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A Study on VANET Routing Protocols

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ABSTRACT: In recent times VANETs are gaining importance among researchers due to their inherent advantages. In VANETs vehicles can communicate with each other autonomously to exchange information about traffic and potential accident zones and thus save lots of travel time and human life. But there are challenges that still need to be addressed such as routing. This paper discusses the various routing protocols in the existing models and compares them on various parameters. This will help the system designers to choose the appropriate routing techniques to get better results.

KEYWORDS:VANETs, routing, QoS, Clustering, Broadcast

1. INTRODUCTION

Over the past few years, intelligent transportation systems (ITS) have seen a steep growth due to its unique characteristics. The persistent mobility of people and the ever increasing number of vehicles on roads have created huge demand for infrastructure-less communication technologyfor ITS. Vehicular ad hoc networks (VANET) is a type ofITSwhich is an important research topic in today's world among many scientists. VANETs are used to enhancetraffic safety, and are offering mobile infotainment to passengers by improving on-road communication and making vehicles aware of their surroundings [1].

The basic idea behind VANETs is addressed to safety issues of vehicles, and then by with a proper combination of functionalities like communications, control and computing technologies, it will become possible to assist the driver decisions, and also helps to prevent driver's wrong behaviors' [8].

In VANETs, any node may move at high relative velocity. This makes the lifetimeof communication links between nodes quite short. Node density is also unpredictable; during rush hours, the roads are crowded with vehicles. Similarly someroads have more traffic than other roads

The rapid growth in vehicular communications has inspired many researchers to study their performance and methods for up-scaling the performance. Aspects such as , channel modeling [2], appropriate scalable design of medium-access-layer (MAC) procedures [3], security and privacy policies [4], reliability and latency improvements [5], integration of VANET-LTE [6], and routing protocols are dealt in detail by many scientists.

Routing protocols are extremely important in vehicular networks because they are responsible for initiating and maintaining routes to facilitate multi-hop communication and extend the service area of the network. Moreover, VANET routing protocols are designed for different scenarios considering the main characteristics and constraints in vehicular networks, such as mobility of nodes, interference, and bandwidth limitations. As we said, VANET has dynamic topology and, at run time, the network may support any kind of application. So, continuous research is in progress to improve routing decisions while considering the restrictions and challenging issues of VANETs [5].

The VANET, the routing protocols are broadly classified into five categories namely, Topology based routing protocols, Position based routing protocols, Cluster based routing protocols, Geo cast routing protocols and Broadcast routing protocols. This classification looks to distinguish protocols with the efficient utilization of limited resources and quality-of-service (QoS) improvement. In this context, cluster-based routing protocols provide centralized control and they can be very useful to avoid saturation in very crowded networks [8]. Other protocols designed for low-latency applications based on topology or position information are presented in [9]. Finally, for reliable QoS routing, there are different approaches to obtain an optimal protocol according to different parameters [10] such as end-to-end delay [11], security, low collision, and interference [12].

Despite the different application-oriented classifications, standard criteria have been used more often to survey and classify them. Depending on if vehicles use infrastructure (e.g., RSUs) or not to forward packets to the final

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destination, VANET routing protocols can be categorized as V2I and V2V [8,11]. The former can be seen as a special case of V2V routing protocols, so almost no survey distinguishes between them. A typical classification of routing protocols is presented in [2] and it is based on transmission strategies in which a protocol can be unicast, multicast, broadcast, or geocast. This well-accepted classification of routing protocols was used in the survey of [7,8]. Moreover, unicast protocols were further split based on routing information in topology or position-based in and cluster-based in [10].

Surveys of VANET routing protocols along years show that the forwarding criteria, especially in geographical protocols, have evolved from using only one metric to more novel proposals that employ several metrics, like vehicle speed and direction. In this paper, we concentrated on unicast routing protocols designed for VANETs using different metrics in hop-by-hop selection to improve vehicular communications. We present the principal metrics, their importance in vehicular scenarios, and which of them are selected by the proposals explained below.

The rest of this paper is organized as follows: Section 2 presents the related work on VANETs that are relevant in the context of the paper. After that, Section 3 presents the main characteristics systematic literature-review process used in this survey. Section 4 discusses the most common metrics used by researchers in their routing protocols and their multimetric proposals. Next, Section 5 presents a comparisonof various routing protocols, and Section 6 presents conclusions.

