

Review

An Overview of the Current Challenges, Trends, and Protocols in the Field of Vehicular Communication

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Abstract: Intelligent transportation systems (ITS) provides a safe and reliable means of transferring data between vehicles. The document describes the transmission systems, protocols, networks, taxonomy, and applications of Intelligent Systems. Detailed analysis of the existing transmission flow systems is required, including classification, standards, coverage, applications, as well as their advantages and disadvantages. The adaptability of transmission networks, such as ad hoc, hybrid, mobile ad hoc networks (MANET), and Vehicular ad hoc networks (VANETs), has a significant advantage. Described protocols for a variety of communication types, including routing techniques, platforms, structures, and the use of information areas as well. The use of intelligent technology can determine reliable, comfortable, safe, and trustworthy vehicular communication. This paper analyzes the current vehicular communication (VC) research flow and their deployments with indicated areas where further development is necessary. This paper examines how emerging technologies in the upcoming markets will enable the development of high-featured VC technologies. The challenges of improving upon existing VC systems in the development of future systems are discussed in this paper, including medium selection, link and service quality, security, channel characteristics, and mobility. The purpose of this study is to identify the need for the development of improved VC technologies, networks, and protocols for a wide range of applications in the future.

Keywords: protocols; vehicular communication; intelligent technologies and applications; networking and taxonomy



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1. Introduction

In the early days, the first mode of transportation was the road system throughout the world. Road transport research was based on a variety of factors, including oil prices, safety concerns, environmental concerns, energy consumption, and many more. There are many people who spend a lot of time in their vehicles on a daily basis. Therefore, it is imperative to make this time pleasant, brief, and safe. In 1991, the United States (US) transportation department introduced Intelligent Transportation Systems (ITS).

ITS research has focused mainly on reducing the complexity associated with advanced traffic problems that we face today through the use of advanced technology. In terms of ITS, roads and intelligent vehicles are key components, and they provide an infrastructure that is essential for the efficient and productive transmission of information [1]. Vehicle communication requires new technology to transmit and receive messages from and to each vehicle, and transportation systems can provide a variety of traffic and safety aspects.

Onboard sensors of the vehicle can be used to produce important information to clarify the surrounding environment in intelligent vehicles for additional control techniques [2]. Researchers have also focused on forwarding video and image data among vehicles. VC technology enables the transmission of digital data between vehicles and roadside infrastructure of roadside (I2V/V2I) or a collection of these models [3].

On the other hand, the design and development of vehicle manufacturers have gained researchers' interest recently. In an automated smart vehicle manufacturing business, for the controlling and process execution, a federated learning (FL) mechanism is introduced to make a decision [4]. The proposal suggested design provides a Trust Threshold Limit (TTL) to control the extra use of energy, embedded equipment, tools, and cost functions, reducing manufacturing waste. It emphasizes the intelligent system usage in decentralized Blockchain-based smart contracts, the company's trading rules, and its benefits to manage assessments of marketing risk during socio-economic crises. The real-time model included pricing, delivery, and energy functions. FAI improves decision accuracy for the smart contract-based Automobile Assembly Model (AAM), restricting cost, energy, and other control functions in procurement, assembly, and manufacture. However, the model faces problems with customizability and cloud integration [4].

This paper explains the communication of vehicular systems and applicable functions, considering the increasing need for vehicular communications. In order to avoid requiring costly frameworks to be established, appropriate transmission media and good routing protocols be selected for the connections made among vehicles.

According to Abioye et al. [5], it can be defined as the building of machines with the capability of solving a number of problems in multiple domains by controlling themselves automatically, with thoughts, feelings, worries, pros, and cons. There is no doubt that this remains a major goal of AI. However, it has been tough to obtain and has proven to be elusive. The intelligence system is a concept of designing machines that are capable of achieving higher levels of performance than humans.

The purpose of this paper is to provide a communication overview of vehicular technologies and their classification. The current types of networks, systems of protocols, and transmission of data in intelligent technologies are outlined, as well as the nature and function of VCs. The proposed associated arguments and conclusions are described.

2. Taxonomy Intelligent Communication Networks

Transmission between vehicles can be accomplished in a variety of ways using different equipment and technologies. In a vehicular communication system, data is transmitted from the vehicle to vehicle (V2V). The transmission of data between two vehicles requires that the vehicles be within line of sight (LOS), while roadside devices are based on infrastructure intelligent technologies (I2V). The vehicles must be within radio range of each other in order to communicate using I2V. Due to the fact that I2V utilizes roadside units, it is essential to establish communication between them. An ad hoc vehicular network (VANET) enables vehicles to communicate directly with one another and with the framework. With VANETs, automobiles can transmit messages even when they are not within radio range or line of sight. Vehicles transmit messages to infrastructure that lies outside their range by using other vehicles as routers within their range. Furthermore, flows of less traffic can decrease the association of networks [6]. In this overview, we will focus on communication between vehicular systems that do not require any additional equipment.

The IoV communication taxonomy is based on five types of network communication [7], as illustrated in Table 1. Information can be exchanged between vehicles through Vehicle-to-Vehicle (V2V) communication. Vehicles connected by V2V act as nodes and try to communicate with each other. A crash event can be transmitted between vehicles using V2V communications. It should be possible to communicate quickly without much delay so that the other vehicle receives the information without delay [8].

Table 1. Taxonomy of Internet of Vehicles (IoV) communication Systems.

S.No	Taxonomy Networks	Networks Application
1	Vehicle-to-Vehicle (V2V)	(i) Alerts regarding safety (ii) Transmission of data (iii) Sharing of videos
2	vehicle to infrastructure (V2I)	(i) Parking with smart technology (ii) Cities with smart technologies
3	Vehicle-to-Personal devices (V2P)	(i) Alerts sent to a mobile device (ii) Information and entertainment
4	Vehicle-to-Roadside unit (V2R)	(i) Alerts related to safety (ii) Smart traffic lights with the latest technology
5	Vehicle-to-Server (V2S)	(i) Software updates that are automatically carried out (ii) Remote diagnostics of vehicles

The rapid increase in the development of mobile communication-based technologies has enabled the production of new types in the rapid development of communication systems for vehicles in recent years, which has improved driving comfort, road safety, and efficiency [9]. A high level of interest has been generated for VC capability. Further research work on VC is discussed in [10]. To defend the VC, VANETs were established that require communication between roadside and vehicle units. In a MANET, known as a mobile ad hoc network at high speeds, the vehicles moving forward can receive and send packets to other vehicles. Both MANETs and VANETs have the same self-organization and movement of nodes. Furthermore, the nodes differ when the channel conditions are unreliable and the nodes are highly mobile [11]. Other kinds of ad hoc networks have similar characteristics to VANETs, including wireless sensors- and wireless mesh networks.

With unicast, multicast, and flooding, MANET research focuses on the development of transmission protocols that facilitate the exchange of messages across multiple hops [12]. Wireless sensor network (WSN) research addresses the appropriate sensing challenges, such as transmission and resource constraints for nodes [13]. The recent research based on Wireless Mobile Networks (WMN) includes mobile phone systems [14]. In case wireless communication is required, WMNs are based on infrastructure networks. They typically support broadcast and unicast communication and are mature.

In a hybrid network, it is possible to integrate the best features of cellular, ad hoc, and WLAN networks. An architecture proposed by Namboodiri and Gao [15] uses some vehicles with both cellular and wireless capabilities as gateways and mobile network routers; through multi-hop links, automobiles with only wireless capabilities transmit to mobile network routers the gateway vehicles to remain connected to the world at large. Several VANETs utilize gateways that have fixed cellular and WiMAX or WLAN access points at traffic junctions both for routing purposes and to collect traffic information, as well as connect to the Internet [16]. If an access point is present, a VANET can integrate a WLAN and cellular network; otherwise, a 3G (third generation) connection is used. Janokar et al. [17] have developed an agricultural bot controlled by a mobile phone through Bluetooth. The bot can be adjusted based on farmers' need to accomplish some agricultural functions. Salameh and El Tarhuni [18] have presented the shortcomings of 5G in terms of the need for more data-intensive, low-latency, and ultra-high-reliability applications. Lu et al. [19] have proposed a secure communication scheme for the dual-UAV-MEC system to effectively increase the secure calculation capacity of the system.

DRIVE C2X is a field operational test (FOT) carried out by the European Commission, using WLNA and 3G technologies, as it is based on CAR-2-X transmission of helpful systems. FOTs in Europe are interested in evaluating the efficiency of safety systems as well as their impact on traffic. Other FOTs, such as simTD German and SCORE@FFOTs French, have been initiated at the national level, while some FOTs have been carried out across Europe. In order to validate the infrastructure, the goal of the DRIVE C2X project is to evaluate the test results and prepare for the development of cooperation [20].

An edge server that is housed in a small data center and supports a limited number of cars nearby is referred to as a handover in this context. Using mobility processes, 5G CAR analyzed the Third Generation Partnership Project (3GPP). Cars send information about their location to RANs, which are evaluated to determine whether handovers are needed. Based on analytical data methods, the location information indicates whether Edge cloud servers are nearby. If the connected vehicle's signal strength deteriorates and it switches to a new base station, the target RAN uses the handover information to select a new edge computing server. Table 2 shows some literature reviewed for handover in 5G-V2X.

Table 2. Algorithm for the handover of 5G-Vehicle-to-everything (V2X).

