GEOCAST ROUTING PROTOCOLS FOR VEHICULAR AD-HOC NETWORKS: A SURVEY

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ABSTRACT

Geocast routing is considered to be advantageous in VANETs, as most of the safety applications are location-based and are relevant to a particular geographical area rather than individual vehicles. Hence, the geocast routing approach where data packets are delivered to a specific geographic area or zone of relevance has become an important research area among researchers and academicians. This article surveys the existing geocast routing protocols for the vehicular environment and compares them qualitatively based on various parameters. The pros and cons of each routing protocol are discussed. Certain directions for future research related to geocast routing protocols are also presented.

KEYWORDS

Vehicularad-hoc networks, Geocastrouting protocols, Inter-vehicular communication, Intelligent transportation systems, V2V and V2I communication.

1. INTRODUCTION

Despite rising concerns about the harmful impact of vehicles on the environment, vehicular transportation remains and will continue to be the foremost mode of transportation for millions of people. A dreadful and unsustainable situation regarding traffic congestion and safety can be forecasted seeing the present trend of vehicle usage. According to a global status report on world safety [1], approximately 1.24 million people die on the road each year, mostly preventable road crashes equating to 2 deaths in a minute. An estimated 2 million people in India alone are living with injuries caused due to traffic accidents. Sometimes, injuries caused by road accidents are life-changing and source of poverty, debt, and despair. Road traffic injuries are seen as unpredictable events that happen to the unlucky individuals. However, this is not true. Road traffic injuries that claim so many lives are predictable. Road safety is a well-researched and well documented global topic. Moreover, traffic congestion has become a worldwide problem. Traffic congestion not only tests people's patience but is also a significant drain on their wallets and country's economy. In the United States and Europe, an ordinary man spends an average of 111 hours per annum in traffic congestion. The combined cost of traffic congestion is likely to rise to $293.1 billion by 2030, an almost 50% increase from 2013[2].

Researchers and academicians have become quite interested in vehicular ad hoc networks (VANETs) as a result of its ability to provide solutions to the majority of traffic issues. As seen in Figure 1, cars equipped with wireless sensors and on-board computers can communicate with one another to exchange traffic-related data. Intelligent Transportation System (ITS) integration of vehicles as active computation and communication agents opens up a wide range of possibilities, including the ability to choose the least crowded routes, alert drivers to accidents, play multiplayer games with other drivers, and more[3]. Numerous initiatives and consortia were established to explore the potential of VANETs due to the significance of VANETs in lowering accidents and enhancing traffic safety. In the early 1980s, one of the pioneering research on vehicular communication was conducted by the Japanese organisation JSK (Association of Electronic Technology for Automobile Traffic and Driving). The method of constructing a train by two or more vehicles was also shown by Chauffer of Europe [4] and California's PATH [5]. A European project called CarTalk [6] also looked for issues with enjoyable and safe driving based on communicating vehicles. After then, other research projects were carried out in order to examine the idea of vehicular communication and to standardise in order to make it possible for all vehicles, irrespective of model or construction, to communicate with one another.. The research initiatives, consortiums, and testbeds created by the research community for VANETs and ITS are listed in Table 1.

VANET is a special subclass of Mobile Ad-hoc Network (MANET), but it has a variety of features that define it apart from MANET. These characteristics include high mobility, preconfigured vehicle traffic conditions, rapid dynamic topology, and enough storage capabilities [7]. The network architecture of VANETs incorporates many types of vehicular communications. Vehicle-to-Vehicle (V2V) and Vehicle-to-Infrastructure (V2I) cellular networks are examples (see figure 1). Due to its distinctive features, VANETs provide a variety of difficult research problems, including routing, data aggregation, data distribution, security, and many more. The routing method chooses the most effective route for a packet to travel from source to destination. The research community has been actively advancing the field of routing in VANETs for more than ten years by putting forth fresh algorithms and protocols to address difficult problems. All the nodes in a certain instance that are part of a particular geographic region will receive the message through geocast routing, which is a type of position-based multicast routing. This routing technique is useful in VANETs since the majority of safety applications are location-based and pertinent to a specific geographic area rather than specific vehicle. The Global Positioning Systems are used to obtain a vehicle's geographic location needed for routing (GPS). In the near future, it's highly possible that most, if not all, vehicles will be fitted with GPS receivers, which are already common in many vehicles today.

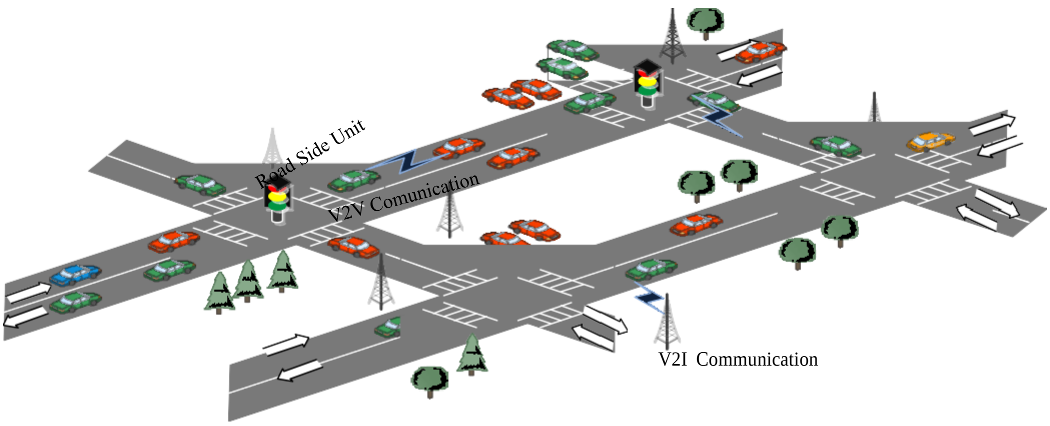


Figure 1. A typical vehicular ad-hoc network scenario

This paper's major objective, in contrast to other wireless ad hoc networks, is to discuss techniques created expressly for geocast routing in VANETs. However, just a few geocast routing algorithms that are appropriate for the VANET environment are selected and contrasted based on the forwarding strategy, communication environment, and other pertinent criteria. There are many other suggested solutions. The benefits and drawbacks of various routing methods are also discussed, and some promising directions for future research in the field of geocast routing protocols for VANETs are offered.

