Enhancing Transportation Efficiency: Integrating VANETs into Intelligent Transport Management Systems (ITS)

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ABSTRACT

Modern transport systems face many challenges, and Intelligent Transport Systems (ITS) have emerged as a promising solution that aims to increase sustainability, efficiency, and safety. Among the various ITS technologies, Vehicular Ad Hoc Networks (VANETs) are essential for enabling communication and coordination between vehicles, infrastructure, and other elements of the transportation ecosystem.. It looks at the underlying ideas behind VANETs, such as network architectures, communication protocols, and security mechanisms. The study looks at the various ways that VANETs are used in ITS, including traffic management, collision avoidance, intelligent routing, and emergency services, by applying various emerging technologies. This article provides an analysis of the current security landscape in Intelligent Transportation Systems and VANET with a focus on integrating different routing protocols and algorithms. It examines the potential security threats and challenges faced by ITS and VANET, including attacks on V2V and V2I communications, privacy breaches, and data integrity issues. The survey investigates the role of routing protocols and algorithms in addressing these security concerns and improving overall security in ITS and VANET. It evaluates the strengths and limitations of various protocols, considering factors like scalability, adaptability, and resilience to security threats. The article explores the influence of external factors such as environmental conditions, traffic patterns, and user behavior on the performance of VANET-based ITS. Furthermore, emerging innovations such as artificial intelligence, Intelligent learning System, and Blockchain are examined in the context of addressing these challenges in enhancing security in ITS and VANET. The findings and recommendations of this survey provide guidance for researchers, practitioners, and policymakers in developing secure ITS and VANET environments.

Keywords: VANET, ITS, Communication protocols, AI, Intelligent Learning System, Blockchain.

I. INTRODUCTION

As our cities become more populated and traffic congestion worsens, ITS and VANET have attracted a lot of attention. The need for cutting-edge technologies to improve transportation sustainability, safety, and efficiency has never been more pressing. ITS and VANET offer promising answers to these problems by incorporating technological advances in communication and information into the transportation infrastructure development. Although decades have been spent researching this topic, widespread practical implementation is still a work in progress [1]. In the automotive sector, emerging models that can communicate in real time with one another, forming vehicular ad hoc networks (VANET), and playing a crucial part in intelligent transportation systems (ITS) are being developed [2]. Vehicle-to-everything (V2X) communication, which enables seamless interactions among vehicles, pedestrians, road infrastructure, and the Internet [3], is a crucial part of emerging ITS applications. V2X enables connected vehicles to exchange alerts and warnings, giving drivers important information about the state of the road and any dangers that may be present. Vehicles will soon be able to communicate with their surroundings and other nearby vehicles, making it possible to effectively avoid traffic jams and ensuring road safety. The V2V network's vehicle nodes work together as a mesh network to enable message transmission, reception, and relaying.

Information and communication technologies (ICT) are used in intelligent transport systems (ITS) [5] to support and streamline a wide range of activities associated with transportation on the roads. The basic idea is to use computers, electronic devices, wireless communications, sensors, and navigation systems like global navigation satellite systems (GNSS) to make it possible to collect and transmit data to and from vehicles. To increase the efficiency of road transport, for example, this data can be analyzed and used for a variety of purposes.

A. Historic Evolution of Intelligent Transport System

The development of computerized urban traffic signal control systems is where Intelligent Transportation Systems (ITS) got its start. SCOOT (Split Cycle Offset Optimisation Technique) and SCATS (Sydney Coordinated Adaptive Traffic System), which were initially developed for road networks, are two innovations that have significantly advanced ITS. Each continent, including Japan, Europe, and North America, contributed something unique to the history of ITS while these developments were taking place.

Japan's ITS development and history trace the beginnings of urban traffic control research and development to the Tokyo traffic control system, initiated in 1967, marked the inception of a significant initiative. Commencing from 1971, Japan adopted signal control systems throughout all metropolitan regions via a sequence of 5-year strategies [6].; by 1985, there were 74 police-operated urban traffic control centers. By 1990, control centers for congested motorways had been established in Tokyo and Osaka thanks to investments made by the Ministry of Construction in traffic detection and surveillance equipment on highways[7]. Japan has made sizable investments in traveler information services, such as dynamic message boards, radio broadcasts on the side of the road, and highway advisory radio for traffic updates. Furthermore, Japan was a pioneer in the development of route guidance technologies and automobile control systems, which gave rise to programs like All-Inclusive Automotive Management System (AAMS) and Automotive Traffic

Information and Control Network (ATICS)[8]. These early advancements laid the groundwork for the adoption of ITS in Japan, which culminated in the establishment of the VICS Promotion Council in 1991 to create a national system for the retrieval and sharing of dynamic traffic updates.