S.No	Title	Algorithm	Contribution
1	A resource management framework for multi-user V2X communication in dynamic networks based on virtual cells	This paper discusses a system known as the user-centric virtual cell (DUVC) [17]	(1) Analyzing the characteristics of vehicle movement, (2) Concerning the issue of resource management, (3) A method for approximating the min-max-fair problem is presented so as to solve the problem of resource management in virtual environments. Furthermore, it provides better performance when compared to previous algorithms as well
2	An efficient cluster-based resource management scheme and its performance analysis	A cluster-based resource management scheme for V2X networks and its performance analysis have been developed [18].	(1) A cluster-based resource management system and its performance analysis are recommended for V2X networks to improve reliability, throughput, and latency. (2) V2V and V2I users are assigned radio resource blocks (RB) and power levels according to the resource management problem. (3) Develop a method for analyzing vehicle interference. (4) An unlicensed spectrum for cellular and VANET interference assessment. Meanwhile, interference within the territory of the mobile phone user is investigated. (5) A fast-fading random-effects analysis technique is explored to reflect the V2X latency and reliability requirements in analysis constraints only quantifiable from slow channel state information (CSI). (6) Cluster-based approaches provide the best resource allocation. Based on the experimental data, the proposed technique has promising performance.
3	Vehicle-to-infrastructure handover algorithm based on multiple criteria	Multicriteria handover algorithm for V2I communications [19].	Reduction of the number of unnecessary handovers as well as improved the overall handover time by limiting the number of candidates that have to be scanned for AP/BS

In this paper, we group cellular and WLAN technologies as extended 3G and WLAN technologies (Figure 1). The information that is collected through the communication of a vehicle can be utilized to meet the needs of drivers and passengers, helping to improve the efficiency and safety of the road.

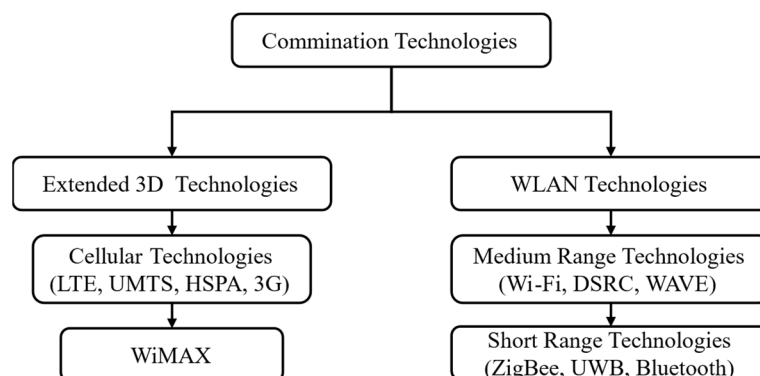


Figure 1. Intelligent systems technologies.

2.1. Intelligent Communication Technologies

Figure 1 illustrates the cellular communication technologies to provide data over distances of miles and can be utilized for creating a backhaul network between two sites or to distribute messages to devices of mobile users, such as laptops and smartphones. Therefore, the technologies can be more useful for VC systems. Technologies such as UMTS/LTE (Long Term Evolution) and WiMAX are useful in I2V systems for assigning priorities to vehicles and changing lanes while transacting. As shown in Table 3, the long-range communication technologies, standards, coverage, bit rates, and descriptions are described [21].

Table 3. Intelligent wireless systems communication.

	Cellular Technologies	WiMAX
Standard	ETSI, 3GPP, standard Based on 3G cellular technology	Broadband technology in 2007 Based on the IEEE 802.16 standard
Coverage	Up to 15 km	5 km
Network	Full mobile	Full mobile, P2M
Modulation technique	CDMA, TDD, FDD	QAM-16, OFDMA, QAM -64 (QPSK 1/2, BPSK-1/2)
Advantages	Large coverage High data rates Currently available, especially in the case of LTE	Large coverage High data rates
Disadvantages	Very high deployment costs Scalability (backhaul)	High deployment costs Scalability (backhaul)
Bit Rate	<2 Mbps to 100 Mbps	75 Mbps
Applications	Communication between high-speed vehicles and mobile phones	VoIP (Voice over IP), Internet access, Email
References	[3]	[19]

2.1.1. Cellular Technology

(a) 3G

In order to support faster and wider band communication services, third-generation cellular systems are being developed. High-speed Internet access could allow Wideband communication in addition to the delivery of high-quality videos and images with a similar quality as fixed by the network. The services have quick communication, including internet, voice, and fax services, as well as seamless global roaming. The use of cellular communication systems, including 3G, 2G, and 4G, with data rates of 58 kbps to 116 kbps for users to connect to the internet. The 2.05 Mbps data rate represents the third generation of stationary devices wireless networks, with 384 kbps for slow-moving nodes and 128 kbps for fast-moving nodes [22].

Networks of cellular technology with the third generation can contribute significantly to VC technology when applied to highways and cities that are larger and cover a large area. Given certain services of video-on-demand internet protocol television, the data rate of 128 kbps of 3G networks is not compatible with fast-moving vehicles on highways. Also, because cellular networks are naturally concentrated and in V2V transmission, there is no centralized framework, it is not possible to directly apply 3G technologies [23]. As a result, many of the proposed VC technologies utilize 3G wireless communication networks in conjunction with other wireless technologies [24].

(b) Universal Mobile Telecommunications Systems (UMTS)

The UMTS system, also known as 3G, is being deployed into the 4G technology. During ad hoc communication, the network does not specify a means due to the data is not directly transmitted between the nodes but through the backbone network, routed, and then communicated to the receiver from the base station. Furthermore, ad hoc wireless communication has lower latency than UMTS communications. UMTS used a code division multiple access (CDMA) mechanism as a mobile device that guaranteed slots of

communication [25]. By assigning orthogonal channel codes to every simultaneous transmission between different devices, a similar frequency can be used across devices. The original downlink bandwidth of UMTS is 384 kbps, which has been increased to 7.2 Mbps data rates by the high-speed downlink packet access (HSDPA). Further, the high-speed uplink packet access (HSUPA) protocol is used to increase the uplink bandwidth up to 64 kbps. HSUPA is theoretically capable of delivering up to 5.8 Mbps [26]. It is important to note that both HSDPA and HSUPA are types of HSPA.

Since point-to-multi-point communication is employed, UMTS is extremely useful in vehicular applications in which, such as for warnings about road conditions and traffic jams [27]. UMTS networks can be deployed according to the performance in different applications of this study. A set of UMTS standardized transmit services includes the Multimedia Broadcast Multicast Service (MBMS) and the advanced Cell Broadcast Service (CBS), which network operators can use in a specific geographic area to broadcast messages to the equipment of the user. In vehicular applications, MBMS can specify sophisticated multicast services with low transmission delays. In UMTS, traffic warnings are transmitted with a delay of approximately 300 milliseconds (ms). Use of MBMS for transmission distribution pass to vehicle-to-vehicle delays of around 500 ms [28].

(c) Long-Term Evolution (LTE)

With the UMTS Terrestrial Radio Access (E-UTRA) air interface, LTE collects a high data rate optimized packet of radio access and has low latency. To meet these requirements, significant changes were required at the physical layer, new coding schemes and modulation techniques were adopted, and the transmission time interval (TTI) was reduced. Enhancements set for UMTS LTE, comprising an all-IP flat architecture of networking in the Third Generation Partnership Project (3GPP), are proposed to make use of the mobile communication system of the 4G fourth generation [29].

The European Telecommunications Standards Institute (ETSI) consists of a partnership that is leading the project. The development of 4G and advanced radio systems is a step toward increasing the speed and capacity of mobile networks. The LTE standard facilitates spectrum flexibility broadcasting bandwidths to be chosen between 1.4 MHz and 20 MHz, based on the available spectrum. In 2×2 input-multiple output-multiple (IMOM) transmissions, an 18 MHz bandwidth can provide up to a 160 MHz data rate, and in 4×4 IMOM transmissions, up to 400 Mbps. The high uplink data rate is 80 Mbps [30].

There was 1000 times more traffic on 5G networks than on 4G networks in a heterogeneous world. As in the 5G vehicular network, mobility management is a problem for the intensive use of video-based content anytime and anywhere. Handover decisions for connected vehicles in ultra-dense 5G networks use modern handover techniques that differ from the techniques used in 4G and LTE networks. In ultra-dense 5G networks, the speed at which cars make handover choices impact the QoS provided to users [31].

2.1.2. WiMAX

A wireless technology known as WiMAX (Worldwide Interoperability for Microwave Access) [32] provides wireless data, as well as full mobile cellular access from point-to-point links to long distances. According to an update in 2011, it can transmit data up to 1 Gbps speed with fixed stations. The current research has shown that WiMAX is a candidate system that is suitable for vehicle applications. A WiMAX fixed transmission can reach up to tens of kilometers and provide 20 Mbps (six channels) of data rates in a sight-of-line environment. Additionally, it supports other modulation modes (QPSK-1/2 and BPSK-1/2) and time division duplex transmissions.

Moreover, WiMAX fixed enables a relatively smaller number of RSUs (roadside units) to transmit a broad area, thereby expediting the maintenance and deployment of base stations. For mobile WiMAX, 40 Mbps is the data rate, which is sufficient bandwidth in vehicular communication for a variety of services [33].

In WiMAX mobile devices, there is a unidirectional antenna, which has less advantage than a directional antenna. However, it is more portable. Moreover, this means that when

mobile WiMAX CEP (customer equipment premises) is used in a sight-of-line location, 10 Mbps speeds can be spread over up to 10 km. Additionally, in urban environments, sight-of-line access is often not available, and over a distance of 3 km, speeds may be as low as 10 Mbps. To decrease these objections, WiMAX transmission for vehicle communications would need to be built as a new network. This is not necessary for LTE as long as it is an advancement on current HSPA (high-speed packet access) networks and W-CDMA [33]. The other drawback of WiMAX is a bit error rate. A common misconception is that 60 Mbps can be achieved over 40 km. At the high range (40 km) of WiMAX, the rate of bit error increases, which means that a lower bit rate must be used. A device can operate at higher bitrates by decreasing the range [34].