Table 1. VANETS and ITS Research Project, Consortiums, and Testbeds

Projects	Project Description
C2C-CC (Car-to-Car Communication Consortium)[9]	The primary objective of C2C-CC, a non-profit organization, is to increase traffic safety and efficiency using cooperative ITS. It is an attempt by the European manufacturers to assist the creation of standards that will eventually enable vehicles of different brands and designs to interact with one another. This will be possible thanks to this initiative.. http://www.car-to-car.org/
CARLINK Consortium (Wireless Traffic Service Platform for Linking Cars Project)[10]	To develop a smart wireless traffic service platform to link cars having wireless transceivers. The fundamental applications of this platform are urban transport traffic management, real-time local weather data collection, and urban traffic information announcement. http://carlink.lcc.uma.es/
SEISCIENTOS (Providing ubiquitous adaptive services in vehicular contexts)[11]	To create a framework that provides dedicated service to end-users in a pervasive vehicular environment. http://www.grc.upv.es/600
DIRICOM (Intelligent Design of Wireless Communication Networks)[12]	To solve wireless network design problems using meta-heuristic techniques. http://diricom.lcc.uma.es/
WiSafeCar (Wireless Traffic Safety network between Cars)[13]	To develop a reliable wireless traffic safety network among cars to prevent traffic accidents, enhance traffic safety, and to provide various other services to vehicles. http://wisafecar.gforge.uni.lu/
MARTA (Mobility and Automation through Advanced Transport Networks)[14]	To analyze the ITS from the scientific perspective focusing on areas such as safety, efficacy, and sustainability. www.centimarta.org/
COMeSafety (CO-OPerative SystEms forIntelligent Road Safety)[15]	To support the eSafety forum towards issues related to V2V and V2I communications as the basis for co-operative intelligent road transport systems. http://www.comesafety.org/
iTETRIS (An integrated Wireless and Traffic Platform for Real-Time Road Traffic Management Solution)[16]	To develop an integrated wireless and traffic evaluation platform for long-term and large-scale simulations of cooperative traffic management applications. http://www.ict-itetris.eu/
NOW (Network On Wheels)[17]	To solve key technical problems of the communication protocols and data security for car-2-car communications. www.network-on-wheels.de
COOPERS[18]	To set up and test a system for the mobile supply of safety-related information on traffic conditions and infrastructure. http://www.coopers-ip.eu/
PReVENT (PReVENTive and Active Safety Applications)[19]	The purpose of this project is to create and assess safety-related applications by integrating cutting-edge sensor and communication technology into onboard systems intended to aid drivers. http://www.prevent-ip.org/
SAFESPOT (Smart Vehicles on Smart Roads)[20]	The capability of autonomous vehicle systems is limited by the peripheral vision of their sensors. Cooperative systems using V2V and V2I communications can considerably enhance this vision, thus advancing to a revolution for road safety. www.safespot-eu.org
SEVECOM (SEcureVEhicle COMmunication)[21]	To provide the full definition and implementation of security requirements for vehicular communication. www.sevecom.org
SIMTD (Safe Intelligent Mobility-Test Area	The goal of this project is to design, develop, and explicitly test a networking technique that can be used as a stand-alone software component that can be integrated

Germany)[22]	into cooperative systems. http://www.simtd.de/
GeoNet (Geographic addressing and routing for vehicular communications)[23]	To implement and formally test a networking mechanism as a standalone software module that can be incorporated into cooperative systems. This project specifies, develops and test IPv6 geo-networking to use it with cooperative systems. http://www.geonet-project.eu/
EVITA (E-Safety Vehicle Intrusion Protected Applications)[24]	To develop, validate, and prototype structural components for automobile on-board networks that secure security-relevant parts from manipulation and sensitive data from attack. http://evita-project.org/
eSafetySupport[25]	To help transport stakeholders in raising public understanding of the immense impact intelligent vehicle safety systems, often known as eSafety systems, may have on traffic safety. http://www.esafetysupport.org
COM2REACT (COoperative CoMMunication Systems to Realise Enhanced EffiCiency in European Road Transport)[26]	To develop and test a cooperative and multi-level Virtual Sub-Centre (VSC) concept for road traffic management using bidirectional Vehicle-to-Vehicle (V2V) and Vehicle-to-Centre (VTC) communication. http://www.com2react-project.org/
AKTIV (Adaptive and Cooperative Technologies for Intelligent Traffic)[27]	To design, develop, and evaluate driver assistance systems, knowledge and information technologies, efficient traffic management systems. http://www.aktiv-online.org/index.html
CVIS (Cooperative Vehicle-Infrastructure Systems)[28]	To develop pan-European technology platform between vehicles and the infrastructure for wireless communication. http://www.cvisproject.org/
PRE-DRIVE C2X (PREparation for DRIVing implementation of C-2-X communication technology)[29]	To organise a massive field test of vehicular communication technologies. http://www.pre-drive-c2x.eu/
TRAVOLUTION[30]	Using evolutionary algorithms to optimise network-wide traffic signal coordination and evaluating traffic signal communication. http://www.gevas.eu/unternehmen/
FleetNet (Internet on the Road)[31]	To provide a communication platform for data exchange in car-to-x communication and to standardize the solutions found so as to improve driver and passenger safety and comfort. http://www.fleetnet.de/
GST (Global System for Telematics[32]	To develop an open architecture for interoperable telematics applications. http://www.gstforum.org/

2. VANET OVERVIEW

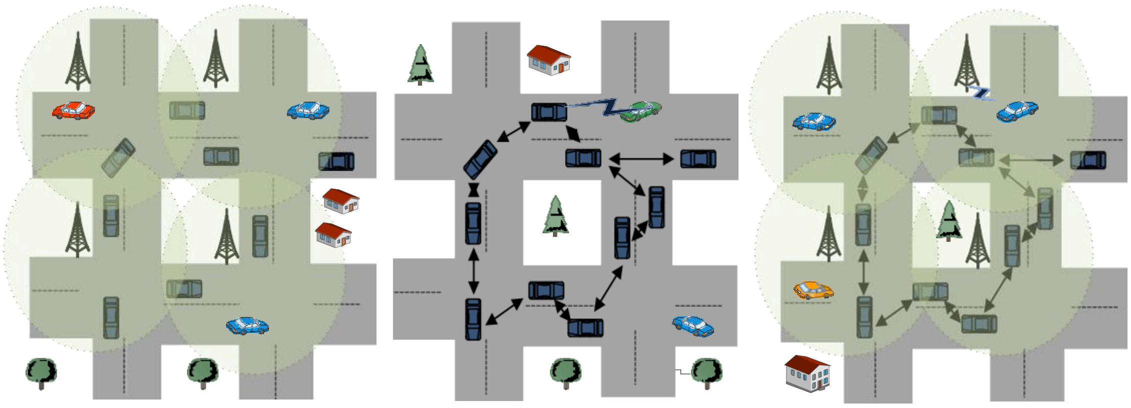
2.1. Architecture

The architecture of VANETs can be categorized typically into three kinds[7]: pure infrastructure, pure ad-hoc, and hybrid as shown in
Figure 2.

- **Pure infrastructure architecture**: In this architecture, At traffic intersections, VANETs use static cellular gateways and access points to collect traffic data, route data, or connect to the internet. Long term evolution (LTE), IEEE 802.16, IEEE 802.11, and 3G cellular networks are examples of upcoming heterogeneous technologies that can be integrated using this type of VANET architecture.
- **Pure ad-hoc architecture**: Costs associated with setting up cellular gateways and access points rise as the network gets bigger. Therefore, for big networks, pure infrastructure

architecture is impracticable. As a result, automobiles are encouraged to connect with one another to create pure ad-hoc communication, an infrastructure-free network. Information is gathered from the sensors installed in vehicles in the case of an accident or other emergency event, and it is then used to alert other vehicles to prevent traffic congestion.

- **Hybrid architecture**: In a hybrid architecture, vehicles can ask infrastructure for some relevant information and then, through ad hoc communication, exchange this information with other vehicles. More helpful content and greater freedom in sharing content with other nodes are both provided by hybrid communication.



