A Systematic Literature Review : Intelligent Vehicular Communication System on VANET

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Abstract - Problems and challenges of the vehicular ad hoc network (VANET) system are always at the forefront of research. The communication system between nodes is a major issue that is frequently confronted. The model and concept of communication have a significant impact on communication quality. The communication models were compared at each node in terms of vehicle speed on the highway, coverage area, supporting infrastructure, and the type of information sent by users to other road users. There are several types of vehicle communication on the VANET system, such as vehicle-to-vehicle (V2V), vehicle-to-infrastructure (V2I), vehicle-to-everything (V2X), etc. The function of routing in the protocol in the VANET system cannot be separated from the process of transferring data in VANET communication, so the ability to identify routing protocols may have an impact on the quality of the communication produced. There are numerous issues with the ability to transfer data correctly in congested and fast-moving traffic. As a result, many variables must be addressed to improve communication models.

Index Terms – Communication System, Routing Protocol, VANET System, Vehicle-to-Vehicle, Nodes

INTRODUCTION

Evolution of vehicle technology both in terms of vehicle and system is becoming increasingly innovative. The process of developing autonomous and self-driving vehicle technology is advancing following current demands [1]. As a result, substantial improvement is required, particularly in the case of traffic demands that necessitate reliable and secure services. Vehicle coordination is facilitated by vehicle autonomy in transferring data and information acquired from local sensors via a cooperative communication mechanism [2]. This is done to enhance the efficiency of road use in congested areas and to improve driving comfort. Vehicle communication is an important element of intelligent transportation systems and self-driving systems since information can be transferred between vehicles and other entities [3]. There are varieties of vehicle communication, including vehicle-to-everything (V2X), vehicle-to-vehicle (V2V), vehicle-to-pedestrian (V2P), vehicle-to-infrastructure (V2I), and vehicle-to-network communication (V2N) [4][5]. The communication on the vehicular ad hoc network (VANET) system can provide data and information for each vehicle user, such as information on road traffic conditions, route maps to be taken, the situation of nearby vehicles, and road safety situations. In the VANET system, vehicles and drivers are capable of determining the proper driving route [6]. Vehicles can download weather notifications from any available internet network, as well as certain information from other apps to enhance comfort while driving. As a promising technology [7], the VANET system is critical for establishing reliable and efficient pathways that allow vehicles to communicate at any time. Services in VANET such as those linked to vehicle safety demand precise information and timely notifications as this will assist the driver to take the best course of action when required [7].

Aside from security-related information, the accurate and timely transmission of route information is required. Routing used in communication is specified by routing protocols, such as Ad hoc On-demand Vector Routing (AODV), Destination-Sequenced Distance Vector Routing (DSDV), and Dynamic Source Routing (DSR) [8]. There are two types of conventional routing protocols employed in VANET, namely proactive routing protocol and reactive routing protocol. Sometimes users encounters several obstacles when choosing a route, this becomes a challenge in developing the type of routing protocol so that it can be used appropriately for the scenario on the vanet system. Since vehicles move at high speed on the highway, the topology that is built on a VANET can be quite complicated [9]. The information and data on the packet must be transmitted with minimal latency, else the information would be worthless since certain packets may include vital safety information while some information may be about video and audio. The communication line must be stable for the vehicle to effectively receive and decode the information in the packet. Too many forms of communication on the VANET network simultaneously as well as sensor networks with a small or limited network range can cause congestion and waste energy [10]. Improvements are required to achieve a better communication model with excellent network quality and accurate and timely transmission of information and data to road users. It is also essential to have an efficient communication method to reduce network congestion and provide reliable communication between vehicles and other devices. Communication with data aggregation can conserve bandwidth and facilitate large-scale vehicle networks. Communication in the VANET system requires information to be shared in a reliable, low-latency, and efficient manner [11].

The contribution of this research is to examine the efficiency of combining communication systems on VANET in calculating variables such as node type, communication type and model, number of vehicles, vehicle distance, and vehicle speed. The effect of cluster size and overhead levels on the quality of sending information between nodes can be seen by determining routing on communication between nodes. The supporting infrastructure in the VANET communication system plays an important role in analyzing the minimum capabilities of each existing infrastructure. Combining communication data is expected to result in a more efficient system with accurate and timely information, as well as protection from disruptions caused by the quality of the existing infrastructure.

METHODOLOGY

Systematic literature review (SLR) was used as the research strategy in this study. SLR is a method for analyzing or critically analyzing knowledge, ideas, or results found in a corpus of academically focused literature and developing theoretical and methodological contributions to particular themes. It is a method for categorizing, selecting, and critically evaluating most of the questions addressed by prior research, and employs a structured model to locate data sets and related research. This research paper is a descriptive analysis, which goes over all of the data collected and explains the features, benefits, and drawbacks of each study. The findings are accompanied by an interpretation and explanation to ensure that they are fully understood. The procedure entails defining, analyzing, and interpreting a specific research topic, area, subject, or phenomenon of interest. For this research, the communication model established on the VANET system is observed along with the benefits and drawbacks that arise in each type of communication. This stage includes data collection, topic-based search, separation based on required criteria (such as inclusion and exclusion criteria), quality evaluation, and data processing.

The SLR method is carried out methodically by following the right phases of research procedures using the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) [12]. The PRISMA flow diagram is shown in Figure 1. PRISMA is a method that employs reviews, research, structured assessments, classifications, and categorizations based on previously created information. The procedures for conducting a systematic review are meticulously planned and structured, making this technique distinct from that of simply conveying literature research [13]. The phases of this systematic review are as follows: 1) establish background and objectives, 2) identify the problems or research questions, 3) conduct a literature search, 4) select criteria and 3implement practical screening, 5) implement quality control procedures, 6) implement data extraction strategy, and 7) implement data synthesis strategy.

a. **Background and Objectives:** In a systematic review, the first step is to study the background and establish the research objectives. In this study, the background is described in the introduction by defining goals, determining the established communication, the barriers and restrictions, as well as the advantages of each type of communication.
b. **Problem Identification:** The research topic is investigated using research journals compiled from reports of previous research findings. The goal of this systematic review is to survey which communication model on the VANET system is the most effective.
c. **Literature from Data Search:** Scopus, IEEE, Google Scholar, and Science Direct were used as database repositories for this research. The journal data was searched using the following keywords: "communication", "vehicular ad hoc networks", "data communication systems", "vehicle-to-vehicle communication", "mobile communications systems", "vehicle-to-infrastructure communication", and "wireless communication". There are 650 journal articles in total that have been collected hitherto.
d. **Criteria Selection and Screening:** This research explores the link between the VANET system communication and communication quality. As shown in Table 1, the research materials filtered for this topic were based on the following criteria: (a) the document is published within 5 years between 2016 and 2021, (b) the document need to be of certain types, and (c) the document need to be written in English.
e. **Quality Assessment:** This process aims to determine which research papers will be included and excluded from the systematic review based on their quality. Journals published between 2016 and 2021 need to cover the topic of the link between communication on the VANET system and the quality of communication. A total of 650 journals published in the previous 5 years with the keyword VANET system communication were screened, after which 155 journals were eliminated and combined with existing subjects until 42 journals were acquired.

TABLE I
CRITERIA FOR RESEARCH PAPERS

Criteria	Inclusion	Exclusion
Timeline	2016 - 2021	... - 2015
Document Type	Article Journal, Conference Proceeding, Article Review	Duplication
Language	English	Chinese, Portuguese, Indonesian, etc

f. **Data Extraction:** This phase may be carried out if all data that meets the standards has been categorized. The data extraction results can reveal the number of research papers that meet the criteria for further study. Data were extracted for this systematic review by reading all 42 selected articles and then writing down the essential findings from each article.

g. **Data Synthesis:** Meta-analysis techniques (forest plot) or narrative approaches (metasynthesis) were used to synthesize the results from data extraction. Essential data were grouped and analyzed using the data, facts, and information obtained from the research articles to form further conclusions that can address the objectives.

