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A Survey of Vehicular Ad hoc Networks Routing Protocols

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ABSTRACT: In recent years, the aspect of vehicular ad hoc network (VANET) is becoming an interesting research area; VANET is a mobile ad hoc network considered as a special case of mobile ad hoc network (MANET). Similar to MANET, VANET is characterized as autonomous and self-configured wireless network. However, VANET has very dynamic topology, large and variable network size, and constrained mobility; these characteristics led to the need for efficient routing and resource saving VANET protocols, to fit with different VANET environments. These differences render traditional MANET's protocols unsuitable for VANET. The aim of this work is to give a survey of the VANETs routing mechanisms, this paper gives an overview of Vehicular ad hoc networks (VANETs) and the existing VANET routing protocols; mainly it focused on vehicle to vehicle (V2V) communication and protocols. The paper also represents the general outlines and goals of VANETs, investigates different routing schemes that have been developed for VANETs, as well as providing classifications of VANET routing protocols (focusing on two classification forms), and gives summarized comparisons between different classes in the context of their methodologies used, strengths, and limitations of each class scheme compared to other classes. Finally, it extracts the current trends and the challenges for efficient routing mechanisms in VANETs.

KEYWORDS: VANET, Route, Routing Protocols, Topology-based, Position-based, V2V.

1 INTRODUCTION

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 [1]. 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). 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 [2]-[4], all these characteristics made VANETs environment a challenging for developing efficient routing protocols.

VANETs applications types are classified into safety and efficiency application [1], [5], [6]. There are many difficulties facing VANETs systems design and implementation, including: security, privacy, routing, connectivity, and quality of services. This paper will focus on routing problem in vehicle to vehicle communication (V2V); discusses some proposed routing solutions, routing protocols classifications, and illustrates some challenges and open issues in VANET routing.

The main goal for routing protocol is to provide optimal paths between network nodes via minimum overhead. Many routing protocols have been developed for VANETs environment, which can be classified in many ways, according to different aspects; such as: protocols characteristics, techniques used, routing information, quality of services, network structures, routing algorithms, and so on. Some research papers classified VANETs routing protocols into five classes: topology-based, position-based, geocast-based, broadcast, and cluster-based routing protocols, this classification is based on the routing protocols characteristics and techniques used [2], [5], [7]. As well, other papers classified VANETs routing protocols according to the network structures, into three classes: hierarchical routing, flat routing, and position-base routing. Moreover, they can be categorized into two classes according to routing strategies: proactive and reactive [8]. On the other hand other papers classified them into two categories: geographic-based and topology-based, according to the routing information used in packet forwarding [4]. Also based on quality of services classification, there are three types of protocols that dealing with network topology (hierarchical, flat, and position aware), concerning with route discovery (reactive, proactive, hybrid and predictive), or based on the MAC layer interaction [9]. However all previous classifications did not concern by transmission strategies classification (such as unicast, broadcast, and multicast).

This paper will address two types of classifications as shown in Fig. 1; the first one is the routing information which used in packet forwarding, it mainly focuses on topology-based and graphic-based routing. And the other class is the transmission strategies, which is we thought it has a significant impact in protocol design and network performance (in case of network overhead, delay, and packet loss).

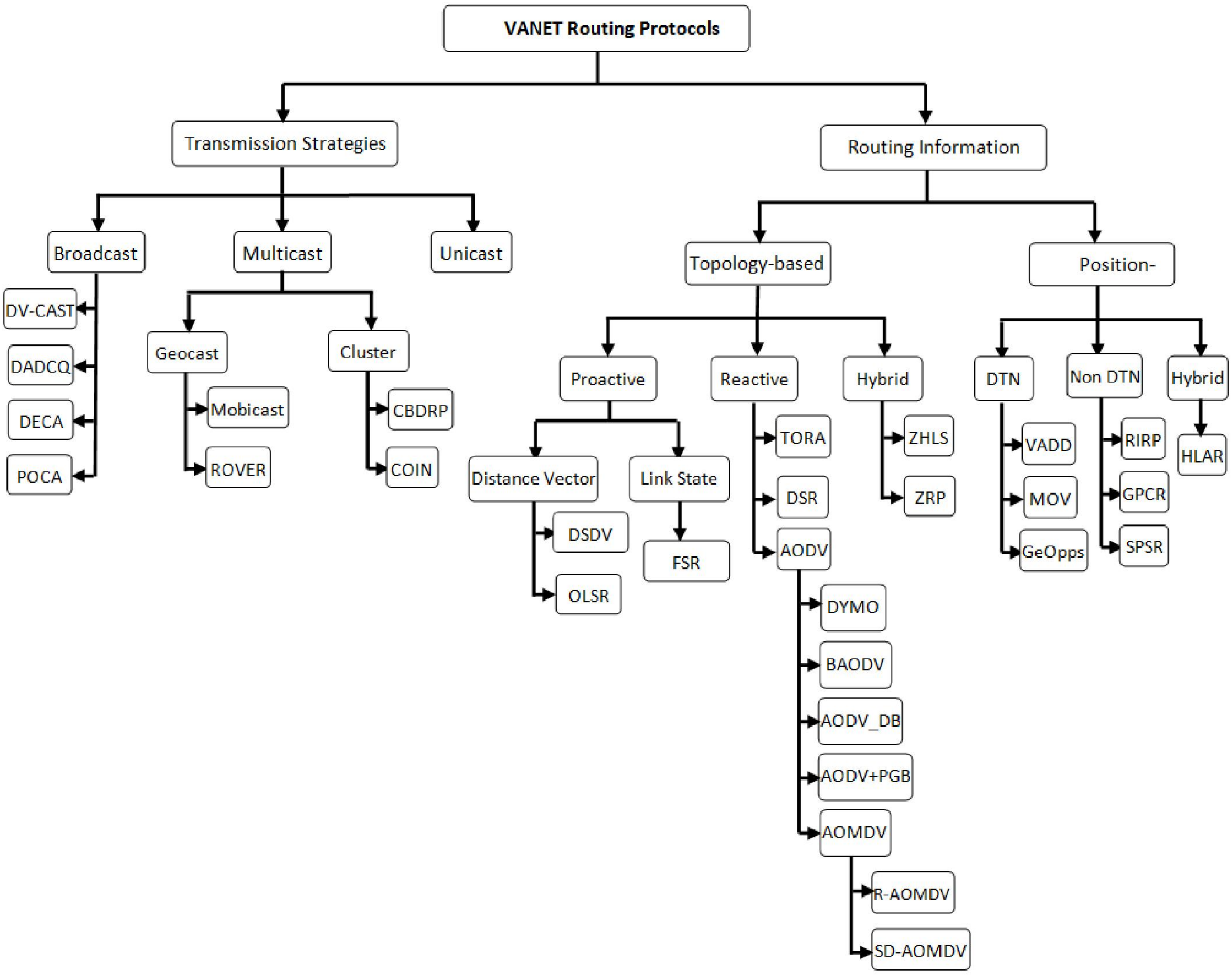

Fig. 1. Classification of VANET routing protocols

The rest of the paper is organized as follows: section 2 presents class one: the routing information used in packet forwarding, discusses topology-based and position-based routing protocol, and illustrate some related protocols with a brief showing to their strengths and limitations, and comparisons between the different class types. Section 3 just like section 2, represents the second class types; transmission strategies, shows various categories of routing protocols, and discusses some related protocols along with their strengths and limitations, also gives brief comparisons between the different categories. Section 3 discusses some research area and open issues in VANETs. And final section summarizes and concludes this paper.