2.2. WLAN Technologies

2.2.1. Medium-Range Communication Technologies

WLANs (wireless local area networks) are also known as medium-range communication technologies. Radio range is available, which is typically a few feet to tens of hundreds of feet. V2V transmission makes use of the DSRC-based (Dedicated Short-Range Communication) WAVE protocol for collision avoidance messages [35]. The ad hoc mode, in contrast, allows the assignment of flexible radio demands for data transmission using CDMA and may provide a greater level of granularity. The ad hoc method of coordination, however, requires a complex design [36].

Despite these drawbacks, most VC systems employ various approaches [37]. The general communication standards used are Wi-Fi, Bluetooth, and mobile cellular networks (for example, GSM, 3G, and 4G). Ferro and Portorti [38] compared the characteristics of Wi-Fi and Bluetooth (802.11 IEEE a/b/g/n) using a variety of metrics. These metrics included topology, capacity, security, service support quality, and power consumption. Baker [39] assessed the strengths and weaknesses of ZigBee (802.15.4 IEEE) and Bluetooth applications for industrial and stated that ZigBee could show a different variation of industrial requirements than Bluetooth due to its greater range, higher flexibility, longer battery life, and mesh networking architecture's reliability. Table 4 illustrates the applications, coverage, bit rates, and standards of the range of medium-technology communication applications. Following is a description of the range of medium technology communication applications.

(a) Wireless Fidelity (WiFi)

IEEE WiFi transmission is based on standards (802.11a/b/g/n) and employs a cellular model for WLAN. According to the 802.11 IEEE standard [40], it provides wireless connectivity to nodes, which requires fast installation, i.e., PDAs, smartphones, or Laptop computers in a WLAN. VC Wi-Fi has been used by Car2Car [41], a nonprofit organization established by European car manufacturers. In order to reduce the number of accidents, the following features will be introduced: a driving progressive benefit, a floating decentralized car message for improved native traffic efficiency, and connections between business and passenger comfort data. The European Wheels-on-Network (WoN) is a research project in this area [42].

Because of its capacity level, Wi-Fi communication has limitations within VANETs, in terms of coverage and interference, the mobility of nodes, frequent changes in topology, and fragmentation of the network. To offer new MAC access strategies, substantial effort has been devoted to the development of efficient routing protocols [43]. The 802.11 standard MAC protocol uses a based connection access structure because adjacent devices using the same channel may cause interference. Additionally, this mechanism can greatly limit network through. The fact that mobility is handled at the MAC layer allows the handoff among adjacent cells to be made clear to the layers that are arranged on top of an 802.11 IEEE node. Many routing techniques developed for earlier ad hoc networks have been presented to meet the needs of particular VANET applications and scenarios [44].

(b) Dedicated Short Range Communication (DSRC)

DSRC is a collection of several wireless standards initially developed by IEEE, which operates on the 5.750 to 5.825 GHz band assigned by USFCC (United States Federal Communication Commission). IEEE 802.11a is primarily designed for use in indoor WLAN applications. For the indoor low-mobility propagation environment, all PHY layer parameters are optimized [45]. A layer of MAC DSRC is designed for outdoor functions. Examples include vehicles that are capable of speeds of 150 km per hour. DSRC's MAC modulation and frequency band are the same as those of 802.11a, with the exception of main differences in the application environment, operating frequency of the band, and the physical layer and MAC layer. Although multiple channels are supported by the physical layer of the IEEE 802.11, MAC action over the different channels is left up to the vendor. The standard is not implemented. The band plan of DSRC consists of seven channels, with one command channel supporting safety messages of preference and six channels supporting no safety functions [46]. DSRC channels have a bandwidth of 10 MHz, as opposed to the 20 MHz of IEEE 802.11a channels. With a data rate of 26 Mbps, DSRC can deliver this service with a small-range radio two-way system, with the perception of a lower price than cellular, satellite, or WiMAX communications.

Currently, for the vehicular network, the workgroup of the DSRC adopts Wi-Fi standards appropriate for infrastructure V2I as well as modes of ad hoc communication V2V. The CICAS (cooperation and intersection collision avoidance systems group) has developed its own structure with DSRC services in mind in order to integrate framework vehicles with other consortiums [47]. In the vehicular communication environment, DSRC has been specifically designed for public safety and special operations. IEEE standard 802.11p based on DSRC is being critically acclaimed for its use in improving highway safety communication and efficiency. Several protocols should be used in strict environments to enable low-rate communication, safe vehicle speeding, strict quality of service, and delay of predefined thresholds, as well as minimize communication power consumption, maintain user privacy, and accommodate other challenges. Among the potential uses of this system are the collection of electronic tolls, the avoidance of collision intersections, the automatic safety inspection of vehicles, the designation of priority signals for traffic and emergency vehicles, and many other applications [48].

Currently, DSRC utilizes several features for V2I transmission; however, V2V functions will not be fully functional until the majority of vehicles on the road are equipped with DSRC systems. A complex DSRC development problem arises as a result of the lack of guarantees that manufacturers have on the network nodes with which to broadcast their systems. However, local infrastructure installation agencies will not invest until their devices can communicate with the based infrastructure if they have devices [49].

A major challenge in the deployment of DSRC, particularly for safety applications, is that reception is likely to be poor due to conditions of non-line-of-sight reception at road intersections. With good coverage for information exchange, a cellular system alternative is needed. Unlike other wireless technologies, DSRC is not expected to interchange, nor is it anticipated to attend to all the vehicle's communication requirements. Rather, the functions of DSRC are treated as safe, applications of small distances, subscriptions free, electronic toll collection, and similar primarily functions of localized systems [50].

(c) Wireless Access in Vehicular Environments (WAVE)

The combination of two well-known standards, the 1609 and DSRC protocol suite, formed the 802.11p, as shown in Figure 2. It should be noted that 802.11p IEEE is the latest adaptation of 802.11a IEEE, and 1609 IEEE is an entire family of protocols. In the standard IEEE family of 802.11p, the basic MAC layer and the physical layer are described, whereas the network and MAC protocol layers are explained in the 1609 IEEE standard [51]. IEEE 1609.3 describes the services of transport and routing and provides an alternative to IPv6. It also specifies the information management base for the protocol stack. IEEE standard MAC 1609.4 primarily addresses multiple channel specifications in the DSRC standard.

1609.5 IEEE standard addresses layer management, and 1609.6 IEEE standard defines an application layer and additional transport [52].

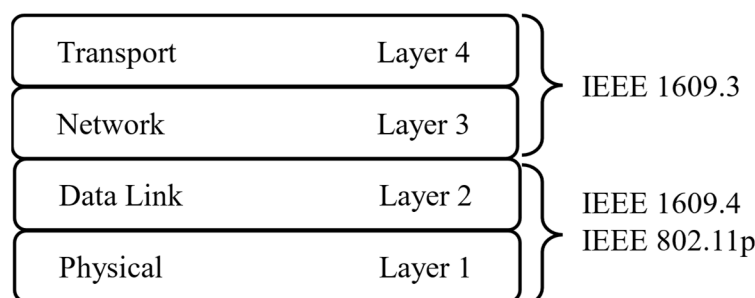


Figure 2. OSI model WAVE requirements.

According to the USFCC, ITS has been allocated a bandwidth of 70 MHz in the range of 5.755–5.825 GHz. This bandwidth is divided into seven 10 MHz channels, one control channel, and six service channels. There is an IEEE 802.11p standard, known as DSRC in the United States, that has been adopted in this frequency band to provide ITS services. In Europe, different investigations have suggested a channel of 30 MHz (5775–5805 MHz) for road safety applications, as well as a channel of 20 MHz (5805–5825 MHz) for future ITS expansion [53]. The channel of 30 MHz is divided into two parts, Control Channel (CCH) and Service Channel (SCH). The WAVE system, which uses OFDM technology with a frequency channel spacing of 10 MHz, supports data rates of up to 27 Mbps with a maximum power output of 760 mW. In OFDM communication systems, all I-to-I and V-to-V communications can be carried out over distances of up to 1 km and with the compulsion of a suitable communication environment: high relative velocities up to 150 km/h, severe multipathing, and a completely separate communications environment. Optional 20 MHz channels with data payload capabilities of up to 54 Mbps are available by using OFDM. In general, the main WAVE MAC protocol uses the IEEE 802.11 DCF (distributed coordination function), which is based on multiple sense carriers and collision avoidance CSMA/CA. In order to share links, the CSMA/CA protocol is used. In one control channel, broadcasts are set up, which are then forwarded to the channels of transmission. In 802.11e IEEE, in 802.11 IEEE, WLAN is used for distributed quality of service. The MAC WAVE layer expansion is described in the standard of 1609.4 IEEE and accepts the EDCA (Enhanced Distributed Channel Access) capability. When composed, the foundation can provide these standards for a range of applications related to transportation, including the safety of vehicles, the automation of toll payments, enhanced navigation, and traffic arrangements, among others [54].

Table 4. Intelligent Technology medium range technologies.