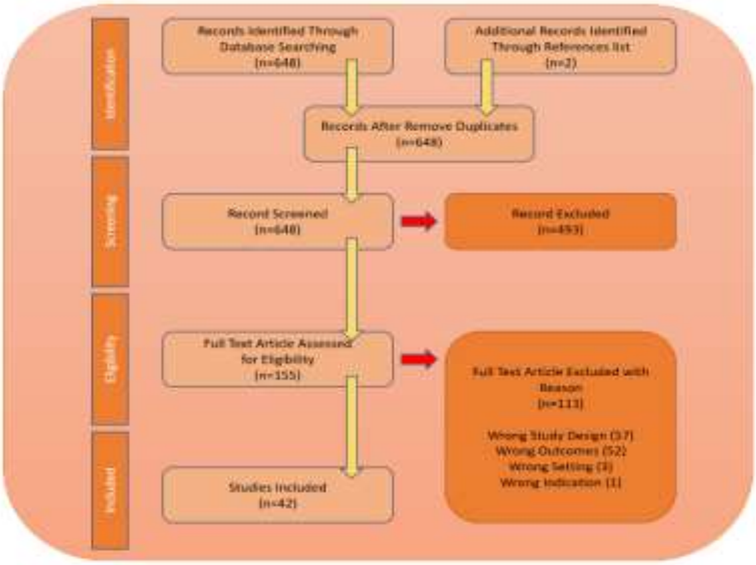

FIGURE 1
PRISMA FLOW DIAGRAM

The VANET communication system requires a good communication model to achieve better data transmission in the development of a new network that relies on emergencies and to exchange information among vehicles. The goal of this research is to verify that using multiple models in V2V communication improves the decision-making process in vehicle communication. The research questions were developed to address how important model selection in communication on the VANET system is and how communication models can be used to improve route selection. The research questions for objectives this study are as follows:

a. What issues could emerge during the data and information transmission process between vehicles?
b. Which communication architecture between nodes is best for minimizing routing and delays in communication?
c. How to increase the quality of data communication ?

VEHICULAR ADHOC NETWORKS COMMUNICATION

VANET is an ad hoc network concept created from diverse components and mobile parts. It is a component of the technical development of the Intelligent Transportation System (ITS) [14][15]. As illustrated in Figure 2, there are three primary domains in the VANET communication system design paradigm, namely the in-vehicle domain, ad hoc domain, and infrastructure domain.

a. In-vehicle domain comprises of an On-Board Unit (OBU) and multiple Application Units (AUs), where the AUs are linked to one OBU [16]. The communication that is established may take the form of a cabled link or wireless technologies. The OBU is equipped with IEEE 802.11p radio technology, allowing the vehicle to connect to infrastructure or another vehicle.
b. Ad hoc domain comprises vehicles equipped with OBU and components or fixed variables situated on the side of the road or frequently referred to as Road Side Units (RSUs) [17]. OBU and RSU are static communication networks of an ad hoc network. The purpose of RSU is to provide an internet connection to OBU via a gateway. This connection can be done directly or via multi-hop, establishing an ad hoc network that permits communication between vehicles without the need for centralized coordination.
c. Infrastructure domain can connect to an infrastructure network or the internet, permitting an OBU to access an existing infrastructure network [18]. It is feasible that an AU can be recorded communicating with an OBU and connecting to an internet-based host.

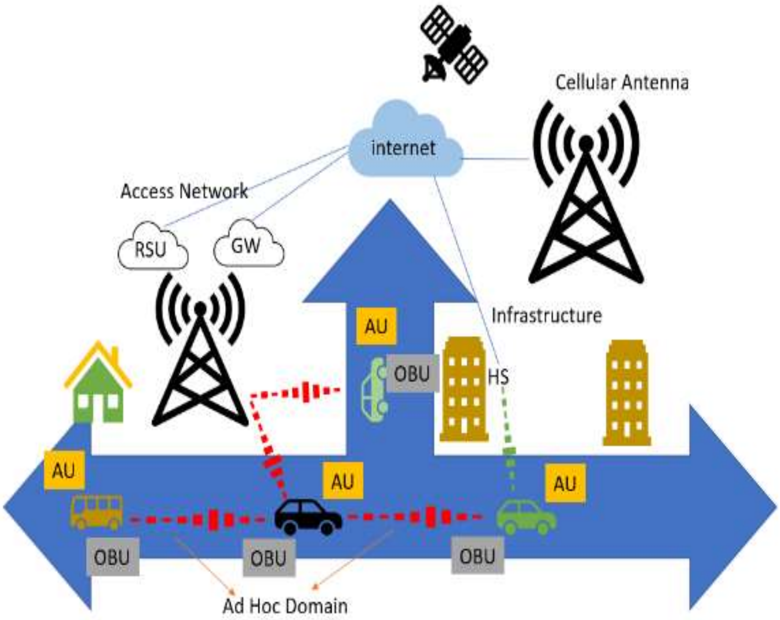

FIGURE 2
VANET COMMUNICATION

There are three categories of communication models between vehicles on the VANET system [4] [19] [20]:

a. V2V communication allows direct communication among vehicles without having to see the current supporting infrastructure around the vehicle. V2V is utilized to provide one-stop access to safety information, vehicle security, and vehicle deployment. Communication among vehicles is done by exchanging data that provides information on the condition and internal environment of the vehicle. The V2V communication is illustrated in Figure 3.

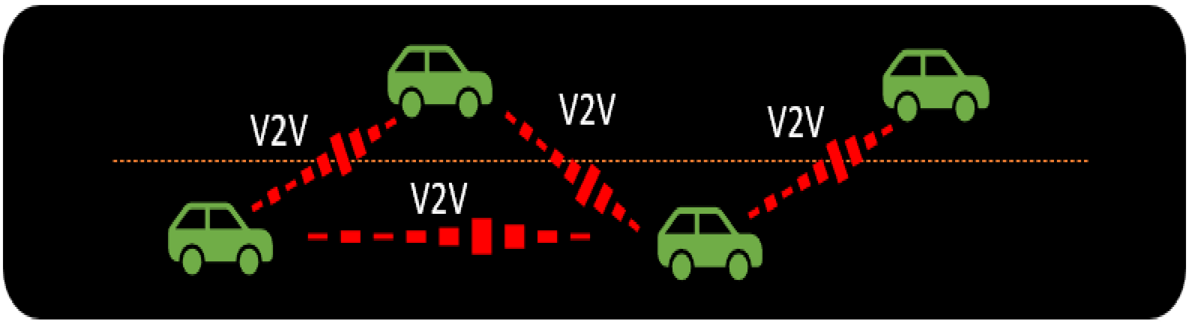

FIGURE 3
VANET COMMUNICATION

b. V2I communication enables vehicles to communicate with available infrastructure. Vehicles exchange data and information via mobile communication networks and wireless space networks to meet a variety of user demands, including weather forecasts, traffic density statistics, entertainment information, and other information. The infrastructure can be utilized for destination determination in vehicle routing in VANET. The V2I communication is illustrated in Figure 4.

