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SURVEY ARTICLE

A Survey on Artificial Intelligence-Enabled Vehicular Ad-Hoc Networks (VANETs) for Smart Automotive Systems

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Abstract – Artificial Intelligence (AI) has turned into a new form of revolution in the automotive industry worldwide, pushing technological innovations, productivity, and safety through all stages of vehicle design, manufacturing, and autonomous performance. The importance of AI used to be underestimated, but it has now become one of the core technologies that help to facilitate automation, real-time decision-making, and predictive analytics. Using AI, machine learning, and computer vision, manufacturers are able to create vehicles with advanced driver assistance systems (ADAS), autonomous navigation, and smart user interfaces. Together with the Internet of Things (IoT), these innovations have formed highly interconnected ecosystems in which vehicles and other vehicles and infrastructure can interact via Vehicular Ad-hoc Networks (VANETs). This research paper explores how AI is changing the automotive industry, both in terms of technological adoption and in real-world uses. Descriptive research methodology was applied and primary data was collected using surveys of actual performance and virtual performance of the vehicle. The Chi-square test statistical validation showed that there are significant differences between the expected and observed results, which proves hypothesis that AI-based solutions can increase efficiency, safety, and reliability of modern vehicles. The study sheds light on the usefulness of AI in minimising human error, reducing accidents, and solving challenges related to aggressive driving and traffic congestion. The paper also discusses the uses of AI in driverless cars, artificial intelligence, predictive maintenance, and smart traffic light systems. Self-driving and adaptive vehicle control requires new technologies, such as deep-learning algorithms, sensor fusion, and better actuators. Meanwhile, AI-based virtual assistants like Amazon Alexa, Apple Car Play, and Google Android Auto are changing the way people interact with their vehicles by offering flawless voice-based assistants. These innovations also increase customer satisfaction by simplifying in-vehicle operations besides improving safety. In addition to driving applications, AI and data science are also used more in logistics, production, supply chain optimisation, and after-sale services in the automotive industry. Innovative optimisation and data-driven decision-making also allow manufacturers to automate procurement, enhance their marketing policies, and provide clients with personalised customer experiences. The transformative potential of these technologies has been well exhibited in carefully chosen use cases, and they are just in their infancy. Nonetheless, issues still persist, especially regarding safety, privacy, scalability, and regulatory conformance of implementing AI-based systems. These issues will be key in the mainstream implementation of autonomous vehicles and connected mobility solutions.

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Index Terms – Internet of Things, Secure Routing, Trust Management, Elephant Herding Optimization, Convolutional Neural Network, Routing Attacks.

1. INTRODUCTION

As artificial intelligence (AI) has developed, it is likely that businesses and nations will have to rethink their long-held beliefs and perspectives toward emerging technology [1]. Given that Artificial Intelligence has the capacity to profoundly impact numerous the efficient application of AI technology will be critical to the competitiveness of businesses, society and even entire nations in the future. Nevertheless, in the global technology competition, China and the USA are now ahead of Japan. Numerous Japanese firms that were once market giants have fallen from grace in the global market place a unique example of the modern Japanese economy is Toyota, the top auto mobile brand in the world that also commands the largest share of the country's automotive market. But since AI is drastically altering the competitive landscape, even Toyota is up against a lot of difficulties. At first, Toyota was hesitant about the advancement of self-driving cars, even though the big auto makers have been closely monitoring AI-directed versions of these vehicles the business has, however, lately modified its approach. Toyota has been pushing its entry into the new stage of competition with an unparalleled dedication to self-driving cars, in spite of the government's slow policies [2]. The pace at which the Japanese government and the majority of Japanese businesses have responded to the global trend contrasts with Toyota's recent actions in a few ways. The outline of Japan's artificial intelligence is given in this chapter, and then the government of Japan's strategy for self-driving auto mobiles is discussed. A section devoted to self-driving cars shows what Toyota has been up to recently. The final part of the essay explores how Japan might modernise and remain competitive in the digital era while using Toyota's strategic adjustments as a model [3]. The possibilities for a broad range of scientific and industrial applications of artificial intelligence (AI) and deep learning has led to their steady rise in prominence. Several fields, including computer vision and natural language processing, have benefited from the success of deep learning approaches [4]. Creating AI applications is a difficult undertaking that involves numerous obstacles in the areas of data gathering, model training, and deployment. In this work, we assess models, architectures, and deployment worries about the use of deep learning techniques in the auto industry [5]. We specifically concentrate on various computer vision issues in the logistics and automotive manufacturing processes, in conclusion, we offer an evaluation of the architecture, datasets, and models employed, along with performance indicators for every model. Modern cars should be intelligent, safe, and dependable by using artificial intelligence (AI) and related technologies and approaches. It aims to automate the drives at the same time in order to decrease manual lobar, boost productivity, and free up workers from boring, repetitive jobs [6]. Several facets of the automotive business are examined in this essay, including the vehicle itself, the design and production industries, and the after-sales services. It offers ways to transform them into "intelligent" being [7]. Advanced materials such as carbon fibre, polymer composites, and high-strength steel are briefly discussed in the second section. It goes through the different aspects that enable the use of these intelligent materials in the automotive industry possible as well as the ways and domains in which these cutting-edge materials are applied in the sector [8]. The ability of machines to comprehend circumstances, reason, and arrive at appropriate decisions is known as artificial intelligence. Its goal is to equip machines with the ability to learn from their experiences, adapt, and carry out jobs that humans would find difficult. More advanced AI systems can even, to a limited extent, predict what will happen in the future. Seri, Netflix, and autonomous vehicles are a few popular instances of AI systems [9]. Artificial Intelligence can be generally categorised based on its levels of sophistication. The development of systems that can fully replace people and carry out a work on their own is inevitable given the speed at which technology is developing and the human drive to always achieve maximum comfort. The outcome of this is artificial intelligence, which refers to software applications, or machines that possess human-like comprehension, reasoning and decision-making abilities [10]. While artificial intelligence has not yet reached its pinnacle of development, early systems have been used in a variety of industries [11]. The automotive Industry is one that will eventually change as a result of using increasingly sophisticated AI technology [12]. Unlike other industries, the automotive industry is not confined to using AI solely on the assembly line or in production facilities. Artificial intelligence holds great promise for application in the car's design phase, various post-purchase services, and overall. Lon Musk, the well-known businessman and CEO of Tesla, has already advanced to the intermediate stage of creating a fully autonomous vehicle that can operate on public roads without requiring human intervention.

1.1. AI Applications in the Automotive Sector:

Artificial intelligence (AI) has improved Entire driving experience, safety, and efficiency is transforming the vehicle industry in a number of ways [13]. A few notable uses of AI in the automotive sector, including the previously stated driver assistance, are as follows:

- This stands for one of the best uses of artificial intelligence (AI) in the car industry. Artificial intelligence (AI) enabled systems make use of sensors to help with steering and pedestrian identification, monitor blind areas, and notify the driver when something is wrong so they can take preventative action to prevent collisions [14].

- Often known as self-driving cars, rely on artificial intelligence (AI) to sense their environment, make judgments, and navigate without the need for human assistance. AI is being used in the automobile sector by companies such as Tesla and Waymo to build self-driving technologies [15].
- AI systems equipped with sensors and cameras to monitor driver behaviour, detecting distractions, tiredness, and even evaluating the physical health of the driver. This is known as in-cabin monitoring [16].
- Automated and AI-driven robots and automation systems assist in robotic assembly lines, improving accuracy and productivity by doing activities like welding, painting, and assembling [17].
- AI is used to inspect and detect car flaws during production, minimising errors and guaranteeing better product quality [18].
- Voice-Activated Controls: Lots of contemporary auto mobiles are equipped with AI-driven virtual assistants (like Siri and Google Assistant) that let you operate music, navigation, and other features without using your hands. AI-powered predictive maintenance helps drivers plan maintenance and prevent unplanned breakdowns by predicting when vehicle components are likely to fail [19].
- Entertainment Systems: Artificial Intelligence can improve infotainment systems and provide personalised content recommendations improve the in-car entertainment experience [20].
- Using voice commands, passengers can engage with the car's systems, simplifying the control of several features as in table 1.

Table 1 AI Applications in Automotive Sector

AI Area	Purpose	Benefits
ADAS Systems	Detect hazards	Accident reduction
Autonomous Driving	Self-navigation	Human error elimination
Predictive Maintenance	Equipment failure prediction	Lower downtime
Manufacturing Automation	Robotics + AI	Better efficiency
Driver Monitoring	Detect drowsiness	Improved safety

1.2. Use of AI Specifically in the Automotive Sector

In our technologically advanced, AI-driven world, all industries, particularly the auto mobile sector, are being profoundly transformed. These days, it affects the way auto makers design, choose, and operate their cars. A 39.4% compound annual growth rate (CAGR) is anticipated for the AI-infused worldwide industry between 2022 and 2030, or $20.76 billion, according to analysts [21].

1.2.1. The Application of AI in the Age of Pandemics

All aspects of the industry's business have been affected by the start of the worldwide epidemic. In order to solve these problems, auto makers have created creative AI-driven solutions, and they now view artificial intelligence (AI) as a mainstream technology. Given that this auto makers are about to experience a massive Nevertheless, they have been incorporating new features into their array of cars to satisfy the needs of modern consumers [22]. One innovative car-maker tackling this is MG Motor, which debuted the limited-edition India's first SUV with artificial intelligence is the MG Astor. Using with the help of a personal AI assistant and ADAS (LEVEL 2) technology, MG Astor is uniquely built to foster human-car relationships. The SUV is equipped with five cameras, six radars, and artificial intelligence. (AI) technology to handle there are fourteen advanced Autonomous Level 2 characteristics [23]. ADAS (Advanced Driver Assistance Systems) included, the business has teamed with BOSCH, and Astor now offers over 80 linked car functions. Other auto makers have also jumped on the bandwagon to offer their clients tech-driven vehicles, in addition to MG Motor. Fortunately, the adoption of Cutting-edge innovations like artificial intelligence and data analytics have benefited software providers, automotive-related businesses, component suppliers and other auto makers, enabling them to thrive in the pandemic-ridden period [24].

1.2.2. Implementing AI in the Automotive Supply Chain

Effective the automotive value chain is seeing widespread adoption of AI, encompassing systems for Manufacturing, design, supply chain, production, and post-production are all included, as are "driver assistance" and "driver risk assessment [25]. Predictive maintenance and insurance are two more aftermarket businesses that proactive AI has changed. Here's how today's forward-thinking auto makers make sure this technology is used properly:

1.2.3. Production of the Vehicle

Prominent auto mobile manufacturers utilise appropriate data utilisation to provide exceptional goods and services. Product development teams and designers can better adapt future car models to meet consumer expectations thanks to the extensive use of artificial intelligence. Robots with artificial intelligence (AI) are able to work alongside humans to help produce cars by continuously learning automotive production abilities including part fabrication and designs [26]. Additionally, auto makers modify novel elements in their models according to the tastes of their customers. In this sense automotive companies can optimise their resource use with the aid of artificial intelligence and machine learning.

1.2.4. Constructing Customised and Interesting User Experiences

Modern cars are equipped with driver aid technology, which relies heavily on artificial intelligence [27]. It efficiently keeps track of whether a motorist is weary or has fallen asleep. To make travelling more pleasurable, the AI system installed in the vehicle learns everything about the driver, including their favourite tunes and temperature settings.

Less demanding and intuitive automotive firms collaborate with software companies to leverage artificial intelligence (AI) to create highly optimised interior environments for drivers, all while maintaining a focus on personalised and engaging user experiences [28].

1.2.5. ROI-Based AI implementation

Businesses and IT teams would most likely be encouraged to collaborate in the automobile industry. It might assist companies in receiving the potential business outcomes of AI implementations in advance and ensuring automatic maintenance [29].

1.2.6. The "CaaP" Business Model's Popularity

A subscription-based service model that enables auto makers to offer customized solutions is known as "Car as a Platform," or "CaaP." The overall capital investments made by organisations are decreased by this model's assurance of affordability and scalability. By 2022, networks and system procedures may be automated, and a number of cameras and other devices may be centrally monitored.

1.2.7. AI-Powered Extreme Automation

Simplifying to improve the automotive industry's productivity, accuracy, and efficiency. It is necessary to fully automate the use of video analytics and manual monitoring in order to save costs considerably, assess employee productivity, and verify that pandemic regulations are being closely adhered to.

1.3. Artificial Intelligence in Manufacturing

The term artificial intelligence (AI) is bringing in a new era of productivity and creativity on factory floors by fundamentally changing the production process in a number of important ways. Manufacturing, which has always been averse to embracing new technologies, is gradually coming to understand how AI may revolutionising the industry [30].

- Monitoring and enhancing production and quality control is one of artificial intelligence's main advantages in the manufacturing sector. Manufacturers can greatly improve their processes by concentrating on data rather than intricate AI systems. AI is capable of continuously monitoring industrial operations data, allowing for real-time analysis and the early identification of patterns and abnormalities that human operators would miss.
- Artificial Intelligence has also affected the production design stage. AI tools are currently used by designers to recommend the best designs for increased performance based on past data and facts. By accelerating the idea-to-reality process, this data-driven methodology makes it easier to bring cutting-edge concepts to market.
- Unparalleled speed, accuracy and safety in component assembly. Manufacturing processes have been transformed by automation powered by AI. Robotics and automation systems installed in factories have drastically decreased the number of difficult jobs that require human participation. Work like welding and painting are now done by robots.
- AI's capacity to keep an eye on machinery and equipment is revolutionising the manufacturing industry. By using data analysis, artificial intelligence (AI) can forecast maintenance needs and equipment failures far in advance. Predictive maintenance, as opposed to reactive maintenance, minimises unplanned downtime and repair expenses.
- AI has significantly improved manufacturing quality control. Artificial intelligence (AI) technologies precisely detect flaws by carefully examining and analyzing completed goods. This lowers the possibility that consumers will receive defective goods while ensuring the creation of high-quality goods.
- AI-powered customisation is revolutionising the manufacturing sector. Manufacturers can provide customised product options thanks to artificial intelligence (AI) which gathers and analyzes past data and client preferences. Customised designs and configurations can be created by manufacturers using AI recommendations, improving customer satisfaction and the overall consumer experience.
- By enhancing design procedures, automating labour-intensive jobs, anticipating maintenance requirements, guaranteeing product quality, and enabling customised manufacturing, artificial intelligence is transforming the manufacturing industry. The industrial sector is utilising AI to fulfil the needs of the current market and remain competitive by prioritising data-driven solutions over too sophisticated AI systems. This is helping the industry

progressively overcome its reputation as a sluggish adopter of new technology.

1.4. AI's Benefits for the Automotive Industry

If properly integrated, artificial intelligence (AI) in auto mobiles can offer a multitude of benefits to the automotive sector. Artificial Intelligence has the potential to open up new doors. Emergence of novel approaches can reveal fresh advantages.