	Wi-Fi(Wi-Fi a/b/g/n)	DSRC [802.11p]	WAVE
Standard	advanced IEEE802.11/technology of Wi-Fi with MIMO standard 802.11n in 2009	ASTM ISO, IEEE Based on communications IEEE 802.11p./High bandwidth High-speed based on IEEE802.11a A short to medium range	IEEE 1609 based on Network and MAC Layer
Coverage Network	100 m to 1 km Point to point	1000 m, 305 m Point to point	1 km Point to multipoint
Modulation techniques	DSSS or OFDM with CCK. QPSK, BPSK, 64-QAM, 16-QAM	QPSK, BPSK, 64-QAM, 16-QAM, The MAC of WAVE using CSMA/CA The PHY of WAVE using OFDM.	QPSK, BPSK, 64QAM and 16QAM

Table 4. Cont.

	Wi-Fi(Wi-Fi a/b/g/n)	DSRC [802.11p]	WAVE
Advantages	Replace Ethernet cables. Dominating WLAN tech.	low development costs distributed	provides secure and efficient communication service with services of low latency
Disadvantages	Short to medium range Suitability for mobility is low. Traditionally consume high power. Interference due to shared spectrum	With the low rate of penetration, the ad-hoc network of vehicular suffers from network problem of fragmentation	In Adhoc networks, Routing becomes challenging.
Bit Rate	MIMO using 600 mbps	IEEE 802.11a 6 to 27 Mbps IEEE 802.11p 3 to 27 Mbps	up to 27 Mb/s
Applications	Vehicle to roadside and vehicle to Intelligent Technology Replace Ethernet cables. WLAN. Home and Office and networks.	Vehicle to roadside and Remote applications Communication, which is possibly located outside of the vehicular environment. Vehicle to Intelligent Technology.	Cooperative danger warning Wireless local danger warning Traffic dissemination information
References	[55]	[56]	[35]

WAVE assistance transmission specifies two protocols for data transmission: IEEE 1609.3 and IPv6 Wave Short Message Protocol (WSMP) [57]. The WSMP is a set of WAVE standards for specialized applications, which often need security communications of multi-point applications for models and can launch applications using the SCH configuration.

Local broadband communications can be provided with low latency by WAVE. WAVE can persuade people of the necessity to communicate non-safety functions in every position, such as in a city or on a highway, with sparse traffic or in crowded conditions [58]. Furthermore, the introduction of the service will require a sufficient number of RSUs (roadside units).

Safety functions, which require multi-point-to-point communication, are addressed with WSMP. Communicating with it is more efficient and less inactive. Due to the dynamic topology of VANET networks, routing in multi-hop communications is disputed. As stated in [59], the use of geographical information algorithms and location is called position-based geo-casting and routing.

Another significant aspect of WAVE is security. WAVE is an IEEE standard for increasing security by allowing vehicles to replace their MAC and IP addresses on a casual basis [60]. IPV6 has been recommended for vehicular networks. By changing their IP addresses, vehicles would be able to become untraceable. However, the implementation procedure is unclear. Other than that, IP addresses that are replaced can lead to faulty behavior. Once new IP addresses are assigned, the old IP address can't be immediately utilized. In the event of an IP address change by vehicle, the delayed packets that result in unwanted retransmissions will be discarded.

2.2.2. Short-Range Communication Technologies

(a) Bluetooth

Bluetooth technology, also known as IEEE 802.15.1, is a standard for communication that enables short-distance communication with low power consumption [61]. Using Bluetooth technology, data and voice are transmitted over short distances from mobile devices and/or fixed locations, creating wireless PANs (Personal Area Networks) [62] shown in Table 5. In vehicles with Bluetooth embedded, the phone's features are controlled by the audio system. Therefore, Bluetooth can be used to connect other devices such as MP3 players, Compact Disc (CDs), Digital Versatile Disk (DVDs), and to the speakers, other portable devices can be connected. Aside from the phone functions and entertainment,

future possibilities include remote starting and heating of cars or starting air conditioning in the summer, remote parking, home garages, or a controller that opens the garage door, and the payment of tolls and the pump fuel at [63].

Table 5. Wireless short-range technology for intra-communication vehicles.

	ZigBee	UWB	Bluetooth
Standard	Explain in IEEE 802.15.4, Ratified in December 2004	IEEE 802.15.3a	First launched IEEE 802.15.1 in 1998
Coverage	10 to 75 m	<60 cm for a 500 MHz wide pulse, <23 cm for a 1.3 GHz bandwidth pulse	1 m, 10 m, 100 m
Network Techniques modulation	Mesh DSSS	Point to Point DSUWB or OFDM	Point to point FHSS
Advantages	Cryptographic transport keys. Secure communications. Devices controlling. Low power consumption. Static network.	Consumption of low power. Cheap and easy to build. Broad spectrum of frequencies. Provides high bandwidth.	In vehicles today. Hopping tolerant of frequency to harsh environments. Short distance cabling eliminating Easy synchronization of mobile devices.
Disadvantages	Low bandwidth.	Interference Short range. extremely high data rates	Consume medium power. Interference with WiFi. 53–480 Mbps
Bit Rate	20–250 kbit/s per channel	1000+ Mbps	12 Mbps (ver 2.0) (Alliance WiMedia (proposed)) Used in Voice applications.
Applications	Entertainment, Smart Lighting Control/Remote control, advanced temperature control, safety & security, sensors, etc.	Multimedia applications. Healthcare applications.	Exchange and connect information between mobile phones, laptops, personal computers, videogame consoles, etc.
References	[57]	[56]	[54]

Additionally, Bluetooth has many disadvantages when used in VC. The most impressive feature is the piconet structure of Bluetooth use, which is difficult to maintain in VC technology, which is more aggressive than Bluetooth, which is fixed in the conventional technology. Simulations of Bluetooth Precise have shown that piconets are assembled and that they may take a net spread of 45 and 7 seconds. Additionally, delays may occur when an existing piconet is joined by a new node [56]. In addition, the transmission range of a Bluetooth device is up to 100 m. The range of DSRC is significantly greater than even a range of 100 m.

(b) Ultra Wide Band (UWB)

UWB is an intelligent technology system that has recently been considered. The main characteristics of UWB technology are its high data rate (580 Mbps), high interference resistance, and low cost. Moreover, UWB communications interfere with current radio services, such as the Global Navigation Satellite System (GNSS). Despite the low rate of bit error, the pulses of Gaussian-coded waveforms are treated as higher features than monocycle pulses [64]. UWB communication uses a short pulse, and over the emitted signals, several gigahertz spectrums are spread. In radar applications, UWB has been used due to its wide-band capability [65]. The system is not responsive to jitter effects or multipath interference. UWB interference with the source of communication must be addressed before this technique can be used in VC systems. As a result, the UWB radio coverage could spread to non-participating vehicles, resulting in inaccurate or irrelevant information. For vehicular suspension systems and collision detection systems, UWB communications can be used to respond to road conditions [66].

(c) ZigBee

ZigBee technology is a type of wireless technology that has just been developed upon the MAC and Physical layers and is used in numerous commercial and research applications. IEEE 802.15.4 application states that ZigBee is an attractive solution for wireless connectivity due to its lower power consumption, open standard, and lower price [60]. ZigBee, which operates at a low data rate, is a suitable wireless technology for simple devices that require low power consumption and operate in an area of 10 m or less. ZigBee provides a long battery life and a self-organizing, reliable network that is multi-hop. Since ZigBee fills a gap, other technologies cannot connect with wireless sensor applications with ZigBee [67].

In terms of applications, ZigBee is intended to be used for controlling and monitoring applications such as ventilation, heating, lighting, and air-conditioning [68]. ZigBee also has other applications for the benefit of the driver, such as the monitoring of rental cars, tire pressure monitoring, and remote keyless entry [69]. Further, due to the low rate of transmission and limited coverage area, ZigBee technology appears slowly in the market.

3. Protocols

A variety of techniques are used by VC protocols to meet the communication requirements of VANETs and scope with the environment of a VANET. The protocols are based on the OSI model of three layers: the data link layer of the MAC, the application layer, and the network layer. A VANET is an appropriate type of MANET. This is due to its simple characteristics, such as high mobility, frequent topology changes, unbounded size, and support for simple infrastructure. Due to these differences, existing routing protocols cannot be directly applied to VANETs in MANETs. In order for VANETs and MANET architectures to be designed efficiently, routing protocols should be extended to accommodate the mobility of VANET nodes. VANETs must be capable of flexible communication between the infrastructure and the vehicles. The unique architecture of the VANET makes it necessary to create an efficient routing protocol and other challenges associated with advanced networking. In recent studies on VANETs, several routing protocols have been investigated and proposed. The following sections describe and categorize several of the general routing protocols used in the VANET environment [70]. Figure 3 illustrates these routing protocols.