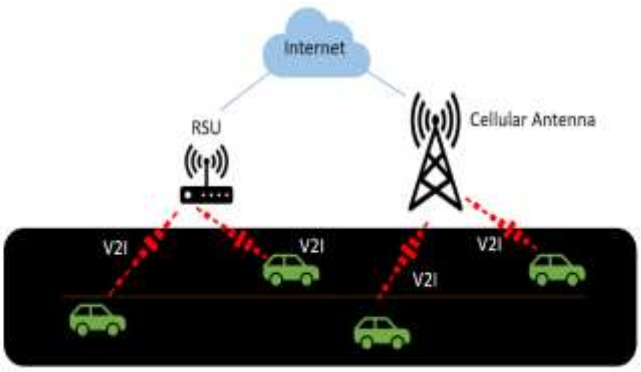

FIGURE 4
VANET COMMUNICATION

c. Hybrid communication is a type of communication that combines V2V and V2I communications. Vehicles communicate with available infrastructure and share information with other vehicles using that infrastructure. By establishing a single-hop V2V link, vehicles can communicate directly with one another. If a direct link between the vehicles does not exist, a unique routing protocol is utilized to transfer data from one vehicle to another until it reaches the target point by establishing a multi-hop V2V communication. On the other hand, the vehicle connects with RSU to improve the range of communication by receiving, delivering and forwarding data from one node to another. The hybrid communication is illustrated in Figure 5.

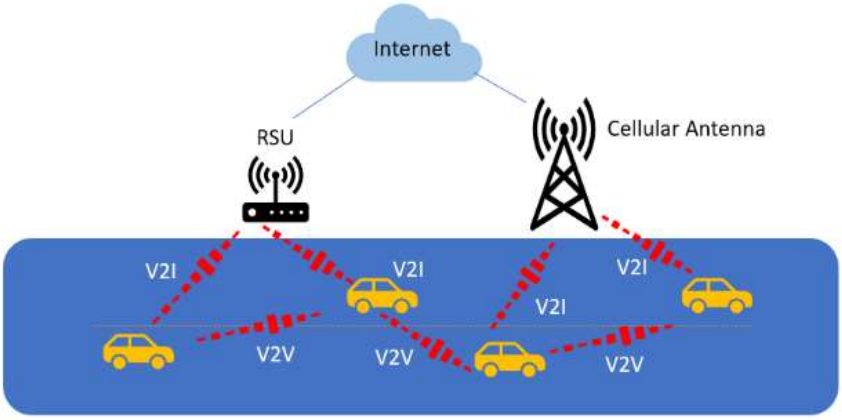

FIGURE 5
VANET COMMUNICATION

ANALYSIS RESULT MODEL

A total of 46 research articles were found to be relevant to the topic of this study, which was the communication process created on the VANET system. The gathered research articles were evaluated using specified indexes and categorized based on the number of documents based on the researcher, affiliation, subject, and a variety of other factors. The research articles were grouped between 2016 and 2021.

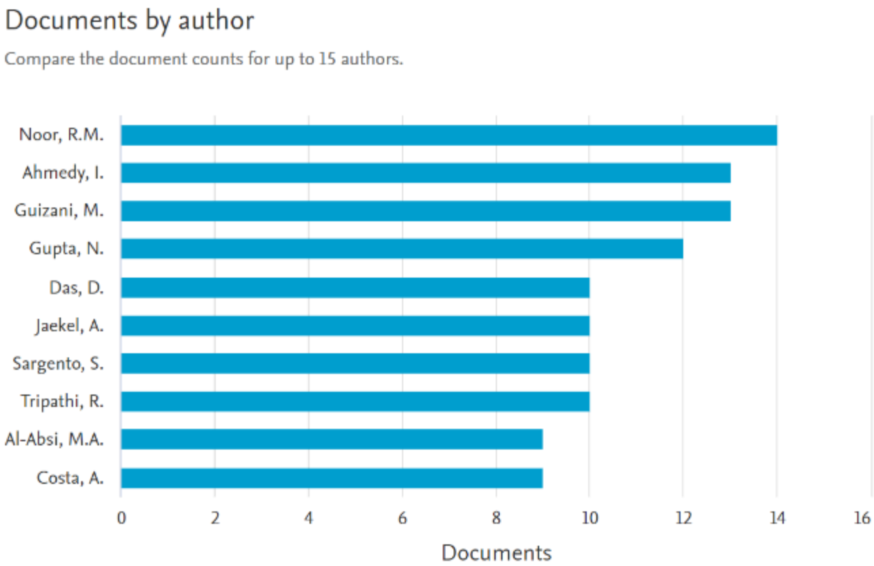

FIGURE 6
DOCUMENT BY AUTHOR

Figure 6 shows a comparison of the number of studies completed by ten researchers, showing that Noor, R.M. contributes the most number of research articles with 14 research publications, followed by Ahmedy, L., and Guizami, M., each with 13 research articles. Numerous other researchers contribute between 9 to 12 research articles that meet the criteria of this study.

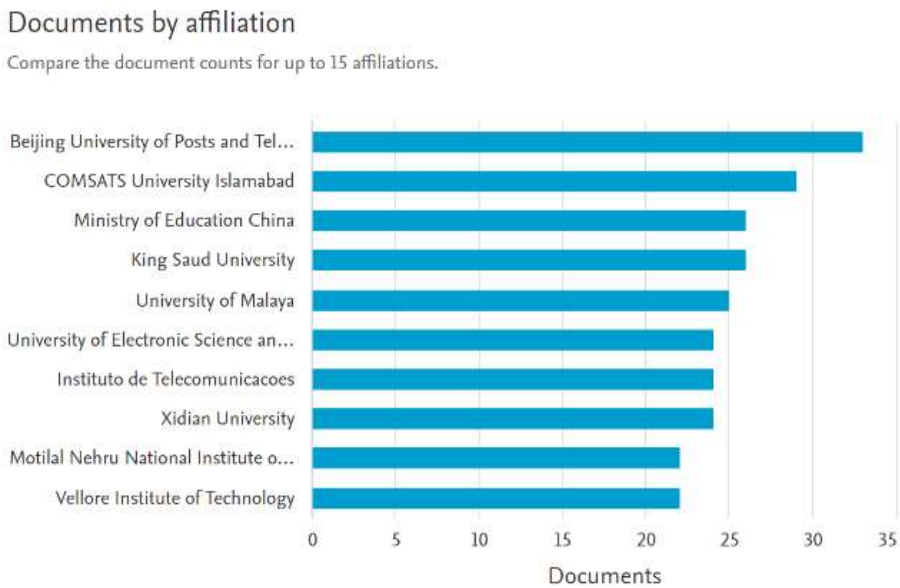

FIGURE 7
DOCUMENTS BY AFILLIATION

With over 30 journals, the Beijing University of Posts and Telecommunications published the most research articles related to communication on the VANET system. COMSATS University Islamabad, Ministry of Education China, and King Saud University each have published more than 25 research articles. Several other institutions have also published research related to communication on VANET systems as shown in Figure 7.

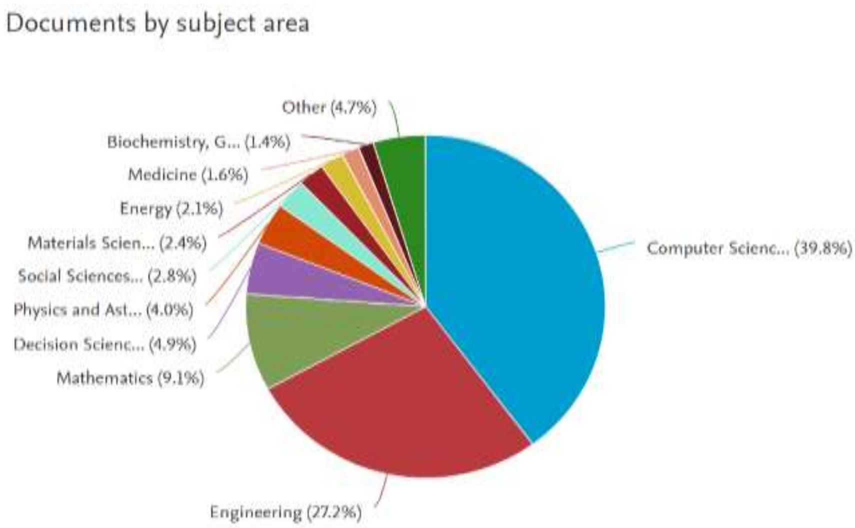

FIGURE 8
DOCUMENT BY SUBJECT

Figure 8 shows the percentage of total research articles categorized by subject. It should be noted that computer science accounts for 39.8 percent of communication research in the VANET system, while engineering accounts for 27.2 percent. This indicates that these two fields are of interest to the research subject.

