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Vehicles communications handover in 5G: A survey

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Abstract

A communications system consists of interconnected telecommunications networks, transmission systems, relay stations, tributary stations, and terminal equipment. Increasing network limits to fulfill the developing needs of consumers has prompted the advancement of cell correspondence networks from 1G to 5G. Many heterogeneous connections request higher information rates, lesser postponements, improved framework limit, and predominant throughput. The accessible range of assets is restricted and should be deftly utilized by mobile network operators (MNOs) to cope with the rising demands. This paper presents a detailed survey on vehicular communications systems, their forms, and handover in each category in 5G networks.

Keywords: Device communication; Road side unit; User equipment; Quality of service; Base stations

Contents

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1. Introduction

With a developing interest in higher information rate applications, the number of hand-held devices is rapidly increasing. The current data rates must be refined to meet the needs of next-generation applications. These growing demands necessitate the deployment of 5G networks. Device connectivity did not acquire many footholds in past ages of remote correspondence; however, it is relied upon to play a critical role in 5G networks. Growing trends are paving the way for this new technology. 4G networks will be phased out in favor of 5G to meet subscribers' growing demands for higher data speeds and support for more applications. Enhanced technologies were developed, such as BDMA, FBMC, and non/quasi-orthogonal techniques. 5G is the aftereffect of a combination of mmWave, Gigantic MIMO, CRNs, and VLC. The first four generations were network-centric since they were reliant on BSs. However, 5G is moving toward a device-centric approach, in which the devices themselves set up and control the network. D2D communication is being seen as a critical part of 5G organizations. It is relied upon to develop other gadget power, spectral performance, throughput, and latency reduction. DC system in 5G, including RSU, cars, and 5G mobile networks, communicate with each other and share information about the vehicles, road, and surrounding conditions. Here, we divide the area into small areas, each of which is serviced by a single operator. This process makes this activity more innovative because vehicle movement would be intra-operator, reducing latency [1]. However, the critical issue is that the region's edges have inflation that can trigger latency when switching from one region to another. The entire network comprises UE with an antenna and IP address to connect to the network operator. The handover process is the most critical aspect of this communication and data sharing. It is impossible to link all devices on one area with a single operator, so the area must be clustered into small regions, each run by a different operator. DC-5G is important in reducing traffic accidents and traffic congestion, making drivers more relaxed, and acquiring information about the road while driving. Several research papers boost vehicle communications using 4G mobile network providers, but as the velocity increases, the topic changes in 5G. Since vehicles have a high degree of mobility and topology changes rapidly, predicting how long a vehicle can stay associated with an organization is challenging. This forecast can rely upon different parameters such as speed, bearing, traffic stream, network signal, the distance between vehicles, RSUs, signal impedance, snag obstructions, multipath blurring, transmission range, transmission strength, transmission power gain, sensitivity to SLA, user expectations, and the QoS [2]. The linking tube between V2V, V2I, and V2X must be as simple as possible. Using existing networking standards, 4G and LTE cannot achieve high-data rates, only up to (20 Mbps) such as DSRC, but 5G can achieve high-data rates up to (1 Tbps) with mmWave-based V2X [3].

In the rest of this paper, an overview of the vehicular communication systems and their types is presented in Section 2. The forms of handover and the variations between them are discussed in Section 3. Section 4 addresses vehicle connectivity in the sense of 5G interpretation which covers the concept of 5G, the differences between 5G and 4G, and the characteristics of 5G-V2X, 5G-V2I, and 5G-V2V data. In addition, each form of handover is described in detail. In addition, IOV architecture, 5G-IOV handover, and IOV handover phases are depicted. VANET technology and 5G-VANET handover are also discussed in Section 4. Section 5 concludes the paper.

Now, we discuss the arrangements proposed lately to enhance the handover efficiency. The super thick and heterogeneous nature of 5G organizations brings about successive handovers that are undesirable, unnecessary Ping-Pong impact, and fall flat, as well as expanding the handover preparing time. Sun et al. [4] introduced a novel PRDP handover scenario in 2020. The main goal was to reduce the overhead of the handover and increase the chances of a successful connection.

In 2020, Storck et al. offered a step-by-step decision support technique for connected cars based on 5G Ultra-Dense networks (5GUDN). Its main objective was to address the high mobility of vehicles and increase the efficiency of vehicle switching; however, as the densification of the cellular network poses challenges in cell selection, more failures despite the expected gain in capacity. To deal with the unnecessary passes (Ping-Pong impact), longer delays, and high-power consumption and misfortunes, the SDN regulator, which collects the organization data, is used as a solution. To reproduce the results, the organization test system, ns3, has been used [5].

Ioannou et al. proposed an appropriate intelligent approach called BDIx to deal with power D2D network age in 2020. Without the assistance of a base station, BDIx deals with each D2D hub freely and independently, which maximizes the data rate by taking into account the computing load by minimizing the network power consumption [6].