2 ROUTING INFORMATION USED IN PACKET FORWARDING

This class is divided into two subclasses: topology-based and position-based routing protocols. In topology-based routing, each node should be aware of the network layout, also should able to forward packets using information about available nodes and links in the network. In contrast, position-based routing should be aware of the nodes locations in the packet forwarding.

2.1 TOPOLOGY-BASED ROUTING PROTOCOL

Topology-based routing protocol usually a traditional MANET routing protocol, it uses link's information which stored in the routing table as a basis to forward packets from source node to destination; it commonly categorized into three categories (base on underlying architecture) [3],[10]: Proactive (periodic), Reactive (on-demand) and Hybrid

2.1.1 PROACTIVE ROUTING PROTOCOLS

Proactive protocols allow a network node to use the routing table to store routes information for all other nodes, each entry in the table contains the next hop node used in the path to the destination, regardless of whether the route is actually needed or not. The table must be updated frequently to reflect the network topology changes, and should be broadcast periodically to the neighbors. This scheme may cause more overhead especially in the high mobility network. However, routes to destinations will always be available when needed [4]. Proactive protocols usually depend on shortest path algorithms to determine which route will be chosen; they generally use two routing strategies: Link state strategy and distance vector strategy.

2.1.1.1 DESTINATION SEQUENCE DISTANCE VECTOR ROUTING (DSDV)

DSDV protocol it is an earliest ad hoc routing protocol, it implements the distance vector strategy and uses a shortest path algorithm to implement only one route to destination which stored in the routing table, each routing table contains information about all accessible network nodes, as well as the total number of hops needed to reach these nodes, and each entry in the routing table is labeled with a sequence number initiated by the destination node. To maintain routes reliability, each node must periodically broadcast its routing table to its neighbors. DSDV protocol guarantees the loop free routs, excludes extra traffic caused by frequent updates, as well as reduces control message overhead, it also keeps only the optimal path to every node, rather than keeping multi paths which will help to reduce the total size of routing table [8]. However, DSDV increases the overhead in the large network; because of unnecessary updating broadcast even if there is no change in the network topology. Besides that, DSDV don't provide multi routes to destination node [8] and has no control over the network congestion which decreases the routing efficiency [11]. As the result of these limitations, Randomized DSDV protocol (R-DSDV) is proposed to support congestion control over DSDV; by maintaining nodes randomized decision which allows each node to make a decision whether to forward or discard a packet. However the R-DSDV produces more overhead compared to the DSDV protocol.

2.1.1.2 OPTIMIZED LINK STATE ROUTING PROTOCOL (OLSR)

OLSR protocol implement the link state strategy; it keeps a routing table contains information about all possible routes to network nodes. Once the network topology is changed each node must send its updated information to some selective nodes, which retransmit this information to its other selective nodes. The nodes which are not in the selected list can just read and process the packet [10].

Some researchers thought that OLSR has easy procedure which allows it to built-in different operating systems, besides it works well in the dynamic topology, also it is generally suitable for applications that required low latency in the data transmission (like warning applications) [11]. However, OLSR may cause network congestion; because of frequent control packets which sent to handle topology changes, moreover OLSR ignore the high resources capabilities of nodes (like transmission range, bandwidth, directional antenna and so on) [12]. Therefore, some researchers propose Hierarchical Optimized Link State Routing (HOLSR) protocol as enhancement of the OLSR protocol, which decreases routing control overhead in the large size networks, also maximizes the routing performance; by the defining network hierarchy architecture with multiple networks [13]. Also some researchers propose QOLSR as a solution of providing a path such that the available bandwidth at each node on the path is not less than the required bandwidth. QOLSR considers delay as a second for path selection [12]. These protocols usually provide average enhancement for the QoS of packets. However, they cause more complexity, increasing packet overhead, and only suitable for some limited applications [9].

2.1.1.3 Fisheye state routing (FSR)

In FSR, the node periodically updates its table based on the latest information received from neighboring nodes. The updating of the routing table entries that concern a certain destination must be broadcast by different frequencies for neighbors. Table entries that are further in the distance are broadcast with lower frequency than entries that are nearer, this scheme doesn't guarantee decreasing broadcast overhead in large distances routing process. However, it could be accurate, if the packets come closer to the destination [4], [14]. The problem with the FSR is that, the growing network sizes will also increase the routing tables, also if the topology changes increased, the route to a remote destination becomes inaccurate. Moreover if the destination moves out of scope of source node then it can not discover the route [4], [15].

The advantage of proactive routing protocols can be abbreviated to there is no need to route discovery process; because the route to the destination is kept in the background, moreover proactive protocols periodically update the routing information which lets these protocols to perform well in low mobility networks. However, they have degraded performance in highly mobility and density network that when compare them with the reactive routing protocols, moreover unused routes consume the available bandwidth and increase the network overhead [2].

Recent studies show that proactive routing protocols (such as OLSR) generally outperform the reactive protocols in terms of network throughput and end to end delay [16]. However; there is no much research in the proactive routing protocols for VANET compared with existing VANET reactive protocols researches.

2.1.2 Reactive Routing Protocols

Reactive routing protocols (also called on-demand) reduce the network overhead; by maintaining routes only when needed, that the source node starts a route discovery process, if it needs a non existing route to a destination, it does this process by flooding the network by a route request message. After the message reaches the destination node (or to the node which has a route to the destination), this node will send a route reply message back to the source node using unicast communication [17]. Reactive routing protocols are applicable to the large size of the mobile ad hoc networks which are highly mobility and frequent topology changes [18]. Many reactive routing protocols have been developed, the following sections will illustrate characteristic of some reactive protocols, as well as illustrates the existing enhancement protocols.

2.1.2.1 Ad hoc on-demand distance vector (AODV)

AODV routing protocol is proposed for mobile ad hoc network, it has been evaluated in several researches and shows good results compared to related routing protocols; so it has a good documentation [19]. AODV offers low network overhead by reducing messages flooding in the network; that when compared to proactive routing protocols, besides reducing the requirement of memory size; by minimizing the routing tables which keep only entries for recent active routes, also keeps next hop for a route rather than the whole route. It also provides dynamically updates for adapting the route conditions and eliminates looping in routes; by using destination sequence numbers. So AODV is flexible to highly dynamic network topology and large-scale network [20]. However, it causes large delays in a route discovery, also route failure may require a new route discovery which produces additional delays that decrease the data transmission rate and increase the network overhead [17]. Moreover, the redundant broadcasts without control will consume extra bandwidth (broadcast storm problem), this problem grows as the number of network nodes increases, that besides collisions which lead to packet lost problem [19]. There are several protocols have been proposed to enhance AODV protocol; by decreasing its problems.

