ROUTING ALGORITHM IN HYBRID NETWORK FOR VANET UNDER LOAD DISTRIBUTION

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Abstract

This study presents the interconnected VANET and 4G mobile networks linked. Its benefit is the high-speed transmission of VANET on the one hand and the massive 4G system on the other, which makes it a valuable resource. Furthermore, the advantages of this network outweigh the disadvantages of WiMAX and ad-hoc networks. Routing in heterogeneous networks has emerged as a prominent study subject in VANET to preserve the varied features of ITS (Intelligent Transport Systems) applications while maintaining their diverse characteristics. We offer a routing technique that includes no extra network cost for hybrid networks. The findings demonstrate that the suggested approach generates better results when varied simulation settings are considered. This technique maximized the average packet deliver ratio while simultaneously minimizing average latency, route length (including transmission time), and request block rate (as measured by the results).

Keywords: VANET, Ad-Hoc Network, Heterogeneous Network, Routing Algorithms

1. Introduction

The growing number of cars causes a traffic bottleneck, and traffic congestion is a big issue in the city. This has prompted academics to concentrate on VANET safety concerns, and this concern has had a significant influence on decreasing fatalities while providing safe, pleasant, and convenient road travel alternatives. In most cases, drivers are oblivious of road conditions [1]. They rely on sensors, radio communication devices, and computers to monitor the speed of each car on the road and determine whether or not there is a danger to their safety. Here are some of the distinctive characteristics of VANET: Nodes move quickly, resulting in a dynamic network topology that changes frequently. Patterns are constrained due to limited road space, and bandwidth is restricted due to a lack of central management to handle communication between nodes. Separation issues and point-to-point communication are also issues. Signal fading is caused by things that create obstructions in the signal's path. One of the essential VANET competitions is determining an operating routing protocol for directing the packet forwarding process across the node. Therefore, it selects the next-hop to use to send the packet so that it may arrive at its final destination. As a result, VANET's solution offers a robust routing protocol.

The routing protocol requires several novel parameters to enhance network performance and improve routing efficiency. A VANET is a subset of a MANET in terms of functionality. MANET has developed several techniques to deal with the transmission delay constraint for packet delivery. Packet loss, bandwidth waste, mobility, and security are examples of this. Because of the constrained mobility patterns in VANET, these methods were unable to be utilized. The integration of current technologies such as UMT and WLAN into the next-generation system is the primary emphasis of the system, and the provision of mobility services is the fundamental necessity of a ubiquitous network. However, unlike typical heterogeneous access technologies (such as WiMAX, WiFi, and cellular), Mobile IP [2] only delivers mobility services to a single device.

Routing protocols in highly mobile networks do not need a permanent infrastructure to accomplish scalability; instead, they change the radio spectrum and power levels depending on the number of nodes in the network to achieve this. In sparse networks, it is possible that the node forwarding the packet will not be able to discover the next-hop necessary to get the packet delivered to its destination. In order to tackle this difficulty, the grid employs a mechanism similar to that presented in Greedy Perimeter Stateless Routing (GPSR) [3].

Finally, because of the integration of many wireless network access interfaces, wireless networks are exceedingly varied in their configuration. Next-generation networks' ubiquitous connectivity integrates disparate wireless access networks to construct heterogeneous networks, which are then connected. As wireless networks become more prevalent, the requirement for dynamic resource allocation and effective transmission in diverse wireless networks has emerged as a critical source of worry for network operators. The current emphasis of the study is on a variety of subjects connected to heterogeneous wireless networks, including The most significant research problems in heterogeneous systems are resource management, load balancing, dependability, and quality of service (QoS) support.

2. Related Work

In order to minimize packet overhead, routing techniques are used to find the shortest route between network nodes. Many routing protocols used in VANET setups are classified based on many characteristics, such as protocol uniqueness, the technology employed, and routing information, among others. Quality of service (QoS), network model, routing algorithm, etc. Classification of VANETs routing protocols is based on their routing strategy:

In comparison, topology-based routing protocols rely on methodology and location-based routing protocols, rely on location-based services. To provide an example, the AODV protocol was implemented and augmented by the car network's geocaching capabilities. They made a system known as Geographic Source Routing available (GSR). AODV and DSR were exceeded by GSR in terms of transfer speed and delayed response time. First, the highway environment is considered, and second, the vehicle ad-hoc network considers the urban environment. The scalability of the cluster-based routing mechanism is ensured. There are several clusters, each of which has its cluster leader. The cluster head handles communication between nodes inside a cluster, while the cluster head handles communication between clusters.

Geocast routing establishes a specified geographic region, and flooding is a technique for routing packets from source to destination across long distances. This is known as location-based routing, and it is used whenever packets are routed inside a particular geographic area. As a result, network congestion is kept to a minimum, and message overhead is likewise kept to a minimum.

It is necessary to employ broadcast routing to convey information on the weather, traffic, and road conditions. Flooding is the most often utilized technique in such protocols, yet it has been shown that more significant network sizes result in bandwidth concerns. As a result, new protocols are introduced to demonstrate the development of bandwidth use. BROADCOM, Vector-Based Tracing Detection and Urban Multi-Hop Broadcast (UMB), are examples of such technologies (V TRADE). When using the location-based routing protocol, nodes in the vehicle network make routing choices based on the information provided by the location information. It is preferable to ad-hoc routing protocols because it obtains information from road maps and traffic models, which are not available with the latter. Beacons, location services, location servers, forwarding methods, and recovery strategies are the primary mechanisms of this protocol, with the others being optional.

The benefit comes in the one-of-a-kind characteristic, which eliminates route maintenance. This is essential for sophisticated mobile networks, such as those used by the military: The VANET environment is effective. In order to forward a packet from the source to the destination, just the location of the destination and additional information, such as node identities and adjacencies, are necessary to be provided. A position-based routing protocol is used in the algorithm design based on the information provided above. The Vehicular Traffic-Aware Routing Algorithm (VTARA) presented in this document varies from the preceding protocol. It creates routes based on the road topology rather than the traffic flow on the road. The geographic position is used to route data between the endpoints of the geographic routing protocol based on the node's location. GPSR [3] and GFG [4] are two protocols that fall under this category. Dead end identification or wireless network characteristics to limit the number of hops along the recovery route are the two approaches offered in [5] and [6] to deal with this problem.

According to those protocols, a source computes the quickest street-primarily based route from its advanced function to the last destination. It is comparable to the planned VTARA. It includes a listing of intersections that define the path from the supply to the vacation spot within the header of every information packet sent by the way by the supply method. However, since they do not consider real-time site visits, they include empty roads due to this. For this reason, A-STAR [7] adjusts GSR by assigning relevance to the city scenario supplied by transit buses each time a new junction is added to the supply route. This helps to ease the problem of traffic congestion. CAR [8] discovers connected pathways between supply-vacation location pairs while considering vehicular traffic. It uses guards to ensure that nodes comply with the behaviors of other nodes.

Bernsen et al. proposed a new function-based set of guidelines known as RIVER [9], principally based totally on the grasping approach and uses the concept of the undirected graph to assign reliability rankings to streets in several different ways. The route is chosen as the moving direction by the rules based on those rankings. The collection of criteria uses real-time site visitor information to provide dependability ratings for various roads and highways. Because of real-time site visitor statistics, there is a slight potential that RIVER will have gaps in the community.

By Wang and Lin [10], the sustainability measurement amongst linkages is achieved using the hyperlink existence time (LLT) concept. The LLT is a phrase that refers to the fact that nodes continue to remain close to one another. These criteria serve as the foundation for determining the order in which CH and CG should be chosen. PassCAR is a routing method that contains three phases: route discovery, course status quo, and statistics transfer, among others. A vehicle must verify the routing desk before sending a statistics packet. If there are just a few available directions, the car forwards the packet to the next hop; otherwise, the car commences the course discovery segment and determines the CH and CG to which the packet should be directed.