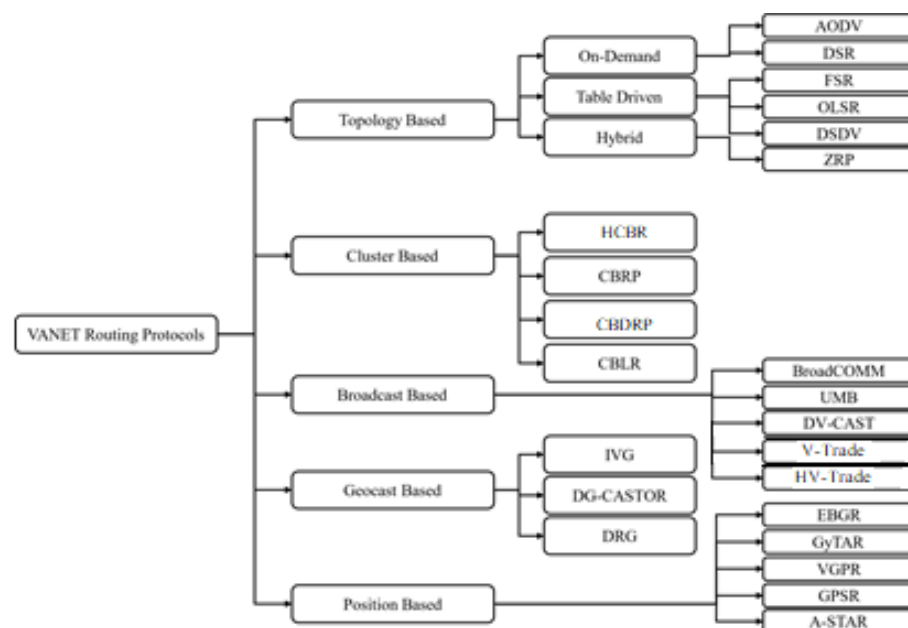


Figure 3. VANET routing protocols.

3.1. Based on Topology Protocols

The sustain and route before data transmission before the data is transmitted. In addition, the protocol is further divided into hybrid, reactive and proactive protocols.

3.1.1. On-Demand Routing Protocols

The on-demand routing protocol is also known as reactive routing because it does not maintain routing information or routing activity at the nodes of the network in the absence of communication [71]. These protocols adopt laziness in which only a car on its way to a destination is able to determine routes on demand. Routes that are currently in use, as well as the routing table, are updated regularly. As a result, the network load will decrease whenever only a few routes are being used. Flooding is the method used by the protocol for the discovery of an initial route, which results in routing delays and overhead and renders the VANET unsuitable for safety applications. Further, in the case of frequent changes in topology, difficulties occur, which may lead to a noticeable increase in network traffic. Furthermore, if the packets are sent to a destination that has changed, the route can be lost.

(a) Ad hoc On-demand Distance Vector (AODV)

In order to determine the routing protocol of Ad hoc On-demand Distance Vector, an on-demand technique is used [72]. Transmission of data, the vehicle source initiates the first discovery process by transmitting a hello packet in a timely manner. Once the packet reply identifies the vehicle source, the route is opened. The number of sequences used by AODV to confirm the loop-free routes and the fresh information. AODV cannot adapt to topology changes, and high mobility cases break slowly. In order to reduce overhead, the local repair is used to restrict the discovery zone of routes in AODV. If a move causes the route to break when the source is moved, the discovery of the route to the destination may be re-created. It is also possible to reduce overhead with this type of maintenance since it uses different route discovery and local repairs to produce high end-to-end delays and, in high zones, flooding. In order to resolve the difficulty in updating and maintaining routes, PRAODVM and PRAODV-based-prediction protocols have been developed [73]. Protocols, PGB, are designed with the purpose of reducing the overhead transmission for AODV's discovery process of routes and giving VANET routes a high degree of stability. Moreover, AODV does not require the enhancement of PGB; it can be incorporated into other routing protocols that utilize either greedy or flooding forwarding.

(b) DSR

DSR is similar to AODV in terms of route establishment. In any case, it occupies the routing source rather than depending on a common vehicle routing table. The network is capable of being completely self-configuring and self-organizing even in the absence of an existing network. In this protocol, there are two different technologies, "Discovery of Route" and "Maintenance of Route", which, together, are used to maintain and discover routes in the ad hoc network in order to allow vehicles to reach subjective stations. The main difference between this protocol and other routing protocols on demand is that it does not require timely transmissions of the packet, hello to inform the presence of neighboring cars. A disadvantage of this protocol is that the process of route repair is not performed locally. This leads to a rapid decline in the protocol's regularity with increasing mobility [74].

3.1.2. Table-Driven Routing Protocols

Based on the shortest path algorithm, a table-driven routing protocol is also known as a positive table-driven routing protocol. The finding route of the active protocol does not have an initial block, although most bandwidth will be consumed, so the topology will be regularly updated. Many routing protocols belong to this category [75].

(a) Fisheye State Routing (FSR)

In FSR [68], there is a table that maintains the topology of each vehicle, and on the state link, it distributes this information to neighboring vehicles. Depending on the broadcast hop distance of the current vehicle, the state link information contains different entries and different frequencies. The routing table size of the network increases by FSR. It may fail route discovery if it surpasses the vehicle range in the source. VANETs are highly mobile, which leads to less accurate routing of remote destinations [76].

(b) Link-State Optimized Routing Protocol (LSOR)

LSOR is a routing protocol of proactive state links with high mobility and low bandwidth. When used in large networks, it broadcasts packets with short delays, integrates easily into existing devices and operating systems, and supports changes to IP data without changing the header, which is a critical feature for VANET applications. The primary challenge of OLSR is to keep the routing table of the possible routes. This is not significant for small networks, but for large networks, dense networks may use another trigger, causing bandwidth congestion [77].

(c) Destination Sequence Distance Vector (DSDV)

The Destination Sequence Distance Vector is widely used in static networks [78]. When used in a VANET, the DSDV protocol broadcasts its own route tables to every vehicle. The vehicles send their entire routing tables to the other non-near-closed vehicles on time. The introduced number sequence indicates that the selected protocol for each destination should utilize the shortest route options. This results in an increase in the speed of convergence and free loop routing. DSDV is beneficial to low-dynamic vehicular networks. Those vehicles that advance slowly on a network lose achievement due to dumping packets, which results in a waste of bandwidth.

3.1.3. Hybrid Routing Protocols

HRPs are a collection of passive and active methods. For example, the ZRP (Zone Routing Protocol) can reduce the expense and control of HRP, and the reactive routing protocols can discover the start-delay of a route.

(a) Zone-Routing Protocol (ZRP)

In ZRP, the network is divided into zones of overlap. A group of vehicles that are located within a known radius is known as a zone [79]. To ensure that local information on routes is kept up to date, a proactive protocol is used for intra-zone routing. As a result, there is no routing delay starting from the same zone as the vehicles. In order to enhance the scalability of the system, a reactive protocol is used in inter-zone routing to perform route discovery globally. Hybrid and ZRP approaches are scalable and effective when dealing with high-scale environments, though many key issues remain unsolved [80].

3.2. Cluster-Based Protocols

Using a hierarchically structured VANET, the vehicles can be divided into groups in the shape of clusters using a protocol group. The result is a reduction in the amount of routing information, the channel allocation, and the best identification of the multiplexing of receipt data [81]. Each cluster's leader is responsible for coordinating intra- and inter-cluster activities. During intra-cluster communications, vehicles share information directly, while inter-cluster communication is handled by heads of clusters using mixed communications to decrease the latency of forwarding. Protocols of cluster routing and the selection of the cluster head are important considerations in cluster mode. Because of the mobility of dynamic clusters, the VANET group procedure is significant [82].

3.2.1. Hierarchical Cluster-Based Routing (HCBR)

Tables that are less compact and that are related to signal routing traffic in HCBR. The cost of decreasing the efficiency of path and traffic management generation. Therefore, in ad hoc networks, HCBR is employed in order to enhance mobility [83]. In HCBR, communication is divided into two tiers, i.e., L1 and L2. Generally, devices in the first layer have a single wireless interface and perform transmission with each other via a multi-hop path. Other nodes, also known as supernodes, can communicate with the base station via layer 2. Radio communication super nodes have a long-range and serve as cluster headers in Layer 1. The cluster leader regularly communicates with other cluster members to enable inter-cluster routing.

3.2.2. Cluster-Based Routing Protocol (CBRP)

The CBRP is based on geographic location, which categorizes into square grid clusters and locations [84]. A packet of data is routed from one grid to another across the headers of the cluster for the purpose of data sharing. Each vehicle in the grid uses geographic information to determine the closest optimal cluster header to share the data with the next vehicle. It is the primary objective of the CBRP protocol to decrease delay and overhead during packet delivery when sending a packet of data to the vehicle destination, thereby increasing the ratio of packet forwarding while saving memory for receiving the routing table. Moreover, direction and speed are not considered in this protocol, which are important parameters in a VANET.

3.2.3. Cluster-Based Location Routing (CBLR) Protocol

It is a cluster-based and reactive routing protocol that shows that via GNSS, data about their location can be collected by all the vehicles [85]. The algorithm divides the network into several clusters. This request is for a predetermined head of cluster formed by the new vehicle after waiting a predetermined amount of time for a reply to the hello message. As long as a hello message response has not been received from a header of a cluster within the specified period of time, the new vehicle becomes a member of the cluster; or it becomes a header of the cluster.

3.2.4. Cluster-Based Directional Routing Protocol (CBDRP)

The CBDRP is dividing the vehicles into clusters in a similar manner. As part of CBDRP, when breakage is detected in the blink of an intermediate vehicle, a forward strategy is employed. According to the CBDRP mechanism of transmission, the packet overhead is proportional to the number of clusters. As the distance increases, the packet overhead increases gradually. VANET can solve the problem of instability via CBDRP and achieve rapid and reliable data broadcasting [86].

3.3. Broadcast Routing

When a message is to be broadcast, broadcasting is used to reach vehicles outside the transmission range [87]. Typical VANET protocol applications include file sharing, emergency and weather messaging, traffic conditions, ad announcements, and delivery. Among the different communication routing protocols are BROADCAST, V-TRADE, HV-TRADE, UMB, and DV-CAST.