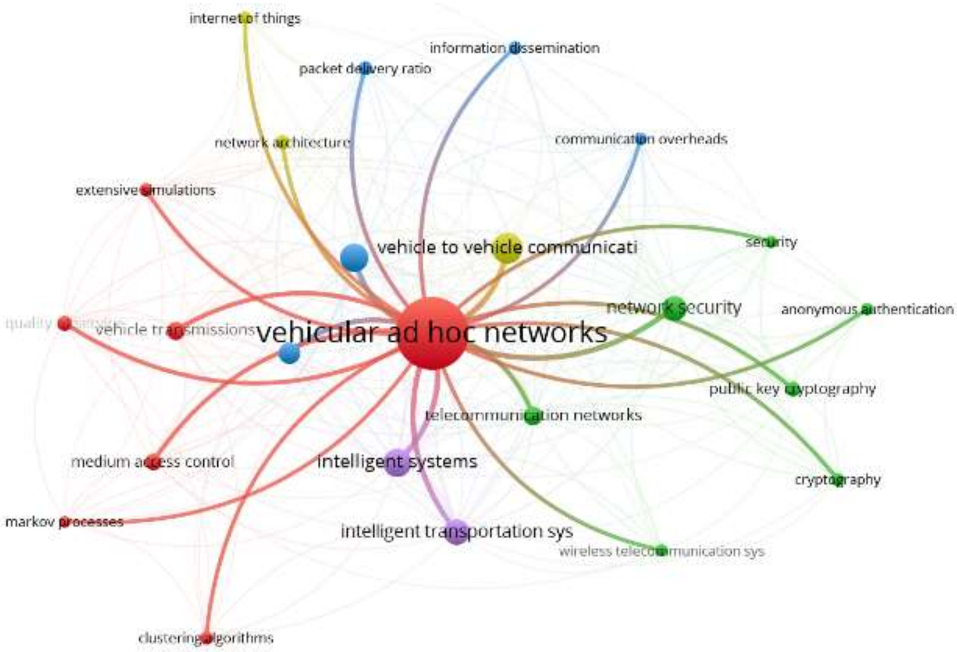

FIGURE 9
KEYWORD VISUALIZATION OF COMMUNICATION MODEL

Data analysis can be done graphically using current mapping technologies to gain an overview and a variety of information on research advancements, notably those related to communication on the VANET system. Not all databases acquired through search results can assist with the current research. This is due to differences in database structure and type. VOSviewer was used as the mapping tool in this study because it has qualities that can map many different types of bibliometric analyses and supports multiple important bibliographic databases. VOSviewer can focus on text processing, employ layout and cluster methods, and display existing data using overlay and density visualizations. Figure 9 shows how the keyword "vehicular ad hoc networks" is linked to other keywords, such as V2V communications, network security, intelligent systems, the internet of things, and several others. [21]. The topic of VANET is closely related to V2V communication in some studies. As shown in Figure 10, V2V communication as the core topic in the context of VANET is closely linked to other topics such as communications overheads, internet of things, network security, telecommunications networks, public-key cryptography, intelligent systems among others [22][23] .

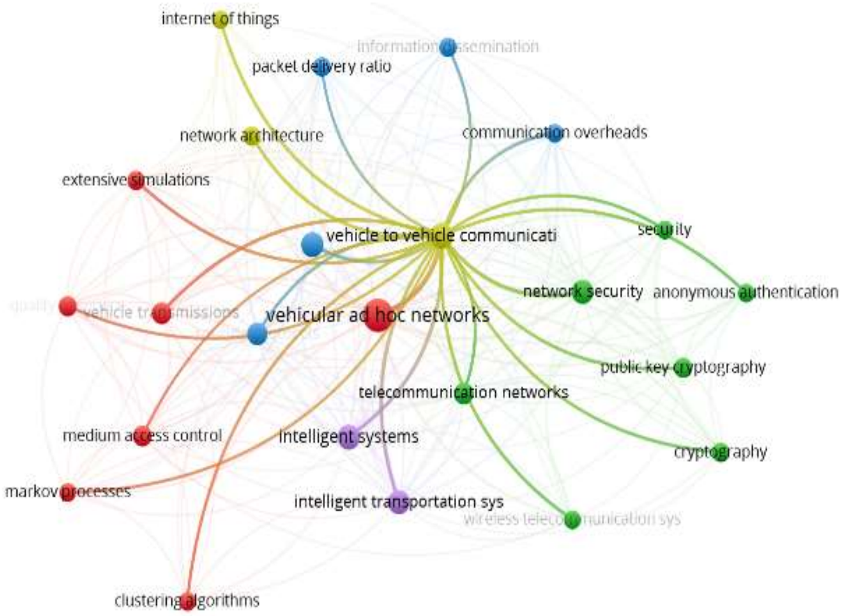

FIGURE 10
VISUALIZATION RELATED V2V COMMUNICATION

DISCUSSION

I. Physical Layer

A communication system can be built using a variety of communication models on a VANET system, such as dedicated short-range communication (DSRC) and Long-Term Evolution (LTE). Table 2 shows the comparison of communication models of DSRC. DSRC is widely used in information and service support, particularly in V2V communication. This model does not interfere with other telecommunication networks, especially cellular communications since cellular communication uses a different network. This does not eliminate the possibility of further development and research on the communication network with the DSRC model, such as the numerous occurrences of information or data collisions in a vehicle-heavy environment, which are caused by the limitations of the carrier-sense multiple access (CSMA) mechanism [24].

Table 3 shows the comparison of communication models of LTE. In the LTE communication network, devices can communicate directly with one another but numerous barriers may arise during the communication process. One of them is the deterioration in communication quality caused by communication models that are static in nature and have different speeds and vehicle mobility [4]. There are also a variety of interferences and transmission disruptions that result in a poor message and information delivery quality and security.