2.1.2.1.1 Ad-hoc On-demand Multipath Distance Vector Routing (AOMDV)

AOMDV protocol is a multi path on-demand protocols comes as an extension of the AODV protocol, it discovers many paths from source to destination in a single route discovery process. Multi path On-demand protocols perform better than single path protocols especially in reducing route discovery retransmission. It stores multi paths to destination using a single route discovery process; therefore no need to discover a new route if only a single path is failing; it's easy use any one of the existing redundancy paths. In multi path protocols a new route discovery is required if and only if all replicated paths to the destination are failing. In contrast, different thing happens in the single path protocols which establish a new route discovery every time a single path from the source to the destination is failing. This made multi path protocols have a better performance in term of uninterrupted communications for the packet transmission, and provide lower overhead; due to decreasing frequent route discovery transmission. AOMDV protocol is an enhancement of AODV protocol, it uses same control messages used in AODV, it just adds extra fields for AODV routing control messages; that to reduce the overhead occurring by discovering multiple paths. Moreover discovering multiple paths doesn't increase the delay of the route discovery process; because the latency of a route discovery is defined by the total source waiting time, before the source received the first path. AOMDV keeps all available paths in the routing table, then the source chose one of the stored paths; the preferred path will be the first established one [21].

2.1.2.1.1.1 Enhancing AOMDV Routing Protocol for V2V Communication (SD-AOMDV)

SD-AOMDV is proposed as an enhancement of the AOMDV protocol; to deal with VANET characteristics. SD-AOMDV appends new factors (speed and direction) to the hop count field to determine the next hop during the rout discovery process. The next hop node is an intermediate node, selected based on two factors: intermediate nodes that can move in the same direction of the source and the destination, or the same direction of the source, or the same direction of the destination, and its speed is equal or near to the average speed of the source and destination. The protocol merges these two factors with a hop count field to choose a route [22].

2.1.2.1.1.2 A Cross-Layer AOMDV Routing Protocol for V2V Communication in Urban VANET (R-AOMDV)

R-AOMDV is a protocol built on AOMDV; it uses a method which merges transmission count and hop counts at the MAC layer, taking into account minimizing delay and performance of intermediate links. In the route discovery process, R-AOMDV is similar to AOMDV; it depends on route request and route reply control packets. This protocol adds two fields to route replay message fields; to compute quality of the whole path, one of these fields is the maximum retransmission count (MRC) which is computed by the MAC layer, and the other is the total hop count which is computed by the network layer. In R-AOMDV, a source node sends a route discovery packet when it hasn't a path to the required destination, stored in its route table. When a route replay packet received to the source, an intermediate node updates its retransmission count value; in case if it was greater than the current MRC. So, when the route replay packet arrives to the source, the source can identify which path has maximum MRC. R-AOMDV protocol inherits all good properties of multi path routing protocols, such as reducing rebroadcast route discovery. This protocol shows better performance than AOMDV in both rural and city vehicular networks [22]-[23], as well as enhances the routing operations by getting information about route's quality based on the neighbors IP addresses. However, the technique based on IP addresses is not convenient for VANET; because it sends the packets to nodes IPs, even though they change their locations; in this case the source node must search for a new intermediate forwarding node; and as a result this may lead to increase the packet delays and packet loss. This problem has largely appeared in city vehicular networks which have multiple paths, several intersections, different node density, and high congestion [23].

2.1.2.1.2 The DYMO Routing Protocol in VANET Scenarios

Dynamic MANET On-demand (DYMO) protocol is a reactive multi hop routing protocol. Like AODV protocol, it uses the sequence numbers to provide loop free routes; it also has two essential processes: Route Discovery and Route Maintenance. DYMO is different from AODV protocol in other characteristic; that in DYMO a new route request process has to maintain information about all intermediate nodes, however in AODV, it just collects information about the destination node and the next hop, moreover in DYMO, every node which participates in a recent route discovery process should collect information about a requested node and all other intermediate nodes in the new path. Particularly at higher node densities, which commonly occurred in VANETs, routing protocols and transport protocols may increase the network overhead. When establishing a new route is required in the congested network, the use of the simple retry mechanism will only cause furthered congestion [24].

2.1.2.1.3 AODV_DB

It will be a challenge in VANET if a route was failing; according to this, AODV protocol spent a long time in discovering a new route; by sending a route request and route replay messages. However, VANET topology is highly dynamic change, which requires an establishment of a new route rediscovery. The route caching scheme that used by the on-demand protocol has a bad performance in the high mobility environment. In this case the using of flooding mechanism is the more suitable for routes maintenance; however it produces many redundant messages and network overhead. AODV_BD discovers and maintains a route by broadcasting the data packet instead of the route request packet. The data packet header contains the reverse path, so intermediate nodes will store the reverse path and rebroadcast the data packet, finally the destination will receive the data packet and at the same time send the route replay to the source. This approach will reduce the time of route setup packet transmission [25]. However it leads to heavy network overhead by flooding data packet broadcast. The problem arises if there is no route to destination.

2.1.2.1.4 AD HOC ON-DEMAND DISTANCE VECTOR PREFERRED GROUP BROADCASTING (AODV+PGB)

This protocol enhances the AODV protocol by Preferred Group Broadcasting (PGB) algorithm, this algorithm aims to reduce control message overhead in addition to offer routes availability which is an important feature in VANET environment, as the reducing routing overhead is a significant issue in ad hoc networks, also the routes consistency is a desirable issue in fast moving environment. There are many issues that critically decreasing ad hoc network performance can be abbreviated in [19]:

- The problem of hidden terminal which arises if the signal from the source to the destination is weaker; this makes easy to interrupt the communication between two nodes by a hidden terminal.
- No particular scheme is used to select intermediate hops. A large number of hops involve the short distance selection; however the link can simply be fail if one of the intermediate nodes goes out of the range, otherwise the weak signal may be changed.
- The larger numbers of errors may reduce the quality of links; which lead to decreasing network throughput.
- Also if the data transmission rate is adapted according to the network congestion, it could be affected by the large data error rate decreases the data transmission rate and may cause a bottleneck in the current node.

PGB tried to deal with all these issues via permits some particular nodes to re-broadcast a route request packet. However, if the node that allowed rebroadcasting the route request is not the nearest node to the destination, then the route discovery could be longer than it should. Also broadcast can be halted if there is no specific node which had a rebroadcast permit (case in light networks). Moreover packet duplication may occur if any two nodes rebroadcast the same packet at the same time.