- Artificial intelligence (AI) technologies that warn of potential hazards and take preventive action to reduce accidents, as self-driving emergency braking, adaptive cruise control, and lane departure warnings, improve road safety.
- AI makes predictive maintenance possible through the Internet of Things by continuously monitoring vehicle data and warning management of possible problems before they become serious ones. This enhances vehicle performance and lowers maintenance costs
- Improved Driving Experience with the help of AI-powered infotainment systems, passengers and drivers can have individualised experiences. Smart voice assistants that can play music, navigate, comprehend local languages, and change vehicle settings can make travels safer and more pleasurable.
- Artificial Intelligence-Powered Autonomous cars these cars have the capacity to completely transform the auto mobile sector by decreasing collisions, enhancing mobility, and streamlining traffic, particularly for those with physical disabilities.
- Cost Savings AI reduces costs in many areas of operations, from design to manufacture, by streamlining supply chains, detecting possible problems with vehicles, and optimising manufacturing processes. The development of AI has, all things considered, greatly aided in the expansion of the automotive sector by revolutionising our interactions with and use of auto mobiles.

1.5. How Autonomous Vehicles May Transform the Automotive Sector

Human curiosity in driverless autos dates back hundreds of years. Plans for a fictitious self-driving cart were doodled by Leonardo Da Vinci in the late 1400s, while air plane mechanical autopilots first appeared in the 1930s.

A self-driving car was first presented to the public at the New York World's Fair as part of General Motors' futuristic vision. It's finally a reality because to technological developments in sensor systems, GPS, digital mapping, and processing power. However, what possible effects might autonomous cars have on the auto sector and the overall economy?

Key Takeaways:

- Expanding commercial prospects, upending entire industries, and upending the economy are all possible outcomes of the widespread adoption of autonomous vehicles.
- As driverless cars become more common, employment opportunities in software development, data analytics, and autonomous vehicle maintenance will increase.
- Auto makers will need to change their business models in order to give software development, AI integration, and data management priority.
- Reducing travel time can boost output, which is advantageous to businesses and individuals alike and has a favourable effect on economic activity.

1.6. How Artificial Intelligence is Changing the Auto Industry's Future

Among the largest investors in AI is the automotive sector. It is propelling the automotive industry's future via a significant transition. Auto makers are utilising machine learning algorithms' power to enhance the Data quality is essential to autonomous driving systems. This guarantees increased safety and precision for self-driving cars.

The car industry is breaking new territory with the help of AI's automation and machine learning skills. Businesses are producing electric vehicles utilising artificial intelligence (AI) as the auto industry progressively moves toward environmental sustainability. The speed at which artificial intelligence (AI) is transforming the automotive industry is demonstrated by these recent advancements continue to do so in the future. Additionally, the convenience and safety of drivers are being greatly improved by AI. Artificial Intelligence-Automatic features like autonomous braking and blind-spot detection are increasingly commonplace. Not only do these innovations increase driving convenience, but they also dramatically lower the likelihood of collisions. AI offers a future where cars will be safer, more efficient, and smarter than ever before.

- 5G: A Novel AI Friend: One of the most recent technological advancements on the web is 5g. The automation sector can create vehicles that contribute to the construction of a digital bridge with the aid of the connectivity those 5G promises. 5G allows for device and person connectivity when travelling. Customers can have a better driving experience on the Internet thanks to the combination of AI. With the right information, our entertainment system can function as a driver-command informant. An automobile's performance and oil life can

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be further investigated using merely voice commands, rather than relying solely on the system to play music or make hands-free calls as shown in figure1.

- Artificial Intelligence in Car Operations: AI can automate modifications to the manufacturing process. It can have an effect on the selling and sales process by giving the salesperson information about potential customers' trips. A salesman can use this to maximise both their discussion and overall sale process. When AI is appropriately implemented into processes, expenses and conversion rates can be decreased [30].

- Improvement of Security: There are several risks and hazards on the roads during commuting and road excursions. Auto makers can now create vehicles that can recognise traffic patterns thanks to AI's sophisticated machine learning system. In order to steer clear of possible hazard, this can assist drivers [31].

- Customised Driving Experience: One method to express oneself is through driving a car. With its capabilities, artificial intelligence (AI) in cars can offer something akin to this; some large auto makers, including Porsche, are offering what is known as a "Recommendation Engine." Depending on each driver's unique preferences, this machine learning can recommend car packages [32].

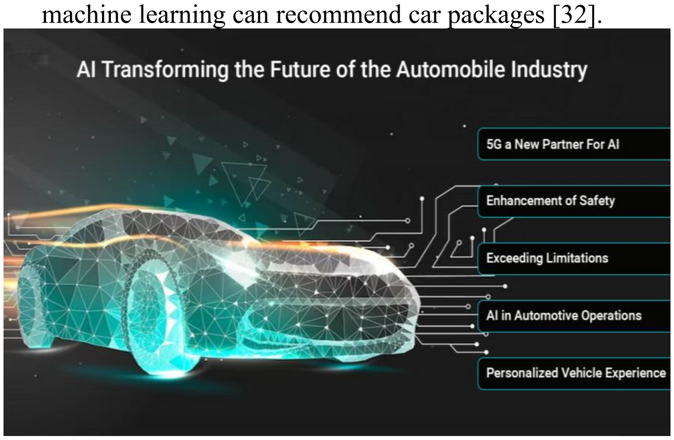

Figure 1 AI Transforming the Future of the Auto Mobile Industry

1.7. The Automotive Industry's Prospects for Artificial Intelligence

The auto mobile sector invests in artificial intelligence anticipated that AI will grow exponentially in the automotive sector, with a projected 55% compound annual growth rate is projected between 2023 and 2033. The ensuing information will demonstrate the extent to which automakers will be concentrating on artificial intelligence going forward:

- Numerous auto makers will employ OEM-based AI chips that are tailored to certain vehicle tasks. AI will enable self-driving cars, cruise control, and lights.

- Software's bright future is largely due to its broad acceptance and integration. The AI market will grow to $200 billion USD in the next ten years [33].

- It is anticipated that by 2023, the autonomous market share in the auto mobile sector would reach US$ 30 billion. The development and introduction of self-driving assistance technologies is credited with this increase.

- A significant 10.9% increase in the market share of autonomous vehicles is anticipated. Due to the growing demand and adoption of autonomous vehicle technology, over 99,451 million units are expected to be sold in the market by 2032 [34].

- It is projected that the automotive advanced driver assistance systems (ADAS) industry would expand at a 9.6% compound annual growth rate. One estimated US$ 131 billion is planned to be invested in the ADAS sector. Consequently, it demonstrates how the autonomous vehicle sector is implementing cutting-edge safety technology.

- A Market Research report projects that the automotive AI market will grow at a compound annual growth rate (CAGR) of 39.8% from 2019 to 2027, reaching $15.9 billion.

- According to Market Researcher, the value of generative AI in the automotive industry is expected to increase from $271 million in 2022 to over $2105 million by 2032.

1.8. The Automotive Sector has Seen Multiple Revolutions Thanks to Artificial Intelligence

- Autonomous Vehicles

Artificial Intelligence is the brains behind autonomous vehicles, allowing them to see their surroundings, decide what to do, and drive safely. AI algorithms are used by companies such as Tesla, Waymo, and Cruise to evaluate data from sensors such as cameras, radar and LiDAR in real-time, enabling them to perceive their environment and make driving judgments.

- Predictive Maintenance

To determine when a component is likely to break, AI systems examine sensor data and previous maintenance logs. By planning maintenance in advance of malfunctions, downtime and expenses can be minimised.

- Improved Safety Features

AI-driven technologies that improve car safety include automated emergency braking, lane departure warning, and collision detection. These systems employ artificial intelligence (AI) to analyse data from cameras and sensors in order to identify possible risks, notify drivers, or take corrective action [35].

- Customised Driving Experience

Through behaviour analysis, habit analysis, and learning from driver behaviour, artificial intelligence may create a more tailored driving experience. AI-driven systems have the ability to personalise entertainment choices, temperature control settings, and seat placements, for instance.

- Traffic Management

To maximise traffic flow and lessen congestion, artificial intelligence (AI) systems examine traffic patterns and information from numerous sources, such as GPS, traffic cameras, and cell phones. This can include dynamic lane management, adaptive traffic signals, and real-time routing recommendations.

- Optimisation of Supply Networks

Artificial Intelligence is utilised to forecast demand, maximise inventory levels, and enhance logistics in order to optimise supply networks. By doing this, manufacturing delays and expenses are minimised because the appropriate parts are guaranteed to be accessible when needed [36].

- Natural Language Processing (NLP)-Equipped Infotainment Systems

Using AI -powered NLP systems, drivers may use voice commands to communicate with infotainment systems and operate numerous services like messaging, music playback, and navigation without taking their hands off the wheel.

- Fuel Efficiency

In order to increase fuel efficiency, AI systems optimise vehicle dynamics and engine output. Intelligent energy management systems, adaptive aerodynamics, and anticipatory cruise control are a few examples of this.

- Quality Control

AI-powered technologies monitor production procedures and identify flaws instantly, guaranteeing that only premium parts are incorporated into vehicle construction. As a result, warranty claims decline and reliability increases. Overall, AI has had a huge impact on the automotive sector, improving customer driving experiences and making cars safer and more efficient.

The rest of the paper is structured in the following way. Section 2 discusses the application of artificial intelligence in the automotive sector and its importance and suitability. Section 3 gives the description of VANET architecture, important application, and routing mechanisms. Section 4 gives an in-depth overview of machine learning models used in VANET environments. Section 5 addresses significant security issues of VANETs and the current solution strategies. Section 6 discusses the various VANET simulation environments and platforms that are applied in research and testing. Lastly, Section 7 touches on the problem of privacy in VANETs and provides a conclusion to the paper by stating the direction of future research in section 8.

2. GENERATIVE AI BRINGS IN A NEW ERA FOR THE AUTO INDUSTRY, FROM ENGINEERING AND DESIGN TO MANUFACTURING AND SALES

The vehicle lifecycle is revolutionised by AI advances, which also increase productivity and inspire creativity. Creating Code and Content Producing pictures and films Syntactic analysis for algorithm testing almost every industry can benefit from the efficiency and creative leaps made possible by generative AI, but transportation is one area where it is most effective at creating new opportunities and optimising procedures. Businesses in the automotive industry can improve car design, engineering, and production, as well as marketing and sales whole auto sector are investigating generative AI. Generic AI is facilitating new developments in autonomous vehicle (AV) development, extending beyond the lifecycle of automotive products. Using neural radiance field (NeRF) among these study topics is technology for using recorded sensor data to build fully interactive 3D simulations. Massive scale development, testing, and validation of AVS can be achieved through the utilisation of these digital twin environments and synthetic data production as depict in figure 2. Generative AI can assist in connecting disparate data streams inputs and outputs like 3D or video, in addition to text to picture or text to text. An assembly plant's physically precise layout might be returned by a text prompt using this potent new computing model.

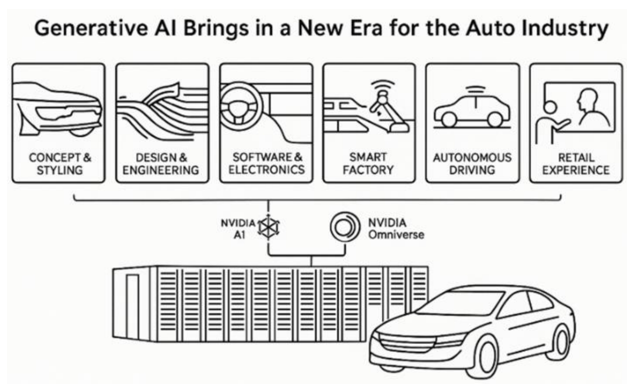

Figure 2 Generative AI Brings in a New Era for the Auto Industry

To guarantee that engineering criteria are incorporated into early design concepts, Toyota, a major automotive manufacturer globally, has created a generative AI technique Mercedes-Benz has, meantime, unveiled a voice assistant that supports Chat GPT in an effort to improve outcomes and speed up design iterations, generative AI is also being considered by other companies in the automotive industry [37].

2.1. Riding Shotgun on Concept and Styling is Generative AI

Visual datasets and generative AI can help design-oriented businesses on several fronts. Coding tools like GitHub Co-pilot, which are trained on billions of lines of code, have already made this possible, and they also hold the promise of assisting in the compression of long design time frames. For example, generative AI models can be trained using both the portfolio of a carmaker and auto mobiles throughout the industry, aiding this workflow when searching for "scrap" design components. This may be achieved by using NVIDIA TAO Toolkit after initially using transfer learning to fine-tune a small collection of photos. Alternatively, based on the needs of the generative AI model, a more substantial dataset of about 100 million photos would be needed. The cloud-based foundry NVIDIA Picasso, which is steadily becoming more popular, may be used by development teams and design teams to create generative AI models for visual design. Bring-yours's-own-model configuration. Here, the generative AI is given instructions for design elements like "rugged," "sophisticated or "sleek by designers and artists. Then, it greatly expedites this first stage by producing samples from both a company's internal picture archive and the exterior world of auto makers. Large language models for text-to-image synthesis in automotive interiors allow designers to describe a texture, such as a synthetic intelligence (AI) will superimpose a floral design on a dashboard, door panel, or seat. Image-to-image texture synthesis is something that generative AI can manage should a designer wish to incorporate a specific image into an interior design texture [38]. When implemented properly, AI can benefit the world's population as well as the industry. In summary, artificial intelligence (AI) is causing a significant shift in the automotive sector. It is transforming retailing, improving the customer experience, and reshaping the auto mobile manufacturing industry. AI is having an impact on everything from personalised design and eco-friendly projects to safety advances and predictive analytics. Artificial Intelligence is providing new life to the automotive business. Manufacturers are able to surpass expectations with the help of new AI-built technology. The only things stopping AI are your imagination and inventiveness. Nonetheless, issues like regulatory complexity and safety concerns need to be undisclosed is revolutionising driving and the relationship between cars and drivers by guiding the automotive industry towards a future of safer more efficient and highly individualised auto mobiles despite these obstacles.

2.2. The Potential Benefits of Designer and Artist Workflows

Currently, the process of moving from initial inspiration and drawing to building full-size models requires months of preparation and design revisions on the part of designers and artists. Serial operations, partitioned data, and mismatched tools frequently make this difficult. When creating a design, artists frequently start by gathering visual references, or "scrap," based on current trends in car styling. They use image libraries that are sorted by keywords to get inspiration for design elements. Examining auto mobiles from all manufacturers, new or old, is part of the procedure. A combination of current trends and original ideas based on a brand's aesthetics then develop with a great lot of human creation. Drawings by hand in two dimensions serve as the foundation for artists' 3D models and clay prototypes. Interior features like dashboards, seats, ergonomics, and user interfaces are designed using these linear and laborious design concept methods, whereas exterior components like grilles, hoods, and wheels are designed using them [39]. Automotive style teams collaborate with engineers to create "NURBS" models, or non-uniform rational B-splines, using software such as Auto desk Alias or Maya in order to create these 3D models. From 2D sketches, the shapes are captured in the resultant mathematical representations of 3D geometry. The final product is a 3D representation that can be used to describe surfaces in computer-aided design software. It is the outcome of custom style, design, and engineering effort. With generative AI, the automotive sector can now quickly convert 2D sketches into NURBS models, resulting in productivity gains. Although they won't replace designers, these technologies will make it easier for them to quickly consider a variety of possibilities.