While applying the greedy approach the results may result in insecure forwarding in the selection of nodes, further reducing the packet delivery ratio. Researchers have developed various techniques [11, 3] that utilize the density of site visits to determine the best routing path. The routes with the most significant number of vehicle site visitors are chosen as the advancing direction; nevertheless, such a grasping strategy will also raise the load of community site visitors, resulting in congestion.

Rondinone and Gozarves have successfully resolved the issues listed above. Road Topology Aware Contention Based Forwarding (TOPOCBF) is the method suggested by them [12]. A dynamic selection of road segments is made by TOPOCBF depending on the number of hops between two points. Whenever there are enough nodes accessible to transport packets from one end of a road segment can be delivered to the other, this is referred to as multi-hop connectivity on the road segment. TOPOCBF is based on the approach of distributed and real-time communication road connection detection technique (DiRCoD) [13] that detects road connections in real-time. It is necessary to assess the multiple connectedness of a road stretch. DiRCoD makes use of beaconing to determine the virtual distance between two points.

Infrastructure Assisted Geo Routing (IAGR) [14], which Borsetti and Gozalvez presented, delivers packets to static nodes that use geographic routing. The use of RSUs has two advantages, according to IAGR. First and foremost, the greater the height of the antenna, the greater the range of V2I communication compared to V2V communication. Second, RSUs must be linked together as backbone networks, with the distance between them being considered as if it were a distance of zero. There are two basic categories of vehicles on regular roads: automobiles and buses, and traffic lights move the vehicles in groups as a result of this division. According to Luo et al. [15], a routing approach that uses the VANET characteristics of such cities is proposed. Buses, which are vast and convenient for transporting transmission equipment, are utilized as mobile infrastructure to provide connection in road sections where needed. Mobile gateways, such as taxis and public transit, are used to link users in the MGRP, which is built on the MIBR. The bus is utilized as a mobile gateway in the MIBR system. Because the bus route is set in stone, access to the surrounding region is limited. To overcome this challenge, bread and other baked goods [16] advocated that taxis be used as mobile gateways.

Locating a vehicle via location-based routing [17, 18] is better suited for VANET setups since it needs more comprehensive information about the vehicle's physical position to accomplish data routing. Assuming that most automobiles will be able to use the Global Positioning System (GPS) in the foreseeable future, this may be accomplished by using alternative positioning systems. Because location-based routing algorithms do not need route maintenance, they are particularly well suited for sophisticated mobile networks such as VANET setups. When a packet has to be sent, the network decides the routing route. When sending data from one source to another, the target location and extra information such node ID, forwarding nodes' identities and their adjacencies must be provided. Based on the facts above, I prefer a position-based approach to building routing algorithms.

Today's wireless networks are diverse due to the integration of many wireless network access interfaces into the single network architecture. [19]. A variety of wireless access networks have been merged to build heterogeneous networks capable of enabling the ubiquitous capabilities of next-generation networks. It is becoming more crucial as awareness across diverse wireless networks rises, as is the dynamic resource use of heterogeneous wireless networks and the necessity for sound transmission engineering practices. Load balancing, dependability, resource management, and quality of service (QoS) support are current research concerns in heterogeneous wireless networks.

The ability to balance load across heterogeneous wireless networks is also essential characteristic that permit resource sharing between heterogeneous wireless networks to optimize resource utilization and user service [20]. Load balancing is often dependent on the architecture of the network and the algorithms used to balance the load. In [21], the author gives network architectural concepts for effectively balancing the demand on the access system, which are described in detail. Network designs may be divided into four types: centralized, decentralized, semi-centralized, and semi-distributed [22, 23]. Centralized network architectures are the most common. There are specific issues with the first two methods that need to be addressed. [24] Centralized techniques are unstable, whereas distributed mechanisms have a significant overhead. Researchers in this field concentrate their efforts on access network providers and technical advancements that will enable seamless mobility in a multi-user, multiple-service, and multiple-technology context.

In most cases, the study focuses on connecting global wireless networks such as WLANs (Wireless Local Area Networks) and cellular networks (3G) to exchange services. As a result of this integration, several issues arise since each network has a unique set of characteristics such as bandwidth, technology access, coverage area, power, standard, etc. One of these issues is the accomplishment of a flawless handover with no data loss throughout the process. This study presents a series of strategies that contribute to the advancement of technology convergence by enhancing several elements of vertical handover [25]. This solution aims to optimize radio resource use while still fulfilling the Quality-of-Service standards established by the application. According to [26], adaptive technology for load balancing-based handovers has been implemented. As opposed to the previous strategy, this one recognizes when necessary to conduct a handover but does not identify the proper destination access network. The author in [27] proposes a location-based routing method (VTARA) for ad-hoc vehicle networks. [28] is an extension of [27]. This approach uses optimal routing to locate routing nodes that follow street patterns and deliver data packets to their destinations. There have been many proposals for heterogeneous network designs to facilitate smooth mobile network movement. Each vehicle is given mobility via a variety of Internet Service Provider Protocols (ISPs). Mobile router (MR)-based handover methods in which MRs receive each other's destination packets in a coordinated way do not cause service interruptions and may greatly minimize packet loss during the changeover are now being developed. Suman, and so forth. Comparing VANET routing protocols [28] AODV and DSRP have the best overall performance over DSR. With the right channel architecture and an effective routing algorithm, the link throughput of a VANET can be significantly boosted while still retaining network capacity. Additionally, network size and routing strategies affect packet loss, packet delivery ratio, average end-to-end latency, and overhead transmission, as demonstrated by the performance evaluation approach used in this study. When constructing routing protocols for VANETs, the authors of Ishtiaq Wahid et al., State of the Art Routing Protocols in VANETs [29] discuss how the frequent change in network topology is a hurdle. Many protocols and techniques have been proposed for VANETs, as well as other things. There are benefits and downsides to both simulation and theory-based techniques. Distance, speed, the number of nodes, hops, and communication overhead are all taken into account when calculating network parameters.

According to their designs, the researchers Annu and Ms. Reema [30] looked at the different routing protocols regarded MANET and VANET by them. MANET protocols may be implemented in a VANET, according to their performance assessment. Their total performance, however, fluctuates depending on the scenario and density of visitors. As a result, they realised that the Reactive protocols might be used to improve the present protocol's quality even more. In addition, AODV is the most successful reactive MANET and VANET protocol, based only on existing research efforts and studies, among the several protocols.

Businessman Amit Kumar Bairwa1 hails from India. This article was written by Sandeep Joshi. Improve the quality of service in MANET using a fully routed search solution based on agents [31]. On the basis of Ad Hoc on Demand Distance Vector (AODV) Routing Algorithm and using just self-monitoring (agent-based totally), a brand new protocol will be tested and evaluated. The Agent-Based Ad Hoc on Demand Distance Vector Routing Algorithm (AB-AODV) Protocol is the name given to it when used in MANETs. Simplest version of this technique is to control locally based on facts at the lowest cost in terms of additional messages and time delay.

The work of Joelson Alves Junior and Emilio C. G. Wille [32] has drawn attention to the essential characteristics and dispositions that exist in automotive ad hoc networks when it comes to routing. Classification of routing protocols was developed based entirely on the kind of structure and operation. For the protocol to function correctly, the topology of the community in which it will be implemented is characterized as the kind of structure that may be classified as ad hoc, infrastructure, or hybrid. In addition to the kind of routing, the operating mode may be classified into topologic, geographic, opportunistic, and dissemination categories, among others.

Ranjit Sadakaleet and colleagues [33], For Vehicular Ad hoc Networks, Intelligent Transportation Systems (ITS) is a critical issue to understand (VANET). Even though VANET is one of the miracles of mobile ad-hoc networks (MANETs), none of the routing protocols used by MANETs apply in the case of a VANET. Because of the enhanced speed and maneuverability of the vehicle, the VANET network is dynamic. The vehicular mobility of VANET nodes influences the overall performance of conventional routing rule sets, which are used to display the dynamics of network nodes. The findings of the suggested technique confirmed the improved overall performance of the VANET community in terms of packet delays, range of transmission, and end-to-end delays, among other measures. A comparative study of the suggested technique with IAODV, AODVR, and AODVL reveals that the proposed TADHOC demonstrated excellent overall performance compared to the other approaches.