For vehicle networks, the HoVe algorithm is a predictive QoE algorithm and a mobility-sensitive transfer algorithm. To provide vigorous forwarding choice and high QoE for video applications in 5G VANET, HoVe takes into account the user's location (current and expected), QoE, and radio devices. HoVe is proven by simulation performance, unlike best calculations in-vehicle situations, delivering video with 18-inch QoE. Skip-HoVe is a multi-criteria skipping-based video distribution algorithm for ultra-dense 5G VANETs. Skip-HoVe is 30 percent more efficient than state-of-the-art algorithms for providing films with a MOS of 30 while maintaining a Ping-Pong rate of roughly 2%, according to simulation data. For adaptively updating the VC by mobile vehicle monitoring, the DUVC scheme was proposed [7].

Moreover, a guess calculation for tackling the greatest min comparative asset, the executives' issue in V2X correspondence, is proposed to help V2X administrations better assist VC. The main contribution of the DUVC scheme is that it was designed to take into account vehicle movement characteristics and allow each AP to be refreshed adaptively in VC through portable vehicle following. It should be noted that the DUVC scheme can be used to define the V2X correspondence channel characteristics [8].

According to the multicast technology requirements, we characterize the maximum min-reasonable subject to a solitary AP power imperative instead of the regular total force limitations by expecting that each AP has a most extreme force requirement. In this case, multicast technology faces an NP-hard challenge. We center on a methodology that plans beamforming with a predefined between VC obstruction to reduce the computational loads of this NP-hard problem.

Measurement-calibrated RT simulations are used to assess blocked V2V channels in the 5 GHz range. There are two particular types of artifacts in the world:

1. Small-scale structures (such as light towers and traffic signs),
2. Large-scale structures (such as skyscrapers, buildings and ground) [9].

After this integration and calibration, complete RT simulations for V2V channels in urban and open space scenarios with and without sloping terrain and Tx and Rx in vehicles entering opposite or the exact directions are carried out. RT carries out the data for each event to explain channel path loss, shadow fading, and delay distribution. All of these channel properties agree with measured results from the literature [9].

High mobility usually produces frequent channel fluctuations; therefore, we must handle this problem. An effective cluster-based resource management system on large-scale fading is constructed to achieve spectrum sharing and power regulation. As an analytical target, the total cellular sum ratio of each V2I connection is employed.

Our findings exhibit that the counseled gadget with robust aid control will increase cell consumer rate, standard packet obtained ratio, and throughput in assessing offer schemes. Experiments suggest that the counseled green aid control approach works appropriately in many scenarios, achieving the exceptional packet obtained ratio and general cell customers sum ratio in a high-density VANETs context [10].

PMIP-MIVH stands for Distributed PMIP-based Mobile Internal Vertical Handover, a flexible vertical handover system based on PMIP6HD, and a logical interface that improves PDR and throughput by reducing packet loss and disconnection times. The smooth running of the sessions also facilitates the deployment of new critical VANET applications [11].

A new SDN-based road routing protocol for IoV is proposed to transfer data packets in V2V and V2X mode. Roads are divided into road segments based on intersections, and unique identifiers are provided in the proposed protocol. In its vicinity, EC maintains routing at the road segment level. The CE collects vehicle data (vehicle speed, direction, route, vehicle identification, and location). SD-IoV sends data packets via RSUs and nearby cars but only sends control and emergency packets over cellular networks (e.g., 4G/5G) because cellular networks are more expensive than RSUs while delivering half the capacity for data distribution. The PMIP-MIVH protocol is compared to the well-known routing protocol HRAR, with the findings demonstrating that SD-IoV outperforms HRAR in nearly every element of routing strategy. Various studies may be undertaken because it is so popular with researchers and corporations [11].

2. Vehicular communication system

In this section, we interpret the term "vehicular communication system" and discuss its types.

2.1. *Vehicular communication system interpretation*

The vehicle communication system includes vehicles and other contact units such as road units, clouds, network, and fog networks, Internet, people, and pedestrian transportation devices. Vehicle communication aims to improve road safety, reduce fuel consumption and CO2 emissions. Save time and offer a new driving experience. The term "V2X contact" refers to this form of communication. V2V, V2I, V2N, V2P communications are included in this category [12]. V2X communication is used in CV technology, enabling vehicles to communicate with individuals in their environment. For safety and non-safety-related applications and services, linked vehicle technology assists in the supply of valuable information to the driver, passengers, transportation authorities, Cloud, and things in the near surroundings (pedestrians, cyclists) [13].

2.2. *Types of vehicular communication system*

2.2.1. *V2X*

Vehicle-to-everything (V2X) communication refers to a collection of standards and technologies that enable cars to communicate with existing infrastructure such as roads and other road users. V2X is mainly concerned with exchanging information in V2I, V2V, V2P, Vehicle-to-Self, and V2R, which is based on hardware and established network technologies and protocols [14]. V2X communications have significantly reduced the number of vehicle collisions and their related fatalities. The benefits of V2X vehicles are not limited to reducing accidents; they can also help with traffic management, resulting in greener vehicles and lower fuel costs [15]. By fostering the development of new modes, new types of automobiles, and transportation services, V2X will help vehicles gain more knowledge, boost innovation and the application of autonomous driving technologies, and build an