2.3. An Overview and Challenges of Ad-Hoc Networks for Vehicles

Vehicular ad-hoc networks (VANETs) technology has emerged as a major area of research in the last few years. The notion of creating a network of cars for a particular purpose or circumstance gives rise to VA NET, an ad hoc sort of network. Currently recognised as dependable networks for auto mobile communication on highways and in metropolitan areas, VANETs are used by vehicles. VANET has several advantages, but it also has many drawbacks, including high bandwidth and connectivity, protecting vehicle and user privacy, and providing QoS. Presenting the state-of-the-art in VANET and associated issues are discussed. Comprehensive discussions are held on network design, mobility modelling, routing protocols, signal modelling and propagation mechanism, and network security. The primary conclusions drawn from this research are that a resilient and efficient VANET is one that meets all design requirements, including high PDR, low BER, minimum latency, and QoS. The conclusion of the study includes a presentation of several important VANET research topics and problems [40]. Vehicle Ad-hoc Networks (VANETs) are not a recently developed problem, but they still present fresh problems and challenges for research. Helping a collection a network of cars creates

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and maintains its own communication system without the need of a controller or central base station is the primary goal of VANET. When there is no infrastructure and information must be shared quickly to save lives, one of the main uses for VANET is in catastrophic medical emergencies. But new issues and obstacles often arise in conjunction with these beneficial VANET applications. The absence of infrastructure in VANET places additional duties on auto mobiles. Each vehicle joins the network and takes responsibility for managing and controlling the network's communication among its own communication requirements. Vehicular ad hoc networks handle the communication between moving cars in a specific situation. A vehicle can communicate directly with another vehicle (known as vehicle-to-vehicle, or V2V) or indirectly with an infrastructure (such as a roadside unit, or RSU) (known as vehicle-to-infrastructure, or V2I) communication).

Modern technology in VANET is the primary contribution of this article. This paper presents an extensive investigation of network architecture using various topologies and network modelling. Ensuring efficient packet routing is a crucial aspect of VA NET design to establish a functional communication network. Different VANET routing algorithms are covered in this study, along with their limitations. The study also addresses security challenges in the VA NET environment, enabling the modelling of reliable network design. The main topics of study and difficulties in this field are also covered in the paper [40].

3. VANET APPLICATIONS, ROUTING, SECURITY, NETWORK MODELLING AND ARCHITECTURE

3.1. VANET Applications in the Automotive Sector

In collaboration with the industry's largest light-duty car Ad-hoc Networks (VANETs) can host a variety of applications and pre-competitive safety solutions that are being developed by car manufacturers, the Vehicle Infrastructure Initiative, the Crash-Avoidance Metrics Partnership (CAMP) consortium, and the Vehicular Safety Consortium (VSC) a unique type With mobile ad-hoc networks, where a network is established by the wirelessly equipped on-board unit (OBU) in cars and the roadside unit (RSU) without the need for need for extra infrastructure. Basically, we are classifying several uses for vehicular networks in this study, along with their characteristics and real-world applications. The RSU can function as a buffer point, router, or access point, storing and supplying data as needed. The cars upload and download all of the data from the RSUs. Furthermore, a categorisation of applications is carried out using the following categories: Routing-based applications, Car to Car Traffic, Car to Infrastructure, and Car to Home as the writers analyze the different types of attacks according to their categorisation. The applications of VANETs are categorised into the V2I or V2V types, depending on the kind of communication as depict in table 2.

- Safety-focused
- Business-focused
- User-friendly
- Fruitful Uses

Table 2 AI Applications in Automotive Sector

AI Area	Purpose	Benefits
ADAS Systems	Detect hazards	Accident reduction
Autonomous Driving	Self-navigation	Human error elimination
Predictive Maintenance	Equipment failure prediction	Lower downtime
Manufacturing Automation	Robotics + AI	Better efficiency
Driver Monitoring	Detect drowsiness	Improved safety

3.1.1. Safety Applications

Applications for safety consist of keeping an eye on the surrounding road, oncoming traffic, on the road's surface, on curves, etc. The applications for road safety fall into one of the following categories:

- Real-Time Traffic: The RSU has the capacity to store real-time traffic data, making it accessible to vehicles at all times and locations. This may be very helpful in preventing traffic bottlenecks, solving issues with traffic, and sending out emergency notifications for things like accidents, etc.
- Cooperative Message Transfer: Slow or stopped vehicles will communicate with one another and work together to assist other vehicles. It might automate processes like emergency braking to prevent accidents, even if latency and dependability would be the main concerns. An additional application could be an emergency electronic brake light.
- Post-Crash Notification: Following vehicles would receive alerts regarding the position of a vehicle involved in a collision, enabling them to take immediate action. Additionally, it would alert the highway patrol to provide tow assistance.
- The Notification of Road Hazards: Vehicles alerting alternative vehicles to the presence of a landslide or

providing information on a road feature because of a bend, abrupt descent, etc.

- Cooperative Collision Warning: Notifies two possibly colliding vehicles so they can avert a collision.
- Traffic Vigilance: The RSU has the option to install cameras as an input and the newest device in campaigns against driving violations that are low or zero tolerance [41].

3.1.2. Use in Commercial Applications

The driver will be able to browse web content, stream audio and video, and enjoy entertainment via commercial applications. The applications for commerce can be divided into the following categories:

- Remote Vehicle Personalisation and Diagnostics: This function makes it easier to upload or download vehicle diagnostics to and from infrastructure.
- Utilising the Internet: When operating as a router, RSU allows vehicles to access the internet.
- Downloading Digital Maps: Before heading to a new location, drivers can download maps of the various regions as needed for advice on their route. Furthermore, accessing crucial information from Content Map Database Download is made possible by home stations or mobile hotspots.
- Real Time Video Relay: The driver will be able to request real-time video streaming of his favorite films, allowing him to enjoy on-demand cinema outside of the house as depict in figure 3.
- Advertising with Added Value: Roadside restaurants and gas stations can use announcements to let passing cars know about their services. Even without an Internet connection, this program can be accessed.

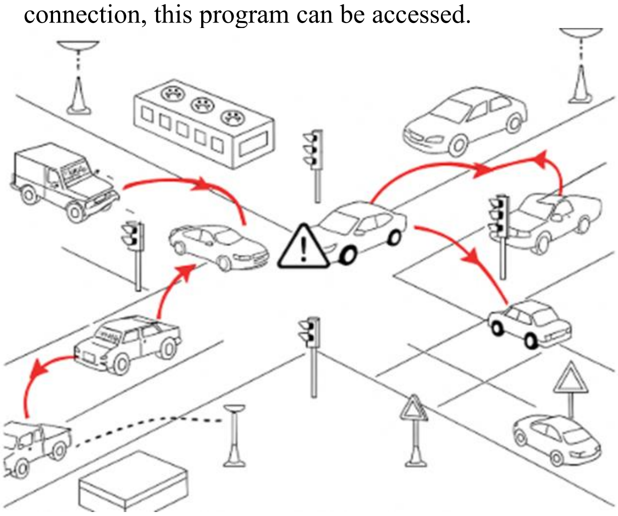

Figure 3 Notification of an Emergency

3.1.3. Applications for Convenience

The main focus of convenience applications is traffic management, where the idea is to increase driver convenience in order to improve traffic efficiency. Applications for convenience can be categorized as follows:

- Route Diversions: When there is traffic, plans for your route and travel can be established.
- Electronic Toll Collection: As shown in figure 4 a Toll Collection Point, allows for the electronic payment of the toll. The OBU of the vehicle must be readable by a toll collection point. OBUs use GPS with the macrograph or on-board odometer as a backup to determine the distance travelled by the Lorries. They then use a wireless link that authorises the toll payment using a digital map and GSM. Both drivers and toll operators benefit from TOLL application [42].
- Parking Availability: Being informed when spaces become available in large cities makes it easier to determine whether spaces are available in parking lots within a specific region.
- Active Prediction: It projects the road's future topology, which should minimise fuel consumption by modifying the cruise speed before to beginning an ascent or descent. Second, help is also provided for the driver.

Figure 4 India's E-Toll Collection

3.1.4. Utilizing Effective Methods

We have chosen to refer to it as productive on purpose because it is an extra application to the ones stated before. The useful apps fall into one of two categories:

- Benefits to the Environment: The goal of the Transportation system operators are encouraged and assisted by the actionable information produced by the AERIS research program, which aims to generate and collect environmentally relevant real-time transportation data users make "green" transportation decisions. The vehicle to vehicle (V2V) communications research project and the AE-RIS program will collaborate to more clearly outline how a multi-modal strategy may be used to reduce some of the negative environmental effects of surface transportation through the use of connected car data and applications.

- Time Utilisation: By downloading his email, a traveller can read thieve traffic is stalled, use the on-board system and read it for yourself, turning traffic jams into useful tasks. While waiting in a car for a friend or family, one can browse the Internet [43].
- Fuel Saving: Up to 3% of fuel is saved when a car uses the application for the TOLL system to continuously collect toll at toll booths. Normally, a vehicle would use fuel to get through a 2–5-minute wait.

3.2. VANET Routing

The topology of vehicle networks is dynamic and unpredictable should not be a problem for the routing protocol. Finding and keeping the best communication routes in the intended contexts is arguably the hardest part of VA NET routing. Most of VANET's routing protocols are closely linked to the topology used in the network architecture, and any modifications to the structure result in deviations in performance as shown in table 3.

Table 3 Routing Protocols Comparison

Routing Type	Example Protocols	Advantages	Limitations
Topology-Based	AODV, DSR	Simple, known	High overhead
Position-Based	GPSR, LAR	Fast, scalable	GPS dependent
Cluster-Based	LORA-CBF	Low overhead	Cluster stability issue
Broadcast	BROADCOMM	Good for alerts	Broadcast storm

VANET routing falls into five main categories, which are as follows:

- Broadcast protocols;
- Ad hoc or topology-driven protocols.
- Recast protocols.
- Location-based routing protocols.
- Cluster-based protocols

3.3. Routing Based on Topology or Ad Hoc

Since VANETs frequently lack infrastructure, many routing protocols created for prior ad hoc networks like MANET that were based on other network topologies can be used to VANETs with little modifications. There are three subcategories of topology-driven protocols: proactive, reactive, and hybrid which they fall. To meet the requirements of the VANET environment, several similar protocols were created. In a pre-emptive protocol Nodes constantly add new routes within the network to their routing table. Periodically, all nodes receive this information by means of HELLO packets. However, there is significant control overheads associated with this strategy. This limits how scarce wireless resources, including available bandwidth, are used Reactive systems, on the other hand, use nodes like AODV, DS, and BRP to deliver control data only when necessary. By doing this, you can spread the actual content more quickly and save money on link establishment overhead. Still, this method incurs excessive resource costs, such as upkeep of utilised or underutilised channels.

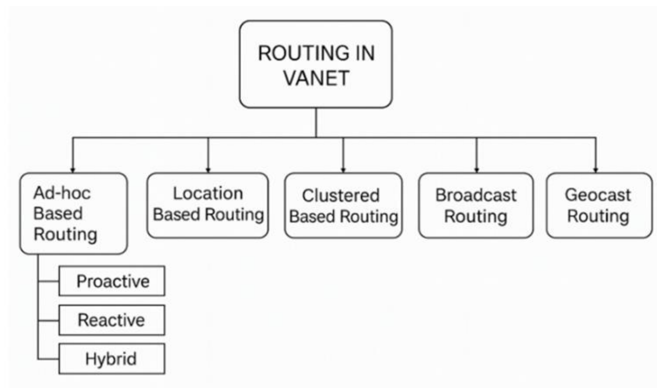

Figure 5 VANET Routing Types

The strict network topology of VA NET causes the creation and breaking of these useless paths [44]. The overheads incurred by reactive protocols stem from figure 5 out how to transmit the data. Route Request Messages (RREQs) are a specific kind of message that is used to start the path finding process to every neighbour, it transmits an RREQ message. Subsequent nodes, such as node 1, verify the intended destination against their unique identifiers upon receiving an RREQ message. In the event that a match is found, node 1 will receive the request; if not, it will rebroadcast the RREQ to all of its Neighbours. This strategy may cause the network to flood. Using the backward learning technique, Restarting Route Reply Message (RREP) at the source after the request has reached the destination (node D in this example). Researchers have shown a strong interest in discovering hybrid protocols in addition to the fundamental reactive and proactive types of protocols. There is a detailed discussion of one such protocol in. Instead of emphasising performance analysis, the inventors of this method have concentrated more on the network's overall architectural architecture as depict in figure 5.

3.4. Geographically-Based Routing

There are also protocols that are dependent on position or location for routing that has piqued the curiosity of researchers. This protocol system gathers geographic position data about auto mobiles from many sources, such as diagrams. Worldwide Positioning System (GPRS) or even residual traffic model components to enable the data's distribution. Many studies have analysed The Position Based approach is used to examine popular topology-based protocols like AODV and DSR in detail. According to the results, the performance was better and more impressive than when using a simple topological approach. Position-based protocols do not require route maintenance, in contrast to topology-based protocols, and the route can be constructed as needed. In the VANET setting, bandwidth is already insufficient, thus this lessens unnecessary constraints on it. One location-based protocol that searches for the neighbour who is closest to you is called Greedy Perimeter Stateless Routing (GPSR). Every node knows where it is, as well as where its nearest Neighbors are. GPSR is ideally suited for dynamic topological networks since it provides this particular information to the main node. When there is no neighbour nearby, GPSR uses perimeter mode in conjunction with face routing to maximise destination search efficiency. This provides a performance comparison between DSR and GPSR in a highway environment. Using GPSR has been shown to decrease route delay in research. GPSR cannot be used in its original form in situations where latency and packet delivery ratio (PDR) requirements are strict, primarily in urban environments. They introduced Advanced Greedy Forwarding (GPSR-A GF), a modified version of GPSR, to address this issue. In this version, the HELLO packets carry information on the target node's direction and speed [45]. Location Assisted Routing (LAR) is a significant location-based routing technique that was introduced. Reactive protocols like AODV and DSR emphasise routing overheads, which are reduced by using node location data, which is what makes LAR different. A window-size-based method and a distance-variable method are the two basic techniques used by LAR to identify the next hope using performance metrics such the packet delivery ratio (PDR) system throughput, average delay, and routing overheads to analyse the LAR scheme for the VA NET in a highway setting, was given by the authors in. It is demonstrated that for a modest node count, the PDR rises, but at a higher network density, it falls. The rationale is that there is less packet loss at larger network densities since there is greater communication between nodes when a network has more than 50 nodes The LAR system's throughput declines [46].

3.5. Routing Utilising Clusters

VANET has created a routing paradigm known as Cluster Based Routing (CBR) to reduce network traffic and routing overheads. Developing network architecture centred on clusters small collections of vehicles as depict in figure 6.