Many research and paintings have been completed on the subject of "load balancing," in general and specifically in the area of strained homogeneous networks. However, load balancing in wireless networks is a research subject that is becoming more important as wireless communications are becoming more widespread every day and as more and more wi-fi networks operate on the same grid. Our understanding is that a few researchers have employed heterogeneous wireless networks based entirely on load distribution systems in VANET to provide communication among autos while traveling on the road, although this is a small number. In this study, we propose hybrid community (or heterogeneous wireless networks), which include 4G cell communities and Vehicular Ad-Hoc networks, as an alternative to traditional wireless networks. It benefits from the high transmission fees in VANET and the large-scale 4G device deployments.

The following is the procedure for preparing the paper's relaxation. In Section 4.1, we describe the heterogeneous wireless network topology and the routing methods that have been developed for HN. Segment 4 discusses the suggested routing set of rules that have been presented. The simulation environment and settings are described in detail in section 5. Section 6 provides an overall performance rating, followed through to the conclusion of Section 7.

3. Proposed Hybrid Network Architecture

The functionalities of the WiMAX network and the vehicle ad hoc network illustrated in Figure 1 are combined in the proposed wireless network, and each vehicle node (VN) is equipped with both WiMAX and an ad hoc interface. Integrated dual-mode interfaces are now available from a plethora of manufacturers. As a result, the routing protocol selects the most suitable interface for delivering the packet to the destination. The WiMAX network is placed on the curb to create a hybrid environment, and each WiMAX has a coverage area of 1000 m2. A unique ID identifies each vehicle node (VN) and WiMAX node (usually, the ID is an IP address).

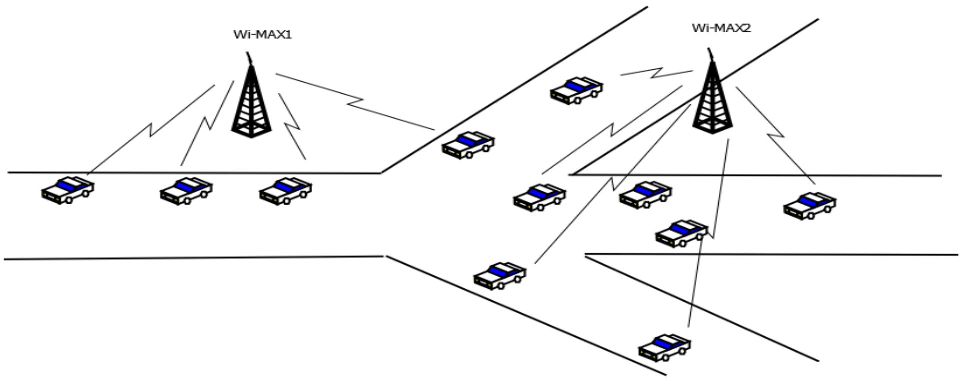

Fig. 1. Shows a hybrid network design for VANETs that has been proposed.

The usage of network architectures in automotive applications is common, and a variety of aspects such as availability assurance, reliability, and throughput must be considered to advance the presentation of data transmission routing algorithms. It is necessary to consider two issues that arise in the current network to develop an effective routing algorithm.

The current networks can only support data transfer between VANET sources and destinations. Whenever a source node attempts to deliver a data packet to a destination over several routing pathways, the most efficient routing path is chosen based on the parameters listed above.

The multi-cell design also helps reduce the amount of traffic carried via heterogeneous networks. An autonomous traffic distribution system is required to increase overall throughput while simultaneously providing more expressive services to many vehicle nodes.

The routing method suggested in this work makes an effort to resolve both issues. The proposed hybrid network (HN) design (see Figure 1). All cars are equipped with GPS, and communication between vehicles is accomplished either directly or via WiMAX. It also connects to the internet through a variety of WiMAX networks. Vehicle-to-vehicle communication via WiMAX is a homogeneous network, but vehicle-to-vehicle communication over WiMAX networks is considered a heterogeneous network.

3.1 Communication Strategy

The short-range vehicle network delivers quick, dependable, and real-time security in nature. In some instances, using vehicle-to-vehicle communication might lead the vehicle to act oddly while on the road, such as delays, exceeding certain thresholds, abrupt changes in the direction of travel, major mechanical breakdowns, etc. In order to notify other cars within a specific range, such vehicles actively create emergency alert messages that contain the vehicle's geographic position, speed, acceleration, and travel direction, among other information. The forwarding optimization technique is used in the suggested routing method. Consider the scenario provided in Figure 2 to better understand how HN operates under different communication tactics. Assume Vs and Vd are the vehicles of origin and destination, respectively.

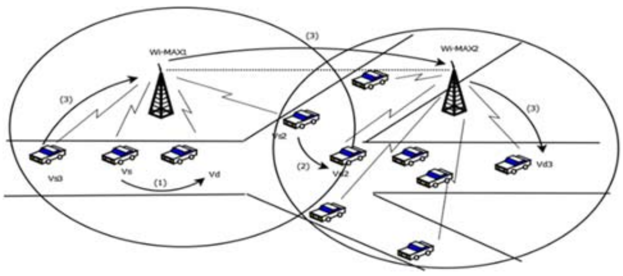

Fig. 2. Different communication scenarios in Hybrid Network Architecture.

Vs and Vd form ad-hoc area: If Vs and Vd form an ad-hoc area under the same or dissimilar WiMAX, Vs delivers packets to Vd by multi-hop routing. The vehicle can use to route the packet to (Vd). This option is signified by the arrow (1) in Figure 2.

Vs, Vd do not form an ad-hoc area: In V2V communication, vehicles move at different speeds, so the network topology can change rapidly, so connections between vehicles may not always exist. For example, if Vs3 in WiMAX 1 sends a data packet to Vd3 in WiMAX 2, Vs3 uses the WiMAX network to deliver the data packet. Vs3 first sends a data packet to WiMAX1 (arrow (3)). The packet is then delivered from WiMAX 1 (arrow (3)) to WiMAX 2 over the fixed network. Lastly, WiMAX 2 delivers the data packet to Vd3 (arrow (3) in Figure 2. The reactive routing technique described in Section 4 is used for data transmission of this type.

Vs Internet Requirements: It is also possible that Vs is using a WiMAX network to access Internet-based services like email and multimedia message access. WiMAX technology is used to build an internet connection in vehicles. WiMAX networks have their bandwidth constraints, which might result in WiMAX congestion in some instances. The load balancing technique specified in Section 4.2 and the suggested reactive routing should be implemented if WiMAX is overloaded.

4. Proposed Routing Algorithm

The suggested routing method combines role-based routing rules and a reactive routing set of rules described below. Suppose the source node discovers the destination node at an ad-hoc location or within the range of WiMAX devices that have been registered. In that case, the source node may deliver the packet to the destination node immediately. If the source is no longer capable of determining the type of traffic or if it is unable to discover the destination node in an ad-hoc location or a variety of registered WiMAX networks, the source resorts to the reactive routing system. A scheme is defined with assistance from the verbal exchange procedures discussed above. This part will go through the above approaches, assuming that Vs and Vd are the source and destination vehicles, respectively.

Set routing principles for multi-hop routing, whereas Vs and Vd form ad-hoc locations. When Vs and Vd create an ad-hoc area and connect to the same or a particular WiMAX network, Vs sends packets to Vd using multi-hop routing to ensure that the packets reach Vd. This procedure continues until a target node is identified by sending the packet to its instantaneous neighbor, it sends the packet to its immediate neighbor, and so on.

While Vs and Vd continue to form ad-hoc places, the reactive routing is no longer in effect: As previously stated in segment 3.1, the vehicle may be moving at a specified pace, and as a consequence, there may be the possibility of brief changes in network topology, with the result that communication between cars may not be available at all times. Any course's final destination node may be anything from a car to the internet, which provides access to a few apps. Consider the vehicular source node to be represented by VN.

VN determines that the criterion for Internet access is met by sending a Route Request message (RREQ) through the WiMAX interface to the registered WiMAX, rather than flooding the RREQ messages via a twin-mode interface as is done by other networks.