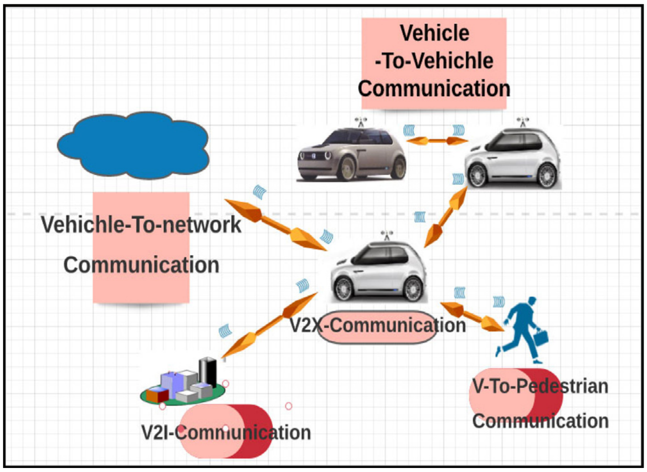

Fig. 1. Vehicle-to-everything (V2X).

intelligent transportation system. V2X not only improves traffic quality, reduces congestion, and lowers accident rates, but it also helps to improve traffic efficiency, reduce pollution, and lower accident rates. V2X has many uses, including intelligent transportation, intelligent connected vehicles, and autonomous driving. The V2X environment's latency, dependability, throughput, user density, and security are different characteristics for different applications [16]. Fig. 1. shows that low latency and a stable network environment are needed for safety applications and automated driving.

2.2.2. V2X network challenges:

(I) **Latency**

Latency and dependability are challenges for handover. Low latency is required for successful handover even with network difficulties and the presence of malicious assaults [17].

(II) **V2X Security Threats**

V2X technology is significantly reliant on network security, which may be broken down into four components:

1. Threats to mobile terminal security
2. Threats to the V2X service platform's security
3. Threats to V2X communication security
4. Threats to vehicle network data and privacy

All of these are threats that face V2X [17].

2.2.3. V2V

V2V refers to direct interaction between two devices without the need for a central point [18]. If two vehicles are within range of each other, they communicate directly; otherwise, VANET and IVC require multi-hop communication to transfer data. Each car can broadcast and receive data from other vehicles in the area (within a 70 m radius). This broadcast range is realistic since it is based on an established communication protocol. Energy use, disturbance control, peer discovery, handover, radio resource management, and protection are all issues that D2D technology faces. When considering that most mobile users use high-data-rate applications like video sharing and proximity-aware social networking, V2V prospects improved the network's spectral performance. Mode selection, resource distribution, and power management design aspects of D2D communication [19]. V2V communication facilitates many future automotive applications such as highway safety services, autonomous driving, roadway information dissemination, and infotainment about road services.

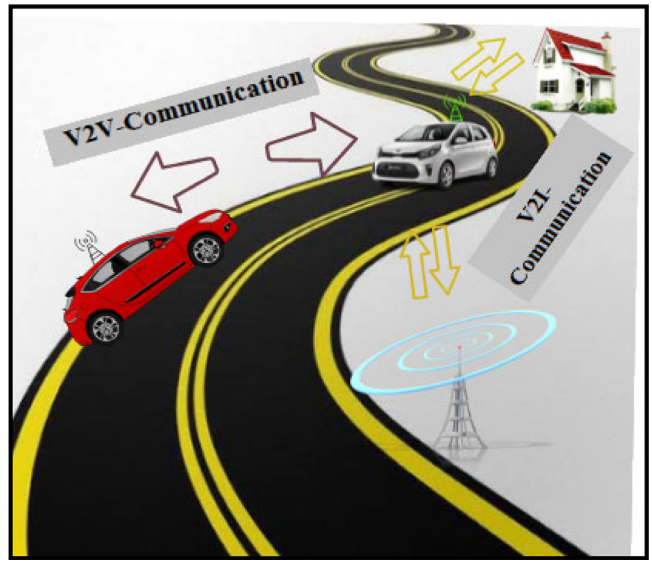

Fig. 2. V2V and V2I.

2.2.4. V2I

In this mode, communication occurs between a car and the communication infrastructure/road network, and vice versa. It allows a car to communicate with roadside devices, including RFID readers and cameras, traffic signs, road markings, lights, and parking meters. Smart city passengers and vehicle drivers try to connect to the Internet while on the move [20]. RSUs, HT, and cellular BSs make up RAN infrastructure. The core network infrastructure consists of wired infrastructure and middleboxes such as switches and routers. Likewise, traffic management supervision systems can use infrastructure and vehicle data to set variable speed limits and adjust traffic signal phase and timing to increase fuel economy and traffic flow. The hardware, software, and firmware that makes communication between vehicles and roadway infrastructure is an important part of all driverless car initiatives [21]. Network infrastructure can include Cloud, fog, and grid networks, as well as server farms at service providers, vendors, and legal authorities, as indicated in the diagram (see Fig. 2).

2.2.5. V2P

This mode enables a vehicle to interact with a computer or mobile held by a pedestrian, a rider, or a cyclist [22]. Pedestrian detection systems can be implemented in vehicles, in the infrastructure, or with pedestrians themselves to provide warnings to drivers, pedestrians, or both:

In-vehicle Systems: In-vehicle warning systems are becoming more and more commonplace (e.g., blind-spot warning, forward collision warning). The current field of V2V communications is providing the development of even more advanced warning systems (e.g., intersection movement assist, left turn assist). In-vehicle warnings to the presence of a pedestrian in the roadway might be logical [23].