The evolution of ITS (Intelligent Transportation Systems) in Europe followed a path resembling that of ITS in Japan. With the ALI system from Bosch/Blaupunkt, which used inductive loops in the roadway to communicate with vehicles, work on vehicle navigation and route guidance in Germany started in the late 1970s. Siemens also created the AUTO-SCOUT system, which makes use of infrared transmissions. The two businesses worked together to create ALI-SCOUT (later known as EUROSCOUT), a two-way roadside-vehicle data link that made use of infrared beacons. Vehicles with ALI-SCOUT capabilities can act as traffic scouts by reporting travel times to a central database for real-time route planning. In 1988, there was a sizable ALI-SCOUT demonstration in Berlin. SCOOT, a computerised urban traffic control system that monitors and reacts to traffic conditions in real-time, was created in England by the Transport Research Laboratory. DRIVE and PROMETHEUS were two other important R&D initiatives in Europe. The London Autoguide project [9] used the ALI-SCOUT technology as its foundation, but it was ultimately scrapped. However, using telephone communication and traffic speed sensors along the UK motorway network, TrafficMaster implemented a real-time traffic information service successfully. The first fully commercial traffic information service based on ITS was TrafficMaster.

In comparison to Japan and Europe, the use of computer technology for traffic management on city streets was relatively delayed in North America. It took until the 1980s and 1990s for automated traffic signal management to take off in big cities like New York and Los Angeles. In Toronto in 1993, the SCOOT evolving traffic monitoring device demonstrated a substantial decrease in delays in traffic [10]. North American urban motorways received more focus when it came to traffic management. With positive effects on mainline speeds and accident reductions, electronic ramp metering was put into place as early as the 1960s. The introduction of high occupancy vehicle (HOV) lanes also enhanced the use of available road space. 1992 was a pivotal year for many important reasons, including the start of the FAST-TRAC project in Detroit, which combines adaptive signal control and dynamic route guidance. The TravTek project in Orlando demonstrated route guidance and navigation, similar to the forerunner to contemporary satellite navigation systems. The development and application of ITS was also accelerated by the publication of a strategic plan for IVS in the US by ITS America and the funding of a thorough study by the USDOT[11-14].

In the early 1990s, the field of ITS saw significant progress with key events and developments. Experts from Europe, Japan, and the United States came together for the international symposium on applications of transport telematics and intelligent vehicle-highway systems in 1994 in Paris, laying the groundwork for subsequent conferences and fostering global cooperation. Around the same time, a conference in Brussels aimed to raise awareness about the digital technology revolution, including its applications in automobile engineering and transport. Japan showcased its advanced traffic control centers and introduced the Vehicle Information and Communication System (VICS) [15] , a real-time traffic information service. These innovations inspired other countries like South Korea and Singapore to adopt similar systems. Norway's Trondheim toll ring and Canada's Highway 407 also demonstrated advancements in nonstop electronic tolling. These developments in the 1990s paved the way for ongoing progress and the establishment of the annual ITS World Congress, contributing to the advancement of intelligent transportation systems worldwide.

B. Innovations and User Services in ITS

Intelligent transportation systems are built on communication, and the development of the Internet and digital cellular phone networks in the late 1990s was instrumental in making the vision of a mobile information society with intelligent transportation But in order to realise this vision, it was necessary to create common systems that integrated a variety of technologies, including smartcards, digital mapping, navigation databases, mobile communications, data models, and location-based standards. Together, these technologies enable more informed and organized use of transportation networks, which is advantageous to highway authorities, road operators, transportation providers, and individual travelers. Applications of ITS are frequently distinguished by the services they provide, and the idea of user services enables the creation of systems specifically designed to address user needs and transportation issues. Recognizing the interdependencies and codependencies between services, the International Standards Organisation (ISO) has created a classification of ITS services across various domains.