Using the Route Request Message (RREQ), VN will inform the WiMAX network of the type of data traffic it expects to carry through its network. There are tests carried out to determine the WiMAX network's intended destination. If the test fails, the destination is a server connected to a fixed network; otherwise, traffic from a single vehicular source and a single vehicular destination is favored. The flowchart of the proposed routing set of rules is shown in Figure 3, and we discuss in detail the operation of the proposed routing set of rules in the next section.

There are two types of routing rules used in the proposed technique, which are discussed below. The source node can instantly send the packet to the destination node if the source node detects the destination node at an ad-hoc location or within the range of registered WiMAX devices. It is necessary to resort to the reactive routing system when a source can no longer distinguish between different types of traffic or when it is impossible to locate the destination node in an unplanned location or a variety of registered WiMAX networks, for example. It is possible to define a scheme with the verbal exchange processes described above. Throughout this section, we

will go through the techniques stated above step by step, assuming that Vs and Vd are the sources and destination vehicles and that the procedures described above are correct.
Routing principles for multi-hop routing are defined as Vs and Vd; respectively, whereas ad-hoc locations are defined as V. During the creation of an ad-hoc area and subsequent connection to the same or a specific WiMAX network, Vs transmits packets to Vd utilizing multi-hop routing to guarantee that the packets reach Vd most efficiently. Once a target node has been found, the operation repeats itself by sending the packet to its immediate neighbor, who in turn transmits the packet to its immediate neighbor, and so on.
The reactive routing is no longer in force. However, Vs and Vd continue to construct ad hoc places: Following on from segment 3.1, it is conceivable that the vehicle moves at a certain speed, which may result in momentary changes in network architecture. As a result, communication between vehicles may not be accessible. Depending on the path, the ultimate destination node may be anything from a vehicle to the internet, which would allow access to a few applications. Take, for example, the vehicular source node, which VN represents.
VN determines that the criterion for Internet access has been met by sending a Route Request message (RREQ) through the WiMAX interface to the registered WiMAX, rather than flooding the RREQ messages through the twin-mode interface as is done by other networks and then notifying the registered WiMAX of the determination.
Once VN has identified the kind of data traffic that will be routed via its WiMAX network, it will send a Route Request message (RREQ) to the network to request a route. The WiMAX network conducts tests to identify the location of the intended destination. Traffic from a single-vehicle source and only one vehicular destination are prioritized if the test fails; otherwise, traffic from a single vehicular source and only one vehicular destination are prioritized. The flowchart of the proposed routing set of rules is shown in Figure 3, and we will analyze the functioning of the proposed routing set of rules in more depth in the next section. Figure 3: The proposed routing set of rules flowchart.

1. RDP- Route Discovery Process
2. LDP- Load Distribution Process

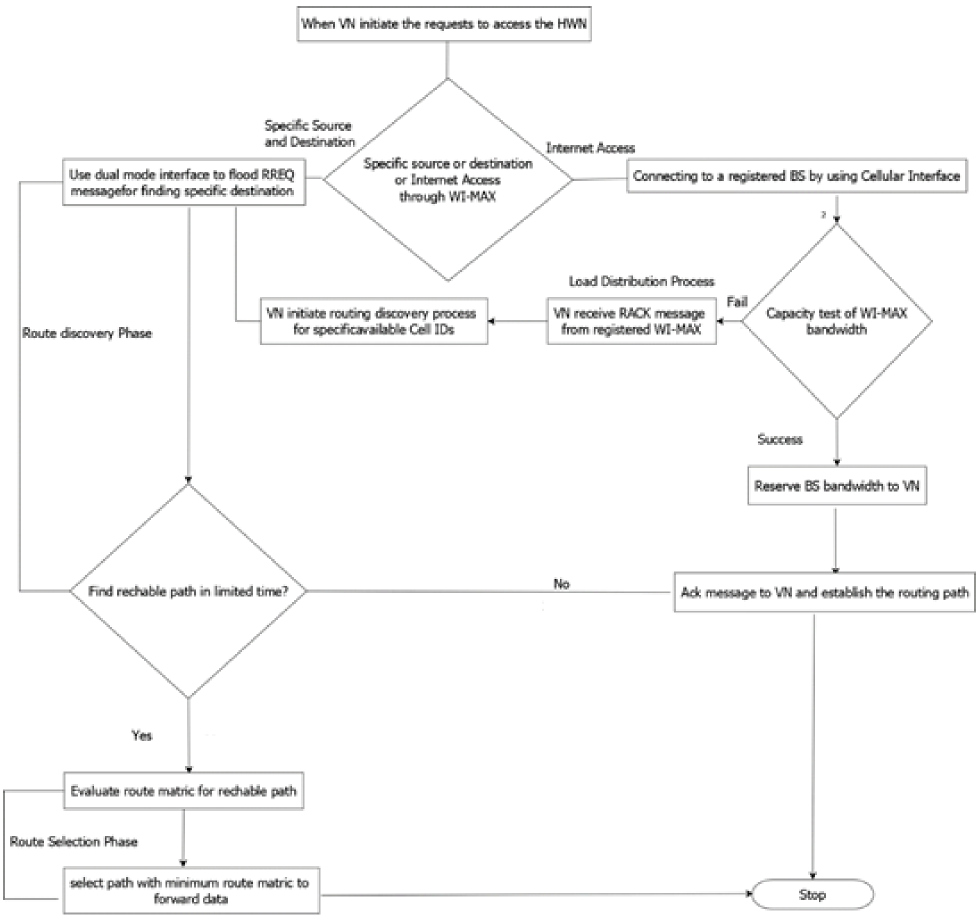

Fig. 3. Routing Algorithm in Hybrid Network.

Route Discovery Process

Upon receiving the RREQ message, the packets are passed to nearby VN and WiMAX until the target node is located, resulting in an increased overhead of the route response packet. Setting the TTL counter value in the RREQ message limits the number of forwarding hops in the routing protocol, which minimizes the system's overhead and latency. The routing technique takes advantage of reactive routing, which is well-suited for hybrid network environments. The route search process is separated into two phases: the route discovery and selection. The route discovery phase is the first step of the procedure.

(a) The packets are sent to neighboring VN and WiMAX nodes until the target node is found, resulting in an increase in the overhead of the route response packet upon receipt of the RREQ message. TTL counter values in the RREQ message regulate how many forward hops are used in the routing protocol's forwarding path, which decreases the overhead and delay associated with the routing protocol. As seen above, the routing strategy uses reactive routing, which is well-suited for use in hybrid network situations. Two steps distinguish the route search process: the route discovery and selection phases. The route discovery phase is the first of these phases. It is the first stage in the method that is known as the route finding phase.

$$\text{Adhoc Service Rate} = \frac{Nomber\ of\ blocked\ request}{Total\ nomber\ of\ requests}$$

Figure 4 depicts the RREQ message format and field.

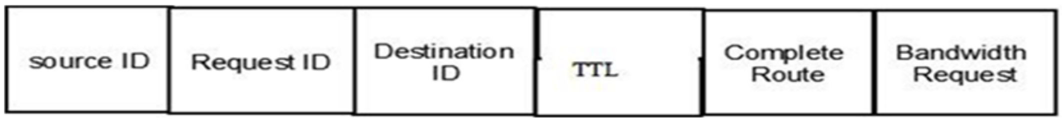

Fig. 4. The RREQ Message Format.

Upon registration, WiMAX evaluates the entry to identify the destination (VN) and prevents the RREQ message from flooding the network again. The Reachable Vehicle is notified if a VN entry is discovered on the registered vehicle by sending an RREQ message (VN). The RREQ message will be routed to another WiMAX utilizing the WiMAX interface if it is not received, and the procedure will continue until the target node is located. Figures 5 and 6 depict the procedures described previously.

