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A Qualitative Survey on Position Based Unicast Routing Protocols in Vehicular Ad hoc Networks (VANETs)

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***Abstract*- Vehicular ad hoc networks (VANETs) have emerged as a prominent technology that facilitates the exciting research and application area for current era of vehicular system. As a sub class of Mobile Ad hoc Networks (MANETs), VANETs provide communication by forwarding datagram over multi hop wireless links. It facilitates the communication among Vehicle to Vehicle (V2V) and Vehicle to Infrastructure (V2I) in wireless environment without any underlying network infrastructure. In current Intelligent Transportation Systems (ITS) vehicles are being equipped with embedded sensors, processing systems and wireless communication capabilities. These features in smart vehicles have opened an ocean of possibilities for safer, efficient, and comfortable driving of vehicles. Some characteristics of VANETs like rapid changes in network topology and sporadic communication connections make a difficult task to solve the routing deficiencies. This paper investigates the various routing algorithm of VANETs and provides a qualitative comparison of these approaches to open the opportunities for the researchers to develop efficient routing techniques.**

***Keywords*- Vehicular Ad hoc networks, VANET, Routing, WAVE**

I. INTRODUCTION

The increasing population of vehicles makes an invitation for the accidents on roads. So driver assistance, safety of vehicle and passengers become very important requirements to mitigate these types of miss happenings while driving a vehicle. Warning about the collision, alert for emergency break, road condition information, pre information of traffic jams are some demands of smart transportation system. VANETs fulfill these requirements of smart vehicles having inbuilt sensors and wireless communication devices. VANETs also offer some value added services like mobile e-commerce, internet access, automated payment of Toll tax, vehicular IPTV etc.

In VANET moving vehicles are the nodes which form distributed self organizing networks. Highly Dynamic Topology, Patterned Mobility, Propagation Model, Unlimited Battery Power and storage and on-board sensors [1] are some key features of VANET that make it different from MANET. Dedicated short range communication (DSRC) is used as a wireless communication technique in VANET. DSRC is IEEE 802.11p standard and is a MAC protocol operating at 5.9 GHz [2]. Wireless Access in Vehicular Environments (WAVE) is a communication stack of IEEE standard, used to establish communication in VANET. It is a challenging task to develop an efficient routing protocol to facilitate a better communication between vehicle to vehicle and vehicle to infrastructure. Following reasons put the hindrance on the way of designing an efficient routing algorithm: unpredictable fading of signals due to the presence of obstacles like buildings, bandwidth constraints, rapid change in the mobility pattern of the vehicles and the speed.

A. IEEE 802.11p (DSRC)

Dedicated Short Range Communication (DSRC) was developed to facilitate the communications between vehicle to vehicle and/or vehicle to road side unit. Having the little amount of communication latency, DSRC provides the transmission of a bulk amount of data. In 1999, the FCC (United States Federal Communications Commission) designated a standard which operate at 5.9 GHz for DSRC. There are seven channels (each one is 10 MHz wide) in DSRC spectrum and each one is reserved for some unique purpose. One is applied for communications in safety applications. Life and public safety applications are covered by other two channels. All other channels are engaged in safety-related and other comfort aided applications.