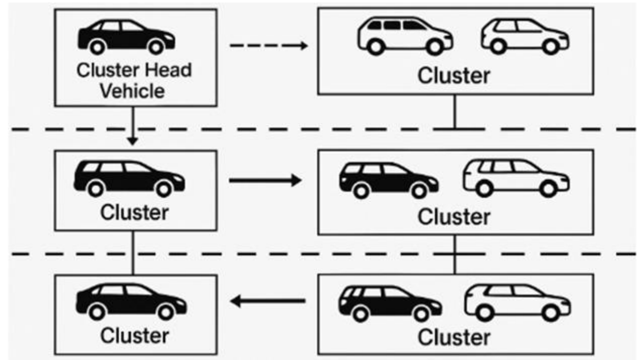

Figure 6 Routing Using Clusters

Ad-hoc networks are not unfamiliar with the idea of CBR. The performance of CBR in MANETs with inflexible network circumstances has been studied and tested in the literature. A process or protocol to generate the cluster range is the foundation of most routing systems, after which the best communication routes are searched for. Because of scalability issues, VA NET cannot directly use MANET's cluster building procedures. By including the creators of LORA-CBF have presented a reactive geographic routing-based algorithm for V2V communication that requires one cluster head, zero or more cluster members, and one or more gateways for communication with other cluster heads [47]. The LORA-CBF architecture reduces the needless overheads associated with retransmissions. Primarily, similar to the reactive method, routes in LORA-CBF are modified only when necessary. Second, it lowers the overheads associated with control traffic by utilising the idea of vehicular gateways to transfer control information. Cluster-head maintains its cluster and updates its parameters by periodically sending beaconing messages. Cluster management is the responsibility of the cluster head updates its parameters by sending out periodic beaconing messages that of The Location information from other clusters is obtained using Request (LREQ) packets, which are comparable to RREQ packets in topology-driven protocols like AODV are only permitted to be retransmitted by gateways and cluster chiefs. Due to its ability to update cluster position information rather than that of individual vehicles, LORA-CBF can be appropriate for highly mobility environments such as VA NET. In comparison to further AODV and DSR reactive routing protocols, simulation findings have demonstrated that LORA-CBF performs better have offered a different method for creating a cluster-based routing protocol, in which grids representing the encompassed geographic region were created. The vehicle designated as the group is determined by the quantity of vehicles in the grid area leader. The source vehicle just transfers the data to the best neighbour cluster-head when it wishes to convey information to reach the goal; determining the full path is not

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necessary. After that, the data will be distributed to the target by the cluster head (in the cluster) [48]. In addition to saving memory space required to maintain routing information, this reduces the overheads related to data distribution. Another cluster-based routing strategy has been presented by the authors, whose main goals are to reduce the dynamic nature of VANET and improve network topology stability. Along with the physical location and intended destination of each vehicle, the routing algorithm also takes the speed variations between the cars into account. Regarding the shift in the efficiency of the proposed threshold-based algorithm is compared with the current position- and weight-based algorithms in terms of average number of clusters algorithms. It is demonstrated that when using the suggested technique, the average cluster change per vehicle is significantly lower than when using alternative routing protocols. This concludes the algorithm's less dynamic character.

3.6. Routing Broadcast

Broadcast routing was one of VA NET's most well-known routing techniques. The broadcast approach is mostly used when a vehicle that is outside of its service area wants to receive a message. Packets are transmitted via flooding techniques. Transmission of information is ensured, but a lot of bandwidth is used. As stated before, this type of approach is used by numerous popular routing protocols, especially during the phase of figuring out the route to the end point. Using the broadcasting principle, two BROADCOMM and the Nth-Powered P-persistent Broadcast protocol (NPPB), two well-known protocols, were developed the entire area is split up into virtual cells in BROADCOMM, which simulates a hierarchical highway structure. Members of the cell create a hierarchy of Cell Reflectors (CRs), which function as base stations to collect signals from nearby cells as well as for a specific call. Making decisions on message forwarding to certain cars is made easier with the aid of CR. When this protocol is compared to other broadcasting protocols, it performs better in terms of message broadcasting, delay, and routing overheads. To efficiently send emergency messages over dense VANETs, NPPB uses a probabilistic broadcasting technique to reduce broadcasting storms. The weighted p-persistent routing strategy that the authors examined demonstrates improved accessibility for the farthest node. The number of nodes in the environment must be chosen reasonably in order for this protocol to operate well [49].

3.7. Geocast Routing

Geo cast one kind of routing that addresses information delivery in a certain area of interest. Numerous Geo cast routing techniques have been proposed since the early introduction of VANET. A lot of VANET applications need position-dependent multi casting, including sending auto mobiles information about dangerous traffic conditions moving in the same direction. Recast routing's main concept is to focus the process of looking up the next hop on a specific Zone of Relevance (ZOR). Let's explore the concept of a system that would automatically alert other cars that are approaching the scene of an accident involving a car by providing the design architecture of Robust Vehicular Routing (ROVER), authors have introduced a Recast routing protocol in. The efficiency and dependability of the routing strategy are increased by ROVER because Data is transmitted over the network using a unicast approach, and only control packets are sent. A ZOR is generated in ROVER through a rectangular window at the back of the source node. The dimensions of the window that is formed are its respective dimensions. The window's dimensions are chosen to encompass every lane on the existing road. If the message reaches the node (vehicle) while it is in ZOR, it will be accepted; if not, it will be rejected. ROVER has been demonstrated to provide superior outcomes in low-density areas [50]. Based on the geographical routing method described in, authors have introduced GROOV, geographic routing method, applicable to scenarios involving cities and highways. GROOV is based on the idea of finding the best relay node rather than avaricious selection criteria. While sacrificing PDR, raising the average end-to-end latency is the foundation of the majority of greedy selection strategies. It has been demonstrated that GROOV outperforms the routing algorithm given in the city environment in terms of PDR. A few methods are based on this concept and allow localising the search space by utilising map information and node placements. In order to make the best routing decision, authors have introduced VCARP, a context-based routing protocol that leverages vehicle information including destination, location, and packet cache status. By temporarily holding the packets in a cache, the retransmissions of the packets are avoided.

3.8. VANET Security

VA NET security ought to be regarded as crucial as that of other computer networks. Since the information transmitted over VANET is so sensitive, any apps created for the vehicle network must be shielded from malevolent manipulation. Consider the damage that could result from a crucial message being modified and not being discovered. Furthermore, in order to avoid losing money, VANET's high-quality applications and comfort must be safeguarded. Addressing security concerns in automotive networks is the main goal of several consortiums, such as Secure Automotive Communications (SEVECOM) and Network on Wheels (NOW). According to fundamental concepts of computer and network security, attacks on three types of risks can be identified in computer networks: those related to resource availability, confidentiality, and authenticity. The one danger that particularly jumps out when using this security paradigm on a vehicle network is the source's confidentiality for instance; an attacker may be able to determine the precise location of the car while they are analysing the certificates that are attached to every message sent over the network (privacy compromise). VA NET security standards currently use a broadcast authentication technique. Instead of employing a single default key, the authors proposed a method whereby each vehicle is loaded with numerous verified public keys.

Another strategy that writers have proposed allows cars to switch between many identities by employing pseudonym pools of IDs these methods have the drawback of overtaxing the network, which is already straining to its breaking point because of insufficient bandwidth, with additional processing limitations. The many types of attacks and the "Attacker Model" that occur in VANETs must be carefully taken into account when developing a secure vehicular network. An attacker's primary motivations are typically self-interest, malevolence [51].

Three primary attack types have been outlined by the writers in:

- False Information: A malicious insider can create false security alerts and disseminate them throughout the network. This may result in catastrophic circumstances (A danger to sincerity).
- ID Disclosure: Location information about a car's exact location, which is private, needs to be protected (a threat to confidentiality).
- Denial of Service: A hacker may overload the system preventing users from accessing the services or apps. If such events happen instantly, they could have disastrous consequences (a danger to Availability).
- Quality of Service (QoS): It's crucial to provide specific QoS levels in VANET. Users can be guaranteed a certain quality of service (QoS) through a network with minimal latency in data transfer, low retransmission rates, and high connectivity times. It is an intriguing and difficult task in VANET architecture to guarantee this form of QoS in the face of diverse user applications and a changing network environment.
- Robustness and Scalability: Due to its difficult features, designing a robust and scalable network in VANET is yet an unexplored field of study. When VANETs transition from high mobility to sluggish traffic conditions, or from sparse to high density mode, several design methods fail. A fully scalable VA NET framework.
- Cooperative Communication: In VANET, establishing communication between various nodes is a major challenge. It might not be possible to directly apply certain cooperative communication theories from wireless network theory to VANET. One of the main study topics in the VANET architecture is cooperative communication, including the degree to which nodes should share information with one another.
- Network Security: Nodes in a VANET context are always trying to communicate with each other. With one another, it is crucial to ensure that some sensitive private information stays on the relevant node. Creating a trustworthy security protocol and appropriate authentication system is an intriguing and unexplored field of study for VANETs.

3.9. Network Modelling and Architecture

In theory, a VA NET is not required to adhere to any certain architecture or topology. In contrast, a general VANET is made up with moving cars corresponding with some neighbouring RSU as well as with each other. Unlike nodes in MANETs, which move randomly, vehicles in a VA NET follow predetermined routes like metropolitan roads and highways. This is how a VA NET differs from a MANET. It is crucial to view VANETs as a separate field of study, even though it is simple to conceive of them as a component of MANETs, particularly when it comes to network architectural design. A wireless transmitter and receiver make up an on-board unit (OBU) in a vehicle according to VANET design as depict in figure 7.

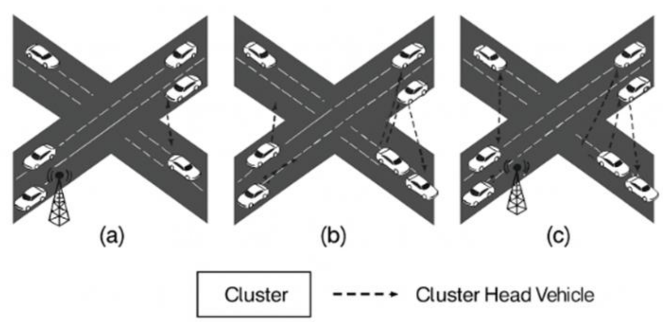

Figure 7 Networks Architecture in VANET

Three main categories of potential vehicle communication scenarios can be identified. It is possible that some sort of RSU is used by every car to communicate with every other vehicle. Wireless local area networks (WLAN) could be similar to this architecture. A second option is for vehicles to speak with one another directly without the use of RSU. Ad-hoc architecture is one way to categorise this. In the third scenario, some vehicles may be able to communicate directly with one another, while others could require an RSU. To fully utilise vehicle communication, it is imperative to have a thorough understanding of network architecture. The majority of researchers have divided VANET settings into three categories: Free way/Highway, Urban Rural, and Urban. Making sure that inter-networking will eventually address the demand for the complete vehicle environment is one of the motivations for conducting such research. For error-free, efficient packet transmission in the VANET paradigm, the mobility model needs to take individual and collective vehicle behavior into account. Generally speaking, depending on the types of information required for modelling, a mobility model can be divided into macro and micro categories. While vehicle behavior is addressed at the microscopic level, roads, buildings, and streets are considered at the macroscopic level. Overall, there are three main categories into which the mobility models in VANET can be divided: Three types of modelling exist:

- Trace-based modelling
- Flow- or traffic-based modelling
- Stochastic or random modelling

Random walks and the collective behaviour of the vehicles, is one example of this, as is fluid flow theory. Yet, the degree of unpredictability in the model that one wishes to incorporate might function as the foundation for the mobility modelling as the dynamic character of cars in a VANET was modelled by numerous researchers using deterministic, hybrid, or totally random approaches. The performance analysis of the networks is impacted by mobility modelling in a number of ways, including latency from end to end, capacity, security, routing, and scalability. Using the proper statistical and mathematical methods It is possible to finish an ad hoc network modelling that is more thorough A You can use one of these to represent a wireless ad hoc network the methods as a random graph, with the nodes represented by the graph's vertices and the pathways via which the nodes communicate with one another in a graph. The formula for multimode wireless network graph modelling is G = (V, L), where V stands for the graph's vertex set and L for its edge set. An RGG (Random Geometric Graph) is used to create such a graph, in which the vertices are independently distributed and meet the Poisson distribution in a given region. The linked graph of a Boolean Model (BM) is comparable to this model. Ad-hoc wireless networks still require a deeper theoretical and analytical comprehension of this subject. Actually, transmitting and receiving the signal is one of the most challenging areas for VANET research. The following summaries a few of VANET's most important uses:

- Road Traffic Safety: Try to lower the amount of fatalities preventing accidents by alerting drivers of possible dangers before they happen.
- Reduce travel time and congestion in order to enhance the general effectiveness of transportation systems through traffic engineering, or efficiency.

Provide practical applications like "electronic payment systems" to enhance the comfort and quality of road travel." "Variable message signs," "advanced traveller information systems," and "electronic toll collection" to make travelling more comfortable.

3.10. The Following are Some Essential Features of a VANET Model

- Dynamic Topology: Because cars in a VANET environment move around a lot, the topology is always changing. A very brief period of time separates two cars traveling in opposing directions at ordinary suburban speed limits. In a freeway or highway setting, this connection time decreases significantly with increasing vehicle speed.
- Frequently Disconnections: Owing to the high mobility of nodes and regular environmental changes, the link connection between the vehicles in VANET frequently disconnects.
- Mobility Modelling: Because the VANET environment is so dynamic, an accurate mobility model is necessary to implement VANET in an effective and realistic manner.
- Predictable Mobility Patterns: The majority of cars in the VA NET environment travel on designated roads and highways. This makes it possible to construct networks using predictable mobility patterns.
- Use of Additional Technology: The majority of the modern VANET vehicles have the ability to integrate them combined their own technology with other current technologies, such as the GPS (Global Positioning technology).
- Absence of Power Limitation: VANET nodes get the benefit of a longer battery life when in contrast to additional devices on the Mobile Ad-hoc Network (MANET). This can be used to process intricate and computationally demanding routing and security protocols in the network efficiently.
- Tight Delay Restraints: VANETs are in charge of transmitting vital medical emergency communications. In order to prevent fatalities, these warnings must be sent on schedule.

3.11. VANET Routing Protocols Based on Artificial Intelligence Methods

Valet Ad Hoc Networks, or VANETs for short, are a type of wireless network made up of auto mobiles and roadside communication equipment. It is crucial to take into account every aspect of VANET design, functionality, software, and issues before introducing them because VANET is linked to life-critical applications. Facilitating seamless communication for drivers is VANET's main goalie the event of emergency situations, including heavy traffic congestion, collisions, lane changes, speed limits, hazard or road condition alerts, position

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alert services, and natural disasters, among others. Several issues with VANETs, including routing, synchronisation, network congestion, network control, information management, privacy, and security, arise from the extreme mobility of the vehicles. The research status on artificial intelligence-based VANET routing techniques is reviewed in this chapter. Future problems in providing artificial intelligence approaches for routing in VANETs are also covered in this chapter, along with ongoing research on the application of these techniques.