(a) (b) (c)

Figure 2. VANET architecture: (a) pure infrastructure (b) pure ad-hoc (c) hybrid

2.2. Characteristics

Vehicles serve as both communication and computation agents in a network called a VANET. Similar to other ad-hoc networks, it is self-organizing, self-managing, and distributed, but it has a few distinctive qualities that make it a difficult class. The distinctive characteristics of this network are as follows:

- **Frequently changing network topology**: Vehicles move at a fast pace that ranges from 90 kmph to 150 kmph on highways and between 30 kmph and 50 kmph in urban areas. They might even go in opposite directions. Since vehicles can regularly join to or disengage from the network in a little time, topological changes happen frequently and quickly [7].
- **Node velocity:** Roadside units, which are stationary structures along the side of the road, are one type of node in VANETs (RSUs). These nodes' velocities can range from zero for RSUs or snarled-up cars to 200 kmph for those travelling on a highway. When nodes in VANETs move quickly, they are only briefly inside each other's transmission range. Only a little quantity of data is transferred since this brief meeting creates a topology that is extremely unstable for routing and data distribution. In contrast, when they move slowly, a network that is incredibly dense forms, which may cause severe interference and channel congestion issues.
- **Variable node density:** Another crucial factor in a vehicular environment is node density. The quantity of moving nodes in a given area at any given time is known as node density. It might be very low in rural and suburban settings or highly high in an urban area particularly during a traffic jam. Node density is also influenced by the time of day. Typically, morning and evening are regarded as "rush hours" or times of peak traffic.

Inter-vehicle communication is unlikely because roads are deserted during off-peak hours, which are typically nights [33].

- **Heterogeneity of nodes:** Coexisting on the roads and taking part in vehicular communication are several types of vehicles and infrastructure. In terms of processing speed, storage capacity, and even transmission range, vehicles could differ from RSUs. Additionally, RSUs or infrastructure units can be identified based on their capabilities. Some RSUs merely transmit data over the network, while others give users access to backbone networks (e.g. to inform traffic operation centre about road conditions). Vehicles can also be divided into categories like private, government, road construction and maintenance, and so forth. In fact, not every programme can be installed in every kind of car. For example, only an emergency vehicle should be able to alert other moving vehicles to its impending presence.
- **Sufficient storage and energy:** Nodes in VANETs are not constrained in terms of power or storage. Their power is limitless. Communication, GPS, and other equipment may be continuously powered by a car's engine.
- **Hard delay constraint:** Hard delay limits, or the requirement that information be transmitted within the allotted time, are necessary for active safety applications of VANETs. For instance, to prevent a collision, other vehicles should get the signal immediately when a vehicle hits the brakes on an automated highway [7].
- **Propagation model:** In general, VANETs exist in three different communication contexts: urban, rural, and interstate. Since buildings, trees, and other objects function as obstacles to the signal propagation that affects wireless connection between vehicles, the communication scenario in cities is highly complicated. These obstructions result in fading multipath effects and shadowing. As a result, applying the free-space propagation concept to a city setting is inappropriate. Additionally, the various terrestrial shapes found in rural locations, such as wide-open fields, mountains, steep climbs, and dense woods, cause signal attenuation and reflection. The propagation model cannot be assumed to be free-space in this circumstance either. Due to the great relative speed of the automobiles on highways, the connection between them frequently breaks. Although highways are thought of as unrestricted spaces, the signal might be reflected by the walls that surround them. Therefore, a propagation model should take into account the impact of interference caused by other vehicles and the presence of widely dispersed access points [34].

3. GEOCAST ROUTING

For the Internet, GPS-multicast [35] was first suggested as a way to expand the Domain Name Server's (DNS) support for geographic addresses[36]. In comparison to conventional IP address-based multicast, it is seen as a more natural and effective routing method for location-based applications [35]. Figure 3 illustrates how geocast routing tries to send data packets to a group of vehicle nodes located in a designated geographic area known as the Zone of Relevance (ZOR). To prevent an unneeded fast response, the cars outside the ZOR are not warned. When a source uses geocast routing, a location-based routing protocol tries to send data packets to every node in the geocast region that was specified by the source. Whether a node receives a message or not depends on its geographical position [37]. Because the majority of safety applications are location-based and apply to a certain area rather than specific cars, the geocast routing strategy is advantageous in VANETs.

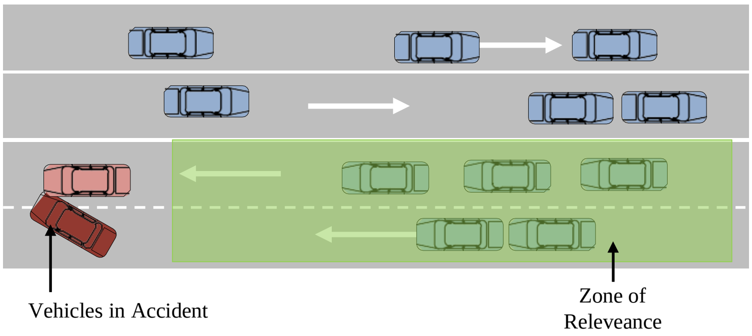


Figure 3. Geocast Routing

Beaconing, location services, position-based routing, and maintenance of neighbor's data are crucial elements of a geocast routing [8].

- By sending out brief messages on a regular basis, beaconing is an easy method of locating neighbours. The location, velocity, speed, heading, and other vital details about the transmitting vehicle are contained in beacons, also known as cooperative awareness messages. Each car broadcasts a beacon randomly and every 100–300 ms, in accordance with the DSRC protocol [38]. The cooperative awareness and safety applications are thought to be supported by beacons.
- To find the position of certain nodes taking part in the vehicular communication, the location service is queried. It is a site where all of the vehicles' geographical locations are kept. A controlled flood of request packets is used to reach a location service. The requested geographic location information is then returned by a qualified and authorised location service provider. Location query and response packet sizes are regarded as being the same as beacon packet sizes.
- Data is forwarded to a ZOR that may be limited or broad using position-based routing. Each data packet is sent to its destination by the source node, which chooses the next forwarding node based on the neighbours' locations. Nodes locally flood the data packets once it has reached one or more nodes in the ZOR.
- Every vehicle keeps a routing database to record the location, proximity, speed, and other pertinent data of other cars and infrastructure units nearby. By exchanging beacon packets among cars, the routing table is created and updated. When a vehicle gets a beacon packet, the entry for the relevant neighbour in its routing table is either created from scratch or modified depending on the data that is contained inside the beacon packet. A neighbor's item in the table is erased if a node does not receive a fresh beacon packet from them for a period of time.

4. GEOCAST ROUTING PROTOCOLS

Numerous geocast routing techniques have been put forth in the literature during the last few years. A couple of these routing protocols are thoroughly examined in this section.

