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A Detail Survey of Vehicular Ad hoc Networks Routing Protocols

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ABSTRACT:
Vehicular Ad Hoc Networks (VANET) is a kind of Mobile ad hoc networks which offers a different technique for Intelligent Transport System (ITS). The review of VANET routing protocols is significant and essential for smart ITS. This paper talks about the benefits / drawbacks and the applications of several routing protocols for vehicular ad hoc networks. It examines the inspiration behind the designed, and traces the emergence of these routing protocols. At last the paper concludes the several routing protocols for VANET.

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

1 INTRODUCTION

Vehicular Ad hoc networks (VANETs) are a particular kind of mobile ad hoc networks; where vehicles are modeled as mobile nodes. VANET consists of two entities: access points and vehicles, the access points are static and often linked to the internet, and they could play role as a distribution point for vehicles [1].

VANET approaches the wireless communication among vehicles (V2V), and between vehicles and infrastructure access point (V2I). Vehicle to vehicle communication (V2V) has two kinds of communication: one hop communication (direct vehicle to vehicle communication), and multi hop communication (vehicle depends on other vehicles to retransfer). VANET also has particular features that differentiates it from other mobile ad hoc networks; the most significant features are: distributed communication, high mobility, self-organization, no network size limitation and road pattern restrictions [2]-[4], all these features build VANETs atmosphere a challenging for developing effective routing protocols. VANETs applications kinds are categorized into efficiency and safety application [1], [5], [6]. There are several difficulties facing VANETs systems design and implementation, involving: privacy, security, connectivity, routing and quality of services. This paper will concentrate on routing issue in vehicle to vehicle communication (V2V); talks about some introduced routing solutions, routing protocols categorization, and represents some challenges and open issues in VANET routing.

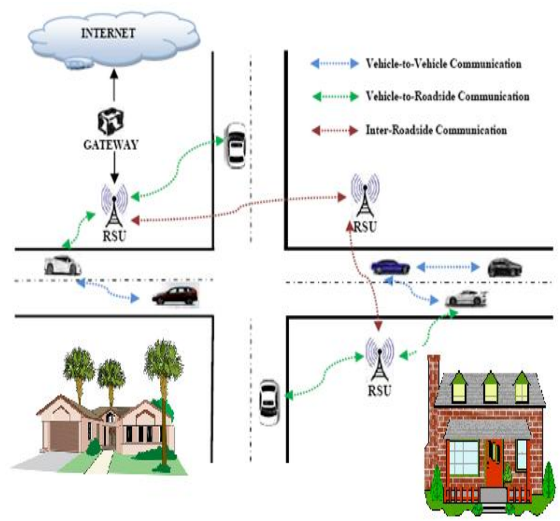

Figure1. Vehicular Ad hoc Network

This paper will approach two kinds of classifications as illustrated in Figure 1; the first one is the routing information which utilized in packet sending, it primarily concentrates on graphic-based and topology-based routing. And the other class is the transmission mechanisms, which is we thought it has an important effect on protocol design and network performance (in case of network delay, overhead and packet loss).

2 ROUTING INFORMATION USED IN PACKET FORWARDING

This class is categorized into two subclasses: topology-based and position-based routing protocols. In topology-based routing, every node should be informed of the network layout, also should capable to send packets utilizing information about existed nodes and connections in the network. In opposite, position-based routing should be aware of the nodes position in the packet sending.

2.1 TOPOLOGY-BASED ROUTING PROTOCOL

Topology-based routing protocol often a conventional MANET routing protocol, it utilizes connections information which recorded in the routing table as a basis to send packets from source node to destination node; it commonly classified into three classes (depending on underlying architecture) [3],[10]: Proactive (periodic), Reactive (on-demand) and Hybrid.