TABLE 2
COMPARISON COMMUNICATION MODELS OF DSRC

Communication Model	Dedicated Short Range Communication (DSRC)	
	Gain	Inquire
Vehicle-to-Vehicle Communication Model	Ad-Hoc Mode, Cheap Cost, Lowerd for WMS	Hidden Node and Broadcst Storm Problem, Channel Congestion with lot of Vehicles
Vehicle-to-Infrastructure Model	Spectral Efficiency, Energy Efficiency	Sparse Pilot Design, Unbalanced Link, Prioritization and Service Selection

TABLE 3
COMPARISON COMMUNICATION MODELS OF LTE

Communication Model	Long Term Evolution (LTE)	
	Gain	Inquire
Vehicle-to-Vehicle Communication Model	Eficiensy High Spectral, Effective Schedulling	Performance Degradation, Interference, Peer and Service Discovery
Vehicle-to-Infrastructure Model	Large Coverage, High Uplink, Centralized and Flat Architecture	High Delay in Disseminating Message, Lack of Efficient Schedulling Schemes

II. Network Layer Model

This section examines some studies on the network layer model in the VANET system. This research reviews the advantages and disadvantages of the simulation results, including the communication process between nodes, the communication model used, and the comparison between different types of communication in the VANET system. In [25], the research was conducted in urban areas, where there were more obstacles in the form of buildings, roadside structures, and other types of construction. It is critical to develop a suitable routing protocol with these obstacles. Low network quality may have an impact on radio propagation due to these obstacles, hence a new protocol is needed, one that heavily relies on obstacle avoidance algorithms capable of determining the shortest optimal path and a potential effective forwarding vehicle selection strategy to route packets [26]. As a solution, this work presented a robust forwarding node selection technique for efficient communication between vehicles for effective data distribution in urban car ad hoc networks, to improve throughput and packet delivery ratios. Delaunay triangulation, Torri celli points, and Dijkstra's algorithm were used to introduce the optimal shortest path search approach from source to destination. As shown in Figure 11, Delaunay triangulation can be used to choose a path that avoids obstacles. The forward angle was utilized in the path to find the optimal forwarding zone while fuzzy logic was utilized to find the best potential forwarding node in that forwarding zone to forward packets effectively.

FIGURE 11
DELAUNAY TRIANGULATION [25]

The path was optimized by eliminating Torricelli points, originally set in the Delaunay triangulation. The forwarding zone was picked in that optimal shortest path. Strong nodes were chosen for optimal data dispersion in such a forwarding zone using fuzzy logic. When compared to existing protocols, the proposed protocol achieved a 9 percent increase in packet delivery rate, an 11 percent increase in throughput, a 9 percent reduction in hop-count, and a 23 percent reduction in end-to-end latency. According to the simulation results, the proposed protocol provides the best performance at a speed of 50 km/h, and beyond that speed, network performance degrades. The simulation results and extensive research show that the proposed protocol outperforms the existing protocols in terms of throughput, PDR, end-to-end latency, and hop count.

III. Simulator

[27] Presented how simulation can be used to see what would happen if it were implemented in real life. This is due to the difficulties of gathering data in the real world. The use of network simulators is highly comprehensive, and realistic vehicle movement is essential for achieving high-quality and precise results. Simulation of Urban MObility (SUMO) was one of the simulation programs used to produce synthetic traces of vehicles. SUMO allows users to create their vehicle routes, generate random traffic, or use a traffic request generator tool. This work described the main features of the SUMO traffic request generator, specified the appropriate input file configuration, determined the configuration choices required to characterize the situation, and tested the operating system's functionality. Five SUMO traffic demand generation tools have been evaluated qualitatively: DUArouter, JTRrouter, DFrouter, OD2trips, and MArouter. The limitations of each of these technologies were incorporated when simulating vehicle movement in real-world scenarios. The vehicle tracks obtained with this program were compared using genuine input data.

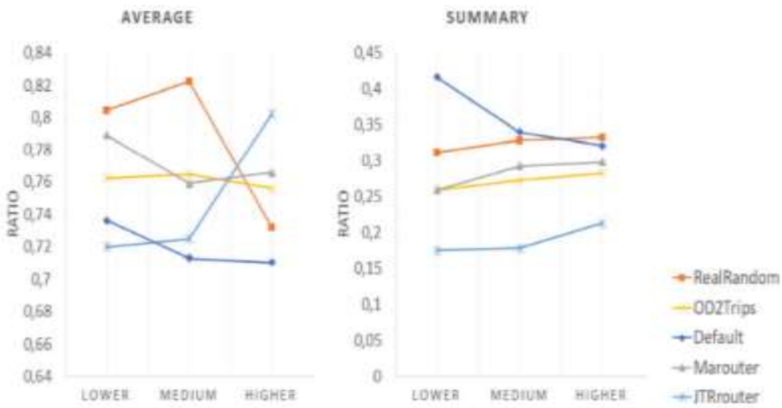

FIGURE 12
NORMALIZED TRANSITIVITY [28]

Transitivity, as illustrated in Figure 12, is the ratio of the triangle link three times over. In the vehicular network, this statistic reflects the proportion of neighbors that share at least one neighbor. Although the edge density is consistent across tools, the edge dispersion varies considerably. Some distinctions include route length, the average number of neighbors, connection density, relevance of nodes in route construction, and the number of clusters.

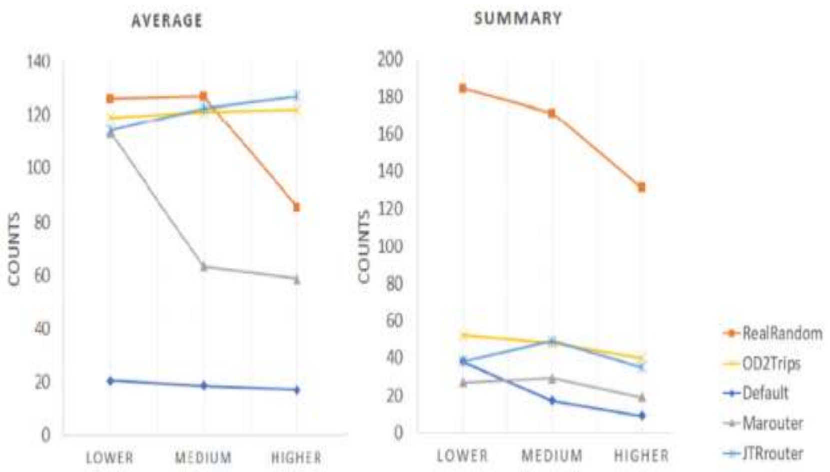

FIGURE 13
NUMBER OF COMMUNITIES [28]

The number of clusters generated by the default scenario is slow since the approach generates a higher linked graph than another. OD2trips, JTRrouter, and RealRandom generated segmented output networks with a high number of clusters. The number of clusters was reduced by half from all temporal perspectives, implying that more vehicles collide during the experiment. The only significant distinction is the actual random situation. This could imply that the origin and destination pairs of vehicle journeys are regularly repeated during the creation of vehicular traffic. There is no unique technique that can provide a more cautious score. Even when using the same input, the results of various network ad hoc communication measures can differ by an order of magnitude. The findings show that realistic and debugged simulation scenarios have an impact on trip duration, which in turn has an impact on network connectivity. The more verified is the vehicle trace, the more trustworthy are the results.

VANET requires smart vehicles on the road to provide service communication among vehicles. This study [29] was conducted to develop a versatile and efficient application. The objective of this research [30] is to improve the level of security while reducing delay time. For message broadcasting, vehicle to cellular in infrastructure communication was enabled.

Due to its dynamic nature, ensuring safe and dependable communication over VANET is a major concern. Various security methods have been developed regularly, but there are disadvantages such as increased latency, bandwidth consumption, security restrictions, and lower communication efficiency. To address these issues, a study [31] was conducted on the sensor-enabled SSVC protocol, which allows for secure and reliable communication in VANET. This is done to reduce network latency and improve network communication efficiency. The number of vehicles was used to create a network, and neighbors were found using the wireless access in vehicular environments (WAVE) protocol. Sensors attached to the vehicle engine are used to gather information, such as air pressure, temperature, and vehicle speed. This information is stored at the gateway, and network cars were registered at the gateway by assigning each vehicle a unique ID and password. Cloud connection was enabled to broadcast pop-up messages to all vehicles. The blowfish approach was used to securely store car location information in the cloud, improving vehicle communications security. Different performance indicators were used to evaluate the results of the proposed system through simulation. The findings were compared to existing mechanisms to determine the efficiency of the proposed SSVC mechanism. Based on simulation results, the proposed SSVC method was assessed using several performance metrics, including PDR, throughput, latency, key generation time, key recovery time, and routing control overhead.