B. WAVE (Wireless Access in Vehicular Environment)

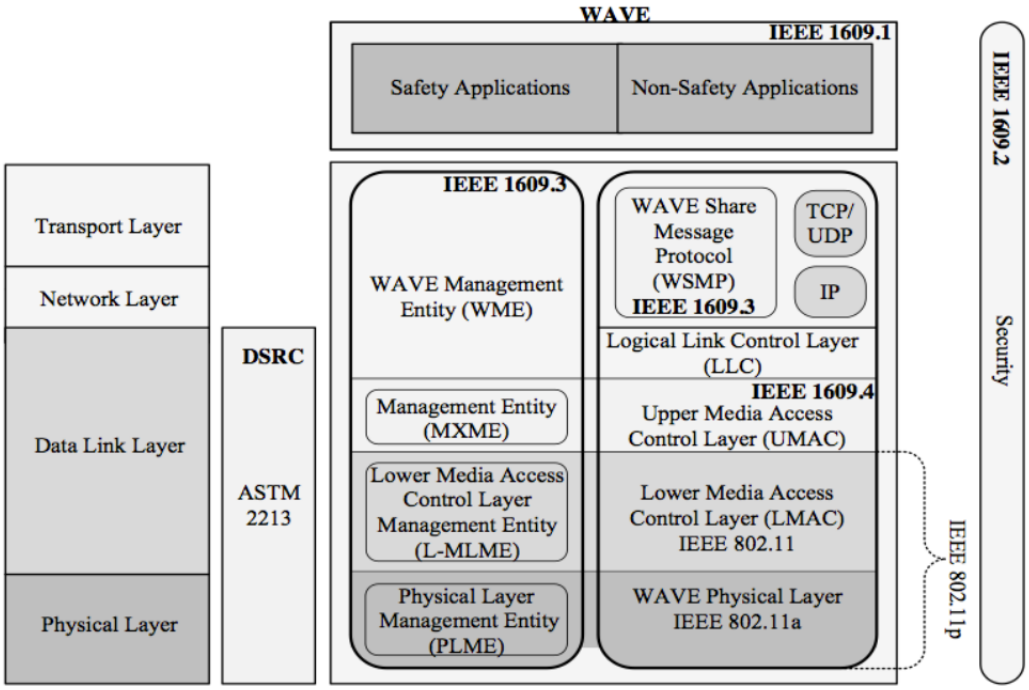
As we know that DSRC standards that are only applicable to regions. WAVE is new standards that could embrace all across the world. Orthogonal Frequency Division Multiplexing (OFDM) is used by WAVE to divide the signal into several narrow band channels. Each channel provides a data payload communication capability of 3, 4.5, 6, 9, 12, 18, 24 and 27 Mbps in 10 MHz channels [3]. Figure (1) well illustrates the concept of WAVE.

II. VANET ROUTING PROTOCOLS

The goal of an efficient routing protocol is to provide optimal route (path) between sender node and receiver node in a multi hop distributed network with minimum overhead. There are so many routing protocols which are well suited for VANETs environment. On the basis of routing techniques and their characteristics, VANET routing protocols can be classified into five major categories:

- Topology-based routing protocols
- Position-based routing protocols
- Geo cast-based routing protocols
- Broadcast routing protocols
- Cluster-based routing protocols

Figure (2) will classify various routing protocols lying in the above mentioned categories.



ASTM: American Society for Testing and Materials
DSRC: Dedicated Short Range Communication
IP: Internet Protocol
TCP: Transmission Control Protocol
UDP: User Datagram Protocol