Hand-held Devices (for pedestrians): Perhaps the simplest and most apparent warning system for pedestrians is a hand-held device [23].

3. Interpretation of handover

With the increasing number of cars on the road every day, DC with 5G mobile networks has become a constant requirement. The term "handover" refers to the process of moving from one cell to another and requires extensive knowledge of the network [2]. There are essential factors in handover such as:

1. Congestion
2. Cellular coverage
3. Mobility
4. Organize available resources into a network
5. Protocols
6. Parameters of topology

Handover should be done to maintain contact between devices as they move away from each other. Also, when a device (e.g., a D2D relay or a D2D cluster head) moves away from the access point to which it is allocated, the subject of turning it over to another access point with a standard medium arises [24]. There are various forms of handovers. Vertical and horizontal handover are well-known examples. The most frequent triggered mechanism that incorporates both QoS and cost is vertical handover.

3.1. Vertical handover

In heterogeneous wireless networks, the handover procedure is divided into two sections:

1. the decision-making process for handover
2. the procedure for handover execution

Additional network data is collected during the transfer execution process, such as when it takes to identify an address in Mobile IPv6 and when the transfer and discovery decision procedures overlap. During the handover decision process, the mobile node and the network decide when the delivery will occur [25].

Once the delivery decision process is complete, the delivery execution phase begins. The three primary mechanisms that trigger handover delays are as follows:

1. Time for exploration
2. Deal with the configuration period.
3. Deal with the configuration period.

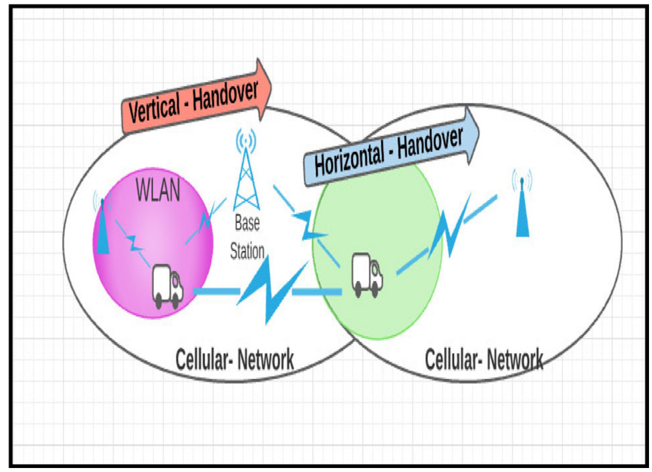

Fig. 3. Vertical and horizontal handover.

The main capabilities of Vertical handovers over Horizontal handovers are:

1. Vertical handovers use different access technology.
2. Vertical handovers use multiple network interfaces.
3. Multiple IP addresses are used in vertical handovers.
4. QoS parameters can be changed in vertical handovers and multiple parameters are used.
5. Multiple network connections are used in Vertical handovers [26].

3.2. Horizontal handover

The vertical handover mechanism differs slightly from the horizontal handover mechanism; they are further divided into two groups based on signal frequency:

1. Upward VHO classification
2. Downward VHO classification [27].

Fig. 3 shows the vertical and horizontal handover.

Implications of inter-operator handover. When a region is split between multiple operators, Inter-operator handover is required by UEs. When moving from one region to another, the following consequences arise:

1. Message replication is needed because, to complete transmission between operators, the Wi-Fi piece must disconnect from one operator and reconnect with another, resulting in a service interruption that may take up to 300 ms. The transmission must then be performed on time to ensure message reception to this UE that conducts inter-operator handover and then interacts with the two operators before getting a notice from the operator with whom the connection was severed. To avoid message loss, each operator must send messages at least twice. The first communication should be made as soon as feasible to decrease latency. Once the delivery decision process is complete, the delivery execution phase begins [28].

2. The worst-case handover scenario occurs when UE moves from one area to another and sends a message. Conversely, another UE sends a message simultaneously, resulting in a delay of up to 660 ms, which is unnecessary. The message should be sent to all cells whose service area straddles the border between regions served by different operators to ensure that all EU members get it.
3. Location Information: ITS server can need to make some adjustments to figure out the BSs. The main delay factor in a transfer between operators is the delay in the network connection to the destination operator. Numerical analysis shows that the fast transfer solution has a latency of 20 ms in the best case and 70 ms in the worst case. It is challenging to maintain a consistent level of application QOS during handover in V2I for heterogeneous networks of varying sizes. This node monitors and passes messages from BSs to the BSs' local application server [29].

4. Vehicle communications in 5G

In a very heterogeneous world with macrocells, small cells, and relays, 5G networks carried 1000 times more traffic than 4G networks. 5G is a promising option for the intensive use of video-based content on mobile devices anytime and anywhere as in the 5G vehicular network, mobility management is a problem. Because of the variations in requirements such as high-speed mobility, handover decisions for connected vehicles in ultra-dense 5G networks have modern handover solutions and techniques distinct from (4G and LTE) techniques. The velocity of cars that make handover choices and impact the QoS supplied to the user is mentioned as a factor influencing connected vehicles in ultra-dense 5G networks [30].

