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Navigating the Future of Intelligent Transportation: Challenges and Solutions in 6G V2X and V2V Networks

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Abstract

Recent advancements in Information and Communication Technologies (ICT) have transformed vehicular communication, facilitating Vehicle-to-Vehicle (V2V) and Vehicle-to-Everything (V2X) connectivity. These technologies enhance travel safety and efficiency while also reducing pollution and accident rates through optimised resource utilisation. V2X applications encounter significant challenges concerning traffic safety, data security, and scalability, necessitating thorough evaluation prior to extensive implementation. The rising prevalence of connected vehicles presents challenges, including network instability, heterogeneity, and extensive data management, which require novel solutions for effective communication. This study gives a new view on how to combine 6G technologies with V2X and V2V communication systems. It addresses important issues like security, resource allocation, and making sure that communication is very reliable and has low latency. Our study is different from others because it looks at all the technologies that make this possible, including Proportional Fairness Algorithms, machine learning, blockchain, and Reconfigurable Intelligent Surfaces (RIS). We emphasise the significance of collective perception (CP) in improving traffic safety and resource efficiency through the sharing of sensor data among V2X-enabled entities, including vehicles, roadside units (RSUs), and vulnerable road users.This research provides a thorough analysis of advanced methodologies and their limitations, making it a valuable resource for scholars, academics, and industry professionals. It offers a framework for developing future intelligent transportation systems that utilise 6G capabilities to achieve high reliability, minimal latency, and optimal spectrum efficiency in vehicular networks.

Keywords: Vehicular Ad hoc Networks, Vehicle to Vehicle, Vehicle to Everything, Collective Perception, Information and Communication Technologies, Road side Units, Data Transmission.

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1. Introduction

The swift advancement of 6G technologies has unveiled transformative opportunities for Vehicle-to-Everything (V2X) and Vehicle-to-Vehicle (V2V) communication, facilitating intelligent transportation systems characterised by improved safety, efficiency, and low-latency connectivity. The rising prevalence of autonomous and connected vehicles necessitates innovative solutions to tackle network instability, security vulnerabilities, and resource allocation issues. This research examines the incorporation of sophisticated methodologies, including machine learning, blockchain, and reconfigurable intelligent surfaces (RIS) to improve communication reliability and optimise spectrum utilisation. Collective

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perception (CP) plays a crucial role in improving real-time decision-making by enabling data exchange among vehicles, roadside units (RSUs), and pedestrians. The document emphasises the importance of proportional fairness algorithms (PFAs) in facilitating equitable resource allocation, which is essential for congestion control in densely populated urban areas. This research examines the impact of intelligent mobility solutions on reducing accidents and traffic delays. The study proposes an adaptive framework for real-time data sharing and secure communication that utilises 6G capabilities. The integration of edge computing and AI-driven models improves vehicular decision-making and optimises latency-sensitive applications. This paper presents a detailed roadmap for the future of V2X-enabled smart transport networks, focusing on critical challenges in security and scalability. The insights provided advance the development of resilient and scalable vehicular communication frameworks in the 6G era. The inception of 6G necessitates a top-down approach in its design and development, ensuring the fulfilment of the requirements of numerous services that are presently awaiting a network with the capacity to accommodate them. 6G's broad purpose is to serve many different vertical markets, but the standard's architecture must become increasingly vertically oriented to fulfil the needs of those businesses [1]. This line of thinking is applicable to the situation of vehicle services, which place demanding QoS requirements on the underlying network infrastructure due to their basic mobility and crucial bandwidth, latency, and reliability needs [2]. Frequency, personal information rate, peak transmission rate, core network, mobility, and latency are the six essential aspects where 6G is expected to outperform 5G, as summarized in Table 1. This highlights the significance of the 6G network's potential for enhancing latency, frequency, data throughput, mobility, and service coverage [3]. The importance of the V2X industry segment is reflected in the 3GPP standards, which are being developed as part of the 6G ecosystem [4]. The Network Exposure Function (NEF) is the foundation for service parameter provisioning in this Technical Specification for V2X communications as it provides access to the core network [5]. This capability enables the 6G app to do actions such as querying the User Equipment (UE) for information on the condition of the network, implementing policies, receiving notifications about changes in location, and requesting that traffic routing be altered [6]. The fulfilment of Quality of Service (QoS) and security requirements in this specific industry depends significantly on this factor. Although the exact methods and consequences of its design are not completely established, they are still extremely important.

Table 1. 6G Vs 5G [21]

Major Factors	**6G**	**5G**
Peak data rate	>100Gb/s	10[20] Gb/s
User experience data rate	>10Gb/s	1Gb/s
Traffic Density	>100Tb/s/km2	10Tb/s/km2
Connection Density	>10million/km2	1million/km2
Delay	<1ms	ms level
Mobility	>1000km/h	350km/h
Spectrum efficiency	>3x relative to 5G	3~5x relative to 4G
Energy efficiency	>10x relative to 5G	1000x relative to 4G
Coverage percent	>99%	About 70%
Reliability	>99.999%	About 99.9%
Positioning precision	Centimetre level	Meter level
Receiver sensitivity	< -130dBm	About -120dBm

Connecting V2X is an important strategy for enhancing the effectiveness of the current transportation system. Since V2X is a cyber-physical system, it is susceptible to the effects of things like traffic and the network's overall state. In addition, latency, dependability, throughput, accessibility, and cyber security requirements to V2X performance are heterogeneous in the design of applications [7]. Some safety applications for connected automobiles, including autonomous pilots, necessitate minimal latency and great dependability. In a congested area, it should be possible for multiple vehicles to access a node within a small radius [8]. Serious incidents involving several vehicles and pedestrians could occur if the V2X requirements for performance of applications are not met. Before widespread deployment and practical use of vehicles, the V2X network of communication should be tested and reviewed thoroughly and methodically [9].
The testing strategies are extensively researched in accordance with the actual requirements of the application. It could be broken down into two types of testing: performance testing and functionality testing [10]. End-to-end latency, transmission range, and packet drop rate are just few of the performance metrics that may be tested with performance testing. Functionality testing is typically used to determine how well an application does its intended tasks, such as the proper execution of predetermined scenes [11], the app's security prowess, and so on. Two-way connections between cars, and cars and infrastructure and pedestrians and the internet, are made possible by cutting-edge information and communication technology with the V2X concept. This technology might allow pedestrians,

cars, roads, and even the cloud to talk to one another. V2X can contribute in the growth of novel techniques and novel forms of cars and facilities for transportation, as well as the building of an intelligent transport system, in addition to The V2V and V2X communication model in Figure 1 which is shown below.

helping vehicles collect more data [12]. Major advantages include better traffic management, less pollution, reduced accident rates, and reduced resource consumption.

