A Survey Paper on Efficient Routing Algorithms for Vehicular Ad Hoc Networks

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Abstract: Wireless technology is developing very quickly. Most researchers work in the field of wireless communication. VANET is an evolving technology in the field of wireless communication and as it progresses it will contribute more to the intelligent transport system in the coming days. VANET offers a communication framework that has improved traffic service and helped reduce road accidents. The exchange of data in this system is urgent and requires a fast and vigorous network connection. VANET fulfils these purposes, but there are some problems and challenges such as efficient management of fast transfers for video streaming applications. Therefore, in this document we have examined and discussed several studies related to routing protocols to judge which is the best for VANET applications. Furthermore, after studying several systems developed by the researchers, a survey is presented on efficient routing algorithms for ad hoc vehicle networks.

Index Terms **- Load Routing, Vehicular Ad Hoc Networks, AODV, V2V, RSU.**

I. INTRODUCTION

The ad hoc vehicle network (VANET) has become the key research study due to the growing demand for road safety and management. VANET is a subclass of Mobile Ad-hoc NETwork (MANET) which belongs to a family of Wireless Ad-hoc NETwork (WANET). Speaking of MANET, it is basically a self-organized communication system that does not depend on any infrastructure. It is mainly used by the military. But today it is becoming common. In a simple way, MANET uses the same basic communication methodology, as well as the ad hoc bluetooth network used to share data between computers. The basic principle of VANET is also the same as MANET. The VANET system consists of mobile nodes which are the sensors integrated in the vehicle, the fixed infrastructure consisting of road side units-RSU. RSUs are permanently installed units that function as a gateway to connect to the server or the Internet for information. The most vital service provided by this network is to drive safety since road accidents are the ninth leading cause of death. Furthermore, according to the survey, most accidents can be avoided if the driver receives the half-second warning before an accident. VANET is accomplishing this by sharing road safety information and traffic analysis over the Internet.

According to Yong et al. (2016), VANET architecture consists of vehicle components and infrastructure. The operation of the vehicle consists of the on-board unit (OBU) and the application that will be work for OBU to allow it to communicate. In addition, the infrastructure components consist of MSW commonly connected to the Internet. Next, Figure 1 shows VANET system architecture. There are mainly two types of communication in VANET, such as Vehicle to Vehicle (V2V) and Infrastructure to Vehicle (V2I). V2V is wireless communication between vehicles, while V2I is communication between the vehicle and the infrastructure. VANET is quite different from other ad hoc networks in terms of functionality such as high mobility, sharp changes in topology, critical times, high processing capacity, etc. In addition to its good features and applications, there are also some challenges related to this network, such as security, scalability, quality of service, power control, etc.