Figure (1): WAVE, IEEE 1609, IEEE 802.11p and the OSI Reference Model

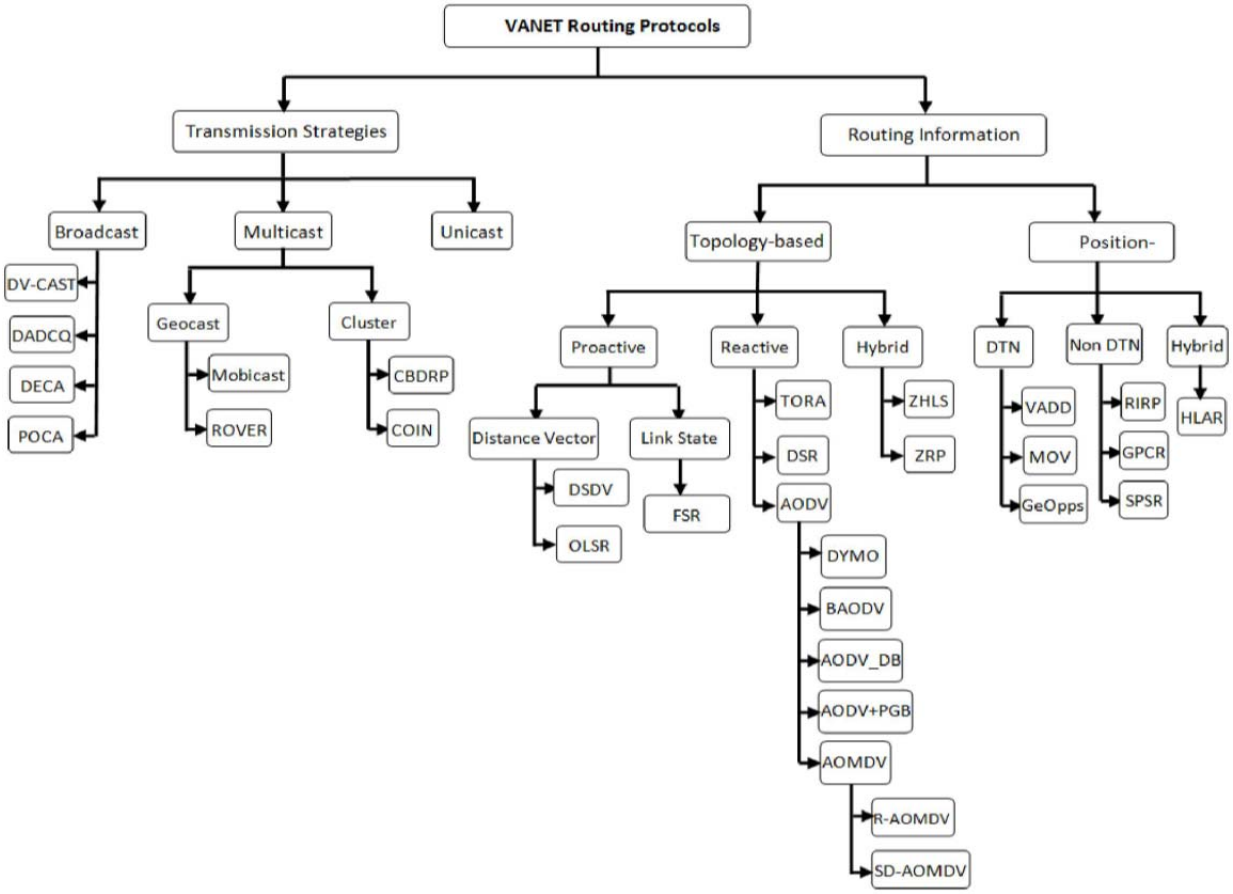


Figure (2): Classification of VANET Routing Protocols

III. DESCRIPTION OF SURVEYED UNICAST ROUTINGPROTOCOLS

Unicast routing protocols can be classified into following three different categories: Position Based Unicast Routing Protocols, Delay Tolerant Protocols and QoS Unicast routing protocols. This paper mainly focuses on various Position Based Unicast routing protocols. The criteria used to classify these routing protocols are: objectives, basic characteristics and their requirements.

1. Position Based Unicast Routing Protocols

1.1 GSR (Geographic Source Routing)

GSR routing was introduced to solve the problems of GPSR like high mobility and topological structure in city environment [4]. To support the city map, position based routing is used in GSR. To get the city map easily, vehicles have been equipped with a navigation system. GSR use reactive location service to find the physical location for node. GSR is a greedy forwarding position based routing protocol which provides a route recovery process for maintaining the routes in case of link breakage. The sender node reaches the destination by using the road topology map and the above information. In other words in GSR the source node finds the shortest path to destination on the graph using simple graph algorithms [5] and mark the packet with destination´s location. In this the packet travels through junctions to reach the destination.

1.2 SAR (Spatially Aware Packet Routing)

SAR is a position-based unicast routing protocol which uses buffer approach to increase packet delivery ratio. In SAR, static street map is extracted by using GIS (Geographic Information Systems) to calculate a shortest path between source and destination nodes and make a spatial model for unicast routing. To find a node a routing path, SAR uses following two strategy: In the first strategy suspension buffer is used to stabilize the packet until a suitable node is located along the routing path. In the second strategy, a packet is greedily forwarded by a node for attempting to reach towards its destination. Beside that some problems like high delay, and inaccurate information about the neighbors rises in the first strategy.

1.3 A-STAR (Anchor-based Street and Traffic Aware Routing)

A-STAR works in city environment. A-STAR also uses traffic information and street awareness in path finding [6]. Road maps are used for node count by which packet successfully transmitted and reach to its destination node. It showed that delivery ratio is more successful and it also decreased end to end delay. A-STAR imposes a new recovery method when some problem occurs for a packet to pass from a junction. This junction is marked as "*out of service*" so that a restriction can be made for other packets to traverse that junction until "*Operational*" state has been reached by this junction [7]. A-STAR has a lower Packet delivery ratio as compared to GSR & GPSR.

1.4 STAR (Spatial and Traffic Aware Routing)

STAR is a link State protocol [8] in which preferred routes to every destination are saved in each node (router). STAR is well suited protocol for large scale network because it eliminates the periodic and provide reduced overhead on the network. Beacon messages are utilized to observe "node neighborhoods "and this information is maintained in a neighbors-table stored at each node. The neighbors-table contains the position of each neighboring node. The neighbors-table and two dependent data structures called the "presence vector" and the "persistence vector" are used to determine sparse and dense traffic conditions. The problem of scalability and wasted bandwidth may arise in STAR due to high dependency on beacons messages.

1.5 GPCR (Greedy Perimeter Coordinator Routing)

GPCR algorithm [9] is approximately similar to GSR. "A natural planar graph is formed by city streets", is the key advantage taken by GPCR and provide an enhanced performance than GSR by eliminating the external static street map. It uses a modified greedy forwarding strategy as messages are routed only along streets. GPCR defining two heuristic methods named as: Neighbor table approach and correlation coefficient approach determining which nodes are located at intersections. Nodes at intersections are known as "coordinators", have the responsibility of routing decisions. Coordinators periodically broadcast their role along with their position information.