4. VANET MACHINE LEARNING MODELS AND METHODOLOGIES

The main objectives of VANET are to guarantee the security of every mobile node and lower the frequency of mishaps and latency in data transfer. Routing problems result from the network structure's volatility. On RSUs, data congestion is caused by the environment of the VANET system that is rich in data. For traffic control, safety, routing, and other particular applications, numerous conventional prediction-based protocols have been developed as depict in figure 8. They did not, however, incorporate machine learning (ML) approach to improve data analytics that promotes the combination of ML models with conventional models to improve performance. These issues are revealed by a number of machine learning approaches, including K-Nearest Neighbours (k-NN), K-Means Clustering, Naive Bays (NB), Support Vector Machine (SVM), Convolution Neural Network (CNN), Artificial Neural Network (ANN), and Support Vector Machine (SVM) are some of the neural networks that analyze the data flow in the VANET system [52].

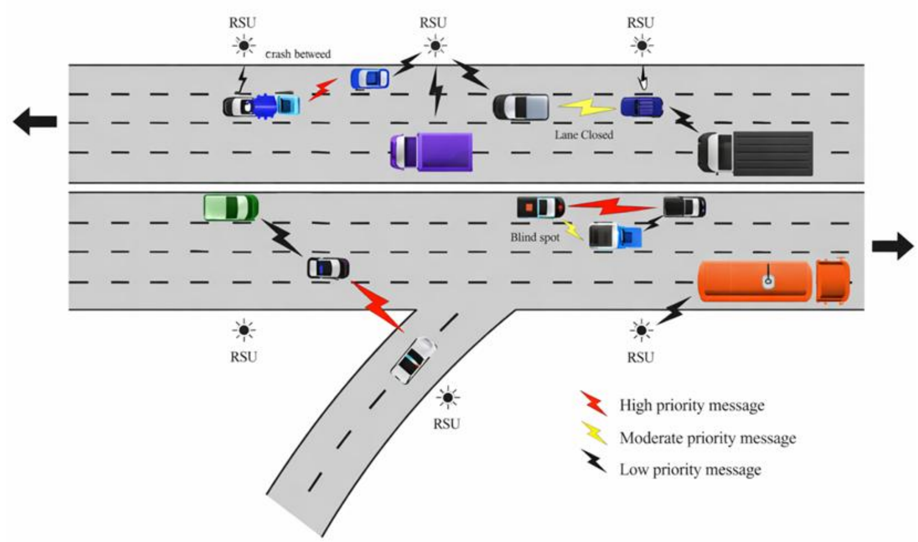

Figure 8 VANET Framework

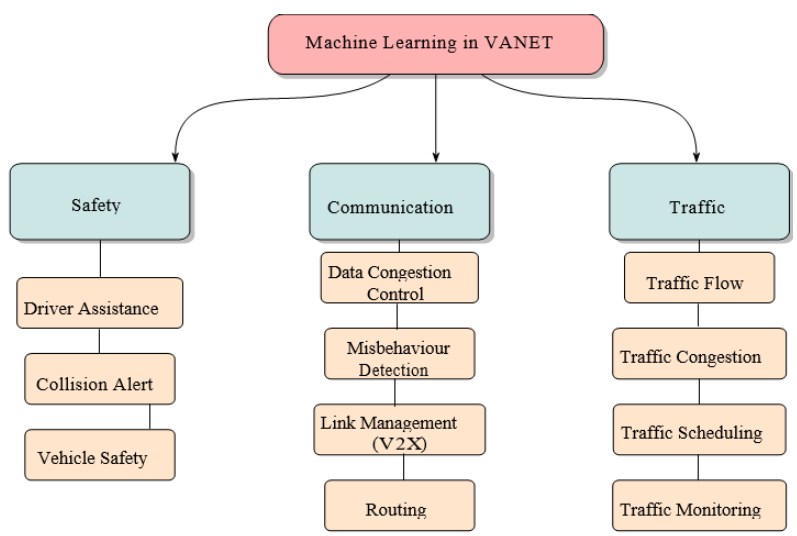

Figure 9 Solution Taxonomy: Using Machine Learning in VANET Adoption

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The primary objective of the intelligent transit system is to ensure safety. Identifying items and roadblocks is a crucial part of safety provisioning. In terms of obstacle detection using visual data, the CNN and k-NN approaches perform better. The most appropriate millimetre waves bands for Gbps links which are necessary for data transmission in 5G-VANET are the surrounding environmental features can be taken into consideration while developing a machine algorithm-based beam selection for data transmission. By applying the Bayesian Coalition Game theory, ML integration into VANET can aid in ensuring dependable data processing and forwarding between nodes or between various ITS system layers. In the data processing process, the intermediary node may or may not cooperate. The dependability of nodes for the transport and processing of spatio-temporal data can be ascertained with the aid of machine learning. Furthermore, different traffic conditions might shed light on a variety of data kinds. In order to examine the circumstances at the microscopic and macroscopic levels, this data can be produced utilising a variety of simulation techniques as depict in figure 9.

4.1. The Role that Machine Learning Plays in VANET

- We looked at the assessment measures employed current technology as well as machine learning's shortcomings models and approaches now available in VANET. Furthermore, we mentioned the ongoing efforts in this field [53].
- We assign several apps to the review work. This classification illustrates how advances in VANET can be achieved by using machine learning methods. In addition, we provided an overview of the research project's benefits, drawbacks, accuracy, and most important technologies.
- Finally, we wrap off by discussing outstanding questions and potential directions for future study as depict in table 4.

Table 4 Machine Learning Models in VANET

ML Method	Use-Case	Benefit
CNN	Object detection	High accuracy
KNN	Traffic density estimation	Simple & fast
SVM	Crash prediction	Good classification
ANN	Traffic flow forecasting	Good generalization

4.1.1. Security

Significant harm to surrounding objects and automobiles can result from traffic accidents, and occasionally, even fatalities may occur to humans. As such, the issue of safety also comes up with the development of the smart traffic system. All safety-related data collected from cars and RSUs in real time must be efficiently communicated by vehicular nodes. To encourage efficient traffic flow free from obstructions or collisions an IT'S should help the driver choose a safe path and recognise traffic signs with accuracy. By transmitting pre-collision alerts to avert dangerous conditions, the traffic system should be able to anticipate unexpected situations that might arise A side from that, On-Board Units are required to give information about the specific vehicle's safety in the event of a collision and structural integrity. We separated the safety survey into three sections where machine learning techniques can be applied in order to effectively integrate such information into VANET. Using machine learning methods to incorporate such safety features for different application scenarios is covered in the section that follows. Figure 10 shows several possible scenarios pertaining to safety issues [54].

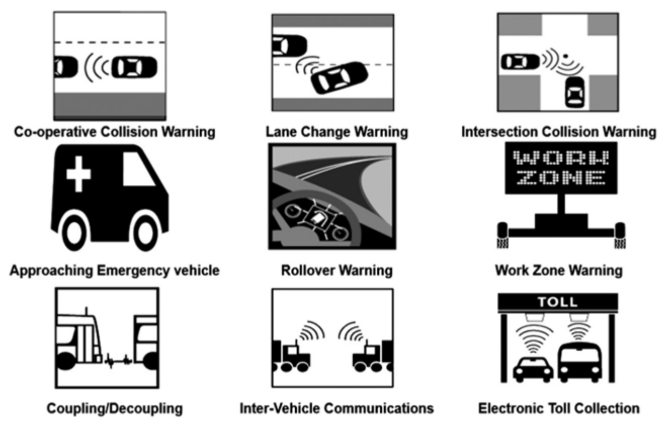

Figure 10 Applications of Safety in VANETs

4.1.2. Driver Support

Numerous sensors integrated into the cars produce a lot of data. In addition, data from the surrounding environment may be analysed to comprehend the driving style and attitude, which in turn enables the provision of intelligent roadside assistance. Using the front camera as the data source, a road type categorisation system was developed. A vehicle's ability to steer, accelerate, and brake can all be improved with reliable and accurate information on the type of road. The DNN method, which has six categories for different types of road pavement, has an average accuracy of 88.8% for road type and condition. Additionally, by anticipating the friction coefficient using the data at hand, they have created a mathematical model that will enhance the regulation of vehicle dynamics through the Anti-Lock Braking System (ABS). For every kind and condition of the road, the suggested work reduces the stopping distance. A system that uses facial recognition and emotional expression analysis to identify a driver's emotional state in order to gauge how attentive they are the face detection model that the author utilised is relies on a combination of trees and makes use of a data pool to accurately identify the face. Two distinct neural networks receive the output of this model. While using facial pictures, the first network is used to extract appearance features while the second network is used to remove geometrical features from landmark locations. In order to precisely identify the emotions, the author also integrated the output of these two networks. This strategy has worked the best as the driver may be informed about their emotional condition when needed by the system [55]. A technique for categorising drivers' driving abilities speed, yaw rate, steering angle, and lateral and longitudinal acceleration are the attributes considered for this classification. To extract features from these attributes, principal component analysis (PCA) was applied.

4.1.3. Alert for a Collision

A vehicle node can be made safer by alerting the driver to an impending serious accident. It comprises identifying potential obstructions to the standard course, monitoring vehicle behaviour, and estimating the likelihood of an accident. Research on collision alerts is presented in this part. The goal of the hybrid architecture, which combines an SVM- based model with a clustering technique to forecast crash probabilities, is to give safety to the vehicle node Two stages make up the model. (A) To identify the model uses the Random Forest (RF) Algorithm to forecast crashes based on the two most significant and vital features. (B) A hybrid model is produced by using the chosen element comparing the models' transferability and cross-validation, for example, two models—the SVM model with variable selection and the model without it Up to 78% accuracy are attained using the suggested model. This means that the outcome indicates how important it is to combine variable selection with clustering. The hybrid model has an accuracy of 80% overall and 78% during crashes. Zhao et al. suggested utilising PCA and neural networks to forecast a collision between cars. I.e. using available feature correlation data and traffic accident data, the model's most notable characteristics are first chosen. PCA decor relates these traits to make them linearly independent. These features are subsequently subjected to a Back propagation (BP) neural network. Less chance of an accident occurs when the output is closer to 0.

4.1.4. Automobile Security

The information that Drivers can access internal vehicle data, including structural integrity, through On-Board Units as well as external details, such as Vehicle safety refers to lane detection and mode of transportation. This data aids in evaluating the vehicle's safety. The work done in this direction is covered in this section the results of Extreme Learning Convolution Neural Networks for Lane Recognition and Identification, a novel learning model. The traditional CNN needs a significant quantity of information and all that is needed to compute the network weights between the hidden layer and output using the Extreme Learning Machine (ELM) learning technique, significantly cutting down on learning time and producing accurate results. A framework for self-learning that blends CNN and ELM is suggested by the author. CNN can operate effectively even on limited datasets thanks to the coupled model. Between the convolution and sub sampling layers, a new layer is inserted in this suggested technique.

4.1.5. Exchange of Information

The most important component of the IT’S is communication. Effective vehicle-to-infrastructure communication is essential to all VANET applications, either directly or indirectly. A vast amount of data is produced by the VANET system for many uses, such as traffic detection, safety alarms, and traffic forecasting, and it must be evaluated appropriately. Because of the increased mobility of vehicular nodes, as the network evolves, maintaining this data becomes increasingly important often VANET all surrounding vehicular nodes that are involved must get urgent priority communications. An effective security framework that can quickly carry out authentication on a network with a dynamic topology is required in such an open-access setting. Therefore, in order to oversee the VANET's communication system's communication links and, consequently, coordination, appropriate procedures are needed. Malicious information can occasionally spread throughout a network due to malfunctions in nodes or RSUs Modern cars come equipped with onboard OBUs like mobile phones and sensors, which compromises communication. Furthermore, one of the hardest attacks to identify is radio frequency jamming. Even more difficult to identify are the vehicles' high mobility and the topology's smooth alterations as depict in figure 11. Machine learning approaches are helpful in preventing such scenarios and in providing the necessary services for the anomalous system behaviour. Routing is critical to vehicle and RSU communication. Because of the changeable topology of VANET, routing is a difficult issue. Because of the network's dynamic nature, a precise and quick routing decision must be made.

4.1.6. Information Management

The information flow within the VANET system is the subject of data control Because vehicular networks depend on reliable data distribution for several uses, including computing, data caching at nodes, and V2V and V2I communication, data control techniques keep an eye on channel utilisation. Following is a discussion of data controlling approaches. Broadcasting all nearby vehicle nodes receiving urgent priority messages that are involved is essential, VANET. An effective security framework that can quickly execute authentication on a network with a dynamic topology is required in such an open-access environment. For the purpose of managing the communication system in the VANET as well as the communication links, appropriate procedures are thus needed. It can occasionally happen that a node or RSU malfunction causes malicious information to spread throughout the network. Contemporary auto mobiles are equipped with built-in onboard communication units (OBUs), including sensors and cell phones. Additionally, one of the most difficult attacks to identify is radio frequency jamming. Detection becomes even more difficult due to high vehicle movement and seamless topological changes. Machine Learning techniques come in handy to prevent such to provide the required services for the unusual system behaviour in scenarios. Routing is critical for communication between RSUs and cars. Because of VANET's changing topology, routing is a challenging task. Due to the dynamic nature of the network, an accurate and timely routing decision is required. Controlling this data is essential to the effective operation of the VANET system because communication requires sending data across the channel. The VANET system's nodes communicate with one another, hence improper behaviour shouldn't exist in these nodes. Establishing a dependable connection with the Neighbours is also necessary for message transfers. Finally, there needs to be a best route for the data to take when moving from one location to another. As such, in the following subsections, we assessed the application of machine learning:

1. Information management
2. Misconduct detection
3. Administration of links
4. The route the communication-related scenarios that could occur in an actual traffic situation are depicted in Figure 12.

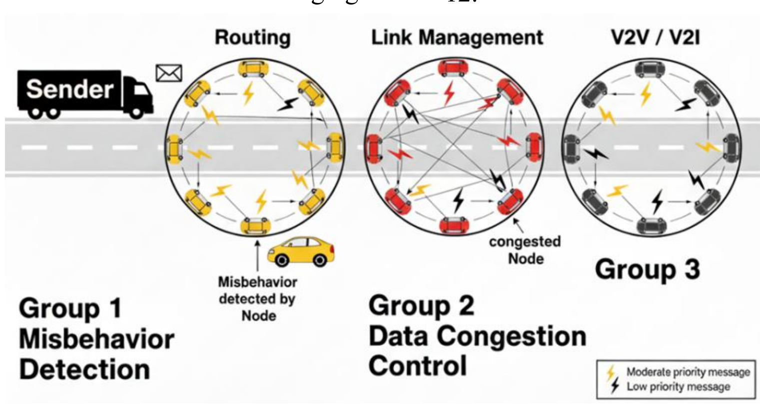

Figure 11 VANET Communication Scenario Illustrating Routing, Security Threats and Misbehaviour Detection for Reliable V2V/V2I Data Delivery Under Highly Dynamic Topology

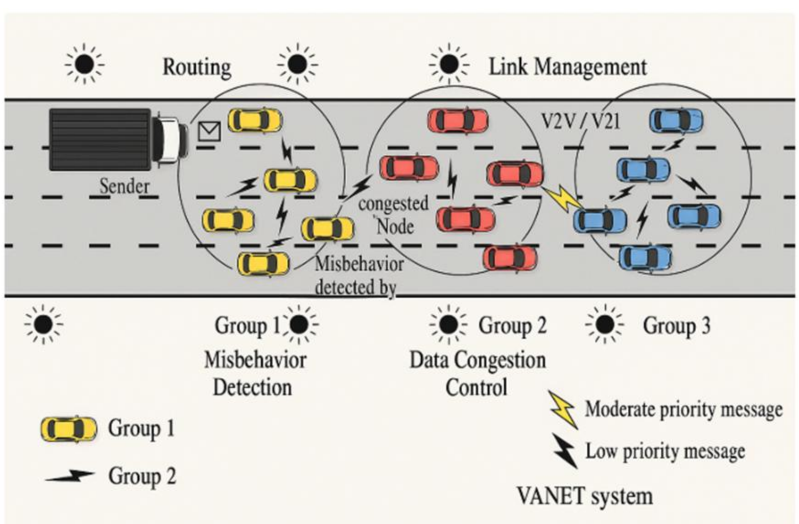

Figure 12 Interactions Within the VANET

4.1.7. Control of Data

The information flow within the VANET system is the subject of data control. Because vehicular networks depend on reliable data distribution for several uses, including computing, data caching at nodes, and V2V and V2I communication, data control techniques keep an eye on channel utilisation. Following is a discussion of data controlling approaches. Because there is a great deal of communication between the cars in the traffic, Machine Learning Congestion Control (ML-CC) can identify traffic congestion at any intersection with traffic signals. This method is typically used when there is heavy traffic. The three units make up the ML-CC method. The first device is a congestion detection unit, which uses channel utilisation measurements to identify congestion.