2.1.1 PROACTIVE ROUTING PROTOCOLS

Proactive protocols permit a network node to utilize the routing table to record routes information for all other nodes, every entry in the table consists the next hop node utilized in the route to the destination, without regarding of whether the route is actually required or not. The table must be maintained frequently to reflect the network configuration changes, and should be flood periodically to the neighbors. This mechanism may cause more overhead particularly in the high mobility network. Since, routes to destinations will always be existed when required [4]. Proactive protocols often based on shortest path algorithms to find which route will be selected; they basically utilize two routing mechanisms: Link state strategy and distance vector strategy.

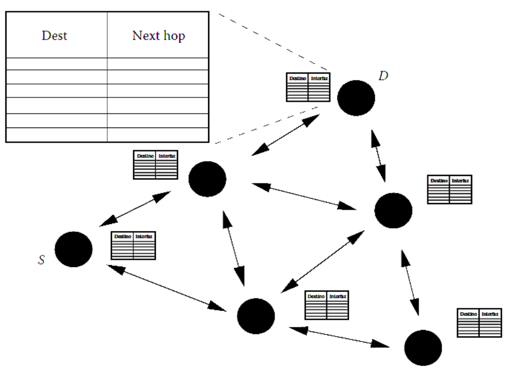

Figure 2. Proactive Routing Scheme

2.1.1.1 DESTINATION SEQUENCE DISTANCE VECTOR ROUTING (DSDV)

DSDV protocol it is an earliest ad hoc routing protocol, it applies the distance vector technique and utilizes a shortest path algorithm to implement only one route to destination node which recorded in the routing table, every routing table has information about all accessible network nodes, as well as the total no. of hops required to arrive these nodes, and every entry in the routing table is labeled with a sequence no. started by the destination node. To manage routes reliability, every node must periodically flood its routing table to its neighboring nodes. DSDV protocol ensures the loop free routes, excludes additional traffic caused by quick updates, as well as decreases control message overhead, it also holds only the optimum path to each node, instead of keeping multi paths which will support to decrease the total routing table size [8]. Since, DSDV increases the overhead in the huge network; due to unessential updating broadcast even if there is no change in the network configuration. Besides that, DSDV don't offer multi routes to destination node [8] and has no control over the network congestion which reduces the routing efficiency [11]. As the result of these restrictions, Randomized DSDV protocol (R-DSDV) is introduced to support congestion control over DSDV; by managing nodes randomized decision which permits every node to build a decision whether to send or drop a packet. Since, the R-DSDV generates more overhead in comparison of the DSDV protocol.

2.1.1.2 OPTIMIZED LINK STATE ROUTING PROTOCOL (OLSR)

OLSR protocol implements the link state technique; it holds a routing table consists of information about all possible routes to network nodes. Once the network configuration is changed every node must forward its managed information to some chosen nodes, which retransfer this information to its other chosen nodes. The nodes which are not in the chosen list can just read and process the packet [10].

Some researchers believe that OLSR has easy process which permits it to built-in different operating systems, besides it operates well in the dynamic configuration, also it is normally appropriate for applications that need low latency in the data transmission (i.e. warning applications) [11]. Since, OLSR may lead network congestion; due to frequent control packets which forwarded to manage configuration changes, furthermore OLSR neglect the high resources abilities of nodes (i.e. bandwidth, transmission range, directional antenna and so on) [12]. Thus, some researchers introduce Hierarchical Optimized Link State Routing (HOLSR) protocol as improvement of the OLSR protocol, which reduces routing control overhead in the large size networks, also increases the routing performance; by the describing network hierarchy architecture with several networks [13]. Also some researchers introduce QOLSR as a solution of offering a path such that the existed bandwidth at every node on the path is not less than the needed bandwidth. QOLSR assumes delay as a second for path selection [12]. These protocols often offer average improvement for the packets QoS. Since, they cause more complexity, increasing packet overhead, and only appropriate for some restricted applications [9].