2.1.2.1.5 THE BUS AD HOC ON-DEMAND DISTANCE VECTOR (BAODV)

BAODV focused on extending the AODV protocol to make it more suitable for VANETs, it has been designed to select a route with the minimum number of vehicles (buses), and it minimized end-to-end packet delay in the network. The protocol also allows drivers to avoid congested roads which contain a large number of buses. The AODV protocol is not an efficient VANET protocol; it has a limitation on when it works for VANET; which mainly shows in the frequent routing table updates. The main idea in the designing BAODV is to overcome AODV protocol limitations that made BAODV works on sensing of the vehicle characteristics and behaviors. In the AODV protocol, the update occurs according to two important factors: the newer sequence number and the lower hop count. But BAODV considers the lower hop count factor alone (mean lower number of vehicles) is insufficient for many VANET environments, so it uses additional factors like vehicle type and behavior to achieve better routing performance. The BAODV protocol modified ADOV messages: RREP and RREQ; by adding new fields defines the number of vehicles (bus, car, trucks, Trailers and so on) in the route by adding new fields in order to calculate the number of buses on the route. This information should be stored in the routing table; thus it required modifying the routing table also. The simulation results show the BAODV protocol performed better than the traditional AODV in terms of end-to-end packet delay in city areas which is a significant factor in VANETs, particularly for warning messages. The protocol also enables drivers to choose preferable routes that help them in avoiding congestion [26]. However, there is a shortcoming of BAODV documentation, it didn't illiterate carefully the modification method used in the routing table and what is the algorithm used to select a suitable route. Also the protocol focused on solving end-to-end delay, but neglected the frequent changeable topology, so the selection of routes based on the less hop count may not work properly in long distance between nodes, because if any intermediate node moved out of the range, the route will break, also it may cause the problem of weak signal.

2.1.2.2 Dynamic Source Routing protocol (DSR)

DSR protocol aims to provide a highly reactive routing process; by implementing a routing mechanism with an extremely low overhead and fast reaction to the frequent network changes, to guarantee successful data packet delivery regardless of network changes. DSR is a multi hop protocol; it decreases the network overhead by reducing periodic messages. This protocol has two main processes: route discovery and route Maintenance. In the route discovery, when a source node needs an unavailable route, it initially broadcasts a route request message. All intermediate nodes which received this message will rebroadcast it, except if it was the destination node or it has a route to the destination; in this case the node will send a route replay message back to the source, later the received route is cashed in the source routing table for future use. If a route is failing, the source node will be informed by a route error message. In DSR protocol, every data packet contains a complete list of the intermediate nodes; so the source node should delete the failed route from its cache, and if it stores other successful route to that destination in its cache, it will exchange the failed one by the other successful route. But if there is no alternative route, it will initiate a new route discovery process [27]. The benefit of DSR protocol is clearly shown in a network with low mobility; because it can use the alternative route before starts a new process for route discovery. However, the multi routes may lead to additional routing overheads by adding all route information to every data packet, besides, as the network span larger distance and including more nodes, the overhead will frequently increase and as result network performance will be degraded [28].

2.1.2.3 Temporally Ordered Routing Algorithm (TORA)

TORA is a distributed routing protocol using multi hop routes; it is designed to reduce the communication overhead related to adapting frequent network changes. This protocol does not implement a shortest path algorithm; thus the routing structure does not represent a distance. TORA constructs a directed graph which contains the source node as the tree root. Packets should be running from higher nodes to lower nodes in the tree. Once a node broadcasts a packet to a particular destination, its neighbor will broadcast a route replay if it has a downward link to the destination, if not, it just drops the packet. TORA ensures multi path loop free routing; since the packet always flows downward to the destination and don't flow upward back to the sending node [29]. The advantages of TORA are that it offers a route to every node in the network, and reduces the control messages broadcast. However, it causes routing overhead in maintaining routes to all network nodes, especially in highly dynamic VANETs [4], [15].

2.1.3 Hybrid Routing Protocols

Hybrid protocol is a mixture of both proactive and reactive protocols; it aims to minimize the proactive routing protocol control overhead and reduce the delay of the route discovery process within on-demand routing protocols. Usually the hybrid protocol divides the network to many zones to provide more reliability for route discovery and maintenance processes. Each node divides the network into two regions: inside and outside regions; it uses a proactive routing mechanism to maintain routes to inside region nodes and using a route discovery mechanism to reach the outside region nodes [3].

2.1.3.1 Zone Routing Protocol (ZRP)

ZRP is the first protocol developed as a hybrid routing protocol, it allows a network node to divide the network into zones according to many factors; like: power of transmission, signal strength, speed and many other factors. The area inside the zone is the routing range area for the node and vice versa for outside zone. ZRP uses the reactive routing schemes for outside the zone and the proactive routing schemes for inside the zone; with a view to keep the latest route information within the inside zone. In the local inside the zone, the source node uses a proactive cached routing table to initiate a route to a destination, which can be helped in transmitting packets directly without delay. ZRP uses independent protocols inside and outside the zone; it may use any existing proactive and reactive routing protocols. For outside zone, the ZRP reactively discover a route; that the source node transmits a route request packet to the border nodes of its routing zone; the packet includes a unique sequence number, the source address and the destination address. When the border node receives a route request packet, it looks for the destination within its inside zone. If the destination is found, it sends a route reply on reverse path to the source node; else if it doesn't find the destination in its local zone, the border node adds its address to the route request packet and forwards it to its own border nodes. After the source received a reply, it stores the path included in the route reply packet to use it for data transmission to the destination [30]. The weakness of ZRP protocol is that it performs like a pure proactive protocol particularly for large size zones; however for small zones it performs similar to a reactive protocol [17]. Thus ZRP protocol is not applicable for large size VANET with highly dynamic topology and frequently change environment.

2.1.3.2 ZONE-BASED HIERARCHICAL LINK STATE (ZHLS)

ZHLS protocol divides the network into non overlapping zones; every network node has its own ID and a zone ID, which is measured by a GPS. There are two levels for structural topology: zone level topology and node level topology. In ZHLS there is no position administrator or cluster head are used to manage the data communication; that means there is no traffic bottleneck. Besides that the ZHLS reduces the transmission overheads when compared it with the reactive protocols. ZHLS broadcast scheme showed lower overhead compared to the flooding scheme in pure reactive protocols. Also in ZHLS, the routes is flexible to the dynamic topology because it required only the zone ID and the node ID of the destination node for routing; that means there is no need to search for the location, if the destination node does not move to another zone. The shortcoming of ZHLS, it needs a static zone map into each node, and this may not be sufficient for a network with dynamic zone edges. Moreover, it is not appropriate for highly dynamic topologies [17].

Generally, the hybrid routing protocols have a higher scalability than pure proactive and pure reactive protocols; because of reducing the number of rebroadcast messages which achieved by allowing network nodes to work together and the most appropriate nodes are used to setup a route [17]. However, pure proactive and pure reactive routing protocols could be more suitable to some highly dynamic level in a network environment.