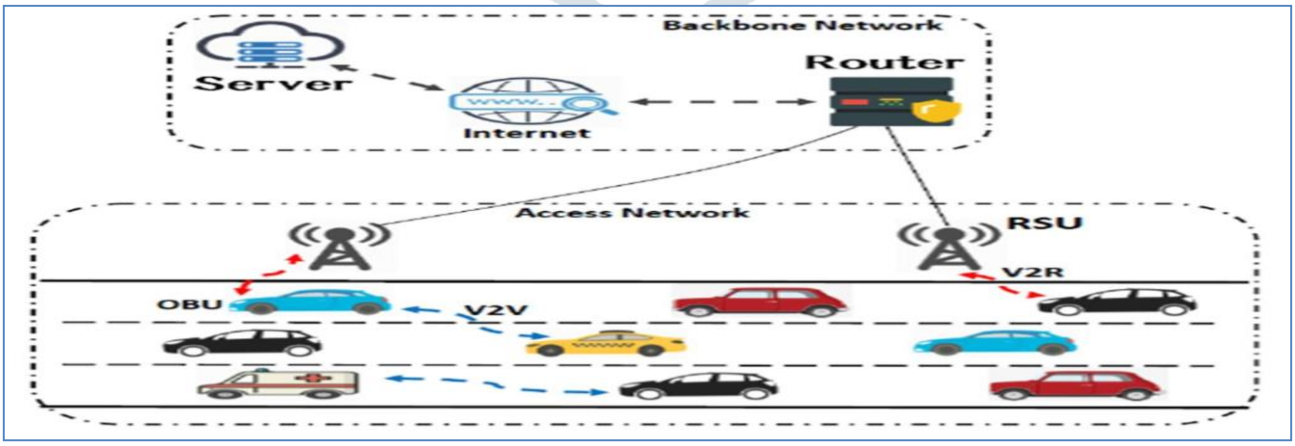

Figure 1: VANET System Architecture

Over the years, much research has been conducted on the development of applications and usage models type of communication VANET. As more and more people are spending time on the road, an increased Internet connection is therefore needed to communicate with each other, receive real-time news, traffic information and weather reports, etc. In addition, some of the latest applications developed related to VANET are online file sharing, real-time video updates and entertainment through the Internet connection via RSU or V2V connections. In addition, VANET applications are classified as safety and comfort applications. The rest of the paper is organized in a manner that in Section 2, the routing protocols used in VANET are discussed while Section 3 will discuss the related works followed by in Section 4, we talked about conclusion and future work related to this survey.

II. Routing Protocols in VANET

Due to the high mobility of VANET, the use of the correct routing protocol is a major concern. Packets in the network are sent from one vehicle to another that move with speed and the density of vehicles also increases and decreases, which increases the challenges related to routing protocols. Due to the highly stimulating nature of VANET, the researcher presented several types of protocols which will be explained in the following sections. In addition, Figure 2 shows the classification of routing protocols.

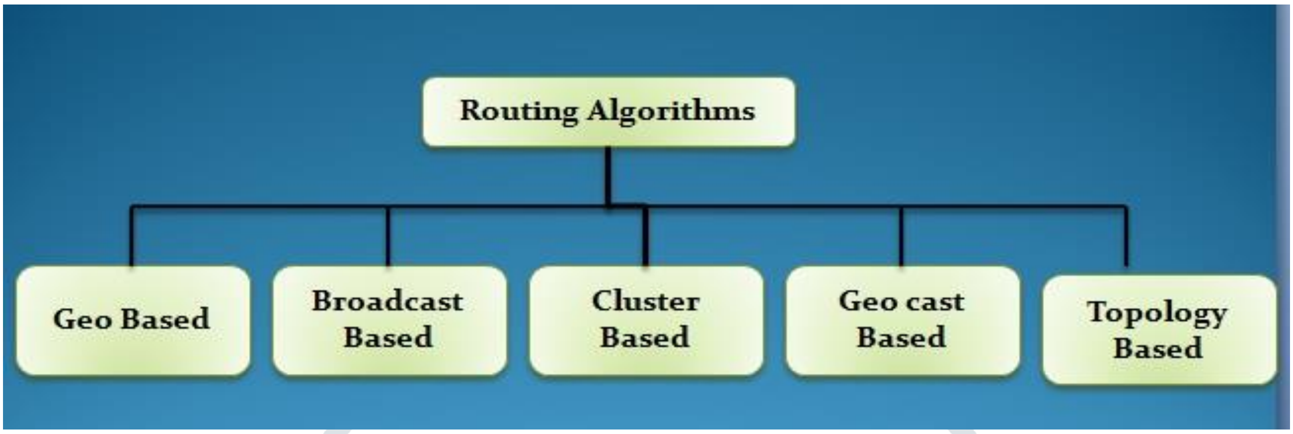

Figure 2: Classification of Routing Protocols

2.1 Geo Based Protocols

In these protocols, a source will communicate with the destination through the use of geographical locations, as well as with its network address. Calculates the load balancing of the routing protocol (LBRP) as well configure the path based on information based on the location of the nodes. Therefore, there is no need to create routing tables. The protocol consists of three components, such as beaconing, localization and forwarding services. The disadvantage of this protocol is that it requires the assistance of the Global Positioning System (GPS) to obtain the position of the vehicles. In addition, satellite signals weaken when the vehicle enters the area like a tunnel. But as far as the highway environment is concerned, it offers the best performance. In addition, its advantages include efficiency in high mobility environments. Examples of these protocols are the routing algorithm without greedy perimeter status and Distance Routing Effect Algorithm for mobility (DREAM).