3.3.1. BROADCAST Protocol

BROADCAST is an emergency protocol for broadcast networks based on hierarchical infrastructure introduced by Durresi et al. [88]. In this protocol, a segment of the road is defined as a cell of virtual movement. There are two parts to highway devices. The first component of the cell consists of all nodes, and the second component consists of reflectors of cell gathering, which are located close to the cell's geographical center. During a certain period of time, the reflectors of cells behave as a cluster of headers. They are responsible for handling messages. They are responsible for receiving and forwarding messages to

and from the closest reflectors within the cell. The performance of the BROADCAST protocol in terms of message transmission and overhead routing is similar to that of base routing protocols. This protocol performs well with a small number of devices and a simple highway structure.

3.3.2. V-TRADE (Vector Based Tracking Detection), HV-TRADE (History and Vector based Tracking Detection)

According to Sun et al. [89], two protocols have been developed based on location information, namely, V-TRADE (Vector based tracking detection) and HV-TRADE (History and Vector based tracking detection). Vehicles are divided into five categories by the author: (i) vehicles moving ahead of this vehicle in the same direction; (ii) vehicles traveling behind this vehicle on the same road in the same direction; (iii) vehicles approaching this vehicle in the opposite direction on the same road; (iv) vehicles leaving this vehicle in the opposite direction on the same road; and (v) vehicles moving on other roads.

3.3.3. Urban Multi-Hop Broadcast (UMB)

This protocol extends the IEEE 802.11 standard with a new handshake of send-to-clear and send-to-request. This protocol allows the node courier to take the device in the direction of exclusive transmission of other prior information on topology. This is for packet acknowledgment and forwarding based on a handshake. At intersections, repeaters mounted on the street are distributed along the roadside [90]. This design aims to reduce interference and collisions of packets and nodes that can arise in multi-hop broadcast messages. The method performs well at best traffic densities and packet loads and can also reduce packet collisions and interference to a large extent.

3.3.4. Distributed Vehicular Broadcast Protocol (DV-CAST)

A DV-CAST protocol creates periodic local information topologies by sending a message called hellow [91]. The packets are repeated, and the flag variable is used by all vehicles. This protocol is based on a classification of vehicles with their near connections as well connected to close neighbors, somewhat connected to close neighbors, or completely disconnected from close neighbors, and it uses a scheme of persistence of protocol for well-connected neighborhoods. In a neighborhood that is marginally connected, the vehicle, upon receiving telecast information, can instantly forward in the same direction. For a neighborhood that is completely disconnected, store share messages on the vehicle until the other vehicles enter the broadcast range, and if there is a time-out, the packet will be discarded by the vehicle. In addition to the additional overhead control, this protocol has a high delay in the end-to-end transfer of information.

3.4. Geocast Routing

By describing the Zone Relevance (ZR) for a multicast group with a multicast service, geocast routing can be performed. In other vehicles, the ZR does not alarm to avoid unneeded reactions from hasty reactions. Geocast routing can be categorized into three types: no flooding, direct flooding, and simple flooding. If a method of directed flooding is used within a defined ZR, the message overhead and network congestion created by flooding can be significantly reduced. A non-flooding approach, which is simple routing based, and packet forwarding, can be implemented within the zone. Geographic partitioning of networks and neighbors is an unfavorable feature of geocast, which may hinder the proper forwarding of messages (such as DG-CASTOR, DRG, and IVG [92]).

3.4.1. Vehicular Geocast (IVG)

A multicast protocol proposed by Bachir et al. [93] is also known as the IVG protocol. According to the IVG protocol, messages may be broadcast on highways within an area of risk for all vehicles. The location of vehicles in the area of risk depends on the location that is dynamically and temporarily associated with them. A timing-based method is used

for the IVG protocol during the forwarding of messages, and timely transmission is used to reduce the fragmentation of the network for the delivery of messages. Applications of VANET, including emergency warning messages and important data sent to all receivers within the ZOR.

3.4.2. DG-CastoR

Protocols of DG-CastoR are similar to protocols of geocast, where packets are sent to devices that belong to the same group as geocast [94]. In this protocol, infotainment applications are developed, and it is best for VANETs. A virtual community is created in this protocol by predicting the next area of the mobile device in the network and communicating multimedia files over time. Device communities that may meet in the near future are called groups of rendezvous. In between the devices, a request is shared that becomes part of a similar group of rendezvous. DG-CastoR reduces traffic load by eliminating packet network flooding, and in VANETs, it enables multiple devices to be connected at once.

3.4.3. Distributed Robust Geocast (DRG)

The protocol DRG is also geocast for VANETs, is divided without control of upward and information state, and is flexible to changes common in topology [89]. It is less-state, and its goal is to allow the sending of data at a high level by describing a forwarding zone (FZ) among regions of interest (ROI). The technique reduces network load when in the ZOF vehicles and sends the message to other vehicles in the ROI.

3.5. Position-Based Routing (PBR)

The paradigm routing protocol, also known as PBR, is one of the most promising protocols in the area of topology routing in VANETs, in urban and highway scenarios [5]. In PBR, it is not necessary to maintain a global route from the sender device to the receiver device. The algorithms of PBR create decisions regarding sending based on the location of the sender device. The data is sent to the location nearest to the recipient without any knowledge of the map. The PBR technique is well suited to vehicles with high-speed mobility, but the technique requires fixed position determination services. Satellite services do not function properly when signals from satellites cannot be received, such as in a tunnel. Different algorithms of PBR are described below.

3.5.1. Vertex-Based Predictive Greedy Routing (VPGR)

VPGR is a routing protocol designed for a many-hop urban environment. By using predictive directional greedy routing to the fixed infrastructure, a junction sequence is calculated approximately from the sender device to the fixed infrastructure, and then the data is broadcast from the sender device to the fixed infrastructure by the sequence of the junction. As a method of calculating sequences of suitable junctions and the position of forward greedy routes, a system based on the navigation direction and velocity of the vehicles is utilized [90]. In every vehicle, there's a VPGR, which shows the position, identification, directions, and velocity of its two closest hops. VPGR is a reliable and efficient way to broadcast packets at low rates. Also, it reduces end-to-end overhead and delays.

3.5.2. Greedy Perimeter Stateless Routing (GPSR)

In GPSR, the vehicle transmits data to the nearest neighbor that is closer geographically to the last receiver. It creates decisions concerning the forwarding of nearest neighbor information, which is used in the network. In the event that the forwarding greedy fails, the forwarding vehicle will use the perimeter to determine the next hop.

The GPSR works best when there is an open space and uniformly divided cars. Furthermore, this technique results in a high level of blockage in a city setting due to the high hop count. Due to the slow movement of vehicles, routing loops are produced, which cause messages to circulate over high routes. The GPSR uses static street maps and location

information about every vehicle. Since the street density of vehicles is not considered in GPSR, it is not a reliable mechanism for VANETs.

3.5.3. Anchor-Based Traffic and Street Aware Routing (ASTAR)

ASTAR is a protocol based on position routing for VC in surrounding metropolitan areas. ASTAR is similar to GSR in that the data are routed by the anchor points of the overlay. Further, ASTAR is attentive to traffic; it promises a high level of communication, which is utilized by buses in city traffic to produce end-to-end connectivity. A strategy of local recovery is used in ASTAR that is good for urban environments by combining the GSR method of greedy and the GPSR mode of the perimeter. The algorithm uses ASTAR to ensure connectivity for longer, even though its data ratio of forwarding is less than GPSR and GSR [95].

3.5.4. Greedy Traffic-Aware Routing Protocol (GyTAR)

In order to support V2V communication with awareness of the street, GyTAR is a routing scheme based on anchors within the urban environment [96]. The protocol provides routing based on a new intersection to overcome the overhead of control messages and end-end delay with less packet loss. GyTAR uses data forwarding and junction selection between modules of two junctions in order to send a packet to its destination. GyTAR considers real-time mobility in densely populated areas. As a result, the GyTAR protocol can be used to transmit data via roads with high numbers of vehicles to establish a connection to the destination. Considering the larger mobility of VANETs, the forwarding of greedy protocol routing loops may also be a source of problems. This is because low data may be sent in an unexpected direction.

3.5.5. Edge Node-Based Greedy Routing Protocol (EBGR)

The EBGR is a PBR protocol based on greedy-based sending [97]. Transmissions of omnicast are employed by EBGR protocol in order to send packets from one device to another, as well as transmissions of broadcast in order to forward packets from one device to all other devices in networks of dynamically interacting devices. When using these protocols, the edge device of the low broadcast range is selected as the incoming node hop for forwarding packets from the sender to the receiver. In the process of forwarding messages from the sender to the receiver, EBGR uses the selection of neighboring nodes for the identification of node direction and the selection of edge node techniques. Table 6 provides a description of VANETs protocols routing in case EBGR is beneficial to reduce the hop count between the source and destination node and to increase network throughput.

Table 6. VANET Comparisons Routing protocols.

Protocols	Scenario	Forwarding Strategy	Infrastructure Requirement	Recovery Strategy	Usage
AODV	Urban	Multi-hop	No	Forward and store	In the environments of urban performance evaluation
DSR	Urban	Multi-hop	No	Forward and store	Performance compares with other specific VANET protocols
FSR	Urban	Multi-hop	No	Multi-hop	Decrease the control messages size in huge Network
OLSR	Urban	Multi-hop	No	Multi-hop	In environments of urban performance evaluation
DSDV	Urban	Multi-hop	No	Forward and store	Use in low network dynamic scenario. It also Decreases overhead control and rise speed of convergence

Table 6. Cont.