OTHER TOPOLOGY-BASED PROTOCOLS

Some researchers [31] assumed it's more efficient to develop a routing protocol based on the topology of roads; that mean road to road transmission rather than the conventional node to node routing scheme; they justify that because of two reasons: the vehicles highly mobility and the data delivery is constrained by road pattern. However, the challenging will be the transmission of packets at intersections. So they proposed Buffer and Switch (BAS) protocol which allow each road to store packets along with many transmitting copies to offer additional chances for a packet to switching at intersections. Different from conventional protocols in VANETs, BAS is a bidirectional duplicate transmission. Also, BAS controlled duplicate transmission by spatiotemporally, which leads to significantly minimum cost compared by other flooding protocols. BAS performance shows better than the traditional protocols, mainly for network with limited resources. However, it may cause transmission delay, and packet loss due to packet expired.

2.2 POSITION-BASED ROUTING PROTOCOL

Position or geographic routing protocol is based on the positional information in routing process; where the source sends a packet to the destination using its geographic position rather than using the network address. This protocol required each node is able to decide its location and the location of its neighbors through the Geographic Position System (GPS) assistance. The node identifies its neighbor as a node that located inside the node's radio range. When the source need to send a packet, it usually stores the position of the destination in the packet header which will help in forwarding the packet to the destination without needs to route discovery, route maintenance, or even awareness of the network topology [3], [4]. Thus the position routing protocols are considered to be more stable and suitable for VANET with a high mobility environment, compared to topology-based routing protocols. Geographic routing protocols commonly classified into three classes: Delay Tolerant Network (DTN) Protocols, Non Delay Tolerant Network (Non DTN) Protocols and hybrid [4].

2.2.1 DELAY TOLERANT NETWORK (DTN) PROTOCOLS

DTN is a wireless network designed to perform efficiently in networks with some characteristics; like frequent disconnection communication, large scale, long unavoidable delays, limited bandwidth, power constraints and high bit fault rates [15]. In this network, all nodes help each other to forward packets (store and forward scheme). These nodes may have a limited transmission range; so packets transmission will take large delays. Commonly, the DTN node is a mobile node, so it establishes routes to other nodes when they reach its transmission range. In DTN protocol, there is no guarantee of unbroken end to end connectivity, so the packets may be cached for a time at intermediate nodes [4], [14], [3]. To design of a routing protocol for DTN network with these characteristics is a significant problem. This section, review many DTN routing protocols that fall under this category.

2.2.1.1 MOTION VECTOR ROUTING ALGORITHM (MOVE)

MOVE algorithm is designed for light networks, especially for road side vehicle communication. This protocol assumes that each node has global locations information, that's beside the knowledge of a mobile router speed and its neighboring nodes velocity. From this information the node can estimate the nodes which are the closest distance to the destination [14]. In this protocol each node regularly broadcasts a HELLO message; and its neighbor replays by a RESPONSE message; by this replayed message the node will know its neighbors and their locations. Given this information, the node can estimate the shortest distance to destination, in that case the node decides how to forward the message according to the information about nodes which are currently located nearby the destination. MOVE protocol uses less memory size compared with Non DTN position-based routing; it also has a higher data transmission rate in light environments [30]. However, Non DTN position-based routing could have better performance only if the routes are stable and consistent [3].

2.2.1.2 VADD: Vehicle-Assisted Data Delivery in Vehicular Ad Hoc Networks

VADD protocol designed to handle frequently disconnected vehicular networks and highly mobility problems. It implements the store and forward scheme; while a node is moving it stores the packet, until a new node arrives to its zone range, and then it forwards the stored packet to this new node. This protocol predicts node mobility based on two factors: network traffic and route type; that help a node to discover the next forwarding node. VADD protocols usually deliver the packet to the path with the least transmission delay; following three main principles [4], [14]:

- Continue use the available wireless channel
- Deliver the packet to the higher speed node in the route to carry it
- VANET is a high mobility environment, so it's difficult to estimate packet delivery by a predefined optimal path, which may lead to frequent discover a new optimal path to transmit a packet.

To break the routing loop, each node adds information about its former hop/hops before forwarding the packet, containing its own information as a former hop. Once the packet received to a node, it looks at the previous hops information to avoid forwards the packet to the previous hops and try to find other available hop; so that may avoid the routing loop problem. To forward a packet, VADD implements four different schemes [4], [14]:

- Location First Probe (L-VADD): it used to deliver the packet to the closest node to the destination without consideration of the movement direction. The drawback in this scheme the occurring of the routing loop.
- Direction First Probe (D-VADD): the selection of the next hop is based on the node has the same movement direction as the destination, which helps in avoiding the route loop.
- Multi-Path Direction First is the Probe VADD (MD-VADD): it provides a multi path rather than one path; however, it consumes the bandwidth by redundancy packets.
- Hybrid Probe VADD (H-VADD): it is a hybrid scheme that takes the advantages of L-VADD and D-VADD, to deliver a packet, it initially uses the L-VADD; but if a route loop is identified, it changes to D-VADD. As a result this scheme performs better than pure L-VADD and D-VADD.

2.2.1.3 Geographical Opportunistic Routing (GeOpps)

GeOpps is a forwarding protocol uses the available navigation system in collecting information about geographical position; this information is used to select vehicles that are closest to a certain destination. The protocol uses store and forward technique, it works just like the Move and Non DTN protocols but it uses navigation system to provide efficient packet delivery. In the GeoOpps, to send a packet from the source to the destination, there are three main steps used to select the next hop of the intermediate nodes [3], [5]:

- Each neighboring node at the estimated routes calculates the future closest point to the destination which it will reach soon.
- Each neighbor node then calculates estimated shortest delay time to reach the specified packet's destination.
- Use the estimated shortest time calculated by each neighbor node; that any node estimated to be closer to the destination in lowest delay time, should be selected to become the next hop carrier to transmit the packet faster to the specified destination.

The protocol concerned some cases which affect its efficiency [3], [5]:

- The node ignores the estimated calculated route and follows other different path; in this case the system will forward the holding packet to any neighbor node.
- The node stops its movement (switch off the engine or long pause time); in this case its packets should be forward to another neighboring node.

The benefit of GeOpps does not require all nodes to calculate the routes; and GeOpps transmission rate depends only on the route topology and the mobility of the nodes. However, it has some complexities in calculating delay time depending on a navigation system measurement.

2.2.2 NON DELAY TOLERANT NETWORK (NON DTN) PROTOCOLS

The non-DTN protocols are geographic routing protocols, but it does not consider a dis-connectivity issue; it assumes there are always a number of nodes to achieve the successful communication; so, this protocol is only suitable for high density network. In these protocols, the node forwards its packet to the closest neighbor to the destination, but this approach may be unsuccessful if there is no closest neighbor to the destination rather than the current node itself. Many non-DTN routing protocols handle this failure; by different strategies will be shown in the following sections [1].