2.1.2 REACTIVE ROUTING PROTOCOLS

Reactive routing protocols (also known as on-demand) decrease the network overhead; by managing routes only when required, that the source node initiates a route discovery procedure, if it requires a non available route to a destination node, it does this procedure by broadcasting the network by a route request message. After the message arrives the destination node (or to the node which has a route to the destination node), this node will forward a route reply message back to the source node utilizing unicast communication [17]. Reactive routing protocols are suitable to the mobile ad hoc networks large size which has highly mobility and frequent configuration changes [18]. Several reactive routing protocols have been formulated, the following sections will present feature of some reactive protocols, as well as represents the available improved protocols.

2.1.2.1 AD HOC ON-DEMAND DISTANCE VECTOR (AODV)

AODV routing protocol is introduced for mobile ad hoc network, it has been measured in various researches and presents good results as compared to related routing protocols; so it has a good documentation [19]. AODV provides low network overhead by decreasing messages broadcasting in the network in comparison of proactive routing protocols, besides decreasing the need of memory size; by decreasing the routing tables which hold only entries for current active routes, also holds next hop for a route instead of the entire route. It also offers dynamically updates for following the route conditions and removes looping in routes; by utilizing destination sequence no. So AODV is reliable to highly dynamic network configuration and large-scale network [20]. Since, it causes large delays in a route finding, also route failure may need a new route discovery which creates extra delays that reduce the data transmission rate and increase the network overhead [17]. Furthermore, the redundant floods without control will consume additional bandwidth (broadcast storm issue), this issue increases as the no. of network nodes increases, that besides collisions which yield to packet lost issue [19].

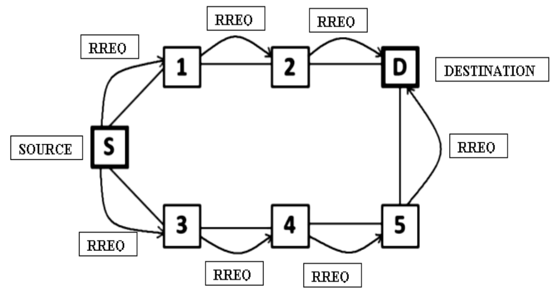

Figure 3. Route Request Reactive Routing

There are various protocols have been introduced to improve AODV protocol; by reducing its problems.

2.1.2.2 DYNAMIC SOURCE ROUTING PROTOCOL (DSR)

DSR protocol objectives to offer a highly reactive routing procedure; by implementing a routing technique with an extremely low overhead and fast reaction to the quick network changes, to ensure successful data packet delivery without regarding of network changes. DSR is a multi hop protocol; it reduces the network overhead by decreasing periodic messages. This protocol has two main phases: route discovery and route Maintenance. In the route discovery phase, when a source node requires an un-existed route, it starts broadcasting a route request message. All intermediary nodes which obtained this message will re-flood it, except if it was the target node or it has a route to the destination node; in this case the node will forward a route response message back to the source, later the obtained route is cashed in the source routing table for future usage. If a route is failing, the source node will be reported by a route error message. In DSR protocol, each data packet has a entire list of the intermediary nodes; so the source node should remove the failed route from its cache, and if it records other successful route to that destination node in its cache, it will interchange the failed one by the other successful route. But if there is no alternative route, it will start a new route discovery procedure [27]. The advantage of DSR protocol is clearly represented in a network with low mobility; because it can utilize the alternative route before initiates a new procedure for route discovery. Since, the multi routes may yield to extra routing overheads by appending all route information to each data packet, besides, as the network span larger distance and involving more nodes, the overhead will quickly increase and as result network performance will be reduced [28].