4.1. 5G interpretation

5G of cellular networks is planned to meet the needs of next-generation systems. The main characteristics are regulated by 5G are:

1. A large amount of data is produced. More than 7.5 billion wireless hand-held devices are in use worldwide, and that number is expected to grow to 25 billion by 2020.
2. High QoS requirements are necessary to achieve ultra-low latency and high data rates.
3. Interoperability of different UEs (e.g., laptops, smartphones), QoS requirements (e.g., different levels of throughput and latency for various applications), and types of networks should all be supported in a network. Heterogeneous 5G (e.g., Internet of Things, IEEE 802.11).
4. Massive MIMO enables the base station to operate large antennas (more than 16 per division) to provide directional communication or beamforming to eliminate interference and allow neighboring nodes to communicate simultaneously [31].

4.2. Vehicles communication handover in 5G networks

In a very heterogeneous world with macrocells, small cells, and relays, 5G networks carried 1000 times more traffic than 4G networks. 5G is a promising option for intensive video-based content on mobile devices anytime and anywhere [32]. In a 5G vehicular network, mobility management is a problem. Because of the variations in requirements such as high-speed mobility, handover decisions for connected vehicles in ultra-dense 5G networks have modern handover solutions and techniques distinct from (4G and LTE) techniques. The velocity of cars that make handover choices and impact the QoS supplied to the user is mentioned as a factor influencing connected vehicles in ultra-dense 5G networks [33].

Handover mechanism in 5G networks. The handover operation's operating cycle follows: Virtualization through Network function virtualization (NFV) is crucial for instantiating v-cells proposals that accept software-defined network controller parameters. Each vehicle is connected to a v-cell created and controlled by NFV, which comprises a cluster of antennas on BSs. V2V, V2I, and V2X communications are all part of this process [34]. It is critical to developing a system that broadcasts safety road information over the backbone and through bi-directional data transmission between RSU and vehicles, allowing the device to determine its location. 5G applications can achieve a very high data capacity with higher throughputs and lower latency to support multimedia services. As the requirements for 5G applications grow more, enhancing RATs to be more suitable for them becomes a high priority. 3GPP has many trials of defining the 5G specifications and applications. 5G is a very challenging radio technology to support the earlier discussed high QoS needs of V2X and the challenging specifications of highly mobile environments. Projects as Next Generation Mobile Networks Alliance (NGMN), and 5G Automotive Association (5GAA) are working to evaluate 5G-New Radio (5G-NR), and LTE-based V2X in cooperation with the vehicular industry [35].

The 3GPP has studied use cases for advanced V2X applications to help in improving road safety and help in other applications as traffic management and a better spread of data among passengers. Some of these advanced applications are remote driving, vehicle platooning, extended sensors, and advanced driving. It shows that reliability and latency requirements are much higher than those required from basic safety applications. Extensive and variable-sized packets are required in these applications while, on the other hand in basic safety applications, messages are periodic (every 100 ms typically). To meet these challenges, it is apparent that a major development in these V2X technologies should be done [36].

4.3. Data characteristics for 5G-V2X

According to the temporal characteristics of the data, V2X data in 5G can be divided into three categories:

1. Complex real-time data: this type of data has set latency criteria (for example, gaming, video streaming, and healthcare).

Table 1
5G -V2X handover algorithm.

Title	Author(s)/Year	Algorithm applied	Contribution
Resource management for multi-user-centric V2X communication in dynamic Virtual-Cell-Based ultra-dense networks	Xiao et al. (2020)	The user-centric virtual cell (DUVC) system [39]	(1) Considering vehicles movement characteristics (2) Regarding the resource management problem (3) The max–min-fair problem of resource management in VCs is solved via an approximation technique. Also, it provides better performance compared with previous algorithms.
An Efficient Cluster-Based Resource Management Scheme and Its Performance Analysis for V2X Networks	Abbas et al. (2020)	An efficient cluster-based resource management scheme and its performance analysis for V2X networks [40]	(1) To increase reliability, throughput, and latency performance, and efficient cluster-based resource management system and its performance analysis for V2X networks are recommended for performance and spectrum management. (2) To assign a set of radio resource blocks (RB) and power levels to V2V and V2I users, the resource management problem is considered. (3) Develop a vehicle interference analysis method that uses. (4) An unlicensed spectrum to assess interference between cellular and VANET users. On the other hand, interference within the territory of the mobile phone user is investigated. (5) A fast fading random-effects analysis technique is explored to reflect the expected latency and reliability requirements for V2X communications in analysis constraints that can only be quantified using slowly changing channel state information (CSI). (6) Cluster-based approaches that provide the best resource allocation are shown. The experimental data reveal that the suggested technique has a promising performance when compared to the current system.

2. Soft real-time data: this sort of data may accept a predetermined but limited delay (for example, a traffic signal control system).
3. Non-real-time data: non-real-time data is not time-sensitive and may survive any delay [37].

4.4. 5G V2X-handover

The distribution of particular edge servers that can be housed in small data centers and support a limited number of cars within the base station's proximity is referred to as handover in this context.5G CAR analyzed the Third Generation Partnership Project (3GPP), which included relocating edge cloud servers through mobility processes. The car is configured to send information about its position to the RAN, then evaluated to determine whether a handover is required. Based on analytical data methods, the location information shows whether the Edge cloud servers are near the car or not. The target RAN receives the handover information and begins selecting a new edge computing server if the connected vehicle's signal strength deteriorates and the vehicle switches to a new target base station [38]. In Table 1, you could see some literature reviewed for handover in 5G -V2X.