2.2.2.1 GREEDY PERIMETER STATELESS ROUTING (GPSR)

GPSR is a famous greedy routing protocol in VANETs. In this protocol, each node forwards packets to other intermediate nodes that are constantly nearer to the packet's destination (greedy forward), until the packet reaches its final destination. If there is no neighboring node close to the destination, it uses perimeter forwarding to decide to which node it will deliver the packet. GPSR is a stateless protocol that keeps information of its first hop neighbor's positions, which could increase protocol scalability more than shortest path ad hoc routing protocols. Another advantage is the dynamic forwarding packet decision [3]. However, GPSR could face a link failure due to the high mobility network and frequent topology changes (it holds old position information). This problem can be handled by perimeter forwarding, but it may cause high packet loss and more latency time due to the large number of hops in perimeter forwarding mode. Moreover, if the destination node moves to a new location, its information which embedded in the packet header will never be updated [2].

2.2.2.2 GREEDY PERIMETER COORDINATOR ROUTING (GPCR)

GPCR protocol is designed to be suitable for the high mobility environments (as in city) based on the greedy forwarding technique; this technique aims to forward the packet to a neighbor node which is closest to the location of the destination. Each node has to be aware of its location gotten by a navigation system, it knows its neighbor by periodic beaconing, and the position of the destination is obtained from the location service. When a node forwards a packet, the packet will be spread over the road until it reaches the next intersection. The maintenance process covers two components: decision making, to decide which intermediate node the packet will be passed on the intersection (a coordinator node selection), and forwarding the packet to the next intersection. The coordinator node decides to which route the packet will be forwarded. But if no coordinator node found in the route, the packet will be forwarded to furthest node [10]. GPCR does not need any global information; however it is based on the connectivity of the destination node and the density of the next roads, it could not connect the destination if the node density is low, which will increase the transmission delay [32].

2.2.2.3 RELIABILITY-IMPROVING POSITION-BASED ROUTING (RIRP)

RIPR is a position-based routing algorithm designed for VANETs, it aims to solve the problems of links failures that found in a position-based routing; which appear due to storing old information about a stale intermediate node. RIPR predicts the vehicle speeds and their moving directions, as well as estimates the characteristics of the city road. In this protocol, the sender selects an intermediate node to forward its packet, based on the mobility estimation for neighboring nodes that done by initially deciding whether a neighbor node exists or not. The sender creates a position record for each neighboring node, this record contains the recent position of the node and its mobility speed; that helps in the selection of the forwarder node which is done based on the route characteristics and the node position record which arranged after the exchange of beacon messages. This record avoids the local problem which prevents a node to select a neighbor node as a forwarder node; that happens because there is no node that is closest to the destination [33]. RIPR protocol is similar to GPSR protocol uses two modes: a greedy mode and perimeter mode, as well as the route characteristics consideration, and the position of the nodes. Therefore, RIPR can solve the link failure problem caused by storing information about a stale intermediate node; so it can reduce the possibility of link failure [32].

2.2.3 HYBRID POSITION-BASED ROUTING

Position routing protocol reduces control routing overhead, it doesn't need to construct or maintain a routing table; because it only uses the location information about the neighbors and destination nodes, these issues made position-based routing protocols scalable. However, position routing protocols have many limitations that restrict their usage; these limitations can be summarized in the following points [6]:

- The performance of position routing can be significantly decreased according to the location accuracy; because the accurate locations information is an essential factor to get a good performance in position routing.
- Position routing could be failing, if there is no any neighbor node which is closer to the destination (null area).
- Position routing solves the absence of closest neighbor toward the destination, by the backup process. However, it required packets to travel larger distances to reach destinations, also packets could be travel in a close circle, or could be dropped.

So no existing routing protocol performs efficiently in all circumstances. Therefore, many researchers developed hybrid schemes, they merge characteristics of two or more position-based routing protocols (non-DTN and DTN schemes), sometimes they merge one or more topology routing protocols (reactive, proactive and hybrid schemes) with position-based routing. The hybrid position routing protocol is a mixture protocol that takes advantage of more than one protocol schemes. The next section will illustrate HLAR protocol which being an example of is a hybrid position-based routing protocol.

2.2.3.1 HYBRID LOCATION-BASED AD HOC ROUTING PROTOCOL (HLAR)

HLAR is a hybrid position routing protocol designed to efficiently use all the available location information and to minimize the routing control overhead. This protocol is planned to switch to the on-demand routing when sufficient location information is unavailable or limited, it also deals with the problem of no closest neighbor to the destination (void regions), and so it is almost a scalable protocol. HLAR works as a reactive protocol in the route discovery process, however if there is no route to the destination node, the source node adds information about its location and the location of the destination in the route request packet then it searches for a closer node near the destination. If the node finds a neighbor which is close to the destination then it forwards the request packet to it. But if no closer neighbor node is found, it floods the route request packet to all its neighbors. The source node repeats these steps until it reaches the desired destination. The simulation results showed that the HLAR protocol minimizes the routing control overhead compared with the on-demand routing protocols, furthermore it generally provides a fresh large size location information [6]. However, HLAR doesn't guarantee the best reliable route; because the intermediate node doesn't have a reverse link to the source, and could not inform other neighboring nodes if it finds a better route to source [34].

Actually, all categories of routing protocols have the same objectives; that they aim to decrease the network overhead, minimizing the transmission delay and increasing the network throughput. However, in VANETs it is more difficult to find a specific routing protocol that works efficiently in all network environment situations; that some protocol may be suitable for the high mobility environment but suffer from end to end delay, in contrast other protocols could provide fast packet delivery, but unsuitable for the high mobility environment, and so on. So it could be not easy work to precisely compare the existing VANETs routing protocols, or even claims which one is the best in all environment situations; however some research papers analyzed the two classes and compare them using some related protocols; and their results is concluded that the position-based routing performs better than topology-based routing for both urban and rural scenarios [35]. Table 1 illustrates a comparison between topology-based and position-based routing, focusing on strengths, limitations, and methods used in each class.

3 TRANSMISSION STRATEGIES USED IN PACKET FORWARDING

Delivery of information from a source to a destination can be classified into four types: unicast, broadcast, multicast, and geocast, however the multicast and geocast can be merged in one class because geocast usually is a special type of multicast transmission.

3.1 UNICAST ROUTING PROTOCOLS

Unicast routing refers to information delivery from a single source to a single destination using the wireless multi hop scheme; where the intermediate nodes are used to forward data from the source to the destination, or by using the store and forward scheme. It is the most class that widely used in the general ad hoc networks. This scheme required the source vehicle to hold its data for a time and then forward it [36]. There are many unicast routing protocols proposed for VANETs; most of the topology-based routing protocols belong to a unicast class; such as VADD, AODV, DSR and many other, which presented in the previous sections.

3.2 BROADCAST ROUTING PROTOCOLS

Broadcasting routing enables packets to flood into the network to all available nodes inside the broadcast domain. Broadcasting routing is widely in VANETs, it mainly used in the route discovery process, some protocols (like AODV) allow nodes to rebroadcast the received packets. This routing scheme allows packets to deliver via many nodes which may achieve a reliable packet transmission, however it could consume the network bandwidth by sending replicated packets, so each node need to identify which packet is replica (it has received it before) to discard.