2.1.2.3 TEMPORALLY ORDERED ROUTING ALGORITHM (TORA)

TORA is a distributed routing protocol utilizing multi hop routes; it is planned to decrease the communication overhead regarded to adapting frequent network modifications. This protocol does not implement a shortest path algorithm; hence the routing structure does not show a distance. TORA builds a directed graph which consist the source node as the tree root. Packets should be transferring from higher nodes to lower nodes in the tree. Once a node floods a packet to a specific destination, its neighbor will flood a route response if it has a downward connection to the destination node, if not, it just discards the packet. TORA assures multi path loop free routing; however the packet always flows downward to the destination node and don't flow upward back to the forwarding node [29]. The benefits of TORA are that it provides a route to each node in the network, and decreases the control messages broadcast. Since, it causes routing overhead in managing routes to all network nodes, particularly in highly dynamic VANETs [4], [15].

2.1.3 HYBRID ROUTING PROTOCOLS

Hybrid protocol is a combination of both reactive and proactive protocols; it objectives to decrease the proactive routing protocol control overhead and decrease the delay of the route discovery procedure within on-demand routing protocols. Often the hybrid protocol partitions the network to several zones to offer more flexibility for route discovery and maintenance procedure. Every node partitions the network into two regions: inside and outside regions; it utilizes a proactive routing technique to manage routes to inside region nodes and utilizing a route discovery technique to arrive the outside region nodes [3].

2.1.3.1 ZONE ROUTING PROTOCOL (ZRP)

ZRP is the first protocol formulated as a hybrid routing protocol, it permits a network node to partition the network into zones according to several factors; like: signal strength, power of transmission, speed and some other factors. The region inside the zone is the routing range region for the node and vice versa for outside zone. ZRP utilizes the reactive routing techniques for outside the zone and the proactive routing techniques for inside the zone; with a view to hold the latest route information within the inside zone. In the local inside zone, the source node utilizes a proactive cached routing table to start a route to a destination node, which can be support in transferring packets directly without delay. ZRP utilizes independent protocols outside and inside the zone; it may employ any available reactive and proactive routing protocols. For outside zone, the ZRP reactively find a route; that the source node transfers a route request packet to the border nodes of its routing zone; the packet involves a unique sequence no., the destination address and the source address. When the border node obtains a route request packet, it views for the destination node within its inside zone. If the destination is detected, it forwards a route response on reverse path to the source node; otherwise if it doesn't discover the destination in its local zone, the border node appends its address to the route request packet and sends it to its own border nodes. After the source obtained a response, it records the path involved in the route response packet to utilize it for data transmission to the destination node [30]. The ZRP protocol weakness is that it performs like a pure proactive protocol specifically for huge size zones; since for small zones it performs same as a reactive protocol [17]. Hence ZRP protocol is not suitable for large size VANET with highly dynamic configuration and frequently change atmosphere.

2.1.3.2 ZONE-BASED HIERARCHICAL LINK STATE (ZHLS)

ZHLS protocol partitions the network into non overlapping zones; each network node has its own ID and a zone ID, which is evaluated by a GPS. There are two levels for structural topology: node level topology and zone level topology. In ZHLS there is no cluster head or position administrator is utilized to maintain the data communication; that means there is no traffic congestion. Besides that the ZHLS decreases the transmission overheads when compared it with the reactive protocols. ZHLS broadcast mechanism represented lower overhead compared to the broadcasting technique in pure reactive protocols. Also in ZHLS, the routes is reliable to the dynamic configuration because it needed only the node ID and the zone ID of the destination node for routing; that means there is no requirement to search for the location, if the destination node does not propagate to another zone. The limitation of ZHLS, it requires a static zone map into every node, and this may not be enough for a network with dynamic zone edges. Furthermore, it is not suitable for highly dynamic configurations [17].

2.2 POSITION-BASED ROUTING PROTOCOL

Geographic or Positioning routing protocol depends on the positional information in routing procedure; where the source forwards a packet to the destination node utilizing its geographic position instead of utilizing the network address. This protocol needed every node is capable to decide its location and its neighbors location via the Geographic Position

System (GPS) assistance. The node determines its neighbor as a node that positioned inside the node's radio range. When the source require to forward a packet, it often records the destination position in the packet header which will support in sending the packet to the destination node without requirements to route discovery, route maintenance, or even the network topology awareness [3], [4].