4.5. 5G V2V-Handover

In V2V, the handover process occurs when both or one of the transmitting devices move to and enter the neighboring cell at some point. When only one of the communication devices moves in the adjacent cell, it is referred to as a half-transfer or a partial transfer [41]. D2D UEs are subject to interference from various sources on the network; As a result, the handover from one cell to another must consider the QoS specifications of the devices and the resource availability of the new cell [42].

There are three stages of the V2V handover process.

1. Handover planning
2. At this point, the UE sends channel-related data to its serving eNB, which decides whether to start the handover based on factors such as the average fade length and the average level transition rate.
3. Handover Execution
4. The information and actions of the UE are transmitted to the other cell during the entire execution process.
5. Handover completion
6. During the completion phase, the acknowledgments are transmitted between the cells, and the state of the UE is changed in the new cell [43].

Below are some literature reviewed for handover in 5G -V2V in Table 2.

4.6. 5G -V2I handover

Due to the high mobility of the vehicle, the V2I connectivity must be able to handle regular handovers in small, dense cell deployments while providing fast and secure V2I connectivity [44]. Below are some literature reviewed for handover in 5G-V2I in Table 3.

4.7. IoV architecture

IOV refers to the integration of intelligence into the vehicular world, through which vehicles would be able to interact

Table 2
5G -V2X handover algorithms.

Title	Author(s)/Year	Algorithm applied	Contribution
A Multi-criteria-based handover algorithm for vehicle-to-infrastructure communications	Ndashimye et al. (2021)	A multicriteria-based handover algorithm for V2I communications (V2I-MHA) [45].	Reduced the number of unnecessary handovers and improved the overall handover delays by limiting the number of candidates AP/BS to be scanned.

Table 3
5G -V2I handover algorithms.

Title	Author(s)/Year	Algorithm applied	Contribution
QoS aware distributed dynamic channel allocation for V2V communication in TVWS spectrum	Midya et al. (2020)	Distributed channel and power allocation technique [46]	Allocated an optimized channel for V2V communication by controlling the transmit power.
V2vnet: Vehicle-to-vehicle communication for joint perception and prediction	Wang et al. (2020)	A new model for predicting motion and perception [47]	The optimal balance between high perception and motion forecasting performance and available hardware transmission bandwidth capabilities was achieved.
Index Coding in Vehicle-to-Vehicle Communication	Pachat et al. (2020)	Index coding methods are used in device-to-device data communication to reduce the number of transmissions necessary [48]	A lower bound is calculated for the total number of transmissions during the V2V phase when each vehicle has duplicate packets. An attainable index coding system is provided for the scenario where the neighboring cars have an equal number of packets in common.
Low-Latency Infrastructure-Based Cellular V2V Communications for Multi-Operator Environments with Regional Split	Martín-Sacristan et al. (2020)	Infrastructure with low latency Cellular V2V communication based on multi-operator environments with regional distribution [49]	They enable a quick change between operators based on the previous registration of the user with several operators, reduce the transmission time considerably and guarantee maximum E2E latency values of 100 ms in non-overloaded environments.

with one another and their surroundings, such as pedestrians, computers, and traffic signs.

IOV architecture aims to enhance standardized vehicular communication architecture by integrating various technologies such as SDN, NFV, edge computing, and AI. Their combined efforts could result in increased QoS, responsiveness, versatility, and automation. Vehicles should be able to interact with their surroundings using a variety of access technologies in this scenario. The emergence of IoT is based on two key concepts:

1. New modes of communications new technologies.
2. The current VANET uses each vehicle connected to the Internet as a node [50] (see Fig. 4).

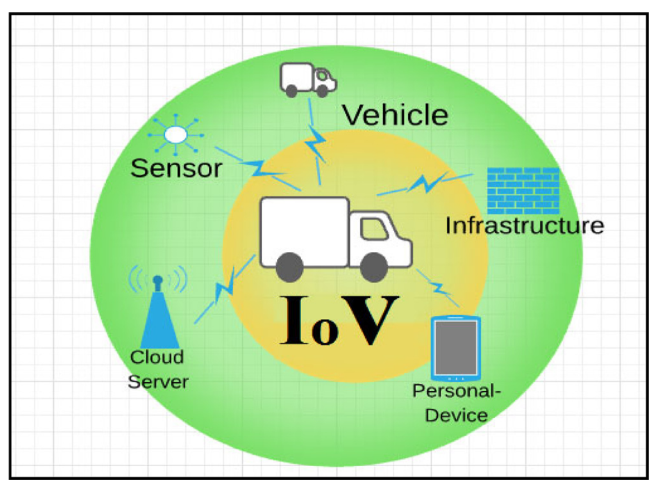

Fig. 4. IOV-based.

4.8. 5G- IOV Handover

Continuous communication, free of transitions across and via diverse networks, is required for V2I. Better network identification, selection, and implementation of rapid, smooth, and stable vertical handover, sustaining QoS, and delivering a better QoE are the significant problems for V2I communication in 5G heterogeneous networks combination of multi-tier and multi-RAT [51].