V2V and V2X Communication Model

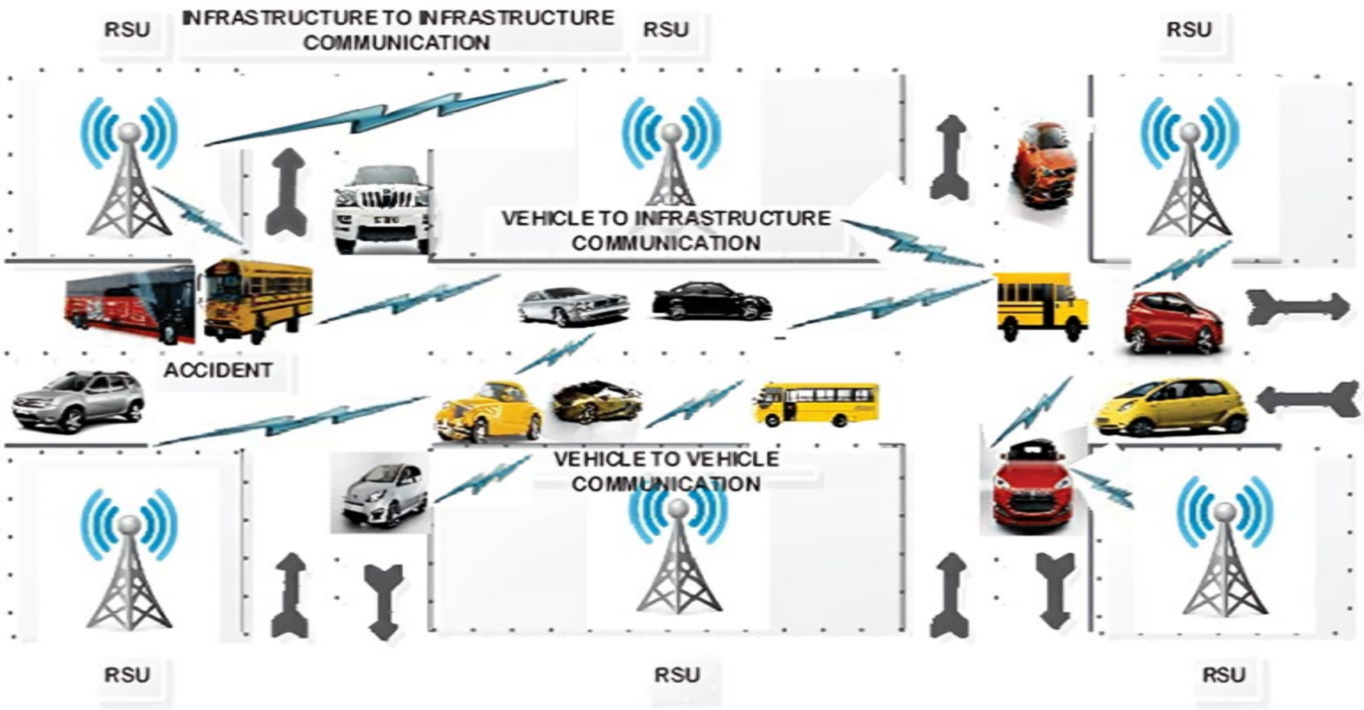

Figure 1. V2V and V2X Communication Model [27]

The present V2X communication technologies comprise of DSRC and Long-Term Evolution for V2X (LTE-V2X). The DSRC system has been standardized by the Institute of Electrical and Electronics Engineers (IEEE) and the Society of Automotive Engineers (SAE). DSRC allows vehicles to transmit pertinent security information directly to nearby cars and pedestrians by utilizing the 802.11p protocol at the physical layer and the medium access control (MAC) layer [13]. This reduces the burden on all parties involved in the verification, connected procedures, and data broadcast that occurs before sending. The network's structure and security protocols are established by IEEE 1609 WAVE. The application-level message format is defined by SAE J2735, whereas the performance criteria for different V2X communication scenarios are defined by the J2945/x family of standards [14]. LTE-V2X, derived from 3GPP's advancements in LTE mobile communication technology, provides a substantial data transfer speed and efficient Quality of Service (QoS) management for Vehicle-to-Everything (V2X) connectivity. It can function in either a cellular (Uu) or direct (PC5) method of communication [15]. Vehicle-to-Everything (V2X) communication includes various paradigms such as Vehicle-to-Vehicle (V2V), Vehicle-to-Infrastructure (V2I), Vehicle-to-Pedestrian (V2P), and Vehicle-to-Network (V2N). These paradigms enable instantaneous data exchange, improving traffic safety, optimizing resource use, and minimizing environmental impacts. For example, V2P notifies drivers of pedestrians, whereas V2N delivers information on traffic congestion. Existing V2X protocols, like Dedicated Short-Range Communication (DSRC) and LTE-V2X, try to solve some problems, but they have trouble with scalability, interference, and ultra-reliable low-latency communication (URLLC), all of which are necessary for self-driving cars. Vehicle-to-vehicle (V2V) communication, crucial for collision avoidance, lane-changing assistance, and cooperative driving, requires low latency (<1 ms), high reliability (>99.999%), and centimetre-level positioning precision. The IEEE 802.11p standards established the foundation for Dedicated Short-Range Communications (DSRC), whereas Cellular Vehicle-to-Everything (C-V2X) has improved reliability and scalability, with 6G anticipated to provide additional advancements. New 6G technologies, like reconfigurable intelligent surfaces (RIS), terahertz communication, and AI/ML integration, aim to fix the problems with current systems by making spectrum use more efficient, increasing scalability, and connecting people through space networks like UAVs and satellites. Nonetheless, obstacles persist, encompassing interference, data security, energy efficiency, and resource allocation. Proportional Fairness Algorithms (PFA), blockchain for secure data sharing, and machine learning for adaptive resource management provide solutions to these challenges. Practical applications encompass autonomous driving, emergency vehicle prioritization, and smart city integration, as exemplified by initiatives such as C-V2X trials and UAV-based traffic monitoring. By utilizing innovative algorithms and experimental frameworks, forthcoming research can facilitate scalable, efficient, and secure V2X networks, thereby advancing intelligent transportation systems.