1. **Inter-Vehicle Geocast(IVG) (2003,** [39]**):** It is a geocast technique that uses GPS to distribute alert messages to moving automobiles on a highway. Vehicles in risk regions are alerted to accidents or other obstacles using the IVG algorithm. The movement of a vehicle and its location in relation to other places help identify risky locations. The vehicle engaged in an accident or encountering an obstruction first alerts neighbouring residents to its situation. Some vehicles operate as relays to rebroadcast the alarm message to other vehicles since

vehicles within the transmission range of the accident vehicle receive the alarm message. After receiving a warning message, a node waits a while before sending out another alarm message. Defer time, the term for this waiting period, can be calculated as follows: (1).

$$defer\_time(x) = Max\_Defer\_Time. \frac{(R - D_{sx})}{R} \quad (1)$$

Here, R is represeting transmission radius and D_{sx} is represeting distance between $sender(s)$and $receiver(x)$. The deferred time is inversely proportional to the distance between the sender and the receiver. The node will conclude there is no relay behind it if it does not receive a similar warning message before the timer expires. The node designates itself as a relay and starts rebroadcasting. As shown in Figure 4, $V1$ choose $V3$ as its relay because IVG chooses the farthest vehicle as a relay. $V3$ can send a message to $V4$ while $V2$ cannot, as $V4$ is not in the transmission range of $V2$. IVG achieves a dependable multicast and lowers complexity and network overhead through simulations. However, IVG uses beacons to choose relay in an unneeded manner. As a result, nodes in close proximity to one another and at the border will have very similar (but not identical) timing values, which causes the spatial broadcast storm problem to occur in IVG. As a result, collisions occur when these nodes broadcast a warning message at the same moment. Ibrahim et al. [40] created probabilistic IVG, a lightweight addition to IVG, to address the issue of spatial broadcast (p-IVG). Depending on the density of nearby vehicles, the protocol decides whether to probabilistically rebroadcast the signal. In p-IVG, a vehicle chooses a random integer between 0 and 1 whenever it receives a frame. The timer starts if the chosen random number is less than $\frac{1}{node\_density}$. Therefore, the number of nodes that can begin their timer decreases with the increase in node density.

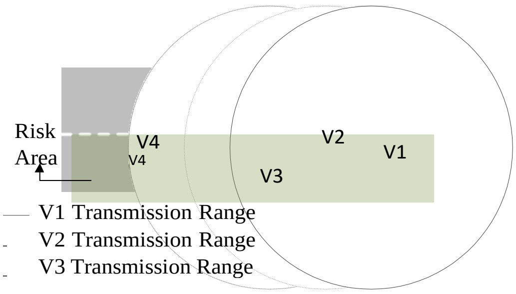


Figure 4. Illustration of IVG relay selection technique

2. **Abiding Geocast Protocol (AGP) (2005,** [41]**):** It is suggested that messages be sent to the fixed geographic area where they are still pertinent and relevant. The authors outline four components for sustaining the geocast message. When a new vehicle enters the area, these notifications are either sent on demand or at regular intervals. AGP employs three strategies to store geocast messages and ensure that they are time stable: server, node election, and neighbour. A geocast message is unicasted to the server when using the server technique. The geocast message is then periodically broadcast to the area by the server via a routing protocol. A node is chosen to serve as a server in the node election approach. The geocast message is then periodically broadcast to the area by the server via a routing protocol. A node is chosen to serve as a server in the node election approach. The chosen node periodically transmits new geocast signals or does so whenever a new vehicle enters the area. When the elected node departs the area, the election process is repeated, and the message is transferred

to the newly selected node. All nodes in the geographical area store geocast messages using the neighbour technique. Each node keeps a neighbour database where it keeps track of the details of its neighbours. The geocast notification is sent to any new vehicles that enter the specified area. AGP, however, has several drawbacks.The procedure of handover, or assigning another node the duty of acting as a server, is not feasible in a sparse network, to start. Second, due to network overhead and the high infrastructure cost, the server strategy is impractical for large ad hoc networks. Additionally, the protocol does not aim for reliability.

3. **Distributed Robust Geocast (DRG) (2007,** [42]**):** It is an inter-vehicle communication routing protocol that is entirely dispersed. The DRG protocol does not keep a neighbour table and tries to transmit messages to every vehicle in ZOR. Outside of ZOR, a geocast message is dropped by vehicles. The zone of forwarding (ZOF) idea is developed to address the issue of regularly changing topology and to improve the trustworthiness of a received geocast message. The only things that can send messages to ZOR are cars in ZOF. To choose a relay to forward the geocast message, it employs a distance-based back-off mechanism. When a vehicle gets a message, it plans to transmit the message once the back-off period is through. The back-off period is inversely correlated with the distance between the competing node and the prior broadcaster. The contest is won and the relay is then the car that is furthest away from the sender vehicle. The time-based back-off based on distance is determined by (2).

$$BO_d(R_{tx}, d) = MaxBO_d . S_d \left(\frac{R_{tx} - d}{R_{tx}} \right) \quad (2)$$

where BO_d is the back-off time, $MaxBO_d$ is the maximum allowed back-off time, S_d is the distance sensitivity factor which fine tunes the back-off time, R_{tx} is the node's transmission range, and d is the distance between current node and the last sender. After sending geocast message for the first time at time t, the relay schedules next transmission after $t + MaxBO_d$, entering the contention for the next transmission. Node has the lowest chance of winning this time. DRG protocol can be used for routing in applications that demand speedy and dependable transmission. DRG, however, has some shortcomings. The first benefit is a high packet delivery ratio in remote, sparsely populated areas, albeit at the expense of higher overhead from repeated transmissions. The second issue with DRG is that it employs a fixed area for ZOF, which could result in network fragmentation and bandwidth wasting. The geocast message will be forwarded by some unrelated cars if ZOF is greater than the ideal ZOF, wasting bandwidth. The issue of network fragmentation may arise if the ZOF is less than the ideal ZOF.

4. **Robust VEhicular Routing (ROVER) (2007, [43]):** In VANETs, this protocol delivers dependable geographic multicast routing. Vehicles in ROVER have individual Vehicle Identification Numbers (VINs), GPS devices, and online access to digital maps. This protocol creates a multicast tree from the source vehicle to cars inside ZOR using a reactive route discovery technique. A multicast tree is created using geographic addressing. Multiple data packets from the source are forwarded via the multicast tree, which is constructed as needed. The triplet [A,M,Z] specifies the message format; "A" denotes the specified application, "M" denotes the message, and "Z" denotes the identity of the zone. If a vehicle is currently inside ZOR, it will accept the message. Like previous geocast protocols, this one makes use of the ZOF notion. The geocast message is forwarded to ZOR using all of the vehicles in the ZOF. It broadcasts the data packets and unicasts the control packets to improve efficiency and reliability. Applications requiring end-to-end quality of service can use this protocol (QoS). However, a lot of redundant messages are produced in the network, which causes congestion and significant delays in data transfer.