The second component is a data control system that collects and eliminates unnecessary messages before employing k-means clustering to sort the messages into the appropriate categories. Congestion control units, the third one, decide on communication parameters for each cluster based on the least amount of time needed to transfer messages. These parameters include contention window size, transmission range and rate, and AIFS. The RSU then transmits these parameters to the cars who are awaiting a traffic signal in order to lessen channel congestion. By increasing average throughput by 27.9% and PDR, the suggested approach decreased average latency and packet loss ratio. It is necessary to compute and cache these data efficiently in order to provide resources to the vehicles when they require them. A deep reinforcement learning method that gathers information from cars and RSUs the system states are then created, indicating the mobility and communication channel information of the vehicle as well as the RSUs' and cars' computer resources as well as the stored content.

4.1.8. Traffic Flow

The purpose of traffic control in the VANET network is to use auto mobiles as mobile nodes to gather various types of data, including route prediction, traffic density, and traffic congestion. The two primary fields that form at the centre of the Intelligent Transportation System (ITS) ought to be: I) examination of the data that the mobile nodes and RSUs collected; and ii) early notification of traffic conditions and the best routes to take to the driver. In addition to managing traffic, traffic management also includes processing high-priority requests from priority nodes, lane management, and crash prediction. Accident detection and traffic control are becoming more and more necessary in the VANET systemic uses photos as input to identify different traffic aspects for traffic management. A number of factors, including the kind of weather, broken traffic signals, collisions, vehicle types, vehicle speeds, and many more, can influence this flow. Additionally, there is extreme traffic congestion when the flow is disrupted. Traffic is constantly observed depending on the velocity of the moving vehicle together with the recognition and scheduling of traffic signals. As the traffic part is separated into the following four subsections based on all of these factors:

- Flow of traffic
- Gridlock in the Traffic
- Scheduled traffic
- Traffic monitoring

4.1.9. Movement of Traffic Flow

A number of factors, including the weather, accidents, unequal traffic distribution, and many more, can alter the flow of traffic as depict in figure 13. This element influences the flow of traffic, contributing to its uncertainty and making data collection challenging. Numerous published works have taken into consideration variables such as the type of vehicle, speed, volume, and density of traffic, as well as prior traffic flow and weather additionally efforts to address data and traffic unpredictability have been made. The forecasting of traffic flow is the primary emphasis of the works. Many efforts are made to improve the prediction's accuracy.

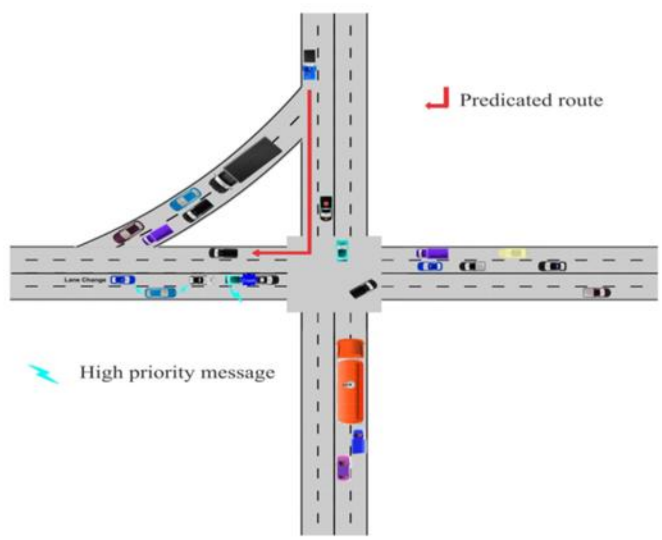

Figure 13 VANET Traffic Management

One model used to analyse the traffic flow was a Deep Belief Network (DBN) and meteorological variables were part of the methodology. The traffic flow prediction accuracy was improved by using the data fusion technique. The suggested model performed better than cutting-edge methods. Better traffic flow management techniques are ensured by the work. Two metrics are used to evaluate the model; the results are 0.05 for RMSE and 0.075 for MAE.

4.2. Implementation Problems and Challenges for VANET-Based Traffic Control Using Machine Learning Models and Techniques

The main issues of the Intelligent Transportation Systems are smooth traffic flow, minimal road safety, and the latency in communication between the vehicles and RSUs. Due to these factors, interest in the Vehicular Ad hoc Network (VANET) has come from a number of academic communities. Constant monitoring is necessary for these systems to function properly, which makes it possible to apply Large-scale data generated by multiple VANET applications using machine learning techniques (such as crowd sourcing, pollution control, environment monitoring, etc.). By using previously processed data, a machine learning approach enables the system to automatically learn and improve. Effectively implementing the goal of VANET, these algorithms enable both learning from the collected data, both supervised and unsupervised. We talked about how traffic, communication, and safety issues in VANET systems can be resolved using machine learning methods, as well as the impracticality of their implementation. We also looked at an example of a VANET- based case study situation and future directions and problems.

Intelligent mobility is becoming more and more necessary as smart cities come into being. Among the key features of a smart city are monitoring and controlling traffic flow. The notion that Intelligent Transportation Systems (ITS) was inspired by the rise in traffic congestion incidents and the ineffectiveness of wireless communication systems for traffic management. Road safety, traffic congestion reduction, and economical infrastructure use are some of the main ITS goals that can be accomplished via VANET. Cars with on-board units fall under the VANET field. Like GPS and mobile phone sensors, as well as additional wireless gadgets to enable communication between vehicles and people, is seeing a rise in demand for study [56].

Due to their great degree of mobility, the vehicles in VANET might cause communication breakdowns, network congestion, and unstable connections among its components. For communication in VANETs to be robust and scalable, authentication mechanisms need to have minimal computational overhead. The decision-making and authenticity of V2X receivers are impacted by rogue nodes or links. These days, VANET also understands Software Defined Networking (SDN) on 5G networks, which calls for effective routing protocols. Traffic management in vehicular networks has become a serious a difficulty as a result of the sharp rise in the number of cars. Roadside units (RSU) and auto mobiles can effectively communicate with one another thanks to VANET. Smartphone's have emerged as a benefit in one way or another within this technologically advanced era. Most issues related this can be used with other technologies like GPS, Internet of Things (IoT), Cloud Computing, and Global Navigation Satellite System (GNSS) to solve issues related to traffic management, safety, routing, and communication with a single touch of the screen. A number of scenarios are visually displayed, such as the frequency of collisions, mobile node communication, the passing of cars with high priority, and RSU data congestion. Massive amounts of data are produced by all these occurrences, which can be fully utilised for additional data analytics and forecasting.

4.3. Automated Road Anomaly Detection and Classification in VANET Using Edge AI-Based Deep Learning Approach

Defects for a safe and effective flow of traffic, the road surface is crucial. A growing number of abnormalities in the road surface are caused by heavy vehicles, high traffic volumes, poor construction material quality, and changing climate conditions. To protect Finding and fixing these flaws is necessary to protect drivers, passengers, and auto mobiles from mechanical problems Nowadays, the development of deep learning (DNN) methods has allowed autonomous are active study area that operate without human intervention thanks to in-vehicle sensors. When it comes to detecting pathways and obstructions to easy access, unmanned vehicles can benefit from a combination of sensors and DNN algorithms. This is because artificial intelligence is being deployed in vehicles. Avoiding severe road faults that could result in deadly scenarios is one of the main issues facing autonomous cars.

The concept of a vehicular network, or vehicular ad hoc network (VANET), was created by the Intelligent Transportation System (ITS) to achieve security and safety in a traffic flow in order to address problem with accidents and exchange emergency updates. A unique It is demonstrated how autonomous cars may automatically identify anomalies in the road and notify approaching vehicles about them using an Edge AI and VANET-based technique decreasing the frequency of accidents and the risk of dangers on badly maintained roads may be possible with the use of camera-captured road photos and a vehicle that has been trained to detect road anomalies.

The methodologies employed include Residual Convolution Neural Network (ResNet-18) and Visual Geometry Group (VGG-11) with datasets from various internet sources for the automatic separation of normal roads from abnormal ones, such as those with potholes, bumps, and cracks. The results show that the models used performed better at detecting anomalies in the road than other approaches.

4.4. AI/ML/DL in VANET's Upcoming Paths

Several investigations have been carried out in various VANET subfields, as illustrated in figure 14. It draws

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attention to the proportion of research statistics conducted under various VANET sub-domains. It is noted that connection management, the protection of travellers, and the safety of extensively studied in research efforts, which mostly concentrate regarding vehicular node traffic management and congestion alleviation.

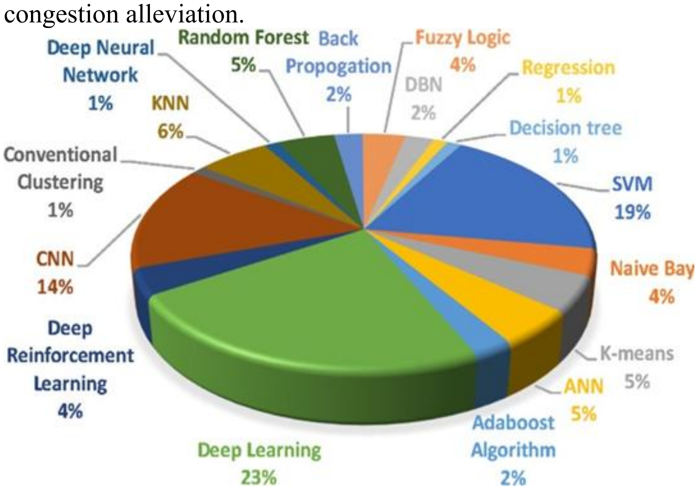

Figure 14 Utilisation Data for Machine Learning Methods in VANET

The most commonly used algorithms are those for learning. For the majority of VANET applications, these techniques proven to be effective only a single algorithm can be utilised; it is not required for any given application. One can choose which methods to utilise for specific applications by practising the implementation of various algorithms. Different features aid in choosing the best machine learning algorithm for a certain VANET application [57].

4.5. The Following Discusses the Future Directions for Several VANET Sectors

- Safety: In terms of safety, the areas where significant current work is being done are lane detection, driving abilities, anticipating collisions, identifying objects, predicting accident risk, and driver fatigue. The challenge here is in adding more road condition, spatio-temporal, and weather forecast data to the current data collection. To improve prediction, the second step is to use machine learning (ML) to error analysis on such a large-scale data collection. In the smart drive vehicular network, future research aims to determine the safest and best route for self-driving cars.
- Communication: The main areas of interest here are packet routing, V2X link duration, malicious node detection, and channel congestion. The emphasis in the future will be on enhancing the routing mechanism's computational complexity and scalability. The difficulty here is to incorporate various physical layer features, channel noise, and the propagation model into the current models.
- Traffic: To enhance both short-incorporating complex scenarios with several intersections and building a virtual network are the challenges faced by the traffic domain in ITS and long-term traffic forecasts. The integration of features such as GPS data and traffic signs is the focus of future study. It will improve the accuracy of traffic flow forecast and congestion detection.
- The purpose of advanced driver assistance systems: ADAS is to help drivers by combining data from a number of sensors linked to the Electronic Control Unit (ECU) of the vehicle with other in-car technology. The engine control unit (ECU) is an embedded device in a vehicle that keeps track of and reports on each component's performance. Additional ADAS options include laser scanners and stereo vision camera sensors.
- The system can better comprehend the surrounding area and its impediments (vehicles, pedestrians, etc.) with the aid of these sensors. Vehicle operations can be efficiently automated by calibrating the arrangement of frames and cluster points gathered by laser scanners and camera sensors. Conventional ADAS rely on thresholds and might forecast a driver's decision or response inaccurately. Data generated by the vehicle's sensors is used by the machine learning-based ADAS to provide more precise driver-specific responses. By adding the surrounding environment of the vehicle to the data from several onboard sensors, ADAS can control the driver's evaluation following a lane shift. That can assist in determining the intention of the driver to change lanes. Additionally, the technology can assist the driver in keeping the car in the middle of the lane to prevent a potential collision with a car that is in a blind spot. Along with helping drivers avoid traffic jams and choose the best route, ADAS can also be coupled with programs that estimate traffic and plan routes optimally, saving time and energy during commutes. We offer insights into the integration of machine learning techniques to optimise VANET performance. The survey is examined from several aspects, such as safety, communication, and traffic as the convergence of machine learning in VANET has been thoroughly examined. The analysis of the merging of machine learning and VANET is predicated on the advancements and improvements in vehicular networks that transpire annually.

The aforementioned results demonstrate that there is a great deal of room for evaluation of machine learning in VANET because of its exceptional performance in a number of AI-related fields.

Lastly, we have talked about the path that the future will go, as well as some unresolved issues and places that still need more focus as illustrated in figure 15.