1.6 CAR (Connectivity-Aware Routing Protocol)

CAR is also a position-based vehicular routing protocol [10]. The unique characteristic of CAR is the maintenance of a cache of successful routes between various pairs of source and destination nodes. It employs geographic marker messages to predict positions of destination vehicles, repairs routes as those positions change. In CAR periodic HELLO beacons containing the information about heading and speed, called "velocity vector", are sent by a node. When a node receives HELLO beacon, it records the sender in its neighbor table and calculates velocity vectors of its own as well as of its neighbors.

These Beacons will be piggybacked on forwarded data packets to reduce wasted bandwidth and network congestion. CAR has a distinct advantage over other protocols because it generates a virtual infrastructure in the form of guards.

2. Delay Tolerant Protocols

Delay Tolerant Protocols are designed to works with varying network density. Some Delay Tolerant Protocols such as MOVE (Motion Vector Routing Algorithm) [11], SKVR (Scalable Knowledge-Based Routing) [12], VADD (Vehicle-Assisted Data Delivery) [13], SADV (Static-Node Assisted Adaptive Routing Protocol) [14], GeOpps (Geographical Opportunistic Routing) [15] and MaxProp [16] are proposed for sparse networks. The description of these protocols on basis of objectives, characteristics and requirements are summarized in table (1).

3. *QoS Routing Protocols*

QoS routing protocol needs to be satisfied some or all QoS parameters which include Delay, Bandwidth, Jitter, Packet delivery ratio and throughput. Routing protocols like MURU (Multi-Hop Routing Protocol for Urban VANETs) [17] and PBR (Prediction-Based Routing) [18] are used to meet these QoS parameters for VANET. These QoS routing protocols attempt to provide robust routes by satisfying the factors like as reliability of links and optimized of link delay.

IV. COMPARISION OF UNICAST ROUTING PROTOCOLS

V. Table (1) Comparison of Unicast Routing Protocols

UNICAST ROUTING PROTOCOLS IN VANET															
		Position Based Protocols						Delay Tolerant Protocols						QoS Protocols	
		GSR	SAR	A-STAR	STAR	GPCR	CAR	MOVE	SKVR	VADD	SADV	GeOpps	MaxProp	MURU	PBR
Objective	vehicle to vehicle	Yes	Yes	Yes	Yes	Yes	Yes		Yes				Yes	Yes	Yes
	delay tolerant / sparse							Yes	Yes	Yes	Yes	Yes	Yes		
	QoS													Yes	Yes
	Internet connectivity														Yes
Characteristics	Position-Based/ Geographic	Yes	Yes	Yes	Yes	Yes	Yes	Yes		Yes	Yes	Yes	Yes	Yes	Yes
	Greedy forwarding	Yes	Yes	Yes	Yes	Yes	Yes			Yes	Yes	Yes			
	Predictive						Yes	Yes		Yes		Yes	Yes	Yes	Yes
	Buffering		Yes				Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
	Street-Aware	Yes	Yes	Yes	Yes	Yes	Yes			Yes	Yes	Yes		Yes	
	Traffic-Aware (probabilistic)			Yes						Yes					
	traffic-aware (real-time)				Yes		Yes				Yes				
	Position-Anchored routes	Yes	Yes	Yes	Yes	Yes	Yes				Yes				
	Route-repair or Recovery	Yes	Yes	Yes	Yes	Yes	Yes							Yes	Yes
	Route Caching						Yes							Yes	Yes
Requirements	Map	Yes	Yes	Yes	Yes					Yes	Yes	Yes		Yes	
	Positioning system	Yes	Yes	Yes	Yes	Yes	Yes	Yes		Yes	Yes	Yes	Yes	Yes	Yes
	Location service	Yes	Yes	Yes	Yes	Yes				Yes	Yes	Yes		Yes	
	Transport routes			Yes					Yes						
	Transport schedules								Yes						
	Traffic data									Yes					
	Mobile gateways														Yes

VI. CONCLUSION

The main goal of this survey was to study the various unicast routing protocols proposed for VANET. The article provides a quality based review of several unicast routing, including Position Based unicast routing protocols, Delay Tolerant Protocols and QoS routing protocols. These protocols are summarized in Table1. This survey mainly focuses on the criteria like objective of protocol, their characteristics and the implementation requirements of the protocols.

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