When requesting a route, check the route cache since the source may be VN. If the route exists and the destination ID is supplied, it can reach the desired location. This results in the routing route being modified in the header and the packet being sent to the next-hop node on the network path. Aside from that, the source buffers the sent data and floods the RREQ to accessible neighbors (which may be intermediate VN or WiMAX) until the RREQ message is reached before the TTL expires. At this point, the source stops buffering the transferred data.

After receiving an RREQ message, the "TTL" field is examined to see whether the packet will be received by an intermediate node (VN) within a certain amount of time. If the decision passes the TTL test and the host ID of the decision is the same as the host ID of the destination node, the host sends the RREP message back to the source node and creates a routing route between the two nodes. If the host ID and the destination ID are not the same, the request will fail.

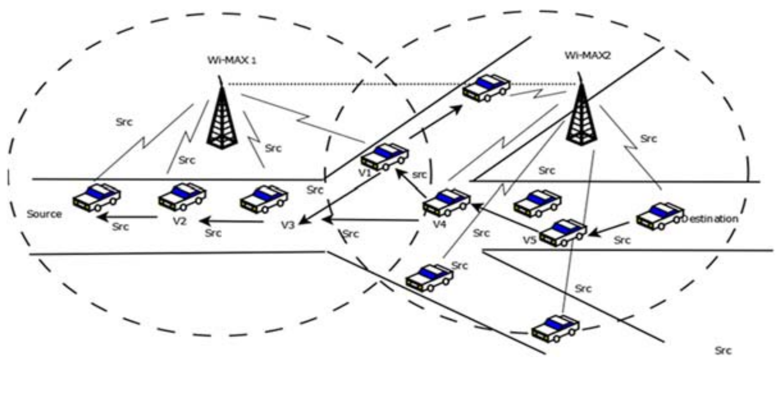

Fig. 5. Route Discovery phase.

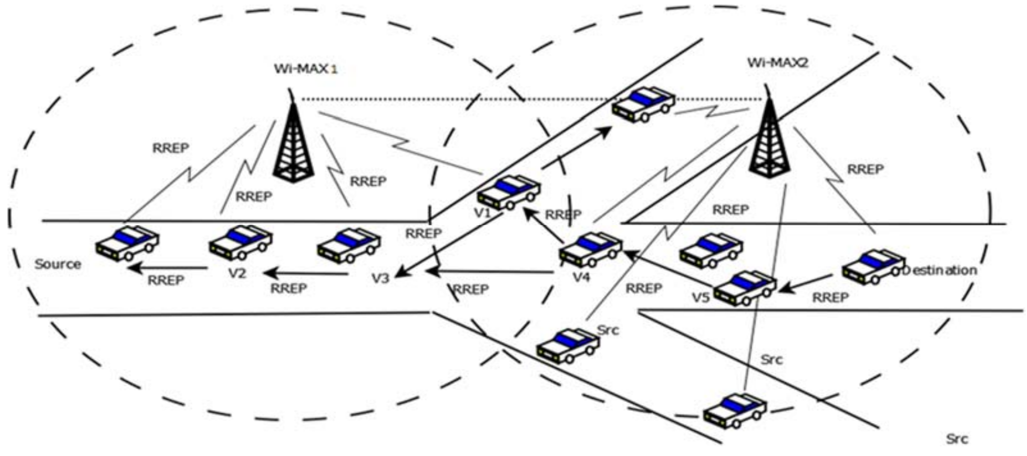

Fig. 6. Route Discovery phase.

VN adds the available bandwidth and host ID to the RREQ message, taking advantage of the dual-mode interface. This method is repeated until the target has been identified. When the RREQ message is received by the intermediate node WiMAX, it performs two functions:
(i) it acts as a visitor's database for identifying the accessible VN, and
(ii) it determines the amount of bandwidth available for executing the request through the RREQ message. Take a look at it. Once an accessible destination is identified, the source ID and bandwidth request fields in the RREQ header are changed with the host ID and available bandwidth information. The amended RREQ packet is forwarded to the destination virtual network. Alternatively, if WiMAX does not identify any accessible nodes from a visitor, WiMAX checks the home register for the presence of a VN entry. If a match is identified for VN, a modified RREQ message is delivered to VN to notify him of the match. To modify RREQ messages, the RREQ header is updated to include both the host ID and the amount of available bandwidth. As illustrated in Figure 2, if no VN entry is identified, another neighboring WiMAX is searched, and an RREQ message is delivered through the WiMAX network to identify the destination node. Vs3-WiMAX1-WiMAX2-Vd3.

(b) Route Selection phase: Taking into account the transmission time and the number of intermediate nodes in our RDP, we designed the metric routing algorithm. It is stated as the routing metric (RM) and routing selection (RS) of RDP:

Let set $= M_1,\ M_2,\ M_3. \ . \ . \ M_n$, where n be the number of nodes (VN and WiMAX) in Hybrid Network.

Multiple paths may be discovered after the route discovery process has been completed. Hence, the found routing path (RP) between any source and destination can be defined as follows:

$RP_{(M_s,\ M_p)} = P_1,\ P_2,\ P_3. \ . \ . \ P_i$, where i be the route number of the path found such that $M_s,\ M_p \in N$ with $M_s \neq M_p$, M_s and M_p represent the source and destination node, respectively and

$P_i = M_s$ with the constraint $M_1,\ M_2,\ M_3, \ . \ . \ . \ M_p$.

The absolute value of P_i is greater or equal to two and less than or equal to Nmax because the source cannot be a destination i.e. $2 \leq |P_i| \leq M_{max}$, where $M_{max} =$ the maximum number of intermediate nodes in P_i and $|P_i| =$ number of nodes in P_i , and for all P_i we have the following conditions:

$d(M_r,\ M_{r+1}) \leq T(M_r),\ such\ that\ \forall\ M_r,\ M_{r+1} \in P_i\ satisfying\ \ 1 \leq r \leq |P_i| - 1$,
where $T(M_r)$ is the transmission range of M_r and $d(M_r,\ M_{r+1})$ and is the distance between M and M_{r+1} i.e $d(M_r,\ M_{r+1}) = |M_{r+1} - M_r|$.

Each pair of $(P_i,\ P_r)$ is disjoint i.e. $P_i \cap P_r = \varphi$ in intermediate node $1 \leq i \leq j,\ \ 1 \leq r \leq j,$ where j is the number of the path in the route discovery phase.

Our goal is to reduce transmission time by using a limited number of intermediary nodes:

$$Transmission\ time(P_i) = \frac{Data\ Size}{\min\ \{AB(M_1),\ AB(M_2),\ \ AB(M_3),\ \ .\ \ .\ \ .\ \ AB(M_{|P_i|})\}}$$

Where $AB(M_j)$ represent the Available Bandwidth of M_j.

Next, we design the RM function of RDP as follows:

$$RM_{RDP}(P_i) = \frac{\chi_{req} - \min \chi(P_i)}{\chi_{req}} + \ |P_i|, \qquad 1 \le i\ \le n, \quad n\ \in N$$

χ_{req} represent the requested bandwidth of M_s and

$$\min \chi(P_i) = \min\ \chi(M_1),\ \ \chi(M_2),\ \ \chi(M_3),\ \ .\ \ .\ \ .\ \ \chi(M_r), \quad \forall\, M_r\ \in\ P_i\,, \quad 1 \le r \le\ |P_i|$$

As you can see, RDP's Route Selection function (RF) is defined this way:

$$RF_{RDP}\left(RP_{(M_s,\ M_p)}\right) = \min\ RF_{RDP}(\,P_1),\ \ RF_{RDP}(\,P_2),\ \ RF_{RDP}(\,P_3).\ \ .\ \ .\ \ RF_{RDP}(\,P_n)$$

Where n is the number of paths found?
More precisely if $RF_{RDP}(\,P_j)$ and $RF_{RDP}(\,P_i)$ Are the same as a route with a higher average value is selected. VN makes the Several times, this process is repeated until the target has been discovered. It serves two roles when the intermediary node receives the RREQ message: (i) it checks the visitor's database for identifying the accessible VN, and (ii) it calculates the amount of bandwidth available for performing the request sent by the RREQ message. Whenever a reachable destination is discovered, the source ID and bandwidth request fields in the RREQ header are updated with information about the destination virtual network's host ID and available bandwidth. The revised RREQ packet is delivered to the virtual destination network. Alternatively, if WiMAX does not detect any accessible nodes from a visitor, WiMAX examines the home register to see whether there is a VN item in the home register. Whenever a match is found for VN, a modified RREQ message is provided to VN in order to alert of the match. RREQ messages are modified by modifying the RREQ header, which includes both the host identification number and the amount of bandwidth available. When no VN entry can be found, another surrounding WiMAX is examined. An RREQ message is issued via the WiMAX network to identify the target node, as depicted in Figure 2. Vs3-WiMAX1-WiMAX2-Vd3.