Recent advancements in data transfer rates and communication networks, including the widespread adoption of 4G and 5G networks, coupled with the increased connectivity within vehicles through Electronic Communication Units (ECUs), such as sensors and communication devices connected to the Internet of Things (IoT), have been catalysts for rapid developments in communication protocols, traffic optimization algorithms, and communication technologies [16,17]. These technological advancements have paved the way for various forms of vehicle connectivity, such as Vehicle-to-Vehicle (V2V) communication, Vehicle-to-Infrastructure (V2I) communication, Vehicle-to-Pedestrian (V2P) communication, and the more recent concept of Vehicle-to-Everything (V2X) communication, ultimately leading to the emergence of Intelligent Transportation Systems (ITS) [18]. ITS leverages these solutions to effectively control and manage traffic while utilizing communication technologies to transmit data generated [19] by ECUs to cloud-based servers for processing and analysis, aiming to address urban and road traffic challenges [20].

C. Historic Evolution of vehicular ad hoc networks (VANET)

The concept of Vehicle Ad Hoc Networks (VANETs) was initially introduced in 2001 in the context of "car-to-car ad-hoc mobile communication and networking" applications [21]. These networks facilitate connections between vehicles, allowing for information exchange among them. VANETs are wireless networks formed among vehicles [22], applying the principles of Mobile Ad Hoc Networks (MANETs) to enable Vehicle-to-Vehicle (V2V) and Vehicle-to-Roadside (V2R) communication. Introduced initially in 2001, VANETs have become a critical part of Intelligent Transportation Systems (ITS) [23] and are often referred to as Intelligent Transportation Networks. They play a major role in enhancing road safety, navigation, and roadside services. VANETs have evolved into the broader concept of the "Internet of Vehicles," where interconnected vehicles create a network for seamless communication. This evolution sets the stage for the future development of an "Internet of autonomous vehicles" [24].

The Mobile Ad Hoc Network (MANET) is one of the most important elements of the Wireless Ad Hoc Network (WANET) [25]. The working group for mobile ad hoc networks is known as MANET in the context of computer technology. Fixed nodes and mobile nodes are two subcategories of ad hoc networks. A MANET is a temporary network made up of moving nodes.

- Vehicle Ad Hoc Networks (VANETs): Using Vehicle-to-Everything (V2X) communication, VANETs enable the coordination of vehicles, people, and roads. V2X uses artificial intelligence to give vehicles the ability to react to hazardous situations intelligently. VANETs significantly increase traffic efficiency and safety.
- Smart Phone Ad Hoc Networks (SPANs): Without the assistance of cellular operator networks, wireless access points, or conventional network infrastructure, SPANs create peer-to-peer networks using already-existing hardware. They allow for direct communication between smartphones for a variety of purposes.
- Mobile Ad-Hoc Networks that are Internet-based (IMANETs): IMANETs support Internet protocols like TCP/UDP and IP. Within the ad hoc network setting, they allow mobile nodes to communicate and access internet services.
- Hub-Spoke Multiple sub-mobile ad hoc networks can connect to a single radiating Virtual Private Network (VPN) using a MANET. It enables the development of mobile ad hoc networks that are geographically dispersed.
- MWANET, also known as the military or tactical wireless ad hoc network, is a specialized self-organizing network made for military applications. To meet mobility demands, it places an emphasis on data security, real-time requirements, data rate, radio range, and quick route establishment.
- Drone-based Flying Ad Hoc Networks (FANETs): FANETs enable connectivity in remote areas and offer high mobility. They make networking and communication possible in aerial environments.

By using vehicles and other roadside equipment as network nodes, vehicular ad hoc networks (VANETs) provide a number of advantages. The optimal operation of wireless communication equipment is guaranteed by the ample energy and spacious carrying capacity provided by vehicles. Additionally, they have powerful computing and storage capabilities. The infrastructure along the roadsides is similarly well-equipped with enough electrical power, computing power, storage space, and wireless communication capabilities. With the widespread use of GPS and GIS technologies, VANETs are enriched with a wealth of external auxiliary data, including precise location information and geographic information like road directions and traffic light distribution. VANET nodes display more consistent mobility patterns in comparison to other Mobile Ad Hoc Networks (MANETs).

The remaining article is organized as: Section II gives the objectives of this survey Section III gives the literature review on the ITS and VANET; Section IV the research challenges in the relevant field; Section V gives the conclusion in this study.

II. OBJECTIVE OF THE SURVEY

The purpose of the survey is to evaluate the current state of ITS research, development, and VANET implementation. It entails identifying the current technologies, protocols, and standards used in ITS applications based on VANET.