Intelligent mobility, intelligently connected vehicles, and autonomous driving are just a few examples of how V2X can be put to use. The latency, dependability, throughput, user density, and security needs of the V2X environment are very application-specific [16]. Extremely low latency and a trustworthy network is necessary for safety applications and automated driving. For instance, since most of the time spent in a car is spent in motion at high speeds, bad actors may easily cause catastrophic traffic accidents by transmitting misleading information. By intercepting data packets, malicious actors can also learn the owner's name, the location of the car, the driver's path, and more [17]. Users' confidentiality is being compromised. The route and geographical information contained in the V2X data has implications for national security [18].5G V2X builds upon the fundamental principles and system architectures of LTE-based V2X, but achieves superior performance by allocating additional resources to both the spectrum and hardware components. The future proliferation of autonomous vehicles is anticipated to be driven by urbanization, increasing incomes, and technological advancements. Consequently, there will be an important rise in the demand for communication tools and digital programs to support AI-driven autonomous cars [19]. The growing need for advanced features in autonomous vehicles, such as 3D displays, holographic control systems, immersive entertainment, and enhanced in-car information, is causing new communication difficulties for the V2X network. The developments in wireless technology will lead to new challenges in data throughput, the factors that will increase demands on current wireless networks include latency, coverage, spectral/energy/cost efficiency, intelligence level, networking, and security. Keeping this in mind, it's possible that 5G V2X networks won't be able to serve a wide variety of needs and applications. While research into ITS concepts has been ongoing for some time now, current-generation V2X communication infrastructure can only offer rudimentary levels of intelligence [20]. Therefore, a drastic paradigm shift toward more flexible and diversified network ways is required for effective communication.

The recently proposed 6G wireless communication network proposes to integrate terrestrial and several non-terrestrial communication networks [21-22]. This integration is regarded as the commencement of this revolution. In other words, this will enable highly intelligent and widespread V2X systems with enhanced dependability and safety, rapid and extensive wireless connectivity, and notably more intelligent, longer-lasting, and environmentally friendly communication coverage. In order to meet the demands of future V2X networks, new strategies must be developed to provide flexible learning and intelligent decision-making. This is necessary since these networks are characterized by a diverse range of network components, varying communication conditions, and stringent service demands [23-24]. Through the integration of machine learning (ML), The implementation of 6G is expected to enhance radio signal performance by developing intelligent and autonomous radio systems. This breakthrough will facilitate the implementation of many cutting-edge functionalities, including improved awareness of context, automatic grouping of data, flexible coordination, and automatic configuration [25]. In this research, a variety of enabling technologies, such as novel data sources, algorithms, and system architectures for V2V, V2X data transmissions, securing the data and communicating with other vehicles and RSUs are discussed. The forthcoming requirements of the next-generation V2X will likely be fulfilled by the 6G communication technology."

1. Integration with Sixth Generation Technologies:

The proposed concept utilizes 6G-specific attributes, including ultra-low latency, high reliability, and enhanced spectrum efficiency to tackle the distinct challenges of V2X and V2V communication. These advancements facilitate the evolution of contemporary intelligent transportation systems by enabling instantaneous communication and decision-making in highly dynamic vehicular contexts.

2. Advanced Resource Allocation:

The implementation of the Proportional Fairness Algorithm (PFA) presents an innovative method for resource management. By optimizing throughput and fairness in congested traffic conditions, it guarantees equitable resource allocation among vehicles, which is essential for the reliability and efficiency of Intelligent Transportation Systems (ITS).

3. Improvement of safety and efficiency:

The concept targets essential Intelligent Transportation System objectives, including the reduction of accidents and the optimization of traffic flow. Attributes such as low-latency communication and real-time data sharing facilitate rapid vehicle responses to potential hazards, thereby improving overall road safety.

4. Integration of Enabling Technologies:

The amalgamation of machine learning, blockchain, and reconfigurable intelligent surfaces (RIS) establishes an intelligent and adaptive communication framework. These technologies facilitate predictive analytics, secure data exchange, and optimal spectrum utilization, enhancing the resilience and sustainability of transportation systems.

5. Future-Proofing ITS:

The proposed concept anticipates the requirements of forthcoming ITS applications, including autonomous vehicles, smart city integration, and UAV-assisted traffic management. By tackling scalability and security issues, it guarantees the enduring viability of V2X systems in developing urban environments.

The proposed concept enhances communication efficiency and resource allocation, thereby diminishing energy consumption and environmental impact. Effective routing and data dissemination reduce congestion and fuel usage, fostering a more sustainable transport environment.

2. Literature Survey

For future V2V networks to effectively enhance traffic safety and the driving experience, it is crucial to have ultra-reliable low-latency communication (URLLC). The rapid fluctuations in the channel, resulting from high mobility, pose significant difficulties in ensuring the latency and reliability performance of V2V networks. Ding et al. [1] presented a new method for allocating resources that improves the efficiency of V2V connections by reducing latency and ensuring reliable transmission. The proposed approach optimizes resources on both a global and micro scale. Assuming that numerous V2V linkages may use the same RB, a single RB would be sufficient for all of them. Using a function mapping Hou et al. [2] presented a factor graph model for the RB allocation problem. That's why the factor graph model's message update and belief inference problems are equivalent to the RB allocation problem. The author introduced Belief Propagation with Real-time Update of Messages (BPRUM), a method that continuously rather than periodically updates the messages of all nodes.