4.2 Load Distribution Process

The process of load balancing is described in depth in this section. We are all aware that the WiMAX network's bandwidth capacity is restricted. The following section will discuss the significance of WiMAX capacity testing. WiMAX capacity testing determines whether or not WiMAX can meet the bandwidth demands of incoming requests. The following is the formula for calculating the WiMAX capacity test:
Bandwidth request by VN = Total bandwidth - Reserved bandwidth

Whenever the accessible WiMAX capacity test is unsuccessful, the WiMAX is designated as a "hotspot." Attempting to access the internet over a WiMAX "hotspot" (the first request to the WiMAX) and failing to do so owing to a failed capacity test results in the commencement of the load balancing procedure. This operation aims to discover another available way to connect to the internet through another available WiMAX network.
Registered virtual networks (VNs) are only supported on WiMAX networks. When WiMAX is overloaded, requests made from registered VNs may not be able to be handled properly. This section presents a WiMAX network expansion that overcomes the earlier issue while also supporting services from various cells via a virtual area network (VANET). This method also aims to decrease the block rate of the original WiMAX network, which is a side effect of this.

Simulation Parameter

The WiMAX network is labeled a "hotspot" whenever the accessible WiMAX capacity test fails. Suppose an attempt to connect to the internet through a WiMAX "hotspot" (the initial request to the WiMAX) fails to connect as a consequence of a failed capacity test. In that case, the load balancing mechanism is initiated. This operation aims to locate another open routing path that can be used to connect to the internet via another accessible WiMAX network that is now available.

In order to be supported, registered virtual networks (VNs) must be running on a WiMAX network that is presently operational. When WiMAX is overloaded, it is possible that requests from registered VNs will not be able to be correctly processed. This section describes a WiMAX network extension that addresses the problem above while also allowing services to be delivered from many cells via a virtual area network (VAN) (VANET). This technique also has the additional goal of reducing the block rate of the original WiMAX network, which is a side consequence of this method's implementation.

Parameters	Value
Number of WiMAX	6
Coverage of WiMAX	1km^2
Dual-mode Interface Specification	CDMA2000 1xEVDO and IEEE 802.11p
Max hops of each route	10
Mobility Model	Highway Scenario
VN Mobility	20km/h (fixed) to 120 km/h(fast)

Table 1 Shows the simulation parameters summarized in the simulation environment.

A "hotspot" is defined as a network that has failed the accessible WiMAX capacity test and has been designated. The load balancing mechanism is activated if an attempt to connect to the internet via a WiMAX "hotspot" (the first request to the WiMAX) fails to connect due to a failed capacity test. One of the objectives of this operation is to identify another accessible routing route that may be utilized for connecting to the internet through another accessible WiMAX network that has just become available.

Registered virtual networks (VNs) must be operating on a WiMAX network that is currently active to get support. Requests from registered VNs may not be able to be handled appropriately if WiMAX is overburdened, which is a possibility when WiMAX is overloaded. A WiMAX network expansion is described in this section, which overcomes the difficulty above while also enabling services to be offered from many cells via a virtual area network (VAN) (VANET). This strategy also has the additional purpose of lowering the block rate of the original WiMAX network, which is a byproduct of the method's implementation and is a side effect of the technique:

$$\text{Service Rate(SR)} = \frac{\text{Number of VN requests to access the HN}}{\text{Total number of VN in HN}} \times 100\ \%$$

The ratio of VNs that begin routing requests (RREQ) in HN is represented by the SR value. Each homogenous network's routing requests are included inside the routing requests. As a result, the RREQ message may request that the path to a particular VN (original Vehicular Ad-Hoc Network) or the WiMAX be determined via investigation (original WiMAX). In the next section, we define the request ratio between the original Vehicular Ad-Hoc network and WiMAX as follows:

$$\text{Adhoc Service Rate} = \frac{R}{S} \times 100\ \%$$

Where R, S are #VN requests to deliver data for specific VN and Total number of VN in HN, respectively.

$$\text{WiMAX Service Rate} \quad = \frac{I}{S} \times 100\ \%$$

I, S are #VN requests to access the internet through WiMAX and Total number of VN in HN. Therefore, we can define service rate as follows:

S R (Service Rate) = Ad-hoc Service Rate + WiMAX Service Rate

The service rate mentioned above is set as an initial value in the simulation. Moreover, the Vehicular Ad-hoc Service Rate and WiMAX Service Rate ratio are half of the service rate. The classes of request bandwidth are set according to the service capabilities in 3GPP (Third Generation Partnership Project) standardization. The maximum moving speed of VNs varied from 0 to 120 km/h. The maximum hop ten is set to forward the data.

Performance Analysis

An algorithm's performance is measured by how many packets are delivered, how long it takes to send a packet, and how many paths it takes —block rate, transmission time, request block ratio, and request block rate with load distribution.

6.1 Average Delivery Ratio

FIGURE 7 illustrates that the suggested method outperforms previous protocols in terms of performance for each density. It is worth noting that all protocols get more sensitive as the number of nodes becomes larger. Because the proposed method works better, it is more likely that the majority of the delivered packets will reach their destinations, resulting in a reduced rate of packet drops. As the number of nodes in a GPSR network grows, the packet delivery ratio decreases substantially. A significant reason for this is that an increase in overhead packets would cause the network load to grow dramatically, increasing the number of lost packets. The suggested solution has the added advantage of optimizing forwarding traffic. When comparing GPSR performance to that of the suggested one, it is evident that GPSR performance is more influenced by network competition. Compared to the existing network, the proposed one retains a broad connection with highways and WiMAX across the network.

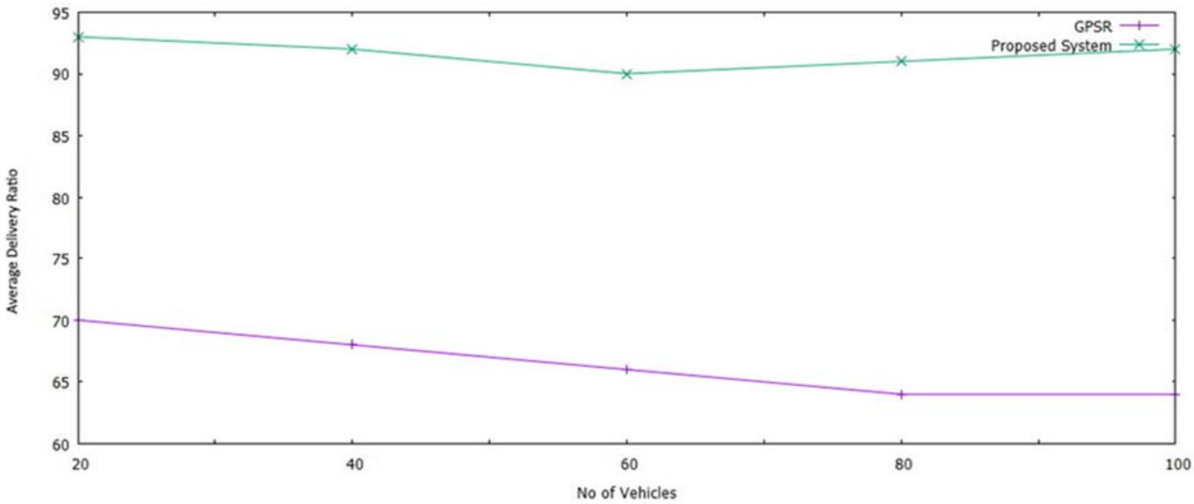

Fig. 7: Node count as a percentage of average delivery ratio.