2.2 Broadcast Based Routing Protocols

This protocol forwards the data packet to the entire VANET to all the nodes available in the transmission domain. This protocol is used whenever the target node is outside the range of the source node. For the most part, these protocols are used with safety-related applications, such as road and weather conditions warnings, emergency warning messages, etc. The example of the transmission routing protocols includes the Distributed Vehicular Broadcast Protocol (DV-CAST), Position Aware Reliable Broadcasting Protocol (POCA) and Density Aware Reliable Broadcasting Protocol (DECA). The positive point of these protocols is their reliability. But these types of protocols consume more bandwidth and many duplicate packets reach the node, which is not good for protocol performance.

2.3 Cluster Based Routing Protocols

In this protocol, the vehicle with the same characteristics, such as speed, direction, etc they combine into a group. Furthermore, if a vehicle node is to communicate with the node within the cluster, the data will follow a direct path, since it is considered to be local communication. Also, if the vehicle node is to communicate the external node to the cluster, its cluster head's help is needed to reach the destination. Scalability factors make it a good option for network designers. But traffic delays are its drawbacks. Clustering for Open Inter Vehicular Communication Network (COIN) is the best example of this protocol.

2.4 Geo-cast Routing Protocols

The geographical conversion protocol consists of two main areas, namely the Zone Of Relevance (ZOR) and Zone Of Forwarding (ZOF). ZOR is that area dedicated to the nodes of that region. The main objective of this protocol is to allow communication between the vehicles present in the ZOR. Furthermore, if the originating vehicle wishes to communicate with the vehicle that is not in that vehicle's ZOR, the vehicle will become part of the ZOF and any vehicle entering the ZOF is responsible for sending the information to other ZORs. Due to the frequent changes in the zones, the disconnection of the connection can take place regularly and this point occurs in the range of drawbacks.

2.5 Topology Based Routing Protocols

The focus of this paper is on topology based protocols. The said type consists of three kinds of protocol such as proactive, reactive and hybrid. Moreover, the classification of routing protocols used in ad-hoc environment is shown in Figure 3.