5. **Mobicast Routing Protocol (2008, [44]):** This protocol is a spatiotemporal geocast routing protocol, meaning that it takes both space and time into account. Its objective is to send a mobicast message from the source node to every ZOR node at a specific time t. To do this, a method is put forward to find the exact ZOF that solves the problem of space - time network fragmentation. This technique creates flexible ZOF by using a dynamic zone of approaching (ZOA). It supports a wide range of fascinating and practical VANETs applications, including online gaming, video ads, and many more. However, this approach has significant flaws, namely the fact that the ZOA is determined dynamically at time t. Network fragmentation may occur if ZOA is less than the ideal ZOA. On the other hand, extra cars forward the message if ZOA is greater than the ideal ZOA. Furthermore, the protocol does not adequately address the problem of network fragmentation. The protocol was extended by Chen et al. in [45] to address the issue of network fragmentation. When the network is sparse, they gave the carry and forward technique some thought. Despite efforts to address the issue of network fragmentation, packet delays continued to grow and were now intolerable for security applications.
6. **Dynamic Time-Stable Geocast (DTSG) (2009, [46]):** For a specific period of time, this protocol ensures message delivery to all cars entering a given area. The geocasting time has the option to be reduced or increased, making the protocol dynamic. In order to convey the geocast message and make it time-persistent in a specific area, DTSG protocol uses vehicles in the opposing lane. It distinguishes between pre-stable and stable modes. The pre-stable mode aids in the message's localization, and the stable mode aids in its creation of time stability. For a certain period of time, intermediary nodes can continue to function in the area by storing and relaying geocast messages, as is the case in the stable mode. An enhanced variation of the technique known as iDTSG was proposed by Y S Chen et al. in [47]. This approach is based on both counters and locations. More so than the DTSG, it reduces broadcast storm issues and changes the length of the extra region in accordance with vehicle density. For urban vehicular networks prompted by DTSG, Kaiwartya et al. suggested Traffic Light-based Time Stable Geocast (T-TSG) in [48]. There are three stages to the TTSG operation. In the beginning, the accident point is used to determine the Geocast Region (GR) from the Region of Interest (RoI). Second, depending on the state of the traffic lights, forwarding cars are chosen. Third, the Stable Vehicle Region (SVR) and Geocast Message Stable Region (GMSR) are selected based on the accident type. In SVR, the message is made time-persistent by the vehicles, whereas in GMSR, the geocast message must be accessible for a specific period of time. The forwarding, disseminating, and re-live (FDRL) approach is the name of this three-phase strategy.
7. **Constrained Geocast Protocol (CGP) (2010,** [49]**):** The cooperative adaptive cruise control (CACC) merging protocol is suggested. In CGP, as opposed to other protocols, the target set is determined by the nodes' future placements. Due to the high rate of transmission errors caused by network strain, this protocol seeks to transfer messages reliably and selectively. This protocol's drawback is that it has trouble with network fragmentation in rural locations. Additionally, as node density rises, the protocol's network overhead does too.
8. **GeoCache (2011, [50]):** It is a geocast request-reply protocol used for gathering and sharing congestion data. When a vehicle receives a message from the geocaching protocol asking for the congestion level, it first determines whether the message is coming from a vehicle on the same route or one on a different route. It will disregard the notification if it comes from a car travelling a different route. Then it determines if the ZOR supplied in the message corresponds to its present coordinates. If the vehicle is lying, it will broadcast the message to a different vehicle and respond to the source vehicle with the degree of congestion. To choose the best path to its destination, the source car uses data collected from other vehicles in a proactive and dynamic manner. The congestion level is computed by (3)

$$C_i = \frac{T - T_0}{T_0} \quad (3)$$

where C_i is representing congestion index, T_0 is represetingt the travel time when the car encounters no traffic and T is the true amount of time it takes to get there. The shortest route is calculated using a dynamic implementation of the Dijkstra algorithm. This programme also employs a caching technique to minimise broadcasts. Instead of acquiring the information through additional broadcasts, vehicles use the data that is cached. Geocaching is an on-demand routing system, which means that data collecting takes place as needed. The findings of the simulation demonstrate that there has been a significant improvement in the communication of information in terms of the reaction time and quantity of broadcast messages. However, Geocache uses the time-consuming Dijkstra algorithm to select the least crowded route. The route that was determined might not be the quickest or use the least amount of fuel.

9. **Zone-Based Forwarding(ZBF) (2011, [51]):** This approach offers both temporal and geographical information retention. During a predetermined period of time, ZBF is activated to warn drivers in a designated area of any potential danger (also called effective time). In other words, it's how long the message will remain visible. The algorithm creates segments of length R, where R is the vehicle transmission range, out of the effective region (also known as the designated area). Zones are the names for these sections. A vehicle is chosen to serve as a forwarder in each zone and is tasked with periodically broadcasting warning messages within that zone. A vehicle may be operating in one of the three modes—receive, forward, or relay—at any given moment. A vehicle is assumed to be a forwarder if it is in the forward mode. When a forward-mode vehicle is about to leave the zone, it switches to relay mode and starts the process for choosing a new forwarder. Every other car is set to receive and is getting recurring warning messages. Studies using simulations reveal that the protocol uses fewer network resources than the geocast that is stored. It does, however, have significant drawbacks. The technique can only be used in circumstances on highways and is not appropriate for city scenarios. Second, it is impossible in the actual world to define each vehicle's zone without a precise positioning system. Thirdly, it increases control overhead because it disseminates information using three different message types: info, query, and reply.
10. **Relative Position-based Message Dissemination (RPB-MD) (2012,** [52]**):** This plan is put forth to effectively and consistently convey messages to the cars within a given geographic area. RPB-MD makes the assumption that automobiles use GPS receivers to determine the relative distance between nearby vehicles. Authors suggested Directional Greedy Broadcast Routing (DGBR) to make the candidate nodes hold the message with high reliability and achieve optimum delivery ratio and low end-to-end delay. The efficiency of the protocol is ensured by the adaptive design of the protocol time parameters based on the local vehicular traffic density and message properties. In terms of low overhead, high delivery ratio, and high network reachability, simulation results show that the protocol excels over Epidemic routing [53], GPSR [54], and IVG [39]. It does, however, have significant drawbacks. First, the time period value depends on the local traffic density attained by neighbours exchanging beacons, which can delay the warning message's rebroadcast and involves a substantial time and bandwidth overhead, especially in dense networks. Second, this protocol should be changed to make it applicable to urban scenarios as well because it is currently only applicable to highway scenarios. Third, in the low-density case, where there aren't enough cars to forward the packet, there hasn't been a solution offered.
11. **Vehicular ad-hoc network context-aware routing protocol (VCARP) (2012,** [55]**):** It makes a routing choice based on the context data of the nodes (such as location, destination,

and packet cache status). Geocast, hello, and response packets are the three packet types used by VCARP. In order to get to their destination, geocast packets are relayed via the network. New neighbouring nodes are found using hello packets, and existing neighbours respond to hello packets using response packets. The protocol stores the nodes' context data in neighbour tables. Shared caching and flow-based routing were used by the authors to enhance the protocol's performance. 1. In a shared cache technique, geocast packets that can't be relayed are delivered to nearby neighbours so they can store them and prevent packet loss from overflowing caches. The use of flow-based routing helps to cut down on network overhead brought on by pointless packet retransmission. The increased packet delivery ratio was attributed to the shared cache, according to simulation results, while flow-based routing is responsible for a drop in the protocol's network overhead. The protocol, however, is not scalable because it cannot be used to huge networks.

12. **Geocast routing based on Spatial INformation in VANETs (GeoSPIN) (2013,** [56]**):** This protocol uses vehicular trajectories—daily vehicle movements—to carry out data dissemination across partitioned networks. In GeoSPIN, the network partitioning issue is dealt with and the data delivery rate in low-density areas is improved by combining the store-and-carry-forward technique with vehicle trajectories. It uses an opportunistic approach, allowing nodes to send messages to any node travelling in that direction, and it chooses the best hop-by-hop route to convey the message. The outcomes of the simulations demonstrate a reduction in network overhead in GeoSPIN. However, because routing decisions are based on vehicle trajectory, there is a low packet delivery ratio, which leads to subpar performance.
13. **Breadcrumb Geocast Routing (BGR) (2014,** [57]**):** This protocol creates a disruption-tolerant geocast routing by fusing technology from the delay-tolerant network (DTN) and geocast routing. BGR established the floating content approach-based idea of breadcrumbs. As depicted in Figure 5, these breadcrumbs are based on anchor zones.