The goal of optimizing resource allocation (RA) efficiency has been made more difficult by rising mobility and the sheer volume of cars on the road. Several RA mechanisms have been created to facilitate the equitable distribution of C-V2X assets. However, routing-aware RA hasn't been talked about much in the research world. In this study, Alrubaye et al. [3] used cluster-based routing for V2I communications and geo-based RA for V2V communications. They looked at a number of situations where routing-awareness could be used for RA to improve performance, and they came up with a method that uses routing-awareness for RA. It is possible for a connected vehicle in the IoVs to share data with other cars and RSUs through V2V and V2I connections. Users thought that vehicles should be able to work together with other fully-equipped and idle vehicles to get the most out of the resources they had. Wu et al. [4] proposed a hybrid task offloading system (HyTOS) based on deep reinforcement learning (DRL) to improve how resources are used and managed. This method takes both time limits and resource needs into account in order to finish vehicle-to-edge (V2E) and vehicle-to-vehicle (V2V) offloading. For optimal offloading decision making, the author used deep Q networks (DQN), a dynamic decision-making method. Spectrum sharing is discussed here in the context of a vehicle platoon with requirements for longitudinal control. In particular, Han et al. [5] pinpointed the maximum and minimum times for sending and receiving messages. After acquiring the delay constraint, it is required to consider intracell interference and various communication needs so that wireless resource management can be done, which includes choosing the best way to share spectrum and distribute power among the involved vehicles. The table 2 represents the Traditional Model Working and Limitations.

Table 2. Traditional Model Working and Limitations

Author Name	Year of Publication	Manuscript Title	Proposed Model	Limitations
Ding et al. [1]	2022	Resource management on two timescales for ultra-reliable and low-latency vehicle communications.	The author developed a resource allocation mechanism for low-latency, reliable vehicle-to-vehicle communication, optimizing both global and micro resources as vehicles transmit substantial channel data to the central base station.	The dual-time scale resource listing for allocation and release detection causes the resource management scheduling model in this study to run more slowly. Although communication latency has decreased, enhancements in scheduling delay are also necessary.
Alrubaye et al. [3]	2023	Allocating Cellular Network Resources Geographically for Combined Vehicle-to-Infrastructure and Vehicle-to-Vehicle Communications	The author suggested cluster-based routing for vehicle-to-infrastructure (V2I) and geolocation-based resource allocation (RA) for vehicle-to-vehicle (V2V). We looked into situations where routing awareness improves RA and then came up with a new method.	Geographically based resource allocation is labor-intensive in both the allocation and reallocation processes. A threshold range-based methodology can enhance the clustered model for improved accuracy.
Wu et al. [4]	2022	Offloading Internet of Vehicle Tasks from Hybrid	The author introduced HyTOS, a hybrid task offloading system based on deep reinforcement learning that aims to	Data offloading to other vehicles uses the computationally complex delay-constrained offloading model.

		Networks with Time Delays Using Deep Reinforcement Learning.	optimize resource utilization and management while accounting for delay constraints and resource requirements for vehicle-to-everything and vehicle-to-vehicle offloading.	Excessive reinforcement may reduce effectiveness. The expense of maintenance is exorbitant.
Han et al. [5]	2023	C-V2X-based spectrum sharing with a focus on longitudinal control for vehicle platoons	The author identified the max and min times for message transmission, enabling wireless resource management and optimal power allocation.	For the purpose of wireless resource management, the author determined the maximum and minimum message transmission times, as well as the best way to distribute power.

There is significant opportunity for UAVs to support service delivery via vehicle networks. Sharing frequencies among multiple users in a dense UAV-assisted vehicular network reduces the impact of a lack of available spectrum. The increasing need for data has renewed concerns about the UAVs' energy usage. Qi et al. [6] focused on a scenario where a UAV shares cached content files with vehicular users using UAV-to-vehicle (U2V) links, while V2V links reuse the UAV spectrum to relay safety-critical information. V2I and V2V communications in V2X use the same network architecture. In this study, Yuan et al. [7] developed two strategies to overcome these obstacles. The author has presented a deep reinforcement learning (DRL)-based resource allocation technique to begin enhancing the efficiency of V2I and V2V connections. A deep Q-network (DQN) is employed to address the sub-band assignment problem, while a deep deterministic policy-gradient (DDPG) handles the continuous power allocation issue. Cellular vehicle-to-everything (C-V2X) radio spectrum utilization increases the risk of vehicular crashes; to mitigate this, Zhou et al. [8] presented a centralized-distributed radio resource management (RRM) system for C-V2X. Power management is done by edge nodes, whereas channel allocation is managed centrally.

Connecting cars together to share processing power is an example of vehicular edge computing (VEC). How to encourage automobiles to pool their computing resources while ensuring the dependability of resource distribution in task offloading is a prevalent problem when cars engage in computation offloading with one another they have never met before. To ensure the security and efficiency of V2V job offloading, Shi et al. [9] presented a VEC architecture that employs block chain technology. To help mobile agents delegate some of their computationally intensive activities to adjacent agents, the author developed a deep reinforcement learning (DRL) based computation offloading approach for use in block chain smart contracts. The author presented a method for choosing consensus nodes and an improved consensus algorithm based on practical Byzantine fault tolerance (PBFT) to reinforce the dependability of job allocation and improve the efficiency of consensus.

The widespread use of automotive applications has led to a significant interest in mmWave-based vehicular networks among both academic and industrial communities. mmWave communications, due to their extensive bandwidth, can achieve transfer speeds between vehicles in the range of several gigabits per second (Gbps). The study conducted by Su et al. [10] focused on examining scheduling issues in mmWave vehicle networks, specifically in relation to content delivery. All vehicles in the same network have struggled to finish content downloading due to the restricted communication resources of RSUs and the frequent mobility of vehicles. The table 3 represents the Traditional Model Working and Limitations.

Table 3. Traditional Model Working and Limitations

Author Name	Year of Publication	Manuscript Title	Proposed Model	Limitations
Qi et al. [6]	2022	Spectrum-Shared Resource Allocation for UAV-Assistant Road Networks	Using U2V links, the author looks at a UAV that exchanges cached content with vehicles; V2V links, on the other hand, repurpose the UAV spectrum to transmit safety-critical information.	The delay levels and ratio of the spectrum sharing model are unsatisfactory. Enhancing vehicle performance and reducing delay levels can improve the energy-efficient model.
Yuan et al. [7]	2021	Meta-Reinforcement Learning Based Resource Allocation for Dynamic V2X Communications	The author came up with two ways to deal with these problems. The first was a DRL-based resource allocation method to make V2I and V2V connections better.	When resources are allocated using the meta-reinforcement model, long-term use causes delays that hurt accuracy and force reduction.
Zhou et al. [8]	2022	Utilizing Graph Matching and Actor-Critical Learning for	For C-V2X, the author proposes a hybrid RRM strategy to mitigate vehicle collision risks.	The proposed resource management process is energy-intensive, degrading performance. Integrating