IV. Medium Access Control (MAC) Layer Model

Several studies have been conducted to examine the medium access control (MAC) layer model on the VANET system. To obtain the appropriate review, the simulation results, including the communication process between nodes, the communication model used, and the advantages and comparisons between types of communication, were analyzed. A VANET network was created in the realm of vehicle communication networks with the aid of RSU [32]. The RSU handles each vehicle in the traffic system with specific mobility parameters, but there are still some issues with mobility management. This is due to the high cost of RSU, although it can improve the mobility management of the VANET system [33]. This study proposed a novel method for organizing a cluster structure (CS) and cluster head (CH) selection process suitable for VANET. The Adaptive Weighted Clustering Protocol (AWCP) clusters random nodes to achieve optimal CH by optimizing network parameters. As illustrated in Figure 14, after grouping sensor nodes at various loops and selecting any node as CH across multiple loops, each vehicle broadcasts any messages at each step to learn about their surroundings and their neighbors' mobility measures.

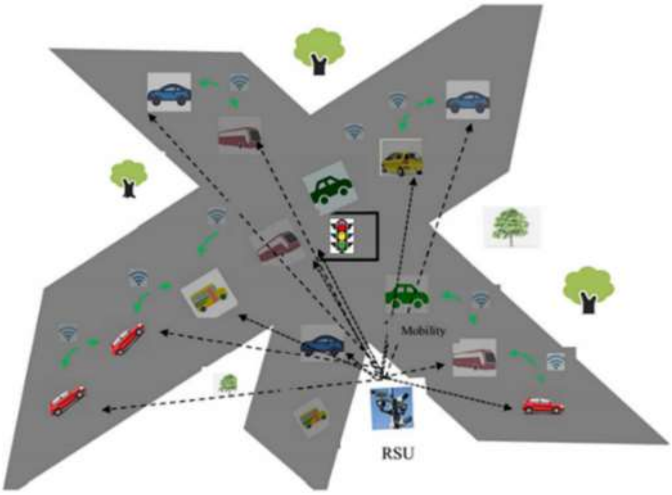

FIGURE 14
MOBILITY ANALYSIS [33]

The enhanced whale optimization algorithm (EWOA) is a new method for optimizing objectives. The vehicle network mobility routing protocol was used to evaluate the movement of each vehicle in the trustworthy clustering model, with known speed and location. The distance between the trusted vehicle node and RSU was evaluated using the AWCP-EWOA method. According to the simulation result, the AWCP-EWOA method provided the best lifespan, clustering efficiency, and so on when compared to existing approaches. As illustrated in Figure 14, the AWCP-EWOA method achieved the highest clustering efficiencies of 94.25 percent and 89.45 percent for 25 and 200 cars, respectively. Table 4 shows that the outer form of the proposed AWCP-EWOA method has better clustering efficiency and mobility than the AWCP protocol and the AWCP-Whale Algorithm.

TABLE 4
CLUSTERING RESULT VS VEHICLE [33]

Number of Vehicles	CH Life Duration, %	Optimal CH Election Time, s	CM Life Duration, %
25	83.22	0.3	72.22
50	76.22	0.34	78.22
100	82.22	0.36	56.22
125	79.22	0.22	53.22
150	75.22	0.22	72.22
175	92.22	0.36	76.22
200	89.22	0.31	71.22

VANET provides network members with information such as traffic lanes, traffic density, and accident information, as well as entertainment for safe and enjoyable driving. The WAVE system is designed to allow VANET to provide services efficiently. In this research [34], the limits of the conventional WAVE for congestion and shadow zones between RSUs between vehicles were investigated and a cooperative communication system was developed to address these constraints. The proposed approach has been shown to improve network performance even when there is inadequate infrastructure, which can result in shadow zones between coverage regions in the skipped region. The proposed method has also been developed following the nuances and specific characteristics of the WAVE standard. It show at Figure 15.

Figure 16 illustrates that to end the relay communication, the relay node sets the Type field to Release and includes the details on the routing path and resources utilized for the cooperative communication to the Coop Release message. The Coop Release message is sent to the RSU by the relay node when it receives it from the destination node. After receiving the Coop Release message, the RSU broadcasts the WSA message except for the relevant information at the next Sync Interval. The relay node that gets the WSA message will no longer participate in the cooperative communication, and the destination node that receives the Coop Release message will no longer perform the cooperative communication.

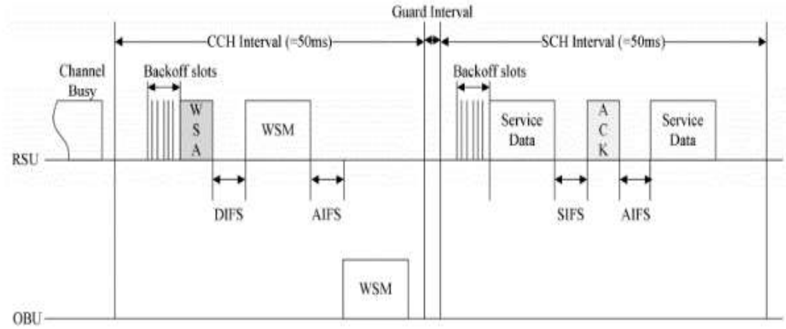

FIGURE 15
CHANNEL STRUCTURE IN THE WAVE STANDARD

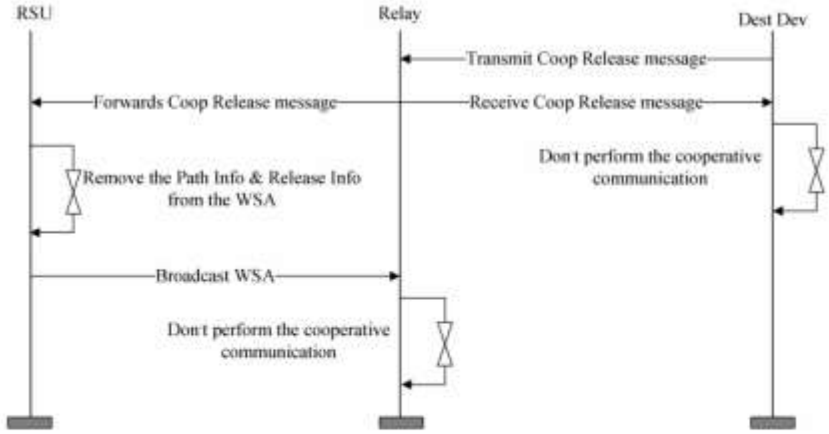

FIGURE 16
THE TIMING DIAGRAM

Disconnection can obstruct the delivery of safety services or other information requested by users, making the WAVE standard difficult to implement. The procedure used in this study [35] improved performance more than the existing algorithm with a cooperative communication strategy that reduces performance deterioration caused by frequent connection interruptions in the road environment. The proposed scheme uses RSU to provide network Quality of Service (QoS) and offers dispute-free data transmission. Through simulation, the proposed protocol has been shown to improve throughput and latency. As the service application offered by the RSU increases, the number of SCHs for the service application increases while the available resources for relay communication decrease. As the number of application services available for automobiles grows, the use of the suggested method becomes more complex. However, since this proposed scheme allows data to be transmitted without contention in the allocated resources, collisions with multiple access OBUs were avoided. The proposed scheme has the shortest delay of the three protocols since it can transmit data frames without contention during the allotted SCH period. Congestion in the WAVE standard increases as the number of vehicles in the vehicular network increases. The WAVE standard does not support multi-hop communication. Link disconnection occurs frequently in the shadow zone between nearby RSUs, and OBUs are unable to receive service data frames from RSUs. As a result, the delay in packet delivery was significantly increased. The OCBDF scheme was less affected by link disconnection; however, its delay increases due to congestion. Regardless of the number or speed of vehicles, the proposed method can provide high throughput, a high delivery success rate, and minimal delay. The simulation results have proven that the WAVE standard can increase the coverage area utilizing multi-hop communication, and the proposed scheme can reduce performance deterioration caused by frequent link disconnections induced by rapid vehicle speed changes. The proposed scheme can also offer QoS since the OBU can transfer data frames without conflict.