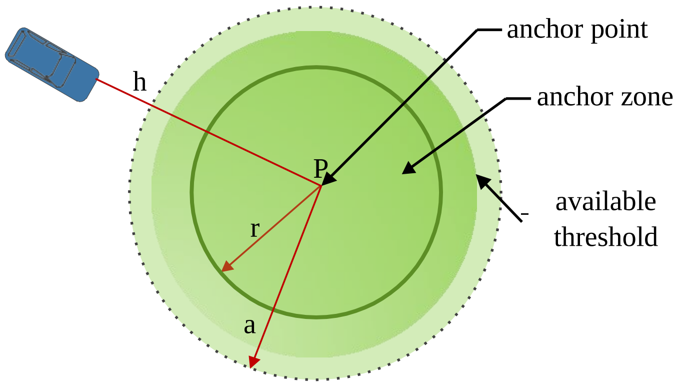


Figure 5. Bread-crumb structure

An anchor zone is defined by an anchor point P, an anchor radius r, an availability threshold and time to live (TTL). The value of the parameter h, which indicates the distance between a node and the anchor point P, is utilised in the calculation of p_f which is the likelihood that the node will deliver its breadcrumb message and is represented by the formula (4).

$$p_f(h) = \begin{cases} 1 & if\ h \leq r \\ F(h) & if\ r < h \leq a \\ 0 & otherwise \end{cases} \quad (4)$$

Query, Response, and Tracking are the three phases that make up the BGR protocol. A query originator (which might be a vehicle or an RSU) submits a query into a RoI during the query phase. When a node in the RoI gets the query, the query phase is complete. The response from a node inside the destination region reaches the requesting site during the Response phase. While the addressed nodes in RoI are occupied with processing the request in the response phase, the query originator may shift its position. The question originator moves about and leaves a trail of breadcrumbs to make sure the response gets there. The respondent sends the query response during the tracking phase along the breadcrumb trail until it reaches the query originator. For applications that don't need a crucial time response, BGR can be utilised on top of any geocast routing protocol. However, the protocol contains a flaw, which is that when a request comes to cache in the direction that the breadcrumb points, the entire trail of breadcrumbs gets invalidated. It results in contentless copy.

14. **Content-based Mobile Tendency Geocast Routing (CMTG)(2014,** [58]**):** This protocol combines a geocast routing protocol with a content-based middleware system. From a DTN standpoint, the CMTG protocol is created for metropolitan regions to better address challenges with high mobility and sporadic connectivity. When a message is produced by the source vehicle, it is broadcast toward the destination roadways. When two vehicles reach each other's communication radii, the messages carried in them will in particular evaluate the relative mobile tendency of the met vehicles. The protocol then chooses a routing action based on the relative mobility of the encountered vehicle and the geographic location of the message. The properties of the message are likewise altered as the vehicle's motion is altered. The protocol lowers additional network overhead, according to simulation results, without affecting the rate of dissemination. The simulation environment, however, is overly simplistic for use in assessing the protocol's performance. The simulated region is regarded as a straight road. In a realistic automotive environment, it is quite challenging to develop an appropriate geometric relationship between the vehicle and the road.
15. **Mobility-aware Geocast (GeoMob) (2014,** [59]**):** To further address challenges with high mobility and sporadic connectivity, this protocol makes advantage of DTN perspective. GeoMob is a proposed solution for the urban vehicle environment and uses actual GPS bus and taxi tracks for routing. These traces are used to derive the macroscopic and microscopic movement patterns. The microscopic mobility pattern, which is self-maintained by each vehicle, captures the motion patterns of individual cars while the macroscopic mobility pattern reflects the overall traffic situation. When a source vehicle generates a message, it is transmitted through several hops to the target location. The message forwarding technique and buffer management make up the protocol's message forwarding scheme. Macroscopic mobility is employed in message forwarding method to choose the forwarding path, while microscopic mobility pattern is used to decide on routing. The protocol employs the following technique to manage buffers. The message with a low likelihood will first be dropped when a vehicle enters a new area, and the likelihood for all of its messages will be updated. Second, a vehicle may have more than one message to convey to another vehicle when they cross paths. As a result, before transmission, it arranges the messages in a buffer in descending order of likelihood of delivery. Third, acknowledgments are flooded to clear the network of duplicate copies of the message. In comparison to state-of-the-art protocols, simulation results reveal that the protocol achieves notable performance in terms of overhead ratio, average hop count, and average latency. The protocol, however, has some shortcomings: The first limitation is that message transmission to a mobile vehicle is not supported. Second, because it frequently requires probing of nearby vehicles, the technique results in significant communication costs. Third, GeoMob relies heavily on the buses or taxis that routinely

travel between the different locations to convey messages. As a result, the technique may cause a significant delay and miss many opportunities for cooperative delivery. Furthermore, it lacks a plan for adjusting the areas to daily changes in traffic flow.

16. **Exploiting Trajectory-based Coverage for Geocast in Vehicular Networks (2014,** [60]**):** In this method, geocast routing in VANETs is achieved by utilising vehicle trajectories. A vehicle has a greater ability to send a message to the target zone if its future coverage or the coverage of other vehicles it will encounter overlaps the target region, according to authors. Trajectory-based coverage for geocast routing is shown in Figure 6. As its direct coverage overlaps the target area, Node B can geocast the message by itself. If the direct coverage does not cover the target location, Node A will geocast messages using the carry-and-forward approach. In order to geocast the message to the intended area, node X will assist node A. The direct coverage of X becomes indirect coverage of A after they encounter. Motivated by the instinct, authors develop message forwarding metric called coverage capability (C_v) to characterize the potential of a vehicle v to deliver a message p to destination region d. C_v is measured as the probability that the extended coverage of vehicle v overlaps the target region of the message within a time constraint of the TTL of the message and is calculated as given in (4)

$$C_v = P_r\{\psi_v overlaps\ d\} \quad (5)$$

where ψ_v is vehicle's v extended coverage

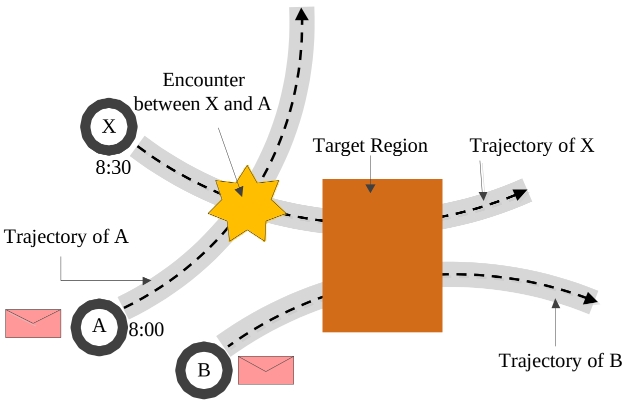


Figure 6. Illustration of exploitation of trajectory-based coverage for geocast in vehicular networks

After calculation of C_v, authors proposed Coverage Aware Geocast Routing (CAGR) to make a forwarding decision. Coverage graphs are used in the CAGR protocol to keep track of the trajectories of all the passing cars. The extended coverage capacity of each vehicle is evaluated using coverage graphs. Distributed construction of the coverage graph is done using locally shared data. Packets are forwarded to vehicles that have a high probability of sending the packet successfully in order to achieve various routing objectives, such as traffic information sharing and emergency alarming. Let us consider a situation in which a set of vehicles V encounter with each other and compete for transmission. Suppose $Y \epsilon V$ wins the contention and uses a channel to forward its message set $\phi(X)$. The central idea of CAG is to replicate a message on a vehicle having higher coverage capability. First, Y sort $\phi(X)$ in order of the most coverage that any vehicle can offer, from most to least V. Messages are then sent until the connection link is severed. Only when a vehicle has the greatest coverage capability can a message get reproduced on it. A trace-driven simulation of the protocol demonstrates that it has lower transmission overhead and a higher packet delivery ratio than the GPSR protocol. The drawback of this protocol is that vehicles must be aware of the entire network, though. To create a coverage graph, they must compile and keep track of both their own trajectory and the trajectories of every vehicle they encounter.