A. Application Scenarios Evaluation: The survey aims to investigate the different application scenarios and use cases of ITS with VANET. This includes researching how VANET can improve traffic control, raise driving standards, enable effective vehicle communication, and support intelligent transportation systems.

- **Traffic Management:** By providing real-time traffic data and enabling intelligent traffic control systems, VANET can significantly contribute to the optimisation of traffic management systems. Dynamic route planning and traffic signal optimization are made possible by the ability of vehicles outfitted with VANET technology to share data on traffic movement, roadway conditions, and congestion dimensions. This can lead to shorter travel times, better traffic flow, and increase the overall effectiveness of transportation networks.
- Road Safety: Through the implementation of proactive safety applications and real-time hazard alerts, VANET has the potential to significantly increase road safety. Vehicles connected to the VANET can communicate location, speed, and moving data that can be used to anticipate and avert collisions. Additionally, VANET can support automatic rescue braking, coordinated collision avoidance technologies, and intersection management.
- Effective Vehicle Communications: VANET enables effective V2V and V2I (vehicles to infrastructure) interaction among vehicles. Numerous applications, including cooperative adaptive speed control, and intersection coordination, can be supported by this communication. Through cooperative procedures and coordination, smoother traffic flow, lower fuel consumption, and increased operational efficiency of vehicle operations are all made possible by VANET, which enables the exchange of information on speed, acceleration, and position between vehicles.
- Smart Transportation Systems: VANET is a vital component of these systems, which are designed to improve the overall effectiveness, viability, and user experience of transportation networks. Smart transportation systems can take advantage of the enormous amount of data collected from vehicles and infrastructure by integrating VANET with other cutting-edge technologies like IoT (Internet of Things) and cloud computing. This enables predictive maintenance, enables personalised services for users, and supports the operation of autonomous and connected vehicles.

B. Examining Communication Protocols: The survey's primary focus is on identifying and analyzing the various protocols for communicating used in VANET-based ITS. In order to do this, it is necessary to look into the protocols SAE J2735/SAE J2945, IEEE 1609, and IEEE 802.11p, which specify the network frameworks, data packets, and physical communication norms for Dedicated Short-Range Communication (DSRC).

C. Evaluation of Performance and Reliability: The survey's objective is to assess the effectiveness and dependability of ITS solutions based on VANET. In order to comprehend the efficiency and constraints of VANET in real-world scenarios, this includes analyzing metrics such as communication latency, throughput, packet loss, network coverage, and scalability.

D. Finding Research Gaps and Challenges: The survey aims to find Research Gaps and Challenges in ITS Implementation with VANET. This entails looking into issues like network congestion management, security and privacy concerns, scalability problems, integration with existing infrastructure, and the need for standardisation.

E. Providing Insights and Recommendations: In considering the survey's results, the goals include outlining future directions for the creation and implementation of ITS with VANET. This can aid in directing academics, businesspeople, government officials, and other interested parties in advancing their research and maximizing the potential of VANET-based ITS applications.

III. LITERATURE REVIEW

This section presents a comprehensive literature review to explore and analyze the existing body of research and advancements in the field of Intelligent Transport Systems (ITS) with a particular emphasis on Vehicular Ad Hoc Networks (VANETs). ITS encompasses a range of technologies and applications that utilize advanced communication and information systems to enhance the efficiency, safety, and sustainability of transportation systems. VANETs, as a subset of ITS, specifically focus on enabling communication and data exchange among vehicles and infrastructure components in a dynamic ad hoc network. By examining the existing literature, we aim to identify the key research areas, methodologies, and challenges in the integration of VANETs into ITS.

Qureshi et.al [26] in their article discussed how crucial Intelligent Transportation Systems (ITS) are for addressing traffic issues and enhancing transportation effectiveness. It emphasizes the requirement for information, communication, and computer technology integration in the transportation industry to develop a thorough and effective transportation management system. The article explores at the development of intelligent transport systems (ITS) in a number of nations, including the US, Japan, the EU, and South Korea. The development of ITS in each nation is discussed, with a focus on particular initiatives and projects that showcase important technologies. The Vehicle Infrastructure Integration (VII) program, which enables communication between vehicles and roadside infrastructure, is the main focus in the United States. The paper highlights the international scope of traffic problems and the significance of international technological cooperation. The article also discusses the foundational ITS technologies, such as GPS, DSRC, wireless networks, mobile telephony, roadside camera recognition, and probe vehicles. The paper suggests an integration model that combines the most beneficial procedures and developments by comparing and analyzing ITS development in various nations.