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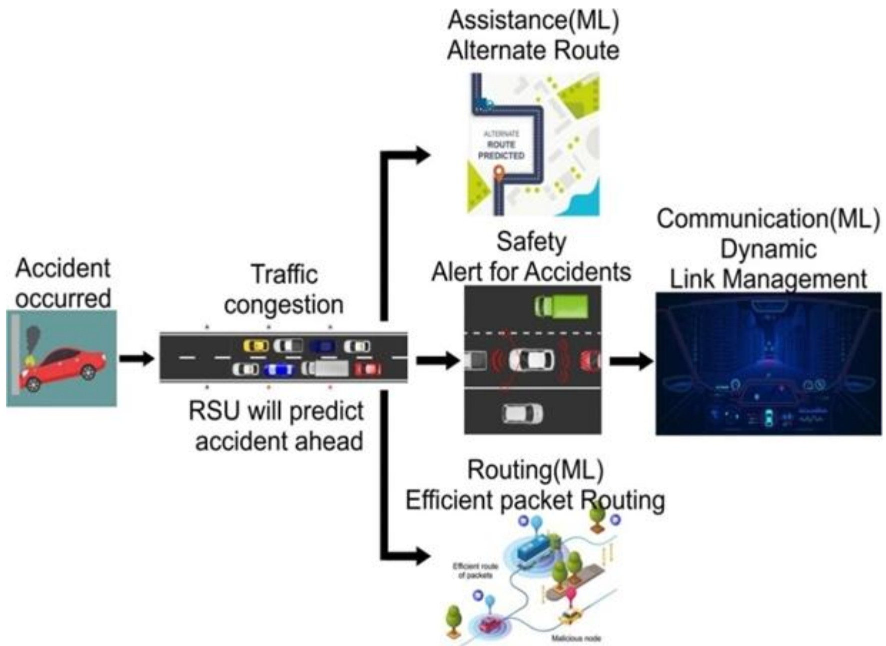

Figure 15 Process Flow of Applications Based on VANETs

5. MULTI-LAYER ISSUES AND FIXES IN VANET

Dedicated Short Range Communication (DSRC) supports the Vehicle to Vehicle (V2V) and Vehicle to Infrastructure (V2I) communications protocols technology, which operates in the U.S. Standard 5.9 GHz band. The IEEE 1609 series of standards define the Wireless Access in Vehicular Environment (WAVE), while the IEEE 802.11p standard defines the Physical (PHY) and Medium Access Control (MAC) Layers, which is a set of security and communication specifications for vehicular area networks (VANETs). Numerous studies have been conducted on a range of VANET difficulties, including multichannel operation, routing, security, and spectrum utilisation. All of these efforts are directed on enhancing network performance and supporting VANET scalability, which is the network's capacity to accommodate the addition of vehicles (nodes) without experiencing appreciable administrative burden or performance degradation.

Our goal in this paper is to draw attention to multilayer issues related to VANET performance, along with previously suggested remedies and potential areas of future research. The amount of an enormous rise in roadside accidents has been caused by traffic on highways and in urban areas. By providing on-demand entertainment options, vehicle communication was developed to increase safety and enhance the traveller's experience, hence preventing accidents and ensuring a dependable driving experience in order to meet user needs for WiFi- based applications for both safety and non-safety standards like DSRC were established while research is being done on LTE- based vehicular networks to address the inadequacies of the DSRC in the future. The DSRC performs better overall because of the problems that each Layer faces when a lot of cars are on the network, congestion can seriously impair performance, which mostly impacts safety applications. Several research initiatives have recently focused on improving the network's Quality of Service (QoS) parameters and tackling the scalability issue in order to enable the reliability and scalability for V2V safety communications.

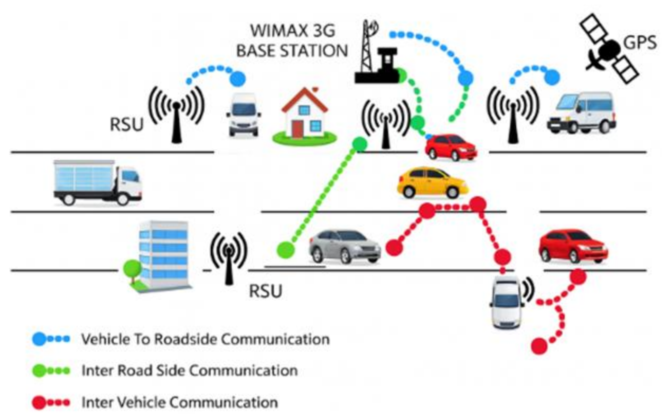

Figure 16 the Dedicated Short Range Communication Architecture (DSRC) V2I: Vehicle to Infrastructure and Roadside Units (RSUs)

In figure 16, the DSRC infrastructure is represented by the cars equipped with On Board Units (OBUs). To exchange messages and applications, the OBUs communicate with the

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Road Side Units (RSUs). Finally, the RSUs are linked to the internet cloud through the external network. Interaction between RSUs and OBUs occurs via V2I communication for providing the infotainment apps, weather reports, and other online services. The exchange of safety messages between the cars using V2V communication helps prevent accidents [58].

5.1. The Physical Layer

The physical layer of the DSRC consists of the 802.11p OFDM, which has a 10 MHz wide channel in the WAVE and runs in the 5.9 GHz range (5.885–5.905). A basic data rate of about 3 Mbps is used, while the default data rate is 6 Mbps. The Physical Layer of VANETs has been extensively studied channel estimate, channel selection, and control of transmission power, among other things. The restrictions placed on the network's scalability are caused by a variety of physical layer factors. Because of the mobility and multi-path delay dispersion, communication in a multi-path environment is extremely demanding. Mobility is the cause of time selective fading, whereas delay spread is the reason of frequency selective fading. Highways exhibit a higher Doppler spread, and non-line of sight (NLOS) situations lead to a significant spread slowly after being dispersed. There are two distinct challenges caused by the inaccurate channel estimation and the lack of time-interleaving. The Physical Layer in VANETs has the following challenges:

- Radios, both single and dual: There is currently uncertainty over the cohabitation of single and dual radio. Even though dual radios have certain clear benefits, adding a second radio when there are already single radios does not enhance under the standard procedure, safety communication.
- The Propagation Model: Cities, highways, and rural areas are the three environments in which VANETs function. Since the signal experiences reflections from for highways, the free space model, which is usually used, is not very realistic in relation to its surroundings. The several obstacles that generate multipath fading and shadowing in cities prevent free space from being used to simulate cities. Hills and trees are two elements of the rural environment that can reflect light well. Thus, these surroundings should be taken into account in the propagation model.
- Channel Selection: The Channel Selection at the Physical layer requires an analytical and simulation research. There is discussion of a game theoretic method in for determining the optimal channel and data rate. Advanced channel estimate algorithms are necessary in VANETs to obtain accurate Channel State Information (CSI).
- Diversity strategies: It is possible to reduce the impacts of interference and fading by using a variety of diversity strategies. Numerous transmission characteristics, including such as coding rate, transmission power modulation techniques, message size, frequency, and all have an effect on communication. Evaluation of channel load and transmission power is essential. By employing variety strategies, the impact of fading can be minimised. By using many antennas, the bit error rate (BER) can be increased [59].

5.2. MAC Layer

A key component of equitable channel access is the MAC protocol. One crucial element influencing VANETs' scalability is the MAC protocol; hence creating a MAC protocol that is dependable and effective is crucial. Under WAVE technology, IEEE 802.11p MAC and 1609 are now the MAC standards for car communications. Several Channels of Operation most of the recent research focuses on effectively using the EDCA Mechanism's multiple channels and performance modelling to create an analytical model that can be used to analyse the behaviour of the MAC Layer. When creating the MAC Protocol for VANETs, the following considerations should be made:

- Bandwidth Limitation: One factor contributing to the rise in Control Overhead is the VANETs' frequently and quickly changing topology. When creating a MAC protocol for VANETs, one should consider the bandwidth constraint.
- Analytical Study of the MAC Layer: Building an effective protocol to meet performance-related goals requires a thorough understanding of the MAC Layer's characteristics. The stochastic modelling has been applied to many projects. A variety of requirements must be met for the performance modelling and analysis, including the mobility of the nodes, computational complexity, back off counter freezing, number of access categories, internal/external collisions, and saturated/unsaturated situations. The transmission and collision probabilities can be calculated with the use of Markov Chains. The outcome of the simulation and it is possible to compare the analytical model. The behaviour of MAC will become comprehensible with an appropriate model. At the moment, Enhancing Distributed Channel Access (EDCA) in IEEE 802.11p has been the subject of the majority of analytical modelling.
- The Contingency Window (CW) Dynamic Adjustment: If a VANET node is equipped with the capability to ascertain whether the network is congested based on the sequence of packets it successfully receives, and with the help of those packets, it ought to be able to adjust the CW size accordingly. Numerous techniques with improved reception rates that have been demonstrated through simulation have been put forth in the literature and

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employed in the Congestion Control and Dynamic Adjustment of CW which is the default method used in CSMA/CA to prevent congestion, is directly linked to this CW modification.

- Congestion Control: By modifying the MAC layer as a channel detecting method and using the Physical layer settings, the Decentralised Congestion Control (DCC) can function as a Cross Layer Approach. There are many methods for MANET congestion control, however because VANETs are dynamic networks, they are not as well suited for them High throughput is offered by congestion control methods (it is noteworthy to mention that a portion of bandwidth should be reserved for urgent safety messages, for example, maintain the channel load below a given threshold.
- Algorithms for Congestion Control Fall into Two Primary Categories: proactive and reactive currently being studied, however, is the third kind, referred to as hybrid algorithms. Fairness is a crucial component in the design of congestion control algorithms, meaning that nearby vehicles should cooperate to reduce congestion. The message rate adjustment and transmission power modification are the main priorities of the congestion control algorithms. These algorithms will be covered in the next section.
- Synchronisation: VANETs use centralised synchronisation techniques. For the purpose of synchronisation, Universal Time Coordinating or UTC is now utilised. When a system-wide failure occurs, which could cause the Global Clock to become unavailable, distributed synchronisation techniques are required in addition to centralised synchronisation amongst nodes to coordinate.
- Effective Utilisation of Several Channels: Multi-channel operation was first introduced in IEEE 1609.4. Currently, there are seven channels total, which include the service channel (SCH) and the control channel (CCH). The service channel handles non-safety applications, while the control channel handles communications related to security. Likewise, is one control channel and one service during a synchronisation interval, or sync interval.

5.3. The Layer Regarding Routing

Routing has a significant effect on a network's overall performance. Using the shortest and least crowded path possible, the optimal routing protocol distributes the data over a number of hops. Because frequent influx and emigration of nodes, an unstable topology, and dedicated paths are occasionally unavailable, VANETs require careful analysis of the network's state before forwarding data. The performance of the network is limited by the traditional routing algorithms because they are not appropriate for vehicle communication. When routing decisions are made solely on the basis of information accessible in the immediate vicinity, the protocol should be able to carry out localised operations. Because the entire network topology is no longer required of the node, control overhead is decreased.

5.4. The Issues with the Routing Layer Include:

- The handling of route data.
- Network portability.
- Variable network density.
- The following characteristics of the optimal routing protocol for VANETs should be present:
- Discovering the Neighbourhood.
- The ability to forward data.
- Geographical Data.
- Predict the position of automobiles in the future. Take into account the different car densities

5.5. Multiple-Layer Difficulties with VANET Systems

The difficulties with the Physical (PHY) and MAC Layers, Multi-Channel Operations in IEEE 1609.4, the behaviour of Carrier Sense Multiple Access (CSMA) in high node densities, and potential congestion control solutions are all thoroughly addressed Some findings from the simulation have been presented along with the performance using Single and Multiple Radios. The article also discusses how the DSRC has changed over time from the viewpoints of the MAC Layer and PHY. It provides an overview of the WAVE Stack, the Multi-Channel Operation; issues and fixes, a few unresolved concerns, and employs both the Multiple Radios and the Single Radios approaches to explain the subject. Comparing the Multiple Access Self-opinionated Time Division System (STDMA) to CSMA, positive outcomes have been observed in terms of reliability and scalability when familiar with the VANETs' scalability issue. The analysis, trends, and popular research questions in VANETs are provided in the different underlying difficulties with VANETs are also presented in this work in a tiered manner. However, only the Application, Security, and Routing Layers have been the focus of the development. In, arguably the most thorough performance analysis of V2V communication was carried out. The author has demonstrated repeatedly that STDMA works better than CSMA in high density networks through thorough study and simulation scenarios. We conducted a review of the variables limiting VANET performance in this work. The limitations of various protocols and the difficulties in constructing them had been covered using a multi-layered approach. Future research opportunities in the field of VANETs are made possible by the compilation of the presently in use protocols with new protocols and a comparison that was made. Congestion

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control algorithms and cross-layer design are two popular feedback strategies these days. The effective use of bandwidth will be ensured by spectrum sensing methods such as Cognitive Radios. Research is also being done on Software Defined Networks to see whether they could be a part of future VANETs. Connectivity of Vehicles (IoV) and Vehicular Clouds (VC), two new VANET technologies, will provide the architecture of the VANET with structural support. Additionally, as LTE-D2D technology advances, vehicular connectivity is changing to conform to cellular communication standards, opening up new research opportunities.

6. SIMULATION OF VANETS

The number of auto mobiles on the road has increased recently. Road accidents and other possible risks are rising as a result of the high vehicle density. By communicating with one another, wireless technology seeks to outfit auto mobiles with equipment that lowers these parameters. Before being used in the actual world, the application for vehicle safety should be properly evaluated. Because it is inexpensive, straight forward, and simple to use, simulator tools have been chosen over outdoor experiments. For the purpose of this test, VANET demands that a traffic and network simulator be utilised in tandem. There are numerous tools available for this purpose however the majority of them struggle with adequate interaction.

6.1. Simulator Types in VANET

VANET deployment and testing need a lot of money and manpower before real implementation, simulation is a valuable and less expensive alternative. The intricacies of the VANET infrastructure make it difficult to build accurate models which are necessary for good results from VANET simulation for example, the movement patterns and communication protocols need to be simulated by the simulators. In this section, we describe the mobility and network components that serve as the foundation for the majority of the existing VANET simulators.

6.1.1. Simulators for Mobility

A mobility model that accurately represents how cars actually behave in traffic is essential for any simulation study on VANETs. The primary purpose of mobility simulators is simulating how a vehicle would move along a certain path. We differentiate between descriptions of macro-mobility and micro-mobility while working with vehicle mobility models. All of the macroscopic factors that affect vehicle traffic, such as the number of lanes, speed limits, road layout, car movement restrictions, safety regulations, and traffic signs that specify cross-road crossing laws must be considered by simulators in order to achieve macro-mobility. Conversely, micro-mobility describes how each motorist acts on the road, whether it is with other drivers or the infrastructure. This includes their general driving attitude, how they accelerate, decelerate, and pass other vehicles, how they behave at intersections and when there are traffic signs, and how fast they drive given their age, gender, or mood.

6.1.2. Simulators for Networks

A network simulator simulates the message exchange between connected nodes. Typically, a VANET consists of use wireless communications primarily in auto mobiles and RSUs. Eventually, the simulation will also include other relevant metrics (such packet error rates and the signal to noise ratio). Ideally, every component of the communication system, including the whole protocol stack, needs to be represented. The network model describes events as well as the network's individual components. Nodes, switches, routers, and links are examples of components. Events in their turn include data transmissions and packet errors. Generally, the results of a network simulator comprise device, link, and network level quantitative measures for a particular simulated situation. Trace data were previously accessible as well. These files can be processed for additional analysis and provide a record of every simulation occurrence. The majority of current network simulators rely on discrete-event simulation. Using this method, each simulation step proceeds sequentially through a list of "pending events" that have been stored. Certain incidents might lead to others. For instance, a packet may start to arrive at a node and cause another packet to be sent. Network simulators such as OMNeT++, OPNET, JiST/SWANS, NS3, and NS are available and some of them are commonly used in VANETs.