IoV Handover Steps

The handover method is broken down into three stages: initiation, judgment, and execution.

1. Handover Initiation A vehicle's connection with the associated network, RSU/AP/ eNB is checked in this process. If the current network's bandwidth is insufficient to maintain a link, the vehicle initiates the handover process. The obtained signal intensity indicator (RSSI)/SINR threshold is the standard method for initiation.
2. Handover Decision In this procedure, a vehicle first identifies the accessible networks, then accumulates the

Table 4
5G -IOV handover algorithms.

Title	Author(s)/Year	Algorithm applied	Contribution
For 5G IoV networks with NOMA, research on cluster over-lap and non-overlap regions.	Gu, Jinyuan et al. (2021)	An improved performance scheme based on non-orthogonal multiple access (NOMA) [53].	NOMA-IoV networks have been carefully studied with two CHVS to increase ergodic RS. Unlike the previous NOMA system, CHVs decode and transmit (DF) essential signals to cars only after they have been received; Meanwhile, the maximum combined ratio (MRC) is used to improve performance. The combination of NOMAV2X networks with the overlap region debate has not been studied to our knowledge, which is broader and more complex. For the given methods, closed-form solutions of the ergodic SR are found with negligible performance loss in the high transmit signal-to-noise ratio (SNR) area. Few studies focus on 2-stage superposed transmission for multiple CHVs NOMA-V2X networks since obtaining a precise description of the ergodic SR is challenging. The proposed NOMA-IoV schemes were compared with the TDMA scheme of ergodic SR. includes NOMA systems by a significant margin.
Intelligent Edge Computing on Internet of Vehicles: AJoint Computation Offloading and Caching Solution	Ning et al. (2020)	A Mix Integer Non-Linear Programming (MINLP) problem to minimize total network [54].	Created a hierarchical design for Peripheral Intelligence Enabled IoV that considers vehicle-to-RSU compute offload, RSU peer offload, and content caching simultaneously. A mixed-programming nonlinear integer (MINLP) optimization problem is then used to reduce the total network latency. Using Lyapunov optimization, provide an online multi-decision method (nicknamed OMEN) that works without asking for future information about the system. Conducted tests in Hangzhou, China, using real-world traffic data. The suggested technique considerably decreased network latency with various traffic flows, according to the results.

data needed to choose the target network for its affiliation. As decision criteria, RSSI, SINR, BER, and location can all be employed. The selection technique determines the target network and the time when the handover will occur. If the vehicle (mobile host) chooses, it is a MIHO.

3. Handover Execution After picking a suitable target network for handover, the vehicle executes the handover for its re-association to the target network. The vehicle acquires resources from a new network while simultaneously releasing resources from the old. In this stage, the vehicle or the network executes and manages the actual handover. If the vehicle has one, it is an MCHO. It is an NCHO otherwise [52].
   Below are some literature reviewed for handover in 5G –IOV in Table 4.

4.9. Characteristics of VANET technology

VANET is a technology that has revolutionized the transportation system. Much architecture can be used in E-VANET depending on the context and infrastructure availability. E-VANET architecture can be built by linking electric vehicles only to each other or to roadside units [55]. They created a network that can improve the efficiency of the current transportation system by providing protection and entertainment to the drivers and passengers. The vehicles will link to form a cloud that includes traditional SaaS, PaaS, IaaS, and Xaas. WLAN, complete ad-hoc network and hybrid-mode network are the three types of VANET architecture. The benefits of SDN-based VANET systems include efficient resource usage, fast network setup, and reduced service latency. The routing protocol determines the contact pattern in VANETs. A routing protocol aims to provide safety information to on-the-road vehicles. Due to its highly dynamic and inconsistent structure, a reliable VANET faces numerous challenges. To overcome the challenges described earlier, a secure and efficient routing protocol is needed for data transmission. In previous studies, several routing protocols for highly complex and dense vehicular networks were presented Load balance [56].

5G-VANET handover. The car must be linked to at least one network at all times in this situation. By installing several radio access technology (RAT) devices on each car. By using a logical interface, we can reduce transfer time and packet loss by following the requirements of PMIPv6 stream mobility extensions [57] (see Fig. 5).

Below is some literature reviewed for handover in 5G –VANET in Table 5

5. Conclusion

Vehicle communication systems are computer networks in which vehicles and road units transmit safety warnings and traffic information in both directions. In most cases, vehicular communications are implemented within the framework of the ITS. The high costs associated with traffic accidents.V2V, V2I, V2X, V2S, and vehicle-to-pedestrians are forms of vehicular communication that can be classified using heterogeneous network architecture. VANET is a type of network that is

Table 5
5G -VANET handover algorithms.