Fayaz, Danish [27] in their article, presents the idea of Intelligent Transportation Systems (ITS) is examined, as well as how it might be used in India's transportation engineering. It draws attention to the difficulties caused by population expansion, emigration, and economic growth, all of which have put tremendous strain on transport services and infrastructure. In order to address traffic issues, parking issues, and congestion, the review discusses the need for an effective management system. The importance of ITS in delivering solutions via innovations like GPS, GNSS, and C-ITS is emphasized. The review also mentions the various ITS applications and their beneficial effects on intermodal connections, efficiency, and safety, such as parking guidance and facility management. Overall, the review of the literature demonstrates how ITS has the power to transform the transportation system by enhancing safety, mobility, and environmental conditions.

Miles, John C, [28], in their research, provides an overview of the previously mentioned material, presenting a broad outline of Intelligent Transport Systems (ITS) and its diverse applications. The author explores how communication, control, and information processing technologies are integrated into the transportation system to enhance convenience, safety, and efficiency. The review highlights the advantages of ITS, including improved public transportation systems, real-time travel information, enhanced traffic management, electronic payment systems, and air quality monitoring. The author also classifies ITS applications into various categories, such as Advanced Traffic Management Systems (ATMS), Advanced Traveler Information Systems (ATIS), Advanced Vehicle Control Systems (AVCS), Commercial Vehicle Operations (CVO), Advanced Public Transport Systems (APTS), Electronic Payment Systems (EP), and Security and Safety Systems (SSS). The study concludes by demonstrating how these initiatives contribute to better navigation, reduced traffic, and effective transportation operations.

Al-Sultan, Saif et.al [29] in the study highlights how VANETs differ from MANETs in terms of their architecture, difficulties, traits, and applications. Architectures of VANET such as On Board Unit (OBU) wave device which is mounted on the vehicle to exchange the data with other roadside units (RSU), also various functions of OBU such as wireless radio access, ad hoc and geographical routing, network congestion control, ensuring reliable message transfer, maintaining data security, and facilitating IP mobility are discussed. The author also presents the communication domains of the VANET such as the In-vehicle domain, Ad-hoc domain, and infrastructure domain. Wireless technologies in the VANET cellular systems, WiMax, GSM, DSRC/WAVE are explored. This study gives researchers important information about the difficulties and uses of VANET. It reveals a thorough comprehension of how to deal with various VANET-related issues, including picking the right architecture parts, figuring out appropriate access technologies, identifying potential applications for this new paradigm, and selecting the best simulation tools for comparing and implementing various strategies. By focusing on these topics, this investigation enables researchers to successfully address the challenging problems related to VANET and make wise choices throughout their research.

Zichichi, Ferretti, and D'angelo [30] present a system architecture using distributed ledger technologies (DLTs) for data management and services in Intelligent Transportation Systems (ITS). The authors present the value of data in contemporary organizations and infrastructure systems, including ITS. To enable the creation, storage, and sharing of data generated by users through their devices or vehicles, they suggest an architecture based on DLTs, particularly IOTA for IoT and Ethereum as a smart contract platform. Through distributed key management systems and Zero Knowledge Proof, the architecture offers features such as data immutability, traceability, verifiability, and privacy guarantees. The potential of DLT and decentralized file storage technologies in supporting complex ITS services is demonstrated by experimental results from a testbed built on actual traffic traces. Further, the study also suggests the need for further improvements in the responsiveness of DLT infrastructures.

Zhang, Hong et.al [32] article discusses the vehicle communication network in an Internet of Things (IoT)-based intelligent transportation system (ITS) as a remedy for urban traffic congestion. Traditional traffic control strategies are insufficient today due to rapid urbanization and rising car ownership. The goal of this study is to examine the ITS IoT vehicle communication network. To create a model of vehicle movement and simulate a multi-hop scenario of a vehicle self-organizing network, the authors use the OPNET Modeller software. The experiments show that a distance of 500–600 meters between roadside units ensures stable network performance. Throughput, average network delay, routing load, packet loss rate, and average routing hops are all found to be better for the AODV protocol than the DSR protocol, making it more suited for network communication requirements. This study offers knowledge on how to maximize network coverage and choose suitable protocols for effective and dependable communication, which aids in the understanding and design of vehicle communication networks in ITS.