6.1.3. NETSIM

A commercial discrete event simulator, NetSim supports a wide variety of networks, including wired, wireless, mobile, and sensor. Three different license options are available for the simulator: pro, standard, and academic. VANET simulations are supported by only the first two. Netsim communicates with SUMO in order to simulate VANETs. While the latter is in charge of modelling road traffic conditions, the former manages the WAVE standard for wireless communication between vehicles. NetSim provides a range of network performance metrics, including link and application throughput graphs. The metrics used will change based on the kind of network that is simulated. Users are able to record every packet's detail as it travels through the network by using packet trace and event trace as illustrated in figure 17.

Figure 17 shows the NetSim architecture in a more reduced format. Each type of network has a corresponding communication protocol and is connected to a specific area within the simulator. A respectable amount of components and the ability to link actual hardware with active applications to the simulation are offered by Netsim. Among the modules of Netsim VANET, RF Propagation Models is one that should be noted. In order to forecast the signal loss or fade, this module has the Path Loss in it Shadowing for the purpose of forecasting signal encounters or loss over distance in buildings, the Path Loss, Shadowing, and Fading models are all essential and other highly populated locations. Similar to a real environment, VANET probably to encounter numerous impediments (such as buildings and high traffic) for signal communication, this module helps to make the simulation more realistic. As new technologies emerge, Netsim's architecture permits the addition of additional components to suit user requirements.

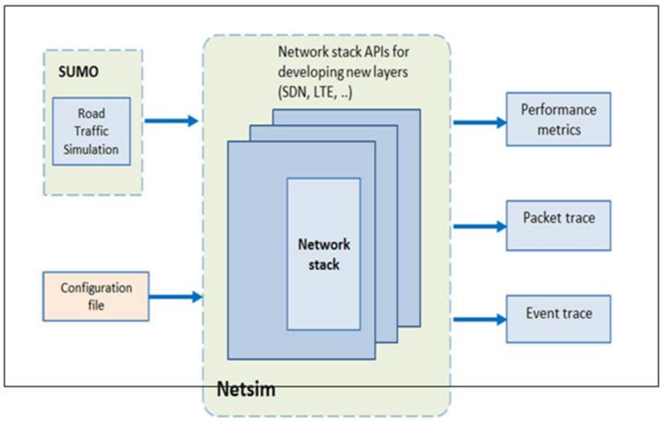

Figure 17 NETSIM Simulation

6.1.4. VANETSIM

The event-driven simulator VANET sim was created specially to examine privacy and security concerns related to vehicle communications. From an application standpoint, it enables the analysis of attacks and countermeasures. For example, an attack can be created and its effect measured on various vehicle kinds. As illustrated in figure 18, the four primary parts of the VANET sim architecture are the Graphical User Interface (GUI), the Post Processing Engine, the Scenario Creator, and the Simulation Core. Road map creation and modification are made possible using the GUI's graphical map editor. Either create your own maps or import ones from Open Street Map. Editing and saving imported maps as XML files is possible which makes it easier for them to work with other programs as illustrated in figure 18. VANET MobiSim the goal of including features that enable real-time interaction (i.e., while the simulator is running) will make the VANET sim interface more user-friendly. It can also show the transmission range of the car, which is an adjustable feature will users can create a series of experiments with the Scenario Author and store their settings in XML documents. Considering that configurations could share online, this capability makes experiments easier to repeat. The simulation is actually run by the Simulation Core. In addition to backbone of the network and each and every module for security and privacy it coordinates traffic map operations. Ultimately, created logs are processed by the Post Processing Engine to provide pertinent metrics and events (such as compromised pseudonyms following an attack). A few pre-configured security and privacy modules that incorporate ideas like Mix Zones and silence periods are included with VANET sim. Vehicles use the A algorithm to route themselves to individually determined destinations. When vehicles communicate with each other, two types of messages can be sent: special-purpose messages that are sent whenever a relevant event occurs (like the approach of an emergency vehicle) or beacons that broadcast regular information (like position and speed). The VANET sim project was shut down in April 2017. But even with the tool's discontinuous updates, the simulator website continues to offer its documentation, downloadable materials, and an extremely user-friendly tutorial on how to operate the simulator. The Windows operating system supports VANET sim.

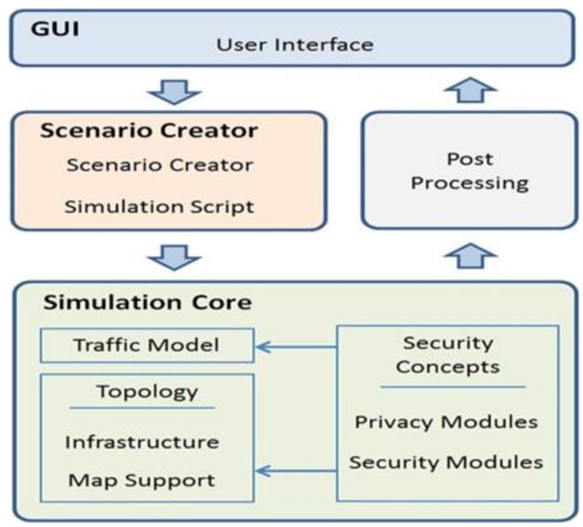

Figure 18 VANET SIM Platform Architecture

6.2. Evaluation of Simulators

Using a simulation to assess the network's performance is the most effective method. It is possible for a sound simulation to yield remarkably realistic outcomes. Building a simulation appears to be necessary for VANET, therefore. There are two parts: network simulation and traffic simulation of VANET simulation. Traces of an urban mobility model are created with the help of the traffic simulation and input into the network simulation. Topologies between the nodes and vice versa are created by the network simulation. It appears that there is no direct connection between the two, which is surprising. It's as if two individuals are conversing in two different languages and are unable to comprehend one another. There are several VANET simulations available, but none of them are very good and none of them can offer a comprehensive solution set for simulating VANET. As seen

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through the lens of a traffic simulator, the traces created initially appear pointless after a while due to sudden changes in traffic dynamics. The inter-communication difficulty between the two simulators, the traffic and network simulators is another issue that is still hard to resolve. The two's ability to communicate with one other is still up for debate in the absence of a firm answer to this issue. The reason these two simulators cannot communicate with each other is still a mystery. Obviously, the format mismatch is the main culprit. The traffic simulator generates mobility models that the network simulator is unable to process. The network simulators do not accept the format that traffic simulators generate when they construct mobility models. The closest network contender is the discrete event simulator NS-2 that can receive trace files from other simulators but not directly feed them into it. The researchers' first attempt to address this compatibility issue was to keep working on traffic simulators, but network simulators were where the issue consistently surfaced. Numerous simulators are available to get the data needed for simulation. A portion of them are freeware, and some are covered by commercial licenses. Numerous The commercial traffic level simulators, VASIM, CORSIM and AIMSUN are strong commercial traffic simulators designed to collect features necessary for traffic level and with robust GUI support. For these commercial software programs, the starting price for a single license is $9,000 USD. For copyright reasons, and mainly because they can't modify their source code, this thesis doesn't address traffic simulators that are licensed for commercial use. Furthermore, they were created to produce extremely high levels of information at the traffic level, something that network simulators are not yet meant to employ. These software products do not meet our needs since the traffic simulator's generated traces cannot be translated by the network simulator for additional usage, and because copy rights are involved. Presented is a thorough analysis of these simulators [60].

6.3. Problem with VANET Simulation

Conducting an outside experiment is the first step towards evaluating VANET protocols and services. Numerous wireless methods have been proposed for dependable traffic information, including IEEE 802.11p, IEEE 802.16, and GPRS. A number of tests should be conducted on the technology before it is implemented and able to live up to expectations. These experiments have the potential to be exceedingly difficult and costly to inherit various situations. Software simulations can be quite helpful in simulating real-world events for this reason. For VANET to operate smoothly, two further simulations—traffic simulation and network simulation—are necessary and connected to it. Network simulators are employed to assess network applications and protocols under diverse circumstances. For traffic engineering and transportation, traffic simulators are utilized. These simulators operate separately, but in order to meet VANET's requirements, a way to use them in tandem must be found. The issues of VANET have been attempted to be addressed by a number of traffic and network simulations; nevertheless, each method has its limitations. A VANET simulator requires the usage of numerous traffic and network simulators, both of which are widely available. A small number of tools exist for simulating VANETs, although most of them struggle with appropriate "interaction." Therefore, choosing a simulator appropriately is another issue for simulation. Consequently, we will discuss the current tools and recommend the option with appropriate "interaction."

6.4. VANET's Characteristics

- A vehicle acts as a transceiver, sending and receiving data simultaneously to create a highly dynamic network that is constantly changing.
- Vehicles and roadside units are the nodes within a VANET.
- These Nodes are extremely fast-moving.
- Motion patterns are restricted by road topology.
- Vehicular density varies periodically; for example, it may increase during morning rush hour and decrease at night.

6.5. Functions for VANET Privacy, Safety and Security

VANET simulations must not only simulate new technologies but also test safety, security, and privacy concerns in vehicle networks along with corresponding countermeasures. In this section, we look at the roles they play in reaching each of these goals.

Safety: Enhancing road safety is among the main factors guiding the development of VANET Since this, a lot of work has gone into developing high-performance apps that use linked cars to communicate safety messages (such collision prevention and hazardous spot recognition).Fault tolerance measures, such as information redundancy and heartbeats, must be used in conjunction with VANETs to ensure that they meet the strict dependability criteria necessary to offer their vital services reliably. We begin this section by examining the support provided by the current VANET simulators for testing VANET safety methodologies and applications related to road safety. Although their critiques mostly centre on VANET safety and dependability issues rather than the simulator itself, we base our commentary on their review's safety of traffic on roads. Through the sharing of vehicle and traffic condition data (such as position, speed, and direction) as well as beacon data (such as accidents, traffic congestion, and aquaplaning), VANETs can improve road protection. In this case, understanding safety warnings is crucial to avert accidents. But when numerous vehicles miscommunication safety alerts and packet transmissions, crashes may result. In order to address this specific problem, the paper suggests A New

Section predicated on disseminating safety alerts within the Cluster (NSSC). Cluster formation, collision avoidance, and disseminating safety messages are essentially are three sequential operations that are combined in the VANET simulator.

7. PRIVACY AND SECURITY

The speed and security of message transmission, or the security of the exchanged communications, greatly influences VANET security. This means that no malevolent party may alter or intercept the messages that are exchanged. Simulators can be used should continue looking at security flaws in order to find viable solutions without putting human lives in danger, even though they cannot resolve any of these problems on their own. Different security mechanisms and how they relate to the experimentally studied VANET simulators. In the table, you can see which security service these mechanisms belong to and whether VANET simulators are included can incorporate them into their simulation. Our discussion is based on the publications in which common security and privacy concerns in VANETs are reported. Rather, every communication has a binary attribute designating if it is "encrypted" or not" The cryptographic primitives that are "employed" by adversaries are assumed to be unbreakable by VANET sim Honor guarantees that no unapproved third party can change the data that is exchanged within a VANET. Digital signatures and message authentication codes, which thwart attacks like message tampering, forging, or replay, are typically linked to this service. Veins, VENTOS, and Eclipse MOSAIC are comparable to secrecy as shown in table 5.

Table 5 Overall Summary of AI + VANET Contributions in Automotive Sector

Category	Key Focus	What the Paper Explains	Benefits / Outcomes
AI in Automotive Industry	Automation, ADAS, Autonomous Driving	AI-based driver assistance, autonomous navigation, predictive maintenance	Safety ↑, Errors ↓, Efficiency ↑
Manufacturing & Production	AI-driven robotics & quality control	Real-time inspection, assembly automation, predictive maintenance in production lines	Cost reduction, High precision, Faster production
AI for User Experience	Driver monitoring & personalisation	Emotion detection, fatigue detection, infotainment personalisation	Safer driving, Smart cabin experience
VANET Overview	Vehicle-to-Vehicle & Vehicle-to-Infrastructure Communication	Applications: safety, commercial, convenience, productive uses	Better road safety, effective alerts, connected mobility
VANET Routing Protocols	Topology-based, Position-based, Cluster-based	Detailed analysis of AODV, DSR, GPSR, LAR, Cluster routing, Broadcast routing	Improved packet delivery, Low latency, optimized path selection
Security in VANET	Authentication, Privacy, Attacks	False alerts, ID disclosure, DoS, attacker models	Secure communication, trusted data exchange
Machine Learning in VANET	CNN, ANN, SVM, k-NN	Traffic prediction, collision warning, congestion control, driver behaviour analysis	Higher accuracy, smarter traffic flow, reduced congestion
Generative AI in Automotive	AI-driven design, simulation, NeRF, text-to-image	Rapid concept design, autonomous systems simulation	Faster design cycle, innovation in automotive R&D
Overall Impact	Combined AI + VANET + ML ecosystem	Integrated intelligent transportation system	Smarter, safer, more efficient mobility ecosystem

8. CONCLUSION

This paper has shown that together with Vehicular Ad-hoc Networks (VANETs) and the Internet of Things (IoT), Artificial Intelligence (AI) is radically changing the automotive industry. Artificial intelligence technologies (AI) including machine learning, computer vision, predictive

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analytics, and robotics have allowed automation, safety improvements, and custom user experience in vehicles. Simultaneously, VANETs offer the necessary communication infrastructure that enables the vehicle to communicate with one another (V2V), with infrastructure (V2I), and with the larger intelligent transportation systems (ITS). The study indicates that AI applications go beyond autonomous driving to include predictive maintenance, automated traffic control, real-time safety alerts, customised infotainments and streamlined supply chain processes. VANET applications like cooperative collision warning, post-crash notification, real-time traffic updates, and commercial services only reflect the scope of opportunities linked to safety-oriented and user-oriented solutions. The Chi-square test carried out in this work proved the hypothesis that AI and IoT applications have a quantifiable positive impact on efficiency, safety, and customer satisfaction in comparison to traditional systems. However, the difficulties are not removed. The challenges of network latency, security vulnerabilities, data privacy, scalability, and standardisation continue to restrict the ability to adopt VANETs and AI-based solutions on a large scale. Further, it can be stated that the alteration of algorithmic behaviour depending on the urban and highway contexts suggests that routing and communication must be dynamic and situational. To overcome these challenges, more work needs to be done on powerful protocols, safe architecture and new mobility models despite such restrictions, the advantages that may be achieved are radical. VANETs with AI will help decrease human error, avoid accidents, simplify the process of traffic flow, and enhance the overall driving experience. Moreover, the implementation of new technologies like 5G, generative AI, or edge computing will speed up the creation of completely autonomous, connected, and intelligent mobility ecosystems. To sum up, AI and VANETs are the new era in the automotive industry. They are creating safer roads, efficient transportation networks, and highly customised mobility solutions through the combination of smart decision-making and live vehicle communication. Researcher-manufacturer-policymaker collaboration will be crucial in the future to address these challenges and ensure that AI-driven automotive innovations are safe, dependable, and sustainable enough to benefit future generations as the industry progresses. The survey of new automotive applications, from entertainment to transactions, was done in this article. All of these applications were tested using the many this document describes the various simulation tools for VANET simulations. VANET researchers will find the taxonomy of applications interesting in the future as they create apps that enhance user comfort.

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