Protocols	Scenario	Forwarding Strategy	Infrastructure Requirement	Recovery Strategy	Usage
ZRP	Urban	Multi-hop	No	Forward and store	Use scalable and efficient strategy of routing for huge networks
HCB	Urban	Multi-hop	No	Forward and store	Appropriate for high mobile Network
CBRP	Urban	Multi-hop	No	Forward and store	Decrease the packet overhead and delivery delay
CBLR	Urban	Multi-hop	No	Flooding	Appropriate for high mobile networks
CBDRP	Urban	Multi-hop	No	Forward and store	Appropriate for a dense traffic Network scenario
BROADCOMM	Simple Highway	Multi-hop	No	Forward and store	On highways, broadcast emergency communication
UMB	Urban	Multi-hop	Yes	Flooding	Reduce the hidden node's effect, and collisions avoid
DV-CAST	Highway	Multi-hop	No	Forward and store	Develop efficiency and transport safety applications
IVG	Simple Highway	Packet forwarding	No	Forward and store	Emergency important information or messages warning.
DG-CASTOR	Urban	Store and forward	Yes	Flooding	Network congestion decrease by avoiding unnecessary transmission of packets on the whole network
DRG	Highway	Store and forward	Yes	Flooding	Across a large area, fast communication
VPGR	Urban	Multi-hop	Yes	Greedy forwarding	Delivery of Reliable packets with end-to-end packet delivery
GPSR	Less dense highway	Greedy forwarding	Yes	Right-hand rule	In the scenario of free space work good with evenly distributed nodes.
A-STAR	Urban	Greedy forwarding	Yes	Forward and carry and	Good for urban traffic and system of routing monitoring
GyTAR	Urban	Greedy forwarding	Yes	Forward and carry and	In dense vehicle networks, successfully forward packet
EBGR	Urban	Greedy forwarding	Yes	End node awareness	Decrease number of hops between destination and source and increase the network throughput

4. Application of Vehicular Communication

Figure 4 shows the different functions that have been incorporated into vehicular communication in order to make driving more comfortable and safer for both passengers and drivers. Transmission between vehicles and, in some cases, infrastructure along the roadside may offer these advantages. The classification of VC functions will help us to address a diverse set of problems and determine the equipment that is required [98]. Various vehicular applications of communication are classified according to their missions and nature. Applications are divided into two main categories: vehicle control commands and vehicle information services (Figure 4). In the first part, passengers or the driver will find information, and in the other part, they will find directions for vehicle actuators that can be executed directly [99].

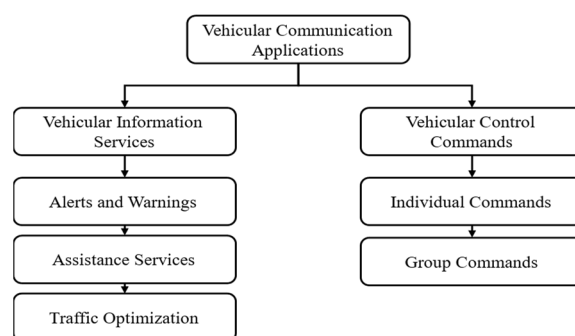


Figure 4. Classification of vehicular communication applications.

4.1. Vehicle Information Service

A service of information consists of broadcasting data over the network of a vehicle or a base to make safe and efficient driving possible [100]. The instructions are intended to help drivers understand alarming positions or to make their trips more comfortable. Moreover, these data can be used in transportation centers to monitor and optimize traffic flow.

4.1.1. Alerts and Warnings

Alerts are sent out to drivers about upcoming accidents and safety issues. A variety of alarming information, such as road conditions, dangerous road collision warnings, and curves in the relevant area, can be easily shared. These functions have a high latency, which increases as the distance between the sender and recipient increases. Roadside alerts can increase safety as well as prevent accidents, injuries, and fatalities. In some unexpected situations, accidents occur due to a lack of knowledge. In identifying accidents of this type, breakdowns of mechanical and other events that occur during the motion of a vehicle, for instance, is an example. Emergency warnings explaining this situation can then be transmitted via a VANET to other areas of the vehicles. The CARTALK project, which was undertaken in 2000, proposed the same method of sharing packets over a multi-hop network to warn drivers of dangerous conditions such as anomalies in traffic [92]. The message repetition rate should be between 60 Hz and 40 ms for this application. Collision warning systems can help prevent serious accidents involving a vehicle, if an airbag in a vehicle.

Develops or dramatically reduces its velocity, the vehicle can send an alarm to nearby vehicles. A relay of intermediate can transmit the signal farther than the vehicle's range of transmission, alerting other drivers of the conditions to enable them to make informed decisions [101]. In the accident scenario, approaching vehicles could cause additional collisions. If these vehicles are equipped with onboard communication systems, other accidents may be prevented. In order for safety alerts to be effective, real-time constraints should be established. Drivers could gain warning time with a suitable amount before the event they encounter for the useful information [102].

4.1.2. Assistance Services

In this class of applications, the emphasis is on the driver's comfort in order to create a more enjoyable journey. It acquires applications that require transmission with other vehicles and roadside infrastructure. These applications require a higher rate of information and less overhead communication. The vehicular communications class provides applications such as instant or voice messaging between vehicle occupants traveling together or between police officers. Different vehicles now have GNSS systems and wireless transceivers, and from other vehicles, they can obtain useful information. The message may include information relating to the updating of maps and the closing of hotels, parking spaces, and fuel stations, as well as restaurant promotions and advertisements [103].

It is possible to create vehicle-to-vehicle communication to send messages to the occupants of vehicles through I2V communication. Internet access in cars enables such activities as web browsing, e-mail, and downloading videos, news, and music. The use of these applications can enhance the driving experience. Using GNSS, I2V communication can assist travelers in finding the nearest fuel station and hotel when traveling. Parking and tolls could be automatically collected without affecting the speed or wasting time [104], and records of maintenance could be sent to repair centers. Power and processing vehicles should have the capability to implement complex protocols in order to provide these applications [105].

4.1.3. Traffic Optimization

There are more vehicles on the road, creating congestion and blocking traffic, which causes uncomfortable driving conditions for drivers. The main purpose of this class of services is to improve traffic flow and assist drivers with selecting the most efficient route to their destination. As time passes, these services may gradually decrease travel times and fuel consumption [106].

By calculating the control and speed commands, every vehicle can be a source of traffic information; this message would be transmitted to the appropriate vehicular network, enabling other drivers to be aware of traffic conditions. It may also be sent to centers of transportation, where the data is analyzed to guide other drivers toward the intended destination, such as the fastest route for emergency vehicles. Information related to traffic, such as accidents and road construction that cause congestion of the road, could be sent to other vehicles. This data can also be gathered by traffic lights to reduce the flow of traffic according to their timing schedule. This information could be used by agencies to control or monitor traffic using humps of traffic or to plan future road designs. A service of this type does not have to be strictly real-time and can be made to be more convenient for drivers [107].

4.2. Vehicle Control Commands

The signals of communication can also be used to monitor the actions and motion of an automobile by direct commands from the actuators. This type of automobile could communicate their trajectories with their neighbors or other vehicles, thus improving the flow of traffic, travel time, safety, and fuel consumption.

4.2.1. Individual Commands

Individual commands control the state and direction of cars by directing their actuators directly, such as the accelerator and brake pedals. By displaying the event before the driver, these rules can reduce damage or prevent a collision. Typically, this type requires a strict time constraint, and the conjunctions among vehicles are usually very brief [107].

Controls the motion of every vehicle using the data collected from the environment in which it is situated. A similar technique has also been used for collision detection and aircraft prevention (For example, Path Prox) [108]. A good decision for the state requires an assessment of the information in order to calculate the likelihood of a collision occurring. With each other, vehicles communicate and respond via actuators to prevent accidents. In the event of a potential accident, the application can alert the vehicle by activating the airbags and utilizing other safety features to reduce the likelihood of an accident. Together, their parameters of motion and locations can be shared with other vehicles within the ZOR. A driver is alerted by audio if a vehicle is approaching an intersection but has not yet reacted. If the estimated time is shorter than the response time of the driver, the appropriate response can be directly applied to the actuators [109]. VC may reduce rear-end collisions on highways by reducing vehicle alerts and taking action to avoid collisions. The autonomous function of the vehicle may also use VC applications to provide control actions [110].

4.2.2. Group Commands

For groups with similar destinations or actions, the vehicle function is helpful. In vehicles of this type, the parameters maintain motion by establishing relationships and participation among one another, lasting an hour which can last up to [111]. These applications provide management of speed, avoidance of congestion, and arrival time coordination. This type of communication requires less latency. There are three parts to the planning group: individual regulation, leader regulation, and virtual leader regulation.

Each individual's regulation determines the optimal travel paths for vehicles that are communicating with one another unless their destinations are different. It is possible to use this service at intersections in order to assist in merging onto highways and provide coordination. In motion control, plans of trajectories are shared among the vehicles. Several plans are calculated simultaneously within the group, and the plan that results in the shortest travel time and distance is selected. This vehicle part manages users' access to intersections to their rights much before they reach the intersection, as opposed to the back part, which relies on only preventing collisions before they occur [112]. On the basis of a leader's command, one vehicle gives parameters for motion control, and the rest of the group performs other actions. In order to observe the course of each vehicle, the action and data of the neighborhood are collected. Using signals, the vehicles leading the group stabilize at fewer distances, and those following do the same. This leads to an increase in traffic flow and fuel consumption. For this type of application, the vehicle lead should be able to provide different scenarios to handle, such as vehicles joining or leaving group maneuvers. Within the group, this task requires a high level of communication [113,114].