II. RELATED WORK

In recent years to improve the conventional vehicular ad-hoc network performance an intelligent incorporated vehicle are introduces. Designing of prediction based multi-hop clustering approach for VANET is a major challenge due to the dynamic change of network and link capacity. Several earlier proposed models do not consider the mobility characteristics, the dynamic topology and the limited driving direction of VANET and theydo not consider the energy problems. In this paper Sami Abdul Jabbar Rashid (2020) have discussed about the routing based on link stability and to increase the coverage area of the cluster to improve the mobility characteristics and the energy efficiency of the VANET. The authors have summarized the studies about both the category in order to improve the link stability, energy efficiency, network lifetime, data aggregation, Quality of service, load balancing and multipath. The authors have conducted a systematic comprehensive survey for link stability and energy efficient clustering based routing protocols reportedfrom 2012 to 2018. By the help of the survey, a technical direction is provided to the researchers about the pros and cons of the earlier studies. To fulfil the research gap, a novelmethodology is introduced which is the prediction based efficient multi-hop clustering approach with adaptive relay node selection for VANET. The model consists of four layers. They are multi-hop clustering algorithm; predictionbased clustering approach, adaptive link selection method and improved routing protocol.

Shivam et al., (2017) have worked on the use of GPS signals for navigation. They found that, due to the sensibility of GPS signals to terrain, vehicles cannot get their locations. To address the issue, the authors have proposed a novel Grid-based on-road localization system, where vehicles with and without accurate GPS signals self-organize into a VANET, exchange location and distance information and help each other to calculate an accurate position for all the vehicles inside the network. And they have proposed the novel technique to improve our base work, in our technique; the vehicle can find the location even its available inside the tunnel by using Road side unit model (RSU). The authors aim to create the Street road and simulate the vehicles created on that road considering the traffic using the traffic lights. It gives an idea how the movement of vehicles in a network take place to show the affect traffic on the vehicle and how to tackle with the heavy traffic and ways to ignore the ongoing traffic by taking different routes. It a very good application of VANET which helps to analyses that which route should be taken by the vehicle and how we should complete the journey in minimal time and what will be the optimal path with less traffic in it.

K. Golestan et al (2012) have discussed some of the attributes and challenging issues related to Vehicular Ad-hoc Networks (VANETs). A lot of VANET research work have focused on specific areas including routing, broadcasting, Quality of Service (QoS), and security. In this paper, the authors have done a detailed overview of the current information gathering and data fusion capabilities and challenges in the context of VANET. In addition, an overall VANET framework, an illustrative VANET scenario is provided in order to enhance safety, flow, and efficiency of the transportation system.

Muhammad Rizwan Ghori ET AL (2018) have studied and discussed various research works related to the applications, protocols and security in VANET. After reviewing the existing works, they have analyzed them and found the pros and cons for the future research.Bharati Sharma et al (2019) in there research study, discussed the recent problems such as developments, exploitation, safety, security problems and the latest plans successively run in various environments.

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They provided the information about simulators needed to execute the VANET. The primary objective of this paper was to review and generate a new idea in vehicular communication.

Ahmed Yasser et al (2017) in their work on the implementation of Vehicle-to-Vehicle (V2V) communication and how it can be used as a standalone for ITS architecture in the developing countries without Road site units (RSU) infrastructure to overcome the current challenges. To do that, the authors have performed a full simulation for different Vehicular Ad-Hoc Network (VANET) routing protocols using Opnet simulator to select the best protocol for V2V Implementation. Then the best V2V routing protocol based on the paper's Key Performance Indicators and point of view were used to compare between two different architectures, one with V2V + RSU implementation and the other one with proposed V2V only implementation. The authors demonstrated that the proposed ITS architecture based on V2V only without RSU is capable of implementing ITS in developing countries.

III. VANET CHARACTERISTICS

Infrastructureless: VANET does not require any infrastructure except RSUs and TAs which are maintained on the roads. There is no need switch or hub or any physical medium between vehicles for communication. Even if we consider road side units (RSU)s and trusted authority (TA)s in the network, these are very basic resources which are deployed along the road side during the construction of roads by the road authorities.
Self-Organized: This is one of the essential characteristics of VANETs. Each node in VANET acts as a router takes its own decisions for forwarding messages.These features make VANET as a self-organized network.
Distributed Network: VANET consists of moving vehicles, RSUs, and TAs. This forms a distributed network and TAs are the topmost controllers. The registration and the removal of a node within the network are done by TAs. RSUs are regional authorities providing services to vehicles coming under their regions. This forms a scenario of distributed network.
Highly Dynamic Nodes: VANETs are highly dynamic in the sense that the nodes are moving in high speeds from 60 to 200 km/hr,
Critical Latency Requirement: Communication in the VANET network should be made with low latency. Latency is nothing but the time interval between sending messages by a source node and receiving messages by a receiver node. In a VANET, due to high relative velocity among mobile nodes, the nodes remain in the vicinity of each other for very short time periods. It is important to receive the message by the destination vehicle in a given time period. To achieve this network, a critical latency requirement is needed.