		C-V2X Radio Resource Management		energy-efficient models can improve it.
Shi et al. [9]	2023	DRL-based V2V computation offloading for vehicle networks that use block chain	The author proposed a VEC architecture that utilizes blockchain for secure and efficient vehicle-to-vehicle work offloading. They used deep reinforcement learning (DRL) to create a way for blockchain smart contracts to offload computational tasks to nearby agents. This lets mobile agents give resource-intensive tasks to agents that are closer to them.	The block chain enabled model is secured. However, the maintenance and time for offloading process and recoding in the block need to be reduced.
Su et al. [10]	2022	Content Distribution Based on Joint V2I and V2V Scheduling in mmWave Vehicular Network	The author investigated scheduling challenges in mmWave vehicular networks, focussing on content delivery. Scarce RSU resources and rapidly moving vehicles impede network-wide material downloading.	The process of content distribution and scheduling is effective in this model. However the resource request handling time need to be reduced for quick distribution that impacts the performance.

Inspired by the promise of RIS-based transmission, this study investigates the use of RIS in a socially trusted V2X communication system, where several V2I links and V2V links compete for spectrum. Joint optimization of power allocation, RIS reflection coefficients, and spectrum allocation maximizes the total capacity of V2I links within the V2V reliability constraint. To efficiently solve the described mix-integer and non-convex issue, Gu, et al. [11] presented a three-stage approach for joint resource allocation and RIS optimization (JRARO). The simulation findings validate the efficacy of the proposed algorithm and demonstrate that the RIS has the potential to significantly improve vehicle communications in terms of overall V2I capacity.

Ju et al. [12] came up with a way to improve privacy and resource efficiency in multi-user VEC networks where the VU offloading links share the frequency spectrum used by V2V communication links. They called it secure offloading and resource allocation (SORA), and it uses deep reinforcement learning. This goal is reached by using the physical layer security (PLS) method and putting in place a spectrum-sharing plan. In the event of illegal data transmission, it is also difficult to trace back the leak's initial source. To prevent secondary data sharing, Cui et al. [13] implemented a consortium block chain system for transparent and anonymous V2V data transfer in this study. Data may be exchanged without having to swap restricted stock units thanks to 5G and block chain technology. The author created a novel delegated proof-of-stake consensus technique to better support use cases in the distributed IoV. Because of its ability to adapt to its wireless surroundings, a reconfigurable intelligent surface's (RIS) performance as a communication medium can be greatly enhanced. As a result, RISs have the potential to be a helpful resource for enhancing V2X services. Since many V2V links utilize the spectrum already held by V2I lines, Chen et al. [14] investigated the problem of spectrum sharing in RIS-enhanced vehicular networks. For V2I and V2V communications, the author relied on global CSI because of the challenges of obtaining real-time CSI due to the fast-changing nature of some V2X channels. Throughput and spectrum efficiency can both be improved with the help of the wireless full-duplex (FD) technique. In this study, Guo et al. [15] reported on the integration of V2V connections into an FD mobile network. Resource allocation and power control at the FD base station become problematic when the uplink and downlink of the V2I share the same RB, causing unwanted interference. To solve this difficult issue, the writer came up with a Dual Graph Colouring-based Interference Management (DGCIM) method. Table 4 represents the Traditional Model Working and its Limitations.

Table 4. Traditional Model Working and Limitations

Author Name	Year of Publication	Manuscript Title	Proposed Model	Limitations
Gu et al. [11]	2022	Socially Aware V2X Networks With RIS: Joint Resource Optimization	The author proposes a three-phase JRARO methodology for resource allocation and RIS optimization. Simulations validate	While the joint resource optimization model is effective, hybrid methods that minimize latency can enhance V2X network resource management

			the algorithm's efficacy and the RIS's capability to augment V2I capacity.	and optimization.
Ju et al. [12]	2023	A multi-agent deep reinforcement learning approach is used for joint secure offloading and resource allocation for a vehicular edge computing network.	The author introduced a deep reinforcement learning-based SORA method designed for the joint optimization of secure offloading and resource allocation, utilizing physical layer security (PLS) in conjunction with a spectrum sharing system.	The proposed model demonstrates accuracy and efficiency, focusing on time-constrained resource scheduling to mitigate misuse and improve performance.
Cui et al. [13]	2022	Based on Consortium Blockchain, sharing data between vehicles is safe and quick	The author developed a consortium blockchain to facilitate transparent and anonymous vehicle-to-vehicle data transfer. 5G and blockchain technology facilitate data exchange, which happens independently of the transfer of restricted stock units.	The centralized architecture of a consortium increases the likelihood of rule violations by malicious users within the network. As the number of users increases, the process of upgrading becomes more complex, necessitating approval from all users involved.
Chen et al. [14]	2021	Spectrum sharing based on quality of service for reconfigurable intelligent surfaces (RISs) helped vehicle networks.	The author used global CSI for V2I and V2V communications in RIS-enhanced vehicular networks because real-time CSI was hard to use in V2X channels that changed quickly.	Resource detection and allocation time hinders network performance, and intelligent surface spectrum sharing raises energy consumption.
Guo et al. [15]	2022	Full-Duplex Vehicle-to-Infrastructure (V2I) Communications Require Joint Resource Allocation and Power Control in High-Density Networks	The author introduced a Dual Graph Coloring-based Interference Management (DGCIM) technique to tackle this intricate problem.	The proposed joint resource allocation model identifies collisions in the network that increases loss rate.

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Using a fleet of vehicles with varied levels of automation as a case study, Wang et al. [18] investigated the field of conflict analysis. The two main types of cooperation made possible by V2X communication are status-sharing and intent-sharing. Intent sharing allows cars to communicate about their planned future movements, including things like top speeds and acceleration limits, in addition to status sharing, which allows them to communicate about their current states, including speed and location. In this research, Wang et al. [19] provided a foundation for conflict analysis and demonstrated how it may be utilized to enhance the decision-making of vehicles operating with varied degrees of automation and collaboration. The author focused on scenarios in which cars can exchange data about their locations, speeds, and intentions with one another via V2X communication technology. Table 5 represents the Traditional Model Working and Limitations.