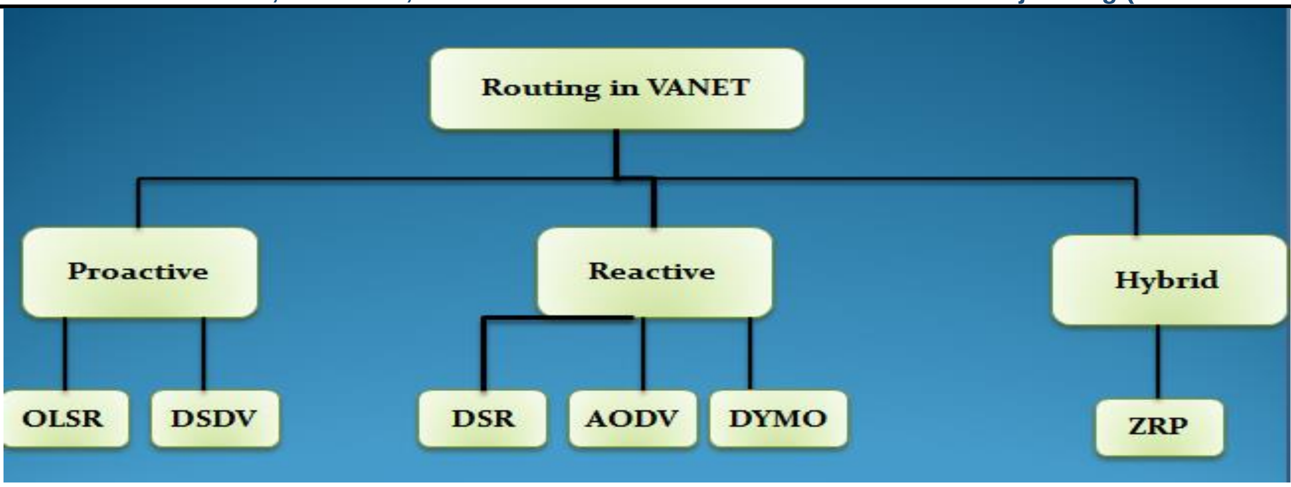

Figure 3: Classification of Ad-hoc Routing Protocols

2.5.1 Proactive Protocols

The protocols continue to calculate the route regularly and therefore the routing table changes or are updated frequently. These protocols use the Bellman Ford algorithm in which all nodes keep information related to the next node. The advantage of this protocol is that the path will be known each time a packet wishes to send data. The example of this protocol includes Optimized Link State Routing (OLSR) and Destination Sequenced Distance Vector (DSDV) protocol.

OLSR is basically a refined version of the link state protocol. The operation of the link state protocol is such that any changes in a topology will be transmitted to all nodes on a network, which will increase network overload. OLSR handles with two types of messages like hello and a message to check the topology. Greetings are used to find data about the connection status. While the topology control message is used to transmit your neighbouring information with the help of the selected multi point relay (MPR) list. Thanks to the use of MPR, the overhead has been reduced as in the case of the pure link state protocol.

DSDV is a modification of the Bellman Ford algorithm. This algorithm solved the routing cycle problem by keeping information about the sequence number of each node.

2.5.2 Reactive Protocols

This type of protocols does not have information on all nodes. Just save the information of the nodes that arrive in the path. The example of reactive protocols is an Ad-hoc On-Demand Distance Vector (AODV), Dynamic Source Control Routing (DSR) and Dynamic Manet on Demand (DYMO) protocol.

AODV is the most used protocol in VANET. It has the following jump information for the target nodes. In addition, each routing table lasts for a specific period. If there is no route request within the specified time, the route will expire and a new route will be defined upon request. According to AODV, whenever a source node wishes to send data to the destination node, it will check the path in its routing table. If the path information exists in the table, the packet will be sent to the destination. Otherwise, the originating node will transmit the request for route detection to the neighbours. AODV is an ad hoc mobile protocol suitable for high mobility traffic. These protocols reduced the general transmission costs. In addition, the route discovery process will be carried out on request.

DSR is a production protocol for routing. It is basically made for multi-hop WANET. It is a self-organization and configuration protocol that requires no administration. The two main functions of this protocol are path detection and maintenance. These functions interact with each other for the identification of nodes and the maintenance of routes.

DYMO is another on demand protocol designed after AODV. The DYMO routing protocol can be implemented both proactively and reactively. On the other hand, the path discovery methodology is required whenever necessary.

2.5.3 Hybrid Protocols

The hybrid is a compound of proactive and reactive routing protocols that reduce overload and delays the occurrence due to the periodic exchange of information on topology. With the hybrid approach, the efficiency and scalability functionality of the network has improved. On the other hand, the disadvantage of the hybrid approach is the high latency to navigate new routes. The common protocol based on the hybrid approach is the Zone Routing Protocol (ZRP).

III. LITERATURE SURVEY

With the advancement of wireless communication, different types of networks are being developed according to the requirement of the people. The use of wireless devices has increased enormously. New Networks are introduced and among all VANET is one of them. Also, in VANET, packet routing is the main challenge to manage. In light of the above, some works related to VANET routing are discussed in this section.

Chen Yin [1] , investigates the problem of vehicle path optimization to improve the efficiency of vehicle programming. With the increasing complexity of the traffic network, the vehicle will face the interference of accidents and congestions; this situation is random and cannot be predicted. The traditional vehicle route planning model has no risk of interference analysis, a precise model cannot be established, and the operational efficiency of vehicle programming is poor. To avoid these defects, the vehicle route optimization method based on a hybrid algorithm is proposed. In accordance with the theory of the traffic information feedback method, the road information feedback model is established which provides the basis for the optimization of the vehicle path. The ant colony algorithm and the extreme optimization algorithm are combined, the hybrid algorithm is obtained. In accordance with the theory of the hybrid algorithm, the vehicle route optimization model is constructed and the related vehicle data is entered in the model. Vehicle route optimization processing is performed. The results of the experiment show that this algorithm can improve the efficiency of programming, in order to satisfy the real demand for traffic management. ***(IEEE, 2014)***