The development of autonomous driving technologies is the focus of VANET research in [6]. In VANET, vehicles can interact with everything via routes established by routing algorithms. The algorithm presented in this area is beneficial for consolidating data when communicating and preserving important spectrum resources. For the first time, the algorithm requires the initial part for the communication routing algorithm that may provide a steady and efficient path for communication as shown in Algorithm 1. All nodes are on the same level in outbound routing methods, such as AODV, DSR, and DSDV, which can cause packet data congestion and even loss as the number of communication vehicles grows. The routing algorithms that need to gather data effectively while communicating may waste communication resources due to a lack of data collection. Outgoing cluster routing methods such as CBRP have a small cluster size, making them ideal for mobile ad hoc networks (MANETs) with tiny scenes but not for VANETs, where the scene can be much larger and more complicated. When conversing, CGW in CBRP may result in a waste of communication resources, thus the cluster routing method must be improved to adapt to the scenario in VANETs. This improvement is shown in Algorithm 2.

```
Operation Flow
Input: cluster information
If the node index is the source of the RREQ it received
   discard this RREQ
else
   set up a reverse route or update the exiting reverse route
   read the cluster information from the cluster algorithm
End
```

ALGORITHM 1
THE INITIAL PART OF THE TWO-LEVEL COMMUNICATION ROUTING ALGORITHM [6]

```
Operation Flow
Input: cluster information
If the ih – >saddr() is the source of the RREQ it received
    if the ih – >saddr() and the node index are in the same cluster
        node index sends RREP
        free this RREQ
    else
        free this RREQ
else
    if the destination node index is the CH[index] and the ih – >saddr() is the CH_dst_prehop[ih–>saddr()]
        node index sends RREP
        free this RREQ
    else
        if ih – >saddr() is the CH[index]
            node index sends RREP
            free this RREQ
End
```

ALGORITHM 2
HOW DESTINATION NODES SEND RREP [6]

The VANET architecture changes frequently as vehicles move swiftly. As the number of vehicles increases, so does the amount of communication, increasing the risk of data collisions and transmission delays. VANET system requires reliable, low-latency, and efficient pathways for vehicles to interact with each other. Existing routing algorithms are unable to integrate data or are unsuitable for large-scale VANET systems. In this research vehicle attribute information was examined and a new cluster method was proposed to arrange vehicles on the road. CHs were dynamically chosen based on their attribute information at any given time. Figure 17 a model for the cluster method, which includes three types of vehicles, namely cars, buses, and trucks. At the moment, there are three clusters on the road. The study examined a variety of nodes in a VANET where the source node can connect to the destination node via CHs. The proposed method is based on the AODV routing algorithm and cluster information. Compared to standard single-level algorithms, this method can collect more communication data and retain more important communication resources. Under the proposed two-level communication method, all types of network nodes and vehicle nodes would interact with each other through clusters. Compared to the existing cluster routing methods, the proposed method is considerably better suited for large VANET since the clusters do not require a gateway to communicate. In the simulation part, the researcher included genuine street scenes in SUMO, and the vehicles may travel according to traffic regulations as they would in the real world, which is better suited for VANET. After examining the communication performance of Network Simulator version 2 (NS2), it was discovered that its packet loss rate, average transmission latency, and the normalized fraction of routing overhead were all superior to standard routing methods. Figure 18 shows that provided the maximum speed is limited to the same lane, the speed packet loss of the proposed method is considerably more stable as the number of vehicles increases. The charges were too small compared to typical AODV, with an average value of 1.5 percent lower. The routes set by the proposed method were significantly more stable and efficient than standard routing techniques, they have lower latency, hence meeting the requirements of the VANET system.

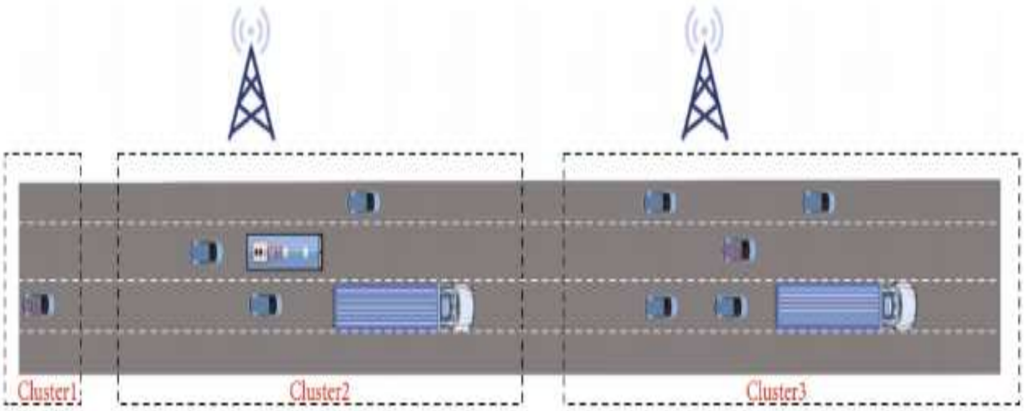

FIGURE 17
MODEL OF CLUSTER ALGORITHM

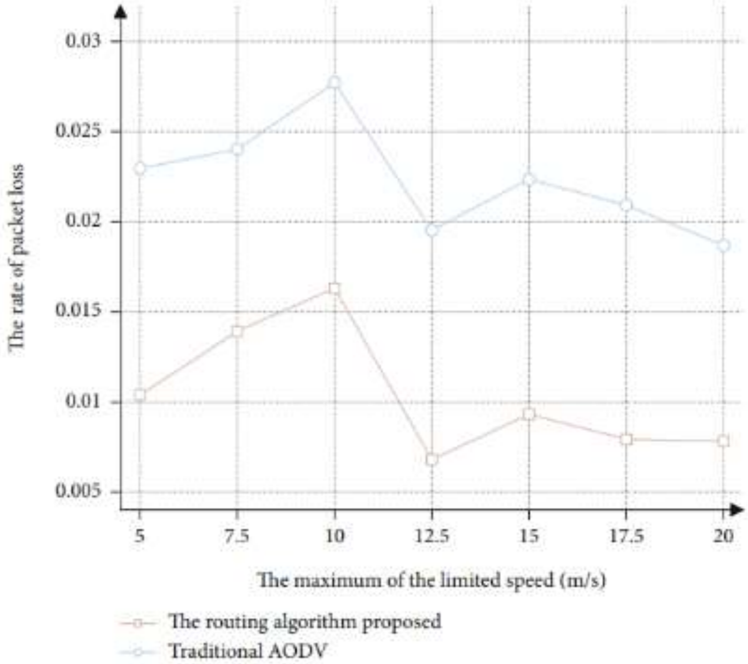

FIGURE 18
RATE OF PACKET LOSS

Due to the growth of fifth-generation (5G) technology, combining V2X and device-to-device (D2D) communications in a vehicle environment has been a focus of research in [36]. Establishing V2X and D2D communications in urban environments remains a difficult task since vehicles are subject to dynamic changes in their movement and direction, which are influenced by traffic congestion. Also, disseminating safety messages over VANET without causing broadcast storms poses a challenge. The transmission delay in the proposed work is shown to range between 10 and 15 milliseconds. The various discrepancies in transmission latency suggest that existing approaches were unable to improve data transmission performance. The two-level clustering process was time-consuming and unstable, as cluster creation and reformation occur far too frequently, slowing data transmission.. Security messages were transmitted in 2.2 mm in the planned 5G mobile VANET, which is significantly faster than existing approaches. The two-level clustering method required 18 milliseconds for data dispersion even with MS 5 m/s, which is comparable to transmission delay [37]. Since this method does not use a deployment efficiency strategy, the deployment delay is quite long, making it unsuitable for safety-related applications. The developed hierarchical tree of security awareness for dissemination (SA-HTD) mechanism for safety message transmission in the research allows for the dissemination of safety messages without delay and data duplication, making this technique suitable for security applications in VANET.