Table 5. Traditional Model Working and Limitations

Author Name	Year of Publication	Manuscript Title	Proposed Model	Limitations
Bute et al. [16]	2023	Distributing Cellular and V2V Content with QoS Consciousness Using a Fusion of Social and Physical Attributes	The author proposed a demographic and geographic-based content distribution method. V2V users pair based on shared interests and connection reliability, while V2N users' QoS is considered uplink and downlink.	The list of attributes considered are less that can be extended by considering the internal and external factors to improve the quality of service levels.
Zhang et al. [17]	2021	A Protocol for Distributing Data Utilizing Unmanned Aerial Vehicles, Featuring Anticipatory File Sharing and Caching in V2X Networks	The author designed a model to increase the efficacy of data distribution by introducing a unique scheduling system for file sharing and proactive caching in V2X networks that is facilitated by UAVs	The file sharing model consumes more time and the delay levels are also high. The delay levels results in performance degradation that need to be improved.
Wang et al. [18]	2023	Multi-vehicle conflict resolution with delayed status and intent updates	The author investigated the field of conflict analysis. The two main types of cooperation made possible by V2X communication are status-sharing and intent-sharing.	The vehicle location detection and the parameters for the detection need to be updated for reducing the conflicts and also information sharing need to be updated to perform in less time.
Wang et al. [19]	2023	Analysis of Potential Conflicts in Cooperative Maneuvers That Use V2X Communication to Disclose Status and Goals	The author provided a foundation for conflict analysis and demonstrated how it may be utilized to enhance the decision-making of vehicles operating with varied degrees of automation and collaboration	The security levels of the intent sharing is less as the number of attacks is high and there need to be a better attack management model to improve the security levels.
Zhao et al. [20]	2023	Allocating Resources Efficiently in SCMA-V2X Networks With Random Multiple Access	The author proposed SCMA-orientated RMA-based V2X resource allocation. This study examines SCMA-based RMA for V2I and V2V users. choose codebooks from a shared pool for transmission on.	The proposed model is suggested to use hybrid deep learning and optimization models for better resource allocation. The cluster generation process helps in detection

With this study, Zhao et al. [20] provided a method for resource allocation in V2X networks that fully takes advantage of the SCMA-oriented RMA used by these systems. In this study, the author investigated an SCMA based on random multiple access (RMA), wherein users of both V2I and V2V choose codebooks from a shared pool for transmission. The full bandwidth is divided in half for V2I transmission and half for V2V transmission to prevent user interference. To maximize throughput for all V2I users while satisfying the reliability needs of V2V users, we devised a problem that involves maximizing both the selection of users to receive codebooks and the allocation of available bandwidth. There is no easy answer to this problem since it is a mixed-integer programming (MIP) problem with a probabilistic constraint.

A simulation-based experimental framework is delineated below to validate the proposed resource allocation methods and assess their efficacy.

• ***Tools and Environment:*** Use MATLAB or NS-3 in conjunction with SUMO (Simulation of Urban Mobility) to simulate vehicular dynamics and network interactions

. • ***Simulation Parameters:***

The network type is a 6G-enabled V2X network that uses DSRC and LTE-V2X communication protocols. The traffic environment is urban, characterized by fluctuating vehicle densities ranging from 10 to 100 vehicles per kilometre.

Evaluation Metrics: Latency, throughput, packet delivery ratio, and fairness index.

• **Proposed Framework:**

1. Establish a foundational resource allocation model using deep reinforcement learning (DRL).

2. Create a model for resource allocation based on PFA.

3. Assess both models under uniform conditions to evaluate performance.

• ***Results and Analysis:*** The simulation will evaluate latency, throughput, and fairness. PFA is anticipated to perform exceptionally well in situations demanding high fairness while maintaining throughput, especially in dense networks.

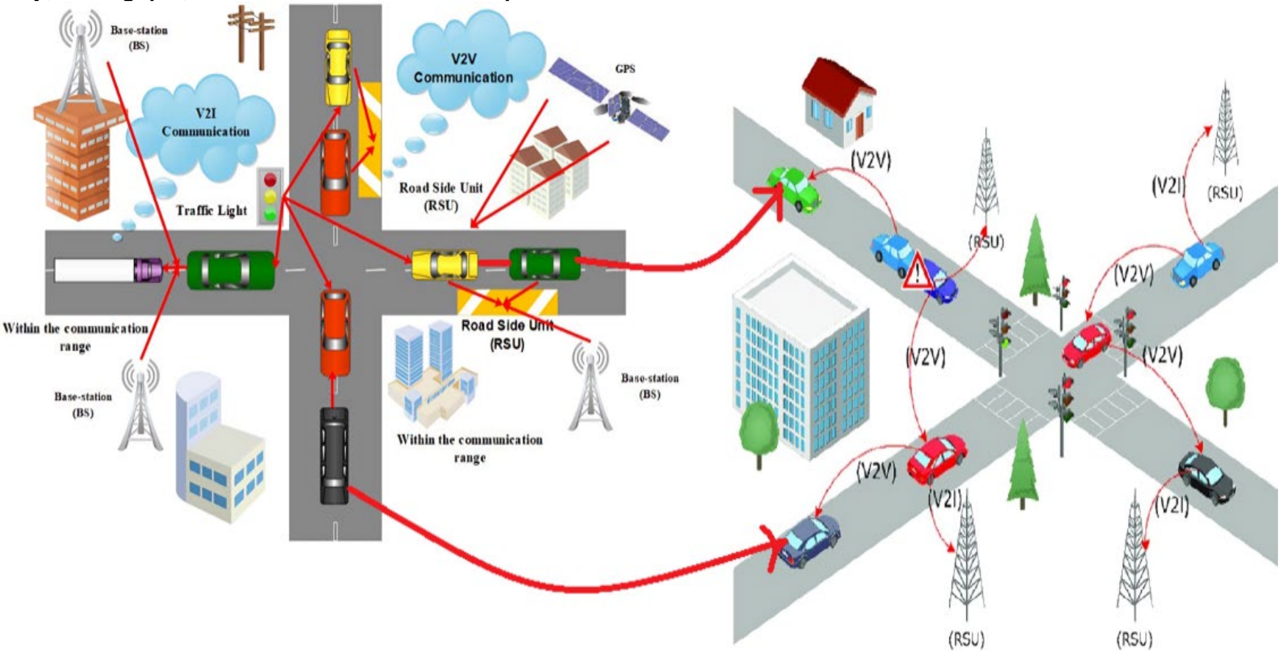

Figure 2. Block Diagram Illustrating the Interaction Between Vehicles, Roadside Units (RSUs), and the Base Station in the Proposed V2X Communication Framework