6.2 Average Delay

Figure 8 illustrates that the proposal functions best when there is a delay of 100 nodes between each request. There is evident competition on the radio channel in this situation, and the average delay value of GPSR is sufficiently large. This refers to the amount of time a packet spends in transit before reaching its destination. However, GPSR greedily forwards the packet to its destination, so the effect of delay is reduced. Because it takes advantage of the suggested forwarding optimization, the proposed routing algorithm performs much better than other routing algorithms.

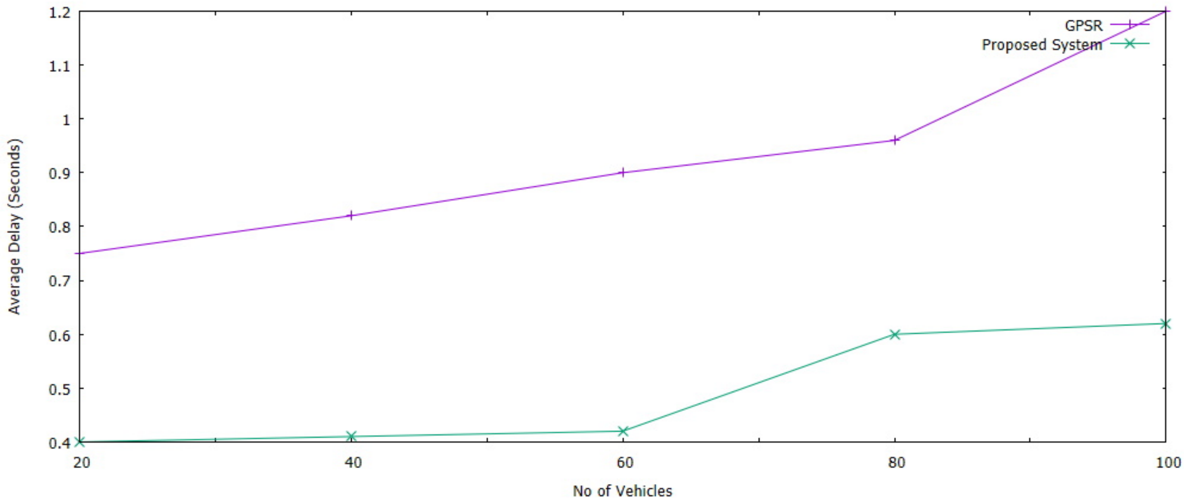

Fig. 8 Number of nodes versus average delay ratio.

6.3 Impact of Number of flows

As seen in Figure 9, the number of concurrent flows is used to determine the system's performance. The transmission speed of packets is the same for all the protocols. According to the literature, the fewer the number of flows, the better the protocol's performance in terms of packet delivery rate. The suggested method outperforms the other protocols when compared to the others. As a result, the GPSR system always maintains a low average latency. On the other hand, the suggested average delay is more sensitive to extra flows that maintain a short average delay. As a result, the simulated procedure in the suggested one is designed to minimize the loss of delivery rate.

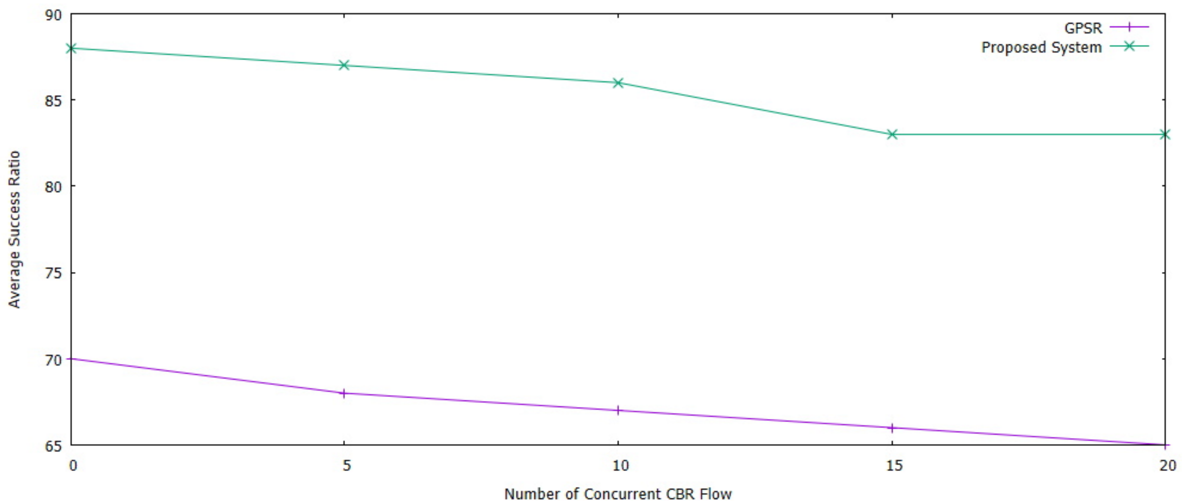

Fig. 9. Percentage of times a flow has been completed.

6.4 Average Path Length

As you can see in Figure 10, the average number of node hops for packets that arrive at the end point is 100. This proposal uses a method called "optimised forwarding," which means that packets are sent to the farthest node that is closest to the destination. This means that there are fewer hops than there are with GPSR. GPSR forwards packets to the most geographically distant node in a greedy way that may not be in the direction of the destination, resulting in a longer average path length compared to the proposed one.

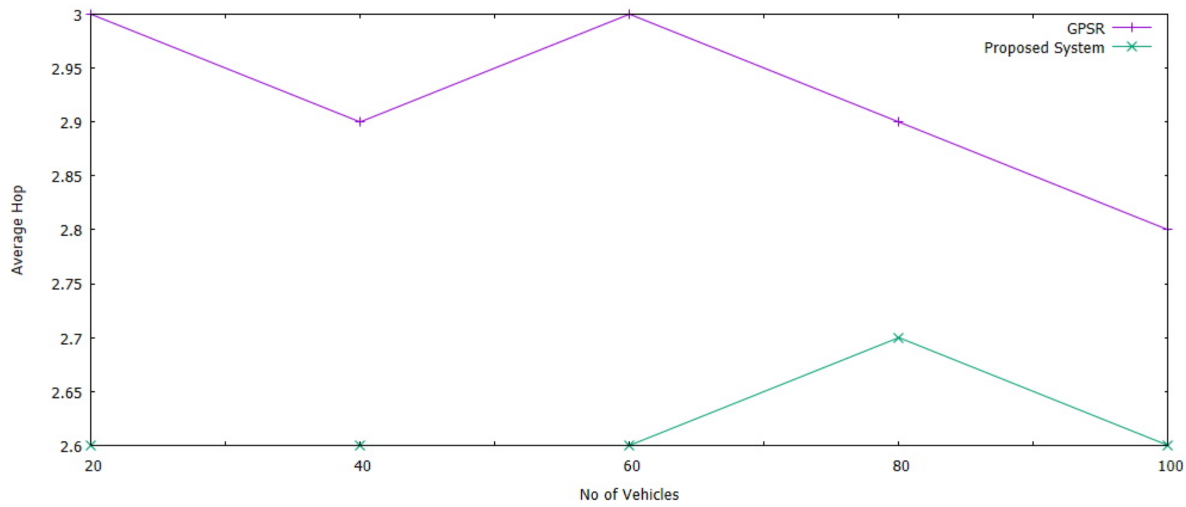

Fig. 10. Path length vs. the number of nodes in the network.

6.5 Block Rate

An example of the comparison between a homogeneous ad hoc network and a suggested hybrid network utilizing a routing algorithm is shown in Figure 11. I have configured the car ad hoc service rate as the same as a comparable ad hoc network that uses the GPSR algorithm but with a WiMAX service rate set as a backup plan. This decrease in the desired block rate is since GPSR is not present in the WiMAX network.