IV. VANET ROUTING PROTOCOLS

The VANET, the routing protocols are broadly classified into five categories:

- Topology based routing protocol
- Position based routing protocol
- Cluster based routing protocol
- Geo cast routing protocol and

This classification is based on the type of applications and on the area in which they will be operated on. We shall discuss now these protocols in detail.These protocols are characterized on the basis of area / application where they are most suitable [1].

a) Topology Based Routing Protocols: These routing protocols use links information that exists in the network to perform packet forwarding. They are further divided into Proactive and Reactive.
   i) Proactive routing protocols:In this, the routing information such as the next forwarding hop is maintained before any request for such information is received. These protocols by pass the route discovery phase and thus save significant routing time. But at the same time these protocols are not suitable for real-time applications because of low latency. Topology Based Routing Protocols work in the following way. Each node maintains a routing table that shows the next hop information in any particular direction. It also leads to the maintenance of unused data paths, which causes the reduction in the available bandwidth. The various types of proactive routing protocols are: LSR, FSR.
   ii) Reactive/Ad hoc based routing protocols: These protocols starts operating only when there is need for data communication. It starts with route discovery phase followed by other steps of the routing process. It maintains only the routes that are currently in use, as a result it reduces the burden in the network. Reactive routing consists of route discovery phase in which the query packets are flooded into the network for the path search and this phase completes when route is found. The various types of reactive routing protocols are AODV, PGB, DSR and TORA

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b) Position Based Routing Protocols: Position based routing algorithms use geographic positioning information to select the next forwarding hops. The packet is sent without any map knowledge to the one hop neighbor, which is closest to destination. Position based routing is beneficial since no global route from source node to destination node need to be created and maintained. Position based routing is broadly divided in two types: Position based greedy V2V protocols and Delay Tolerant Protocols.

c) Cluster Based Routing: Due to its inherent high mobility, the VANET topology changes rapidly, resulting in high communication overhead for exchanging new topological information. All routing configurations therefore must be performed from the cluster IP address and the configurations are propagated to the other cluster nodes. Clusters are formed by grouping a set of nodes based on some parameters. A cluster head (CH) is identified to manage the entire communication process within and outside the cluster. The perfect election of the cluster will offer an efficient network performance and high reliability. Most of the clustering routing protocols normally elect the CH based on the location or velocity. On the one hand, the selection using location is not usually an optimum choice, because the location of the selected vehicle may rapidly change according to the relative speed with the other vehicles in the network. This means that the vehicle with the best location may quickly become unsuitable as the CH. On the other hand, selecting the CH according to the velocity is also not appropriate in many situations, particularly when the relative movement between vehicles is very high. This will consequently lead to cluster instability. Moreover, the speed of the vehicles directly affects their locations. Therefore, the perfect CH selection method should consider many factors to obtain high cluster stability and network reliability. After finishing the clustering process, the vehicles' movement may change the structure of the cluster. Therefore, the cluster structure continuously needs maintenance, until the vehicle exits the network. Vehicles periodically check the neighbor list and the neighbors' cluster listing status, in the case of adding a new cluster member or one of the cluster members leaves its cluster; cluster structure will not change, and only the CH can modify the cluster members list. When a boundary vehicle leaves the cluster, then the CH needs to select a new border vehicle using a similar clustering process and selection criteria. Due to the movement, CHs may move closer to each other, which lead to clusters merging. The loser CH sends a message to inform its cluster member about the new elected CH. In addition, a new CH should be elected when the loss of the CH occurs due to an accident or any other abnormal situations. [1]The various Clusters based routing protocols are COIN and LORA_CBF

d) Geo Cast Routing Geo cast routing is basically allocation based multicast routing. Its objective is to deliver the packet from source node to all other nodes within a specified geographical region (Zone of Relevance ZOR). In Geo cast routing vehicles outside the ZOR are not alerted to avoid unnecessary hasty reaction. Geo cast is considered as a multicast service within a specific geographic region. It normally defines a forwarding zone where it directs the flooding of packets in order to reduce message overhead and network congestion caused by simply flooding packets everywhere. In the destination zone, unicast routing can be used to forward the packet. One pitfall of Geo cast is network partitioning and also unfavourableneighbours, which may hinder the proper forwarding of messages. The various Geo cast routing protocols are IVG, DG-CASTOR and DRG

Sl. No.	Routing overhead	Stability	Data Latency/Routing time	Security	Specific Drawbacks
Topology based routing protocol	Comparatively More	Comparatively less	Low latency	Significant security threat	not suitable for real-time applications because of low latency
Position based routing protocol	less	Comparatively less	Low latency	Significant security threat	Stability of vehicle position
Cluster based routing protocol	high communication overhead	Comparatively less	Significantly low	Cluster head authentication process helps to reduce security threats	Cluster instability
Geo cast routing protocol	Reduces message overhead	Comparatively Stable	Low latency	Network portioning may increase security threats	partitioning and also unfavourableneighbours

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V. CONCLUSION

Inter vehicle communication is an emerging research area and many vehicle manufacturers are trying to incorporate such a system in their new models. Routing and latency are still a bottle neck and many researchers are working on this. A survey on the routing protocols used for VANET applications is done. The comparative study gives an idea about the merits and demerits of all the existing routing approaches used in VANETs.

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