Minghua Chen [2], based on research on vehicle routing problems (VRP), vehicle scheduling and operational work can be more rational, which consequently reduces logistic costs provided that the punctuality requirement of logistics is respected of emergency. In this document, they provided an analysis of the characteristics of VRP in emergency logistics. In accordance with the practical situations of VRP, an improved genetic algorithm (GA) is proposed in this document and applied to a general mathematical model established for VRP in emergency logistics. The simulation results show that the algorithm is feasible and effective. ***(IEEE, 2014)***

Zhihua Song et.al [3], the main goal of this research is to find a solution to the problem of routing air vehicles with distance limitation using a genetic algorithm based on the minimal heuristic of the expansion tree. As the lower limit of the vehicle's routing problem, the minimal expansion shaft provides natural heuristics for finding the route. It is used to generate the initial population and the reorganization project between operators. The proposed algorithm works well with regards to accuracy, consistency, speed and simplicity in all tests in the document. ***(IEEE, 2015)***

Sripriya J et. Al.[4], the Vehicle Routing Problem with Time Windows (VRPTW) consists of a homogeneous set of vehicles and a set of customers located in a city. In VRPTW all vehicles leave the warehouse, visit the customer and end up at the warehouse. Each customer is visited exactly by a vehicle within the specified time period. The goal is to minimize the number of vehicles and the total distance travelled simultaneously. This represents the multi-objective problem of vehicle routing with Time Windows. The proposed work consists of hybrid genetic research with diversity control using the genetic algorithm to solve VRPTW. Pareto's approach is used to find the set of optimal solutions to achieve the multiple objectives. The cross operator is used to exchange the best routes, which have the shortest distance. Two mutation operators have been used in this application, such as the delocalization mutation operator and the split mutation operator. In this, it represents a penalty for impracticable solutions with respect to time and duration restrictions. Calculations are performed using instances obtained from VRPLIB. ***(IEEE, 2015)***

Lingxin Meng et al. [5], a model with multiple customers is studied to minimize the length of the journey and the waiting time of the vehicle. The ant colonization optimization algorithm (ACO) combined with a heuristic insertion algorithm for time window vehicle routing problems is presented. Ants tend to catch impossible solutions in the final stages of the algorithm when they use the ACO algorithm to solve routing problems. Therefore, after having obtained the previous path using the ant colonies algorithm, they take the heuristic insertion according to the classification of the time window. The simulation results show that the proposed algorithm can solve the vehicle trajectory planning with better time windows than the other algorithms. ***(IEEE, 2016)***

K. M. Dhanya et al.[6], the problem of vehicle routing occurs in real life applications when vehicles are routed to various locations to meet customer requirements within the specified limits. An exhaustive study of recent work on the problem of the path of vehicles; mainly in routing the problem of vehicles with a time window is carried out on the basis of their problematic characteristics. Exact methods, heuristics, meta-heuristics and hybrid methods are common methods for solving the problem of the vehicle path. Intelligent hybrid swarming methods to solve the vehicle routing problem must be tested. ***(IEEE, 2016)***

Shijin Wang et al. [7], Energy saving and traffic pollution have been important considerations in vehicle routing problems (VRP). This article considers energy minimization VRP (EMVRP) with heterogeneous vehicles. The goal is the product of the arc length and the weight of the vehicle when it crosses that arc. To solve the problem, an improved genetic algorithm is proposed, which uses new encodings and genetic operations. Computational experiments are performed to verify the performance of the improved genetic algorithm by comparing it with a mathematical model performed in CPLEX. The results show that the improved genetic algorithm can obtain high quality solutions in a short calculation time. ***(IEEE, 2017)***