The study in [38] proposed a new 5G mobile VANET architecture that would overcome all VANET' previous challenges while also improving QoS. To achieve this, the adaptive mobility aware path similarity algorithm (A-MAPS) was used to group all of the vehicles in the study area. Cluster formation and CH selection were based on several significant factors, including the similarity of future routes, which is critical in urban settings. A Bayesian rule-based fuzzy logic method (BRFL) was proposed to create reliable V2V and D2D communications by determining the best forwarder for V2V communication and the best device for

D2D communication. The match function was used to implement a unique two-fitness hypotrochoid spiral optimization method (2F-HSO) for V2I and V2P communications. BRFL not only enables V2V communication but also supports device discovery procedures in D2D communication [39].

TABLE 5
COMPARATIVE ANALYSIS

Performance metric		Two-level clustering	Cellular-5G VANET
PDR in V2X (%)	Based on mobility	87.4	96.8
	Based on network size	88	96.91
Throughput in V2X (Mbps)	Based on mobility	1.29	1.8
	Based on network size	1.23	1.9
Delay (ms)	Transmission delay	23	12.3
	Dissemination delay	20.6	1.8
D2D communication	PDR (%)	85	95
	Throughput (Mbps)	1.26	2.1

Table 5 shows a comparison of the proposed 5G Cellular-5G VANET method with its closest competitor, namely the existing two-tier clustering system. The analysis demonstrated that the suggested approach outperforms its competitors in every important performance metric, regardless of mobility or network size. Due to inefficiencies in cluster formation, forwarder selection, and gateway selection, the current two-level clustering approach was unable to achieve similar performance. The proposed Cellular-5G VANET solution significantly improved overall network performance by incorporating a reliable clustering mechanism, optimized V2V/D2D communication, an effective MGW selection process, and timely deployment of optimized safety messages. The newly created 2F-HSO algorithm, which employs two fitness functions, was used to allow V2I communication. The SA-HTD method ensured message deployment security by preventing both deployment delays and duplicate data deployments. Two different message types (accident and traffic) were examined for the transmission of safety alerts, and an SA-HTD was created to handle them. The planned Cellular-5G VANET method was represented in the OMNeT++ simulator. The results demonstrated an increase in PDR, throughput, transmission delay, and dissemination delay [40] [41].

Currently, VANET focuses on driving safety, driving efficiency, and various types of information and entertainment available on the road network. Each vehicle is treated as a node in this analysis [42], with each node having the ability to interact directly with other nodes within its transmission range. When nodes interact, irresponsible nodes may provide incorrect information, causing network performance to deteriorate which may lead to undesirable outcomes such as traffic congestion and accidents. One of the most pressing security concerns, particularly in safety-related applications, is the detection of malicious nodes. To avoid a flood of information on each erroneous message, malicious nodes can be removed.

Merkle hash tree (MHT) was used for data synchronization and data verification [43]. All leaf nodes are at the same depth and non-leaf nodes are hashes of child nodes. A hash function converts input into a fixed output and calls the result a hash. The output is always unique for each input. The complexity of search and traversal in a binary Merkle tree is O(n), while the complexity of synchronization, search, delete, and insert operations is O(log n). Certificate revocation and other defense mechanisms were designed to root out and protect against other nodes. Information gathered from illegal nodes must be distributed to nodes in the vehicle network. In this work, a novel model for certificate revocation strategy for VANET is presented to solve the drawbacks of the certificate revocation list (CRL). The cluster-based Communication and MHT Certificate Revocation (C2MTCR) concept uses MHT clustering and building to revoke harmful certificates from the vehicle network. The proposed work was simulated with the help of the NS2 and Power BI tools, and the results were compared to existing works.

[44] proposed that GPS management be put in a more precise position by collecting safety information in metropolitan areas via car safety situations, where GPS typically fails to provide the required positioning precision. The AOA measurements collected by the vehicle on its track were used to provide the weighted least squares localization method. For this reason, the vehicle determines the angle of arrival of the breaking packet from the RSU at a known point switching to the Uniform Linear Array (ULA) and uses the Multiple Signal Classification (MUSIC) Algorithm. The method aims to take advantage of trustworthy measurements obtained close to RSUs, where high signal-to-noise ratios and favorable geometric conditions result in precise angular resolution while retaining multipath resistance.

The specifications from ETSI (European Standards Organization) technical report were used to model wireless channel propagation. The route loss described by the double slope model calculates signal attenuation at a given distance from the transmitter using the formula:

$$L_{PL,dB}(d) = \begin{cases} L_{F,dB}(d_0) + 10\gamma_1 \log_{10}\left(\frac{d}{d_0}\right), d_0 < d \leq d_c \\ L_{F,dB}(d_0) + 10\gamma_2 \log_{10}\left(\frac{d}{d_c}\right) \\ + 10\gamma_1 \log_{10}\left(\frac{d_c}{d_0}\right), \qquad d > d_c \end{cases}$$

where d_0 is the reference distance, d_c is the cutoff distance, $LF_{,dB}(d_0)$ is the signal attenuation in free space (Friis propagation model) at distance d_0, and $\gamma 1$, $\gamma 2$ are two attenuation coefficients.

The proposed approach provided a high degree of precision in the predicted location from over a hundred meters before crossing the RSU. This trend is a direct result of the increasing size and quality of the AOA. The performance then stabilizes around the smaller one error number, outperforming GPS accuracy by a significant margin [45]. It is worth noticing the rising trend in the WLS curve following the crossover [46]. This is due to the infamous glitch effect integration that characterizes inertial sensors, such as the odometer, and demonstrates that the localization accuracy remains acceptable until the integrated inertial error grows too large; at that point, however, another RSU will most likely be detected, allowing the vehicle to perform a new localization procedure. Despite the actual situation according to the ETSI standard for VANET, the simulation shows that the method can outperform GPS-based localization. The proposed algorithm is effective and compatible with DSP technology, notwithstanding its complexity.

CONCLUSION

In this systematic literature review, the process of data transmission and information exchange between vehicles affects the quality of data and information transmitted between nodes. Data transmission has a significant impact on the data transmitted, taking into account the variable speed of the vehicle on the highway, coverage area, support infrastructure, and the type of information the user sends to other road users.

The formed of communication architecture can be implemented by vehicles or nodes that communicate with each other using communication routing technology. Some algorithms compare the results to the process of sending a message to another node in terms of speed and security. Communication can not only collect communication data, but also save more valuable communication from limited resources. This helps in the process of minimizing the routing of data and information sent between nodes and reducing the delay in sending data and information.

Communication between source nodes forms a communication pattern with the destination node using the cascading communication method. Some of the simulation examples are more in line with the requirements of VANET communications research, as real-world vehicles move according to traffic rules. From this we can conclude that the normalized percentages of packet loss rate, average transmission delay, and routing overhead are superior to standard routing methods. This means that routing models that use variables are significantly more stable and efficient than standard routing algorithms and have lower latency.

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