3.Discussion

The 6G network could have many applications, but no concrete standards or specifications have been set as of yet. Some people believe that 6G networks should go beyond just being 5G networks with more capacity [26]. The 5G network may have its limitations, but coverage should not be restricted to the ground. The 6G network will also have greatly enhanced Artificial Intelligence (AI). AI is seen by many professionals in the area as a key driver and enabler of the development of the 6G network [27]. Unfortunately, there is still a long way to go before 5G networks can deliver fully autonomous, everything-as-a-service, and really immersive services. The 5G communication system will be a step up from the current systems, but it won't be enough to enable completely automated and intelligent ideas in the next decade. New features and improved reliability in communications are just the beginning for the 5G network. New aspects of 5G technology include licensed and unlicensed channel coexistence, enhanced spectrum management, and expanded frequency ranges [28]. Improved air interfaces, resource allocation [29], decision making, and computation are just some of the cutting-edge technologies that 6G will need to implement to reach its lofty promises. Support from UAVs and low earth orbit satellites [30] may help V2X systems improve communication quality in areas where traditional terrestrial communication systems may have blind spots. Air interfaces, resource allocation, decision making, and computing will all need to be made more reliable and efficient for 6G. As shown in Figure 2, a typical 6G-V2X system integrates multiple types of vehicle communication to pave the way for a wide range of promising future applications.

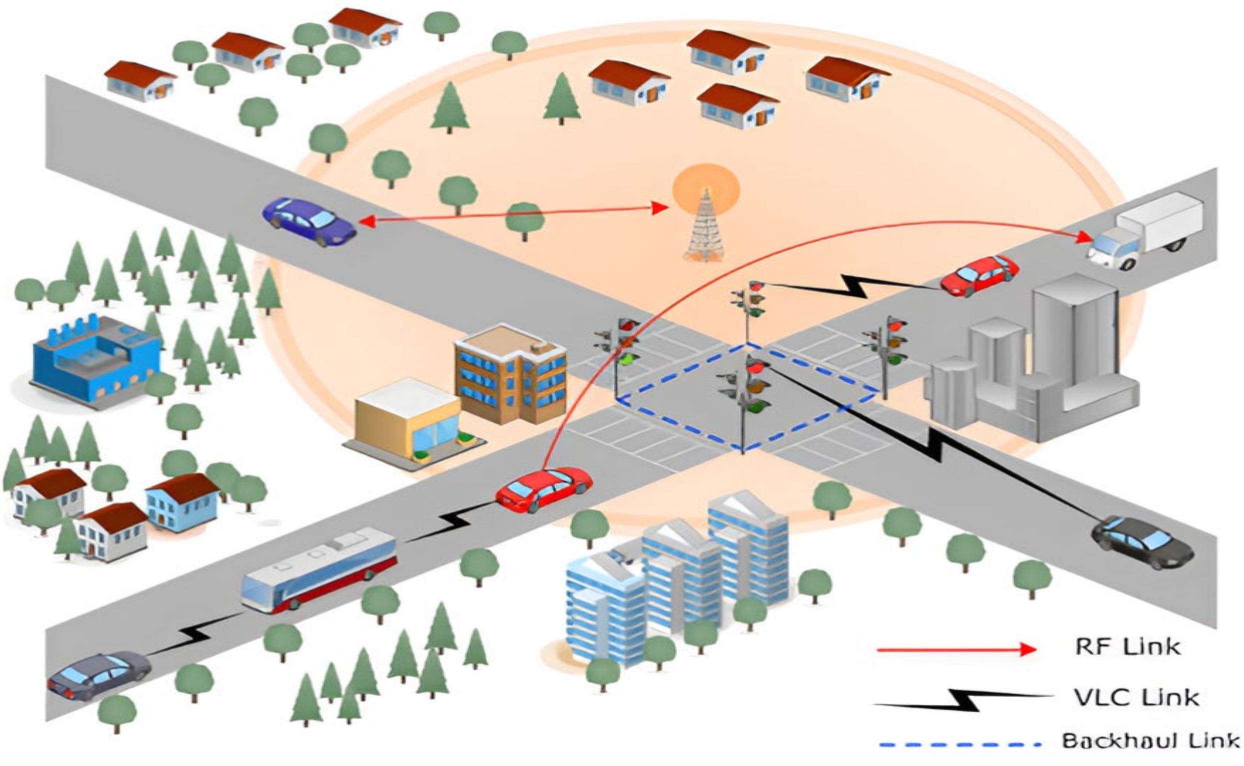

Figure 3. 6G V2X System [29]

Implementation Potential and Deployment Challenges: Vehicle-to-Everything (V2X) systems that are enabled by 6G hold a lot of promise for smart transportation systems, but they need to solve some important social, economic, technological, and infrastructure problems first. Socioeconomic factors encompass the cost of advanced infrastructure and hardware, which may present financial obstacles for low-income areas, as well as the necessity for public confidence in autonomous technologies, data privacy, and safety through educational initiatives. Moreover, revised regulatory frameworks for spectrum allocation, data sharing, and vehicle certification are crucial for worldwide implementation. In the world of technology, getting ultra-reliable low-latency communication (URLLC) for safety-critical applications like collision avoidance is still a big problem. Proportional Fairness Algorithms (PFA) and advanced machine learning techniques have been suggested as possible solutions. Ensuring data security and privacy via blockchain technology and tackling scalability challenges in densely populated urban networks through resource-efficient strategies and reconfigurable intelligent surfaces (RIS) are essential. Infrastructure enhancements, including the shift from 5G to 6G and the incorporation of V2X systems within smart city frameworks, encompassing IoT devices and urban traffic management, are essential for optimal functionality. Non-terrestrial networks, encompassing UAVs and satellites, will be essential in mitigating connectivity deficiencies in remote regions. Deployment plans need to include a step-by-step process that starts in densely populated cities and includes collaboration between automakers, telecom companies, and government agencies, as well as pilot tests in the real world to make these systems better on a smaller scale. Effectively addressing these challenges will facilitate the development of scalable, efficient, and secure 6G-enabled V2X networks.