Zemrane, Hamza et.al [33] in the study compare the effectiveness of various routing protocols for communication applications like HTTP, FTP, and voice and address the use of Mobile AdHoc Networks (MANETs) in Intelligent Transportation Systems (ITS). The author of this study explores that Wireless networks without infrastructure known as MANETs allow for quick deployment and can be used in a variety of situations. By reducing human error, saving lives, controlling traffic congestion, and using less energy, traditional transportation systems are being improved. The study highlights how difficult it is to choose the best routing protocol from the many options available. The findings indicate that AODV outperforms OLSR for HTTP applications, OLSR excels for FTP applications, and OLSR outperforms TORA for voice applications. These discoveries aid in the comprehension and application of effective MANETs for ITS communication systems.

Vatanian Shanjani et.al [34] Survey presents a comprehensive literature review on the evolution and development of transportation systems, with a specific focus on Vehicular Ad Hoc Networks (VANET) as a component of Intelligent Transportation Systems (ITS). The review explores the main issues, characteristics, and applications of VANET, including inter-vehicle communication, mobility models, consortiums, and protocol classifications. The study provides suggestions for routing protocols, data diffusion, media access control protocols, and security. The article identifies future research areas such as mobility models, protected frequency allocation, road safety, routing protocols, integration with wireless technologies, and data dissemination.

Carianha et al. [35] introduced the CMAX method, which involves utilizing a masking region with encrypted mix-zones, to enhance the confidentiality of vehicle location in mix-zones. The CMAX protocol employs a private encryption key provided by the RSU to encode the direction, position, and speed of the data. Only authorized vehicles that enter the mix-zone are assigned private keys by the RSU. The messages or beacons are then encrypted using these private keys. Within the mix-zone, the sender's private key is used to encrypt the status information. Upon decryption using the respective receiving vehicle's private key, the RSU forwards the messages to neighboring vehicles in proximity to the source vehicle, known as neighbor vehicles. However, it is important to note that the CMAX method is susceptible to security threats such as side-channel attacks and replay attacks.

Gillani, Maryam et.al [36] their article, the authors give a thorough analysis of the data collection protocols used in vehicular ad hoc networks (VANETs), which are essential to intelligent transportation systems (ITS) and the Internet of Vehicles (IoV). Due to their dynamic network topologies and high mobility, VANETs pose a challenge for data collection because they frequently experience link disruptions and path discovery issues. The survey divides data collection protocols into three major groups; delay-tolerant, best-effort, and real-time protocols. To improve the accuracy and comprehension of these protocols, a taxonomy is presented. The protocols are thoroughly compared by the authors, who rate them according to criteria like effectiveness, delivery and drop ratio, recovery strategy, and other crucial elements. By categorizing the various data collection protocols, the authors address the diversity of these protocols, taking into account mechanisms, network layers, routing techniques, latency, privacy, motion estimation, and sources of delivery. Each protocol's benefits, drawbacks, and advantages are discussed, allowing for a thorough understanding of its domains.

Manogaran, Gunasekaran et. al [37] in their study propose a multi-variate data fusion (MVDF) technique to enhance data fusion in connected vehicles. The MVDF technique is designed to handle asynchronous and discrete data from the environment and convert it into continuous and delay-less inputs for applications. The fusion process utilizes least square regression learning to identify errors at different time instances. By employing this regression model, the technique distinguishes between indefinite and definite data fusion instances, enabling the identification of errors in advance. The differentiation process takes into account the application's run-time interval, facilitating data fusion within the same or extended time instance and data slots. This iterative approach continues until the required data for the application is obtained. The performance of the proposed technique is evaluated through network simulator experiments, measuring metrics such as error, data utilization ratio, and computation time. The results demonstrate that the MVDF technique improves data utilization within controlled time intervals, reducing errors in the fusion process.

Liu, Jianhang et.al [39] in this study illustrates the difficulties in routing for VANETs, particularly in sparse urban settings. Making the best packet forwarding decisions is challenging due to the dynamic nature of VANETs, insufficient node connectivity, and unreliable inter-vehicle communication. The paper introduces the Real-Time Effective Information Traffic (RTEIT) routing algorithm to address this. RTEIT estimates node connectivity using efficient information traffic, and it chooses the top relay nodes for packet forwarding. To avoid communication hiccups, it additionally assesses link status using a cutting-edge formula based on speed, direction, and location data. According to tests conducted using simulation platforms, RTEIT performs better than existing protocols in terms of packet loss rate, end-to-end delay, and network yield.