Title	Author(s)/Year	Algorithm applied	Contribution
An efficient signature scheme based on identity without bilinear coupling for vehicle-to-vehicle communication in VANET is presented.	Ali et al. (2020)	Identity-Based Signature with Conditional Privacy-Preserving Authentication (IBS-CPPA) is an efficient V2V communication system based on Elliptic Curve Cryptography (ECC) and generic one-way hash functions [58].	(1) An efficient ECC-based IBSCPPA system has been created to authentic traffic messages with conditional privacy protection in V2V communication in VANET. (2) This approach employs generic one-way hash functions rather than Map-To Point hash functions without bilinear pairings to speed up the signature verification process. By certifying a maximum number of traffic-related communications, the batch signature verification approach was utilized further to minimize the computing load on the verifying vehicle.
In VANETs, a mobile internal vertical handover mechanism is used to manage dispersed mobility.	Tuyisenge et al. (2020)	The safety of the IBS-CPPA theme relies on the idea that the ECDL issue within the random oracle model is complicated [59].	(1) Reduce the amount of time necessary for handover. (2) Decrease the number of messages sent during handover radio signaling to a min-mum.
E-VANET stands for Electrical Vehicular Ad Hoc Networks.	Naser et al. (2021)	EVAN (Electric Vehicle Ad Hoc Network) (E-VANET) [60].	(1) Developing a new sort of wireless communication, termed E-VANET, connects a group of electric cars, especially in vehicular networks. (2) Developing numerous novel architectures for pure E-VANET and SDN-Fog-E-VANET that may be used to achieve high performance depending on network conditions.

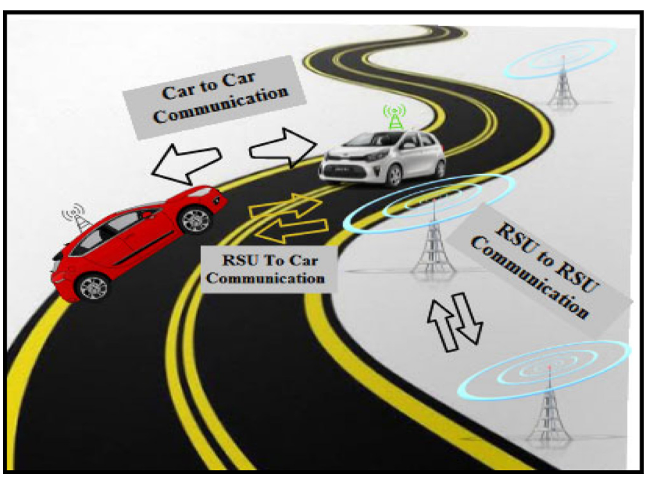

Fig. 5. VANET structure.

created from the concept of establishing a network of cars for a specific need.

In cellular telecommunications, the term handover refers to transferring a current call or data session from one channel connected to the core network to another channel.

This survey focuses on vehicular communication systems, handover in 5G, its types, and algorithms developed to overcome its problems. The paper gives an insight into the handover mechanism in 5G networks . In addition, we tried to cover all essential aspects so that some helpful information can be gained through this review paper.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Appendix

Abbreviation	Explanation
AI	Artificial Intelligence
AP	Access point
Aps	Access points
BDI	Belief Desire Intention
BDMA	Beam Division Multiple Access
BS	Base Station
BSs	Base Stations
CRNs	Cognitive Radio Networks
CV	Connected Vehicle
D2D	Device-to-Device
DAGIoV	Directed Acyclic Graph allowed IoV
DC	Device Communication
DSRC	Short-Range Communication
DUVC	The dynamic user-centric virtual cell
eNB	Evolved Node B
FBMC	Filter Bank Multi Carrier
HHO	Horizontal Handover
HT	Hotspots
IaaS	Infrastructure as a Service
IoT	Internet of Things
IOV	The Internet of vehicle
ITS	Information technology solutions
ITS	intelligent transportation systems
IVC	Inter-vehicle communication
LTE	Long Term Evolution
MANETs	Mobile ad hoc Networks
MCHO	Mobile-Controlled Handover
MIHO	Mobile-Initiated Handover
MIMO	Multiple-Input Multiple-Output

Abbreviation	Explanation
mmWave	Millimeter Wave
MNOs	Mobile Network Operators
MOS	Mean Opinion Score
MU	The Multiplicative Update
NCHO	Network-Controlled Handover
Nesterov SCA	Nesterov Successive Convex Approximation
NGNs	Next-Generation Networks
NIHO	Network-Initiated Handover
NP	Network's Performance
PaaS	Platform as a Service
PRDP	Passive RSU Detection-Based Proactive
QoE	Quality of Experience
QoS	Quality of Service
RAN	Radio Access Network
RAT	Radio Access Technologies
RFID	Radio-Frequency Identification
RSU	Roadside Unit
RSUs	Roadside Units
RT	Ray-Tracing
RU	Roadside Units
SaaS	Software as a Service
SDHO	Software-Defined Handover Solution
SDN	The Software-Defined Network
SINR	Signal-to-Interference-Plus-Noise Ratio
SLA	Service Level Agreement
UE	User Equipment
V2I	Vehicles and Infrastructures
V2N	Vehicle-to-Network
V2P	Vehicle-to-Pedestrian
V2R	Vehicle-to-Roadside Units
V2S	Vehicle-to-Sensors
V2V	Vehicles and other Vehicles
V2X	Vehicles and Everything
VANET	Vehicle Ad Hoc Network
VHO	Vertical Handover
VLC	Visible Light Connectivity
WLAN	Wireless Local Area Network
Xaas	Anything as a Service

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