17. **Data dissemination pRotocol In Vehicular networks (DRIVE) (2014,** [61]**):** This protocol uses neighbour node information rather than a neighbour table to distribute data in both high- and low-density areas. To minimise coverage gaps and address the broadcast storm issue, DRIVE employs a sweet spot. The sweet spot is referred to as the region where vehicles are most effective at disseminating data. In other words, the transmission of a single vehicle within a "sweet spot" is enough to carry out data dissemination regardless of the number of vehicles receiving data for forwarding. Figure 7 provides an illustration of the sweet spot idea.

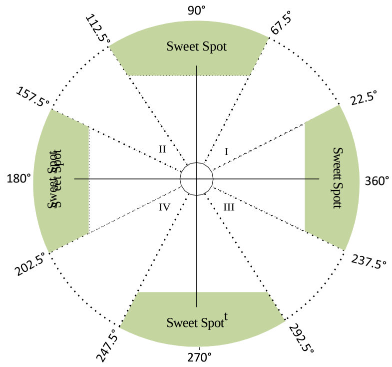


Figure 7. Sweet Spot

Four quadrants are used to partition the communication area, and one sub-region from each quadrant is chosen as the sweet spot. The protocol selects cars that are inside the sweet area to rebroadcast the message in dense networks. To establish the broadcasting time of the vehicles, it employs both position-based and timer-based approachesTherefore, when a vehicle receives a new message, it will keep it in its memory until either the message's lifetime expires or it leaves the region of interest (RoI). Because only vehicles that are inside the sweet spot are allowed to forward the packet, it essentially solves the broadcast storm issue. Nodes inside the sweet area also stop transmitting the same packet if it originates from a node outside of the sweet spot. The node that is farthest from each quadrant will transmit the message if there is no node inside the sweet spot. The protocol also employs vehicles outside an area of interest (AoI) to carry out data dissemination for vehicles connected by a network partition but outside the same AoI. The technique exhibits a high delivery ratio in both the highway simulation and the Manhattan-Grid situations. The technique does, however, have significant drawbacks. First, there is a significant communication overhead created by the overall volume of messages. Second, Manhattan-Grid was used as a simulation area by the authors. However, unlike the Manhattan-Grid approach, the road layout is not necessarily symmetrical in real-world circumstances.

18. **RSU-Assisted Geocast (RAG) (2017,** [62]**)**: It is used to determine the lowest cost to deliver a message to a particular vehicle in a specified location. This algorithm initially sends the message to the least expensive, closest RSU before choosing the best RSU to transmit it to a particular vehicle in the specified area. .The authors propose a quad-tree model (Fig. 8) to represent a hierarchical subdivision of the global region as a means of resolving this issue. The tree trimming method is then applied to obtain the intersection of the destination area with the quad-tree. Next, an election strategy is suggested to choose

an ideal RSU based on the quadtree model to convey the message to the target area. In comparison to cutting-edge protocols, simulation results demonstrate that the RAG algorithm consistently achieves the lowest cost. The technique does, however, have significant drawbacks. First, the authors made the supposition that there would be no transmission conflicts and that both the vehicles and the RSUs would have an indefinite buffer to hold messages. In a scenario involving actual vehicles, this presumption is invalid. Another important issue that influences network expansion and adoption is the requirement for effective operation with a minimal amount of infrastructure in place, at least at the outset of service. However, the minimum number of RSUs required for the protocol to function has not been specified by the authors.

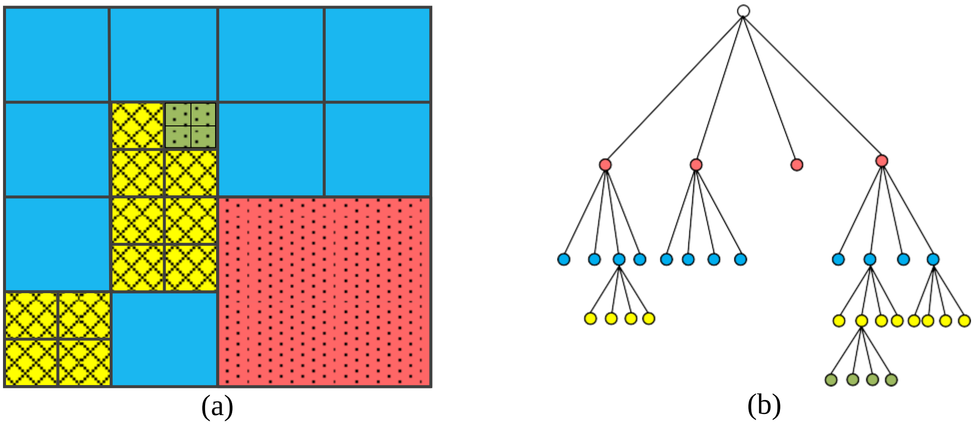


Fig.8. An example of (a) the region graph and (b) the quad-tree

5. COMPARISON TABLE

In terms of forwarding method, assumptions, ZOR mobility, time limitation, communication architecture/environment, application type, and simulators, Table II compares the previously stated geocast routing protocols for VANETs.

- ***Forwarding strategy*:** It outlines the methods protocols employ to transmit data to the intended vehicle. As was already said, geocast routing is a multicast routing based on position. As a result, almost all protocols are position-based, meaning that they use a vehicle's location to route data packets from source to destination. Some of them are distance-based as well as position-based, i.e., they select the neighbour in the intended direction that is the next forwarding vehicle with the shortest distance to the destinationIt has been noted that a number of protocols employ a timer-based strategy, in which nodes wait a certain amount of time before broadcasting, hence minimising packet collisions. To prevent network fragmentation, certain protocols employ a store-carry-and-forward strategy (also known as buffering). Finally, other methods route data packets using a trajectory-based forwarding scheme. In this method, a vehicle with a trajectory toward the destination is chosen as the next forwarding vehicle. The source determines the trajectory, and intermediate vehicles transmit the packet to vehicles near to the trajectory path.
- ***Assumptions***: This criterion identifies external sources of information including buffers, digital maps, and periodic beacons that each protocol depends upon for its operation.

- ***Mobility of ZOR*: ** This criteria discusses whether a protocol disseminates message to a static or a mobile geocast region.
- ***Time constraint*:** One more critical factor influencing network growth and adoption is the need for efficient operation with a minimum of infrastructure in place, at least to begin with. Specifically, all the vehicles entering a geographic region are informed of the message for a specific time.
- ***Communication architecture/environment*:** This criterion categorizes protocols based on the communication environments and architecture of geocast routing protocols.
- ***Application type*:** This criterion discusses the protocols' application type motivated by the specific requirement. Most of the protocols are either developed for safety application or comfort application. Only few of the protocols are for safety as well as comfort applications adaptive i.e. they change its working as per requirement of the application.
- ***Network Simulator*:** Simulations of real-world networks are attempted by network simulators.. They are also particularly useful in allowing the network designers to test new networking protocols or to change the existing protocols in a controlled and reproducible manner.