He, Chenguang et.al [40] in their paper propose a two-level communication routing algorithm that takes into account vehicle attribute information and employs a clustering algorithm to group vehicles on the road. Cluster heads are dynamically selected based on their attribute information, and the proposed algorithm enables vehicle nodes to communicate with each other through the cluster heads. Unlike existing cluster routing algorithms, this approach eliminates the need for gateways to facilitate communication among cluster heads, making it more suitable for large-scale VANETs. The proposed algorithm is evaluated through simulations using real street scenes in Simulation of Urban Mobility (SUMO), where vehicles adhere to traffic rules, mimicking real-world scenarios. Performance analysis conducted in Network Simulator version 2 (NS2) demonstrates that the proposed algorithm outperforms traditional routing algorithms in terms of stability, efficiency, and lower latency, offering promising results for VANET communication.

Gangwani, Divya et. al [41] in their study provides an overview of the applications of Artificial Intelligence (AI) and Machine Learning (ML) in the development of intelligent transportation systems. The focus is on addressing challenges related to traffic congestion and road safety to prevent accidents. Various ML approaches such as SVM, SVR, K-NN, ANN, CNN, LSTM, and Genetic algorithms are explored, including road anomaly detection for obstacle avoidance, real-time traffic flow prediction for smart and efficient transportation, accident detection and prevention for enhanced safety measures, utilization of smart city lights for energy conservation, and the implementation of smart infrastructure for optimized transportation. Additionally, diverse AI approaches are examined, encompassing safety and emergency management systems to ensure public safety.

Mchergui, Abir, Tarek Moulahi et.al.[42] in this article presents a comprehensive survey on the application of Artificial Intelligence (AI) techniques in Vehicular Ad Hoc Networks (VANETs). Various AI techniques are explored, and their potential to enhance the performance of vehicular applications over traditional algorithms is discussed. The author explores the optimization of performance in VANETs faces challenges due to the complex interplay of multiple factors. Thus the author suggests the areas of Machine Learning (ML), Deep Learning (DL), and Swarm Intelligence (SI) within the AI domain can complement each other to achieve optimal solutions that address the limitations of individual techniques. It is acknowledged in their study that AI algorithms typically require significant computational resources, which may not be readily available in vehicles or roadside units. However, advancements in integrated architectures and access technologies, such as fog and edge computing, offer opportunities to alleviate the computational burden by offloading some computations to external servers located at the edge, fog, or cloud. The benefits of AI techniques in the VANET environment are discussed, along with strategies to mitigate the limitations associated with certain AI techniques.

Olugbade, Samuel, et. al [43] in their review provide a comprehensive analysis of the application of artificial intelligence (AI) and machine learning (ML) techniques in incident detection systems for road transport. It emphasizes the role of AI and ML in enhancing road management systems by improving the accuracy and comprehensiveness of input data through the integration of multiple data sources. The author also explores the integration of fixed detectors, which capture point data, and probing vehicles, which collect spatial data, contributing to a more effective event detection on roads. This study also highlights the importance of camera calibration in incident detector usage, particularly in determining vehicle speed for tracking algorithms and event detection. The author concludes accurate acquisition of internal and exterior camera parameters is essential to prevent calculation errors during camera calibration. Additionally, the study explores in detail the various applications of ML and AI in incident detection systems, encompassing recent literature, emerging trends, and potential implementation challenges. It concludes by suggesting that future research should focus on conducting in-depth analyses to address road incidents and further advance the field.

Guerrero-Ibañez et. al [44] in their study explore the integration of deep learning methods with Intelligent Transportation Systems (ITS) to enhance traffic flow, safety, and efficiency. ITS plays a crucial role in improving vehicular flow and reducing accidents in urban traffic. With the increasing generation of vast amounts of data from digital devices connected to the transportation network, deep learning techniques offer the opportunity for in-depth analysis and prediction. By addressing challenges such as improving traffic flow and logistics, optimizing fuel consumption, and enhancing environmental perception, deep learning methods can be effectively integrated into ITS. The author explores the different applications in different domains using Deep Learning. This integration holds the potential to improve autonomous vehicle networks and provide personalized services based on behavior and information from vehicles, and infrastructure. The study concludes integration of Intelligent Transportation Systems (ITS) with deep learning has the potential to enhance autonomous vehicle networks and improve client services by offering personalized experiences based on various factors such as behavior, needs, requirements, and information from vehicles, roadside infrastructure, passengers, drivers, pedestrians, among others.

