficient routing protocol for all applications designed to VANET is very difficult, therefore a comprehensive survey of VANET protocols is absolutely essential to come up with new routing protocol for this kind od networks. The performance of VANET routing protocols depend on various parameters like mobility model, Forwarding strategy, driving environment. Thus, this paper represents an exhaustive survey of routing protocols in VANET, and presents a new comparison of different classes of VANET routing protocols. In our future work, we will present in a separate paper, results related to simulations of recent routing protocols in VANETs.

TABLE 1 : Classification of various routing protocols depending on their categories

		Protocols	Mobility model	Tolerant delay	Forwarding strategy	Scenario	Support high vehicle density	Year
topology-based Routing Protocol	proactive	DSDV	-	No	-	circular line of 30 nodes	No	2012
	Reactive	MIMO	-	No	Hop-count	Map/Urban	Yes	2012
	Prediction	EDNR	-	No	-	Area of 50 nodes	Yes	2013
		DPPR	-	No	greedy forwarding	Street map	Yes	2013
	Hybrid	HLAR	random waypoint	No	-	Urban (Highway and grid)	Yes	2012
position-based routing Protocol	Non DTN	CO-GPSR	Nakagami model	No	greedy forwarding	Highway	Yes	2012
	DTN	IGRP	-	Yes	Carry-Forward	Road map	Yes	2011
		BAHG	-	Yes	Store-carry and forward	City map	Yes	2012
		TBR	-	Yes	greedy forwarding	street map	Yes	2012
		IG-VANET	-	Yes	greedy forwarding	street map	No	2011
Cluster-based routing Protocol	IBCAV		-	No	Store-Carry-Forward	Street & higyway	Yes	2013
	BBCA		aggregate mobility	No	heard by the sender's first neighbors	real-world situations	No	2012

<b>Broadcast-based routing Protocol</b>	ODAM-C	-	No	Multi-hop	real-world road traffic	Yes	2012
	treeBDC	No	No	1-hop neighbors	-	Yes	2012
<b>Geocast-based routing Protocol</b>	Geocache	Stop Sign Model (SSM)	No	Multi-hop	Map (Urban)	Yes	2011
	iDTSG	-	-	-	Highway scenario	yes	2012

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