Hence the position routing protocols are assumed to be more stable and appropriate for VANET with a high mobility atmosphere in comparison of topology-based routing protocols. Geographic routing protocols generally categorized 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 planned to perform effectively in networks with some features; i.e. large scale, frequent disconnection communication, limited bandwidth, long unavoidable delays, power restraints and high bit fault rates [15]. In this network, all nodes support each other to send packets (store and forward scheme). These nodes may have a restricted transmission range; so packets transmission will consume large delays. Generally, the DTN node is a mobile node, so it sets up routes to other nodes when they arrive its transmission range. In DTN protocol, there is no assurance of unbroken end to end link, so the packets may be buffered for a time at intermediary nodes [4], [14], [3]. To design of a routing protocol for DTN network with these features is an important issue. This section, survey several DTN routing protocols that fall under this class.

2.2.2 NON DELAY TOLERANT NETWORK (NON DTN) PROTOCOLS

The non-DTN protocols are geographic routing protocols, but it does not assume a dis-connectivity problem; it considers there are always a no. of nodes to obtain the successful communication; so, this protocol is only appropriate for high density network. In these protocols, the node sends its packet to the nearest neighbor to the destination node, but this mechanism may be unsuccessful if there is no nearest neighbor to the destination node instead of the current node itself.

2.2.3 HYBRID POSITION-BASED ROUTING

Position routing protocol decreases control routing overhead, it doesn't require to build or manage a routing table; because it only utilizes the location information about the destination and neighbors nodes, these issues made position-based routing protocols scalable. Since, position routing protocols have several restrictions that limit their uses; these restrictions can be briefly explained in the following points [6]:

The position routing performance can be importantly reduced according to the location accuracy; because the accurate information of locations is a necessary factor to achieve a good performance in position routing.

Position routing could be failing, if there is no any neighboring node which is nearer to the destination (null area).

Position routing solves the unavailability of nearest neighbor toward the destination node, by the backup procedure. Since, it needed packets to travel larger distances to arrive destinations, also packets could be travel in a close circle, or could be discarded.

3. VANETS ROUTING OPEN ISSUES

By our literature survey in VANETs routing protocols, we discovered there are still some open issues and challenges in VANETs routing, which it is one of the most active topics in VANETs research field, it has various recent publications. This section shows some open research issues in VANETs routing problem (for instance, but not restricted to). It needed designing a single routing protocol that can:

Works effectively for both rural and urban, has the capability to enhanced networks throughput and packet delivery ratio. Also decreases resource consumption, and ensure optimum paths.

Scalable; has the capability to deal with dynamic connectivity for broken connections, as well as handle the conditions of a single network, i.e. existed bandwidth, crowded, congestion, transmission interference permitted speed, and so on.

Adaptive reliable multicast/broadcasting transmissions, that works effectively in forwarding packets for all nodes with least overhead, collisions, duplications and congestions. Can solve hidden terminal issues; to neglect out range collision.

Intelligent to adopt and manage un-required conditions i.e. signal loss, driver behavior, high building, interference by tunnels and intersections condition. Briefly, a required VANETs routing protocol should be capable to offering communication with minimum delay and overhead, highest scalability and adaptable for VANETs atmosphere; by utilizing optimum route selection and powerful reconfiguration algorithm.

4. CONCLUSION

This paper has shown an overview of Vehicular ad hoc networks (VANETs), represents their motivation and features, it studied in detail VANETs routing issue, primarily vehicle to vehicle (V2V) communication, offering two classifications of VANETs routing protocols that available in the last few years, inquired them and representing how do they work and their main benefits and drawbacks. The paper also summarized comparisons among the main classes. Through this study of various VANETs routing protocols, some related open issues and research challenges are discovered and represented, these problems still needed more effort and research to address them. We expect that the instrument shown in this paper to be helpful and useful to researchers and students in the field.

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