Table 1. Comparison of Topology based Routing and Position based Routing

VANET Routing Protocols	Methods Used	Strengths	Limitations	Comments
Topology-based Routing	Link's information stored in the routing table as a basis on forwarding a packet	The shortest route from source to destination Support of messages unicast, multicast and broadcast Less resource consumption Beaconless Save bandwidth	More overhead Routes discover and maintaining delays Fail to discover a complete path (frequent network changes) Unnecessary flooding	These protocols generally are proposed for MANETs Can helpful for small networks (less overhead)
Position-based Routing	Beaconing Vehicles position information Global positioning service	No need to create and maintain global routes More stable in high mobility environment More fitting for network distributed nodes Lowest overhead More scalable	Obstacles in highway scenario Deadlock problem in location server Position services may fail in tunnel or obstacles (missing satellite signal)	More suitable for VANETs; but need more researches for small networks and control congestion

3.2.1 DENSITY-AWARE RELIABLE BROADCASTING PROTOCOL (DECA)

DECA is a density aware protocol; it uses beacon messages to get knowledge about its neighboring nodes and to share information between nodes. It is a reliable broadcast protocol utilizes store and forward transmission scheme. When a node broadcasts a packet, it initially chooses a next hop to rebroadcast the packet; the next hop selection is based on the amount of node information; that means the next hop node will be the node that has the largest density information, after the next hop selection, the node adds the next hop ID, to the packet then broadcast the packet. Other nodes which aren't next hops, should store the packet and startup a waiting timer; if the time is over and no rebroadcast packet received then they rebroadcast the packet by themselves. Any neighboring node which received the broadcasted packet, will add its ID to the regular beacon, to enable other nodes to determine which one of its neighbors that haven't received the broadcasted packet, in order to rebroadcast the packet to it [10]. Mainly, DECA protocol doesn't use any global position information (like GPS) in its processes; that help it to be more flexible and do well in many network environments [10]. However, transmission of periodic beaconing could cause a broadcast storm problem which increases the network overhead and decreases the performance. Also if the waiting time is ended without receiving any broadcasted packet, the network will flood by rebroadcast from neighboring nodes.

3.2.2 POSITION-AWARE RELIABLE BROADCASTING PROTOCOL (POCA)

POCA similar to DECA protocol, it select certain neighbor nodes to rebroadcast a packet, however in this protocol the selection of rebroadcast nodes is based on their position; other unselected nodes stores the packet and startup a waiting timer, if the time is over and no rebroadcast received, they rebroadcast the packet by themselves. POCA also depends on adaptive beaconing which minimizes beacon overhead, to obtain information about neighbors' locations, their speed, and their connectivity status. Thus nodes recognize if their neighbors did no received some packets and rebroadcast to them. POCA provided a good reliability in higher density [10]. However, it will be a problem if the waiting time is over; the network will flood by rebroadcast from neighboring nodes.

3.2.3 DISTRIBUTED VEHICULAR BROADCAST PROTOCOL (DV-CAST)

DV-CAST is a broadcast routing protocol uses multi hop scheme. In this protocol, each node monitors the status of its neighboring connectivity all the time, in order to broadcasts to them. DV-CAST deals with different classes according to many aspects; such as: traffic state, connected state of the neighboring nodes, light traffic, and normal traffic. It uses the periodic beacon messages to get information about the network topology. In a smaller amount of the connected nodes, the node can be rebroadcast along with nodes moving in the same way. In disconnected case of neighboring nodes, the source node should use the store and forward scheme; that it store the broadcasting packet until it find another node move into its broadcast domain, but if there is no node, it will discard the packet after the packet live time is ended. The protocol also enables network nodes to decide if the packet is received before or not; that by using flag parameter [33]. Certainly, DV-CAST protocol minimizes the broadcasting overhead, which made the protocol appropriate for both of light and crowded traffic situations. However, it could cause a highly control overhead and increase the end to end delay in the data transmission [14].

3.2.4 DISTRIBUTION-ADAPTIVE DISTANCE WITH CHANNEL QUALITY (DADCQ)

DADCQ aims to provide a well performed adaptive multi hop broadcast protocol for large networks with high node distribution. It selects forwarding nodes to rebroadcast packets according to positional information. In rebroadcast decision, when a node received a packet, it first checks its distance from the destination; if it was very close there then no need to rebroadcast; because its rebroadcast will not cover a further area. However, if this distance is large, then the node has to rebroadcast the packet. DADCQ has a minimum transmission overhead, because it depends on the node a distributed measurement which is the lower changes than network topology changes [37]. However it may cause a large message overhead.

3.3 MULTICAST-BASED ROUTING PROTOCOL

Multicast is defined by sending packets from a single source to specific group members by multi hop communication [36]. Multicast routing in VANETs can be classified into two categories: geocast and cluster-based routing. The following section illustrates each class in more detail.

3.3.1 GEOCAST-BASED ROUTING PROTOCOL

Geocast routing protocols belongs to a multicast routing protocol which based on sending packets from a source to a particular group of destinations. Some publications remark geocast routing is actually a multicast position-based routing [2], [7]. In VANETs, the geocast routing protocol is a multicast service which enables a single vehicle to transmit a packet to all other vehicles located in the specific geographical area which labeled zone of relevance (ZOR) [7]. Nodes are elements in a one ZOR group, if they located in the same and a specific geographical area. The node membership is changed when the node moves out of the defined geographical area scope, and in this case it drops the packet. A zone of forwarding (ZOF) is defined as the geographic area which vehicles in this area must deliver the packets to other ZOR vehicles. ZOF aims to achieve a reliable packet's delivery in highly dynamic topology. It provides a periodic retransmission, to deal with the network changes. The one drawback of geocast is packet transmission delay that caused by network disconnection. There are a variety of proposed Geo cast routing protocols available.

3.3.1.1 ROBUST VEHICULAR ROUTING (ROVER)

ROVER is a geographical multicast protocol; which permits each vehicle to deliver a packet to all vehicles inside a specific ZOR; using on-demand routing to discover packets inside a ZOR. ROVER similar to AODV protocol; it only floods control packets in the network, and unicasts the data packets, this scheme rising the consistency and efficiency. This protocol assumes vehicles have identification numbers, digital map, and global locations information. The source node starts discover a route by flooding its ZOR by route request packet, this packet included source ID, its location, its recent ZOR, and a sequence number of the route. When a vehicle received the route request packet, it accepts the packet; if it was nearly close to the source and located inside the ZOF and ZOR. If the vehicle was outside the ZOR, it doesn't send a reply. After a vehicle accepts the route request packet, it sends back a reply packet contains its ID to one-hop neighbors, besides recorded the route request packet information in its routing table. And then retransmit the route request packet [1].