Table II Compartive Study of the exisitng geocast routing protocols

Geocast routing protocols	Forwarding Strategy	Assumptions			Mobility of ZOR	Time Constraint	Communication architecture/environment		Application type	Network Simulator used
		Buffer	Digital Map	Beacon			Architecture	Environment		
IVG[39]	1.Position based 2.Timer based	No	No	No	No	No	V2V	Highway	Safety	GlomoSim
DRG[42]	1. Position based 2 .Distance based	ND	No	No	No	Yes	V2V	Highway	Safety	JisT/SWANS
ROVER[43]	1.Position based	No	No	Yes	No	No	V2V	Urban	Safety, comfort	JisT/SWANS
Mobicast[44]	1.Position based 2.Distance based 3.Timer based	No	No	Yes	Yes	Yes	V2V	Highway, Urban	Safety	NCTUns
DTSG [46]	1. Position based 2. Store-carry-and-forward	No	No	Yes	Yes	Yes	V2V	Highway	Safety	C++
Geocache[50]	1. distance based 2. Store-carry-and-forward	Yes	No	Yes	ND	ND	V2V	Urban	Comfort	RTSIM
ZBF [51]	1.Distance based 2.Timer based	No	No	Yes	No	Yes	V2V	Highway	Safety	NS2+ VANETMobiSim
RPB-MD [52]	1. Distance based 2.Timer based 2. Store-carry-and-forward	Yes	No	Yes	No	Yes	V2V	Highway	Safety	NS2
VCARP[55]	Store-carry-and-forward	Yes	Yes	Yes	No	No	V2V	Urban	Safety, Comfort	NS2
GeoSPIN [56]	1.Store-carry-and-forward 2.Trajectory forwarding	Yes	Yes	ND	No	No	V2V	City	Safety, Comfort	OMNet++
BGR[57]	Position based	Yes	No	Yes	Yes	No	V2V	City	Safety, Comfort	ONE
CMTG[58]	Store-carry-and-forward	Yes	No	Yes	No	No	V2V	Urban	Safety, Comfort	ONE
GeoMob[59]	Trajectory based	Yes	Yes	ND	No	No	V2V	Urban	Safety, Comfort	ONE
CAGR[60]	Trajectory based	Yes	Yes	Yes	No	No	V2V	Urban	Safety, Comfort	ND
AGR[41]	Position based	No	No	Yes	No	Yes	V2V and V2I	Highway, Urban	Safety, Comfort	OMNet++
CGP[49]	Store-carry-and forward	Yes	No	Yes	No	ND	V2V and V2I	Highway	Safety	OMNet++

DRIVE[61]	1.Position based 2.Store-carry-and forward 3.Distance-based 4.Timer based	Yes	No	No	No	No	V2V and V2I	Highway, Urban	Safety, comfort	OMNet++
RAG [62]	1.Trajectory based 2.Store and forward	ND	No	Yes	Yes	No	V2V and V2I	ND	ND	ND

*ND – not defined

6. FUTURE RESEARCH CHALLENGES

The following future perspectives should be carefully considered in light of VANETs' particular characteristics:

1) **Frequently disconnected networks:** The majority of geocast routing techniques presumptively consider VANET to be a highly linked network. However, it has been highlighted that because of the great mobility of cars, VANET frequently experiences network problems. Therefore, creating an effective and efficient geocast routing system is difficult due to the problem of often disconnected networks [72]. Network partitioning can be resolved using infrastructure networks. Even in areas with little traffic, the message can spread among vehicles with the help of infrastructure.
2) **Driver behavior:** Driver behaviour has a significant impact on node mobility in VANETs, which in turn can alter many levels of road traffic patterns. Furthermore, a driver's choice of path can have an impact on the entire network structure. In the literature on transportation, there are many studies modelling driver behaviour [64][65][66], but few studies discuss how driver behaviour affects a routing protocol's performance. Therefore, when building a geocast routing protocol, driver behaviour should be taken into account.
3) **Resilient to location errors:** One way to describe the geocast routing protocol is as a location-based multicast routing protocol. This suggests that in order to route geocast messages from a source to a certain region, protocols need to know where they are physically. The main premise behind geocast routing methods is that the GPS devices used in automobiles provide precise position data. But in a real-world setting, this presumption is false. The measuring precision of GPS is inherently inaccurate. A geocast routing algorithm's primary prerequisite is hence precise location information, which is an impractical assumption. Without the ability to accommodate location inconsistencies, a routing system will be wasteful in terms of throughput [67]. A simulation study in [68] demonstrates how the VANET operation is impacted by GPS location mistake, which also reduces hop distance. Therefore, it is important to design geocast routing protocols so that they can effectively handle location mistakes.
4) **Traffic density-aware beaconing:** Each vehicle transmits beacon signals to the vehicles nearby on a regular basis to let them know where it is and other pertinent information. These signals can be used to identify unusual situations in both urban and highway settings. However, frequent shifts in traffic volume from sparse to dense might cause wireless channels to become overloaded from beaconing, which could harm the vehicular network's performance. Additionally, lowering the beaconing rate alone won't solve the channel overloading problem. The gap between the current physical position and the most recent reported position widens as the pace of beacon output decreases. The performance of the routing protocols would suffer as a result of this issue [69]. Therefore, when implementing an adaptive or event-driven update beaconing approach for the geocast routing protocol, the traffic density should be taken into account.
5) **Realistic vehicular network scenarios:** Due to the majority of communication in VANETs being wireless, nodes suffer from severe multipath fading and shadowing[70]. Each node individually assesses the amount of interference created if it needs to

retransmit the message in the interference aware geocast routing (IAGR) [44] protocol. The node determines whether or not to retransmit a received packet based on the expected value of interference. Modern geocast routing methods have been developed using fictitious vehicle scenarios, and the majority of them do not take multipath fading and shadowing into account. There are discrepancies in the simulation outcomes that occur when employing realistic and unrealistic vehicular networks that put human lives in danger and are out of reach. As a result, it is essential to investigate the implications of plausible vehicular network scenarios on the performance of the existing geocast routing protocol in VANETs [71]. In addition, the impacts of multipath and shadowing should be taken into consideration when designing a new geocast routing protocol.

6) **Benchmark protocols:** It is necessary to suggest geocast routing protocol benchmarks. The most recent investigations have shown that there is no benchmark geocast procedure for assessing newly suggested protocols. The position-based routing protocol GPSR [54], which is a widely used benchmark protocol for most research, is insufficient in the dynamic VANET context. A standard routing protocol and a simulation environment should both be included in the benchmark.
7) **Adaptive/Flexible protocol for safety and comfort applications:** The design of information dissemination protocols is application-centric, meaning that it is influenced and motivated by particular needs. Unlike safety applications, which require a set geographic location, comfort applications require a movable one. Sending safety alerts also requires incredibly low transmission latency, although comfort applications can tolerate some delay. The majority of protocols in the literature are only suggested for either comfort applications or safety applications [73]. Therefore, a geocast routing protocol that can adapt to the needs of the application should be created for both comfort and safety applications.

7. CONCLUSION

In the literature, a number of geocast routing methods have been put out to assist effective and efficient message dissemination in vehicular networks. However, a qualitative analysis of the geocast routing methods reveals that numerous issues need to be fixed, necessitating intensive study. Comparive study of the sevral geocast routing protocols have been carried out. The future dorections to develop new geocast routing in VANETS are identified.

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