Elhassania Messaoud et. Al. [8], a recent investigation has shown that the Ant colony System (ACS) algorithm hybridized with the large neighbourhood search algorithm (LNS) works well in the problem of vehicle routing (VRP) in the dynamic environment. In this document, they addressed this hybridization for the problem with traffic factors, which takes into account the change in the cost of travel between two locations. The main objective of this work is to minimize the total cost of the vehicle routing problem with dynamic requests and traffic factors using a hybrid colony system algorithm. ***(IEEE, 2017)***

M. Rabbani et al. Al. [9], the goal of the vehicle routing problem (VRP) is to find reasonable routes for vehicles to serve customers. Transport has significant effects on the environment and these effects can be dangerous. Therefore, an extension of the vehicle routing problem called Pollution Routing Problem (PRP) is introduced to solve environmental problems. Load and speed are the most important factors that can change the amount of pollution emitted by the vehicle. The problem of pollution routing calculates not only the distance travelled, but also the amount of greenhouse effect emitted by the vehicle fleet. In this study, a new type of green vehicle routing problem called MCGVRP, a multi-compartment green vehicle routing problem, is presented. The goal of this problem is to minimize the cost of changes in load, speed and payment for drivers considering the pollution emitted by the vehicle. Two meta-heuristic algorithms were selected which include the genetic algorithm (GA) and simulated annealing (SA) to solve the presented problem together with a hybrid meta-heuristic algorithm. Finally, the results obtained with these methods are compared with each other. ***(IEEE, 2017)***

Lama Alfaseeh et al. Al. [10], the impact of dynamic distributed routing with different market penetration rates (MPRs) of connected autonomous vehicles (CAVs) and congestion levels in urban roads was investigated. The downtown Toronto network is designed in an agent-based traffic simulation. The higher the MPR of the CAVs, especially in the case of heavily congested urban networks, the higher the average speed, the lower the average travel time and the greater the performance. ***(IEEE, 2018)***

Imad Lamouik et al. Al. [11], introduced a dynamic routing system for traffic at intersections based on real-time traffic conditions, such as individual vehicle speed, destination and semaphore status to provide the fasting path between a source and a target point. This system will take advantage of recent advances in machine learning by harnessing the power of deep learning, especially deep convolution neural networks. The simulation shows that the proposed model results in a generally rapid path and avoids frequent stops of red light. ***(IEEE, 2018)***

Sepideh Pourazarm et. Al. [12], studied two versions of the problem: the single-vehicle (user-cantered) routing problem and the multi-vehicle (system-cantered) routing problem. For the first, they formulate a mixed integer nonlinear programming (NLP) problem to simultaneously obtain an optimal path and a loading policy. Then reduce its computational complexity by dividing it into two linear programming problems. For the latter, they used a similar approach in grouping "sub-flow" vehicles and formulating the problem at the sub-flow level with the inclusion of traffic congestion effects. They also proposed an alternative formulation of NLP to obtain almost optimal solutions with orders of reduction in size in the calculation time. They applied an optimal routing approach to a subnet of the Eastern Massachusetts transportation network using real traffic data provided by the Boston Metropolitan Planning Organization. Using these data, they estimate the cost functions (congestion) and study the optimal solutions obtained with different charging stations and loads of energy-sensitive vehicles. ***(IEEE, 2018)***