Table 6. Conceptual Model vs. Existing Surveys: A Comparative Analysis

Feature	Existing Surveys	Proposed Survey
Focus on 6G Integration	Limited	Details analysis of 6G-specific features
Resource Allocation Methods	Discussed but not deeply analysed	In-depth evaluation, including PFA
Enabling Technologies	General overview	Detailed insights on ML,blockchain, and RIS
Challenges and Limitations	Surface-level exploration	Comprehensive identification and solutions

Proportional Fairness in Resource Allocation

Resource allocation presents a significant challenge in V2X and V2V communication networks, necessitating a balance among throughput, latency, and equity among numerous vehicles. The Proportional Fairness Algorithm (PFA) has proven to be an efficient approach for attaining this equilibrium. The PFA functions by optimizing the logarithmic aggregate of users' data rates, preventing any individual vehicle from monopolizing network resources while maintaining elevated overall throughput. This is especially pertinent in congested traffic conditions where resource competition escalates. PFA can adjust resource allocation dynamically according to real-time network conditions, accommodating fluctuations in vehicular speed, density, and communication needs. Compared to current methods like Deep Reinforcement Learning (DRL) approaches or static heuristic models, PFA provides a computationally efficient and mathematically sound framework. Its integration with enabling technologies such as machine learning could further augment its performance by forecasting network congestion and proactively reallocating resources.

V2X has garnered a lot of attention as a key enabler of ITS. Improved road safety, more efficient traffic flow, and the ability to meet infotainment needs are all made possible via V2X connections. V2V, Vehicle-to-Pedestrian (V2P), V2I, and Vehicle-to-Network (V2N) communications are all part of V2X. One possible feature of these interactions is their proximity-based nature, which necessitates coordination between neighbouring cars and other equipment. Ad hoc communications using the 802.11p standard are the first established option for V2X communications. The lack of centralized management is a weakness of this standard, which makes it difficult to ensure requirements for security applications. In the future era of connected self-driving vehicles, there will be a diverse range of transportation scenarios and practical applications, incorporating numerous advanced technologies. In order to realize this ambitious vision, it is necessary to establish a V2X communication network that possesses advanced intelligence and the ability to provide extremely quick, highly dependable, and low-delay transfer of substantial volumes of data. The forthcoming requirements of the next-generation V2X will likely be fulfilled by the 6G communication technology. To enhance the quality of service in the network and address the restrictions indicated in the survey, it is necessary to implement an intelligent routing model and efficient resource sharing models. V2V and V2X communications depend on specialised protocols to enable efficient data exchange among vehicles, infrastructure, and other network elements. The manuscript has been augmented to include additional details on essential communication technologies. Dedicated Short-Range Communications (DSRC) is a wireless standard derived from IEEE 802.11p that functions within the 5.9 GHz spectrum and is used for safety applications, including collision warnings and emergency braking notifications. Cellular Vehicle-to-Everything (C-V2X) is a cellular communication technology (LTE-V2X and 5G-V2X) that provides an extended communication range and facilitates both direct (V2V) and network-based (V2N) communication. Hybrid approaches combine DSRC and C-V2X to enhance reliability and minimise latency across diverse network conditions. The manuscript elucidates the protocols governing vehicle interactions with one another and with infrastructure in practical applications. The network architecture of V2X communication is essential in dictating the transmission and processing of data. The manuscript now encompasses descriptions of three principal architectures. Centralised architecture manages data through a cloud or base station. This makes it good for keeping an eye on a lot of traffic, but it can be slow because it relies on the cloud. Decentralised (Ad-Hoc) Architecture makes it easier for vehicles to talk to each other and to infrastructure (V2I), which reduces reliance on cloud infrastructure and boosts real-time responsiveness, especially in safety-critical tasks like avoiding collisions. A hybrid architecture takes the best parts of both models and combines them in the best way possible. It lets vehicles switch between direct and cloud-based communication based on the state of the network, which makes it perfect for 5G-enabled V2X with edge computing integration. These details elucidate how V2X networks effectively oversee resource allocation and data transmission. To improve clarity, the manuscript now incorporates practical applications illustrating the advantages of V2X and V2V technologies in transportation. Collision Avoidance facilitates the exchange of real-time data between vehicles to avert accidents, providing immediate notifications for abrupt braking. Traffic signal optimisation enhances vehicular flow by enabling communication between vehicles and intelligent traffic lights, thereby minimising superfluous stops. Platooning improves fuel efficiency and mitigates congestion by synchronising the movements of closely travelling vehicles, particularly in autonomous trucking. Emergency vehicle priority facilitates preferential passage for ambulances and fire trucks through the modification of traffic signals. Smart City Integration uses V2X data for instantaneous traffic surveillance and emissions regulation. By integrating these applications, the manuscript offers an in-depth comprehension of V2X/V2V communication, emphasising its practical importance in enhancing road safety and traffic efficiency.

4.Conclusion

Researchers are focusing on 6G networks, which offer better services than previous generations, as 5G network research and deployment nears completion. Each new version of communication technology introduces exciting new features. Interest in vehicle-to-extensive network (V2X) connections has skyrocketed as internet-connected, self-driving cars become the norm in smart cities. In order to demonstrate the benefits of 6G-V2X networks over 5G, this overview investigates important enabling technologies and new features of these networks. It provides an update on the latest developments in intelligent transportation system applications of machine learning for 6G vehicle networks. We cover the most recent successes, major obstacles, and potential future opportunities for each enabling technology. There are concerns regarding the security and confidentiality of real-time data due to the fact that future V2X vehicles are anticipated to produce more than 1 terabyte of traffic data per round. There are a lot of promising prospects for enhancing and growing V2X networks. New communication protocols are necessary for vehicle-to-electro-X (V2X) vehicles to improve efficiency, safety, and dependability. V2X interactions may also become more complicated as a result of security and privacy concerns with wirelessly connected vehicle sensors. Wireless channels are transmitted in the environment, which is both a limitation and an annoyance. Therefore, advancements in wireless infrastructure are needed to guarantee the ubiquitous connectivity and broadband coverage of future V2X networks. The data transmitted via V2X must be secure and reliable. This is crucial for establishing trustworthy transportation networks in smart cities, as data privacy and security infractions are becoming increasingly commonplace in everyday life. This research provides a brief analysis on the challenges and issues on V2X and V2V models that helps researchers to design new models for providing better routing and data security models in VANETs.

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