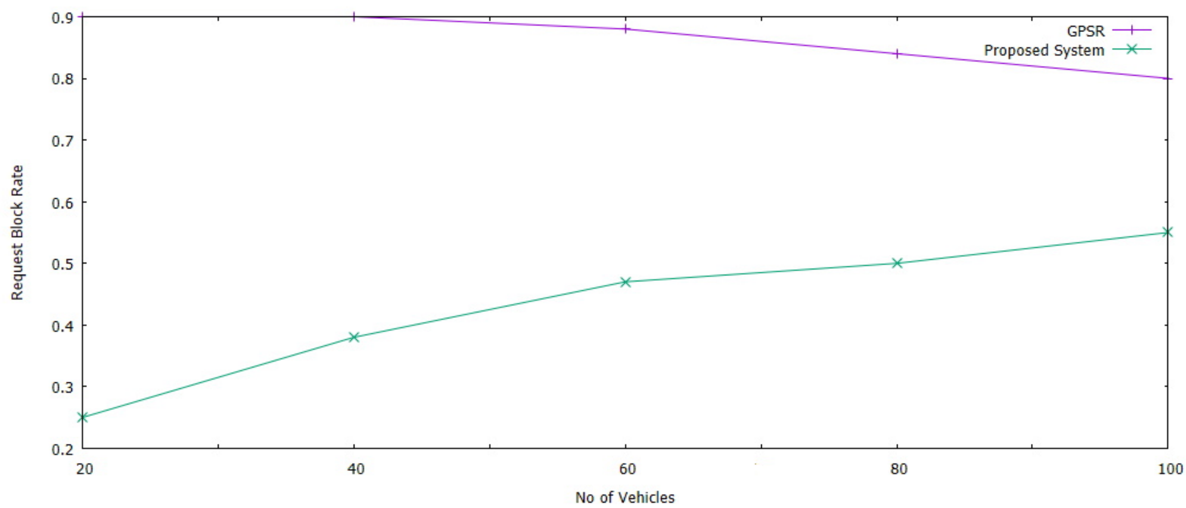

Fig. 11. Network node count vs. request block rate

6.6 Transmission Time

Figure 12 shows the transmission time mentioned above. The transmission time is compared between GPSR and the proposed routing algorithm, and the data size delivered is set to 1MB. SR. The vehicle ad hoc and WiMAX service rates are set to S2R (= 0.15). In Figure 12, the propagation time of the proposed routing algorithm is about 10-30% shorter than the propagation time of GPSR. This reduction occurs because the routing algorithm chooses the path with the lowest route metric. However, GPSR does not select the path with the smallest route metric. Therefore, the GPSR transmission time will be longer than the path detected by the proposed algorithm.

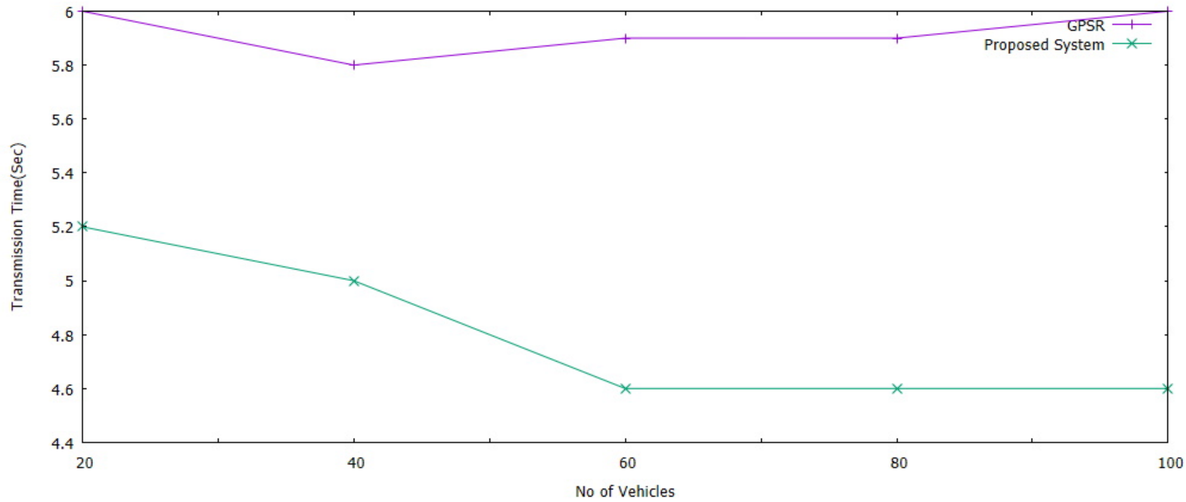

Fig. 12. GPSR transmission time in comparison to the suggested routing's transmission time.

6.7 Request block rate with and without LDP (Load distribution process)

Figure 13 compares the request block charge of a routing set of rules without a load distribution method and a routing set of rules with a load distribution technique in a multi-cell environment. The SR is ready to be utilized to see the outcome of the load distribution method with greater convenience. Furthermore, the WiMAX Service Rate (also known as SR) is ready to ramp up the mobile community traffic. The proposed routing set of rules with a load distribution procedure reduces the block charge of a request because it uses the load distribution procedure to discover another available routing route to gain access to the internet via different available WiMAX. At the same time, the first registered WiMAX of VN becomes a "Hot Spot," while the first registered WiMAX of VN becomes a "Hot Spot." In another way, routing allows for more VNs to have access to the HN via the load distribution mechanism.

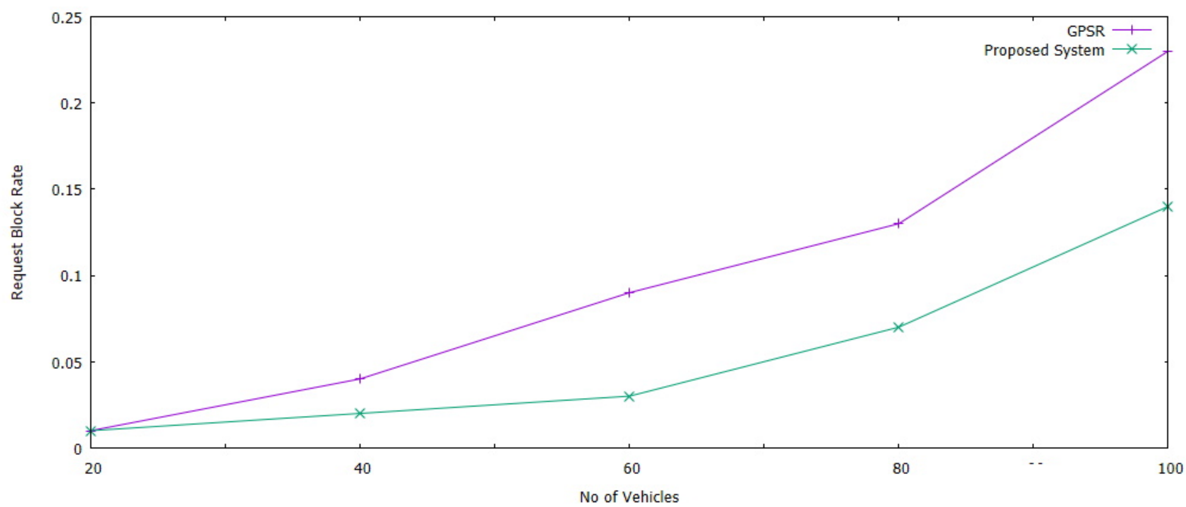

Fig. 13. Using LDP vs. not using LDP to prevent requests from being blocked.

Conclusion

An architecture for a hybrid network, consisting of a multi-WiMAX network and ad-hoc vehicle network, is presented in this article. In order to make use of the benefits of the HN's homologous network, we suggested a routing algorithm composed of two processes: a route search process and a load balancing process. While the suggested hybrid network routing method maximizes the average packet deliver ratio, it also minimizes other parameters such as the average latency, route length, and the block rate. In addition, to check for WiMAX overload, the load balancing procedure employs a straightforward capacity testing technique. It is shown via the simulation process that the suggested routing algorithm beats homogenous routing techniques since it can serve a more significant number of consumers.

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