ROVER is different from AODV in that it sends the reply back to the node which transmitted the route request packet not to the source. So each node can construct a tree of multicast routing which has the source node as the tree root. After the tree is constructed, the data packet is then broadcasted in the tree. ROVER has achieved a reliable geographical multicast routing scheme for VANETs. However, the control packet overhead is increased as well as data delivery delay; due to the increased number of retransmission packets [2].

3.3.1.2 Mobile Just in time Multicasting protocol (Mobicast)

Mobicast is a multicast geographical protocol, different to conventional geocast routing protocol, Mobicast routing protocol takes into account the time aspect. It's designed to provide a management for spatiotemporal needs in VANETs; that by transmitting a Mobicast packet to Vehicles inside a ZOR at time t (ZORt). All vehicles belong to the ZOR at a time t should stay connected to preserve the communication of the real-time data among the entire ZOR vehicles. The communication of ZOR is failing if any ZOR vehicle unexpectedly speeds up or slows down its speed. A location provider (GPS) is used to know the location of each vehicle. When the network is temporal fragmented, vehicle within a ZOR may not efficiently receive Mobicast packets. Mobicast protocol designed to solve this problem using ZOF, and efficiently disseminate Mobicast packets. ZOFt is a ZOF that enables to disseminate a Mobicast packet to every vehicle found in the ZORt. The size of the ZOFt may not usually be the optimal one. That if the ZOFt size is bigger than the ZOFt optimal size, in this case many unrelated vehicles can be requested to deliver Mobicast packets. As well if the ZOFt size is smaller than the optimal ZOFt size, it will cause a temporal network fragmentation problem; actually the ZOFt is not easy to accurately determine it, especially in the high mobility environment, which may lead to misuse of the network resources. Mobicast estimates the ZOFt size to a value is close to the optimal, as well as determines the structure, and location of the ZOFt, to dynamically form flexible ZOF [32]. However, Mobicast has a limitation because of it relies on the location provider (GPS) to know a global knowledge about the network density; because it may not perform well in a large network with a dynamic and density environment. Also the ZOF is may be large without the need (due to incorrect configuration estimation), this may increase the network overhead.

3.4 Cluster-Based Routing Protocol

This protocol divides the network to clusters, where nodes have the same characteristics, like same direction or same velocity, or so on. Each cluster has a cluster head, its task is to manage communication processes inside, and to outside its cluster. Nodes inside the cluster communicate by direct paths, but their communication with other nodes outside the cluster is achieved by their cluster header, and this creates a virtual infrastructure for networks. This scheme can provide a good scalability for large networks; however it may increase network overhead and delays in highly dynamic network [2], [14].

3.4.1 COIN: Clustering for Open IVC Network

COIN is a clustering mechanism designed to improve network scalability, it divides the network to clusters; but not like conventional other clustering protocols, COIN selects clusters according to three parameters: mobility of nodes, nodes positions and behavior of nodes. The protocol provides each cluster specific time which is a time to live; in order to decrease control overhead. Inter vehicles communication system (IVC) deals with the unstable distances of inter vehicles. To enable a head of cluster node and the cluster member node stay continue communicate, their mobility should be low and related to the mobility of each, in this case they can reside in radio contact for a longer time [6], [14].

3.4.2 Cluster-Based Directional Routing Protocol (CBDRP)

In CBRP the network is divided into several clusters. Each cluster has a cluster head which is responsible for the routing procedure. These cluster heads communicate with each other via gateway nodes which are nodes that have more than one cluster head. When a source node requests a route, it floods the network by request packet. The CBRP clustered structure reduces traffic overhead, because request packet only passes among cluster heads. However, in density networks, the packet overhead will increase and the transmission delay will increase; because information of each node in the route should be added to the routed packet which increases the size of the packet. One more limitation of the CBRP, it maintains unidirectional links, while most of link layer protocols support only bidirectional links [38].

Generally, cluster-based routing protocols may perform well in network scalability for large networks; however, they may cause more networks overhead due to structure of clusters and cluster heads [34].

4 VANETs Routing Open Issues

Through our literature review in VANETs routing protocols, we found there are still some open issues and challenges in VANETs routing, which it is one of the most active topics in VANETs research area, it has several recent publications. This section represents some open research issues in VANETs routing problem (for example, but not limited to). It required designing a single routing protocol that can:

- Works efficiently for both urban and rural, has the ability to improved networks throughput and packet delivery ratio. Also reduces resource consumption, and guarantee optimal paths.
- Scalable; has the ability to handle dynamic connectivity for broken links, as well as deals with the conditions of a single network, like crowded, congestion, available bandwidth, transmission interference, allowed speed, and so on.
- Adaptive reliable broadcasting/ multicast transmissions, that works efficiently in sending packets for all nodes with minimum overhead, duplications, collisions and congestions.
- Can solve hidden terminal problems; to avoid out range collision.

Intelligent to adapt and deal with unexpected conditions; like driver behavior, signal loss, interference by tunnels, high building, and intersections condition. Briefly, an expected VAENETs routing protocol should be able to providing communication with minimal overhead and delay, highest scalability and adaptable for VANETs environments; by using optimal route selection and powerful reconfiguration algorithm.

Table 2. Comparison of VANET Transmission Strategies

Transmission strategies	Methods Used	Strengths	Limitations	Comments
Unicast	Information delivery from a single source to a single destination	Less network overhead More privacy Minimum packet delay	Links should be frequently configured and maintain Less reliability Packet loss	Need more researches to enhance reliability, packet retransmission, scalability and avoid collision
Broadcast	Packets flooding to all network nodes inside the broadcast domain	More reliable data transmission Less packet loss	Consumes bandwidth Routes loop Network congestion Less network throughput More packet delay Packet collisions	Required reducing bandwidth consumption Could be useful for alert messages Need some packets flooding constrains
Multicast	Geocast sending packets from a source to a group of destinations using geographic addresses Cluster divides the network to clusters, each cluster has a cluster head to manage communication inside and outside the cluster	Efficient routing by sending one copy to multiple nodes Minimum network consumption Minimum packet delivery delay Easy to implement Transparent to changeable addresses (no requirement to receiver's address)	Consumes bandwidth More overhead in dividing network nodes into groups Routes loop	Scalability control for dynamic groups The cluster may not very efficient because frequent changing heads (like Mobile routers in network mobility but without a guarantee the network nodes will travel as one unit)

5 CONCLUSION

This paper has presented an overview of Vehicular s ad hoc networks (VANETs), illustrates their motivation and characteristics, it studied in detail VANETs routing problem, mainly vehicle to vehicle (V2V) communication, providing two classifications of VANETs routing protocols that exist in the last few years, investigated them and showing how do they work and their main advantages and limitations The paper also summarized comparisons between the main classes.

Thorough this study of different VANETs routing protocols, many related open issues and research challenges are found and represented, these issues still required more effort and research to address them. We hope that the instrument presented in this paper to be useful and helpful to students and researchers in the field.

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