Table 1: Efficient Vehicle Routing Protocols

S.NO.	Author & Year	Routing Algorithm	Performance Analysis
1	Chen Yin [1], IEEE, 2014	Hybrid Ant Colony Algorithm	Vehicle route optimization processing is performed. The results of the experiment show that this algorithm can improve the efficiency of programming, in order to satisfy the real demand for traffic management.
2	Minghua Chen [2], IEEE, 2014	Genetic Algorithm	The genetic algorithm applies to a general mathematical model established for VRP in emergency logistics in this document. The simulation results show that the algorithm is feasible and effective.
3	Zhihua Song et.al [3], IEEE, 2015	Genetic Algorithm	The proposed algorithm works well with regards to accuracy, consistency, speed and simplicity in all tests in the document.
4	Sripriya J et. al. [4], IEEE, 2015	Hybrid Genetic Search with Diversity Control using the Genetic Algorithm	The proposed work consists of hybrid genetic research with diversity control using the genetic algorithm to solve VRPTW. Pareto's approach is used to find the set of optimal solutions to achieve the multiple objectives.
5	Lingxin Meng et. al. [5], IEEE, 2016	Ant colony optimization (ACO) algorithm	The simulation results show that the proposed algorithm can solve the vehicle route planning with better time windows than the other algorithms.
6	K. M. Dhanya et. al. [6], IEEE, 2016	Hybrid Swarm Intelligent Method	Intelligent hybrid swarming methods to solve the vehicle routing problem must be tested.
7	Shijin Wang et. al. [7], IEEE, 2017	Genetic Algorithm	Computational experiments are performed to verify the performance of the improved genetic algorithm by comparing it with a mathematical model performed in CPLEX. The results show that the improved genetic algorithm can obtain high quality solutions in a short calculation time
8	Elhassania Messaoud et. al. [8], IEEE, 2017	Energy Minimization VRP (EMVRP) with Ant Colony Algorithm	The goal of this work is to minimize the total cost of the vehicle routing problem with dynamic requests and traffic factors using a hybrid colony system algorithm.
9	M. Rabbani et. al. [9], IEEE, 2017	genetic algorithm (GA) and simulated annealing (SA)	Two meta-heuristic algorithms were selected which include the genetic algorithm (GA) and simulated annealing (SA) to solve the problem presented together with a hybrid meta-heuristic algorithm. Finally, the results obtained with these methods are compared with each other.
10	Lama Alfaseeh et. al. [10], IEEE, 2018	Congestion Algorithms	The downtown Toronto network is designed in an agent-based traffic simulation. The higher the MPR of the CAVs, especially in the case of heavily congested urban networks, the higher the average speed, the lower the average travel time and the greater the performance.
11	Imad Lamouik et. al. [11], IEEE, 2018	Dynamic Routing Algorithm in Neural	This system will take advantage of recent advances in machine learning by harnessing the power of deep

		Networks	learning, especially deep convolution neural networks. The simulation shows that the proposed model results in a generally rapid path and avoids frequent stops of red light.
12	Sepideh Pourazarm et. al. [12], IEEE, 2018		They also proposed an alternative formulation of NLP to obtain almost optimal solutions with orders of reduction in size in the calculation time. They applied an optimal routing approach to a subnet of the Eastern Massachusetts transportation network using real traffic data provided by the Boston Metropolitan Planning Organization.

IV. Conclusion

Compliance with application requirements when solving basic communication problems in VANET represents a major challenge in the design and design of future forwarding algorithms. Routing is the fundamental problem of the network. Therefore, the main challenge to design the protocols in VANET is to obtain the best protocol reliability and to minimize delay times and packet retransmission. In this investigation, authors have developed and analyzed the unicast and probabilistic routing protocols for VANET. The main challenge in designing algorithms for VANET forwarding is to offer reliable packet transmission with minimal delay, maximum performance and low communication costs. Most of these algorithms address only a subclass of these requirements within the provisions of specific situations. Several unicast forwarding algorithms are proposed which combine the adaptive path in combination with location-based solutions that provide ease of management of optimal local and disconnection problems. In addition, some studies on how to deal with transmission problems, a main goal of packet exchange in VANET. Future research should focus on protocols that point to mixed systems to manage multiple quality applications that meet the requirements. For example, although the forwarding protocol (based on location) seems to be common for VANET due to its constant topological changes; IP-based solutions are most needed to manage Internet-based applications.

V. Future Work

Vehicle networks are assistive technologies to support many applications other than Internet facilities around the world, in addition to applications created to activate urban and road safety, many solutions have been defined to solve problems. Forwarding algorithms: the most important task in the design of VANET forwarding systems was to offer a reliable packet transformation through low communication costs, minimum delay and exceptional performance. Future research should emphasize protocols that point to heterogeneous structures to manage applications with different quality of service requirements. VANET is an important task in the design of forwarding algorithms in the future.

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