When vehicles are in between, motion control commands must be transmitted and must be dictated by a vehicle that is leading to maintain a safe distance while maneuvering the group. The leader can be a distributed or virtual entity. Different vehicles may exist within the distributed architecture. A similar method has been used to monitor the behavior of groups of airplanes and robots. A summary of the applications of vehicle communication systems is presented in Table 7.

Table 7. Application for vehicular communications.

No.	Type	Application	Vehicular Communication Type	Communication Technology	Real-Time Requirement	References
1	Alerts and warnings	Collision warning	V2V	ZigBee, UWB, WAVE	Yes	[3,106]
		Sharp curve warning	V2V-I2V		Yes	[23]
		Dangerous road surface warning	V2V-I2V		Yes	[96]
		Abnormal vehicle warning	V2V		Yes	[93]
2	Assistance services	Toll and parking payment	I2V	Bluetooth, UWB, WiMAX, Cellular Technologies	-	[97]
		Internet access	I2V		-	[4,16]
		Traveler information	V2V-I2V		-	[6,95,107]
3	Traffic optimization	Traffic management	V2V-I2V	Wi-Fi, DSRC, WAVE, WiMAX, Cellular Technologies	-	[6,95]
4	Individual-Group commands	Collision avoidance	V2V-I2V	DSRC, WAVE, WiMAX, Cellular Technologies	Yes	[99,101]
		Intersection collision avoidance	V2V-I2V		Yes	[100,101]
		Platoon and group maneuvers	V2V		Yes	[103]

5. 6G and Its Associated Technologies in Future

There are millions of base stations in place for 5G (the fifth generation of mobile technology), which has meant that 5G is now entering the market for mass commercialization. It is critical to note, however, that 5G still has some limitations [114]. Among the challenges that 5G infrastructure faces are the very high cost that is associated with it. The coverage area for base stations for 5G is much smaller than it is for base stations for 4G. As a result, if you want to achieve full coverage in a 5G network, you will need more base stations. There are also issues related to the security of parts of the 5G technology that need to be addressed. Software-defined networks (SDNs) do not have the mechanisms for evaluating the trustworthiness of the management applications and the controllers of such networks, for instance. It should also be pointed out that the main network structures in 5G, such as heterogeneous networks (HetNets), are only available on ground-based networks. China, the EU, and many other countries have recently begun to explore 6G. This will open up a whole world of connection, intelligence, and sensing for people in the near future. The digital revolution will bring about a comprehensive digital transformation of all industries, which will integrate the physical, biological, and digital worlds [115]. It is foreseeable that 6G technology will have an even more significant effect on the development of smart agriculture in the future. This is because it has the potential to push the field even further forward. The aim of the following section is to review the associated technologies of 6G. Additionally, it will examine their current and potential uses in energy.

One of the primary challenges is the provision of energy-efficient, energy-aware, and environment-aware vehicular connectivity to many users with differing levels of computational resources. The energy efficiency of the 6G-enabled IoV system will be critical. Firstly, the growing number of connected IoV nodes, the associated communication and computing demands, and the increasing energy consumption associated with the adoption of bandwidth in 6G are expected to result in a dramatic increase in the cost of energy in a future IoV environment. Second, the cost of electricity for IoV systems and vehicle fuel emissions will increase the energy demand on VANET networks and communication infrastructure. As a result, VANET will be more difficult to sustain. Thirdly, 5G/6G-enabled V2X applications would consume a large amount of energy due to the high QoS requirements and complicated, intelligent decision procedures based on big data analysis and artificial intelligence [116].

6. Technical Challenges

To transmit data among vehicles, different challenges and technical issues must be dealt with due to the fact that these networks differ from traditional ad hoc networks because they are highly mobile and self-organising. Vehicle networks have unique requirements in terms of quality, security, and market introduction.

- Communication medium selection: the choice of communication medium represents a design interest for VC applications. The medium selection is based on the calculated range of communication suitable for the size of the group and the need of the organization to make direct broadcasts within the group as well as among nearby groups. A reliable and efficient routing protocol is necessary, and in dense VANETs, the routing protocol should support high mobility and large data rates.
- High mobility of dynamic topology: A VANET with high mobility is highly dynamic, and configurations are needed very often, especially on highways, where relative speeds can reach up to 200 km/h. With increasing speeds among vehicles, the topology of vehicular networks is continually changing. As a worst-case scenario, if two vehicles drive in opposite directions at high speeds, the link will be lost for only a brief period of time.

- Frequently disconnected networks: For the same reason, the connectivity of the vehicular networks may also be frequently altered. The probability of a disconnected network is greater when the density of vehicles is lower. In some systems, such as Internet access, the problem must be resolved. In order to maintain road connectivity, you can pre-deploy many nodes of relay or along the points of access.
- Quality of communication link: When too many users are communicating simultaneously in an ad hoc network, the quality of communication links is impaired. Whenever the same message is sent to different network systems that may be of interest, such as information on public utility or service streaming, multicast techniques are necessary to eliminate link saturation caused by excessive transmissions of one-to-one.
- Quality of Service: VC systems require fast and low latency communication among vehicles so they can guarantee: (I) the service reliability for applications considered to be safety-related while considering the sensitivity of time and messages transfer and (II) the quality and continuity of services for applications that are passenger-oriented.
- Security: Communication of vehicles and applications will only be accepted and accepted by customers if they are secure, authentic, including integrity of messages, authentication of source, robustness, and privacy.
- Market penetration: From the beginning, vehicle manufacturers should consider gradually implementing market strategies. Both attractive services are based on infrastructures they must provide and purely communication ad hoc vehicles, such as collision warnings, local safety warnings, and real-time distribution of decentralized traffic information. The use of these applications will encourage drivers to invest in additional wireless equipment for their own benefit.
- Congestion of channel and connectivity lack: Due to the introduction of a gradual market, some vehicles relatively with the technology of DSRC 5.9 GHz will be equipped initially. Introduction phase not deployed all applications of strategies and safety will be required forward-and-store, which the node movement will use to forward the message until a new nearest (such as., another vehicle equipped) appears. Moreover, once a large vehicles percentage are equipped with DSRC of 5.9 GHz, the presence of different nodes connected in a less area might produce a large number of collisions of the packet if the CSMA/CA link layer transmit scheme of the 802.11 IEEE standard is used without any other mechanism of control.
- Radio channel characteristics: In wireless communication, certain things can affect the quality and power of the received signal and therefore have a negative impact on the rate at which information is received. Moreover, due to the mobile nature of the vehicle, the effects of fading should be taken into account. As a result of the fast fading mechanism, a broadcaster can be subjected to a multipath environment every time a packet is transferred, and every piece of information will experience a different attenuation degree.
- Nodes hidden away from each other: radio waves have a low effect among nodes that are far apart or between nodes that are separated by a physical barrier, preventing the detection of the status of the traffic flow or other vehicles. This condition referred to as the problem of hidden nodes, may increase the probability of collisions.
- Aggregation and filtering of data: The VC system's initial use is in the transmission of data between vehicles equipped with onboard sensors and transceivers. Because each vehicle gives a view of events individually, an event block of differentiation must be used to aggregate and filter the input data in order to decrease the amount of transmitted data.
- Hardware and software compatibility: Some cars are currently fitted with VC systems, and the number of cars equipped with these systems is gradually increasing due to the longevity of existing vehicles. This will result in a variety of challenges. As a first step, the system should be valuable enough so that users will choose to purchase the latest technology. Secondly, upgraded strategies of both software and hardware must

allow for the future growth of networks and facilitate future improvements in security, safety, and performance.

Different aspects of vehicle communication require additional research and development. In addition, there are high-performance and physical layer efficient communication mechanisms, scalable and good medium access schemes, dissemination protocols of efficient data, and improvements in routing protocols.

Due to the characteristics of VANETs, such as their highly dynamic nature, intermittent connectivity, varying QoS requirements, and security challenges, several open issues have arisen. This has resulted in a need for future work to improve the efficiency of the MAC in VANETs. VANETs are unable to handle safety and non-safety services due to a number of MAC protocol research concerns, as well as unanswered questions. Several challenges are identified in this section that may be the subject of future research.

7. Conclusions

In this article, we present an explanation of the intelligent system technologies of vehicles, applications, protocols, and networks, along with the appropriate challenges. We discuss the various transmission technologies and their features and applications. It includes an analysis of the current technologies, including their strengths and weaknesses, design coordination, frequencies, flexibility, the network architecture's reliability, sensitivity to multipath, optimization of PHY parameters, synchronization of time, and code assignment. We examine current research on ad hoc, VANETs, and hybrid networks for VC with an emphasis on latency, range, throughput, and application of the technologies. This article provides an analysis of the most appropriate routing protocols, containing ad hoc positioning, clustering, protocols of VC, their parameters, classification, and the advantages and disadvantages of the existing research under a general framework. It investigated the applications of vehicular communication, such as warnings and alerts, driver assistance, traffic optimization, and control, which provide comfortable and safe driving under realistic operating conditions. As a result of this analysis, it appears that the absolute objections to vehicular communication systems development are related to the selection of medium, security, connectivity, topology, disconnection of the network, congestion, penetration of the market, channel characteristics and quality, hidden nodes, and mobility.

In order to attain sufficient systems of vehicular communication that can determine capacity, reliability, comfort, convenience, and safety, appropriate protocols and effective networks will be required. In this paper, we discuss technologies such as protocols for networks and vehicular communication applications, as well as the development of low-cost computer systems for the vehicular network and the future of reliable computer systems for the vehicular network. In order to accomplish this objective, this analysis may serve as a starting point for discovering the requirements of new and updated vehicular communication.

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