Haghighat, Arya Ketabchi et.al [45] main purpose of this article is to provide a comprehensive review and insights into the utilization of deep learning models in intelligent transportation systems (ITS) and to showcase the advancements in ITS research facilitated by deep learning. The paper begins by discussing various deep learning techniques such as CNN, RNN, LSTM, Autoencoders, Deep Reinforcement Learning (DRL) Generative Adversarial Networks (GAN), and their current state-of-the-art in ITS. It then delves into a detailed analysis and explanation of the existing applications of these techniques in transportation systems. The author presents traffic characteristics prediction, traffic incident inference, vehicle identification, traffic signal timings using various DL techniques, and also the evaluation metrics to predict the performance of the DL techniques.

Mollah, Muhammad Baqer, et.al [46] in their study present how blockchain technology in the Internet of Vehicles (IoV) to advance intelligent transportation systems (ITS) can be applied. In order to increase efficiency and safety, the IoV connects smart cars to the Internet and various elements of the transportation environment. However, it is essential to guarantee an open and secure exchange of information. Blockchain offers desirable characteristics for IoV applications, such as decentralization, security, transparency, immutability, and automation, due to its decentralized and immutable nature. The study also highlights the potential of blockchain in enabling a secure and cutting-edge IoV ecosystem for ITS by giving an overview of the most recent developments in blockchain for IoV, discussing application scenarios, exploring key challenges, and presenting future research directions.

IV. THE RESEARCH CHALLENGES IN INTELLIGENT TRANSPORT SYSTEMS (ITS) WITH VEHICULAR AD HOC NETWORKS (VANETS)

A. Communication and Networking Challenges:

- Reliable and Efficient Data Dissemination: VANETs face challenges in achieving reliable and efficient data dissemination due to the highly dynamic nature of vehicular networks. Developing protocols that ensure timely and accurate data delivery is crucial.
- Routing Protocols: Designing robust and scalable routing protocols for VANETs is essential, considering the varying network topologies caused by vehicle mobility. Routing protocols need to adapt to changing network conditions while minimizing latency and maximizing throughput.
- Network Congestion and High Mobility: VANETs experience congestion and high vehicle mobility, which can impact communication performance. Efficient congestion control mechanisms and mobility management techniques need to be developed to maintain network connectivity and stability.
- Quality of Service (QoS) Provisioning: VANETs support various real-time applications and services, such as traffic monitoring and emergency messaging. Ensuring QoS for these applications, including latency, reliability, and bandwidth requirements, is a challenge.

B. Security and Privacy Challenges:

- Secure Communication: VANETs require secure and trustworthy communication to prevent unauthorized access and malicious attacks. Developing robust authentication and encryption mechanisms to protect vehicular communication from unauthorized entities is crucial.
- Privacy Preservation: Vehicular communications involve sensitive information about drivers and vehicles. Ensuring privacy preservation while allowing necessary data sharing for traffic management and safety applications is a challenge.
- Secure Infrastructure: Establishing a secure and trusted vehicular communication infrastructure involves securing the network infrastructure components, such as roadside units and infrastructure-to-vehicle communications, against attacks and compromises.

C. Data Management Challenges:

- Efficient Data Processing: VANETs generate a vast amount of data from vehicle sensors, roadside infrastructure, and other sources. Efficient data processing techniques, including data aggregation and fusion, are needed to extract meaningful information from the data flood.
- Data Heterogeneity and Quality: VANETs involve diverse data sources with varying formats, types, and quality. Managing and integrating heterogeneous data while ensuring data quality is a challenge that needs to be addressed.
- Privacy-Preserving Data Sharing: Enabling data sharing for collaborative applications while protecting individual privacy is a challenge. Developing privacy-preserving techniques for data sharing and analytics is crucial in VANETs.

D. Environmental Factors:

- Adverse Weather Conditions: Adverse weather conditions such as rain, fog, or snow can impact wireless signal propagation and communication reliability in VANETs. Developing adaptive communication protocols and algorithms that can handle changing environmental factors is important.
- Impact on Wireless Communication Range: Environmental factors can affect the communication range between vehicles. Research is needed to understand and mitigate the impact of varying environmental conditions on wireless signal propagation and vehicle-to-vehicle communication range.

CONCLUSION

In conclusion, this article emphasises the research difficulties in Vehicular Ad Hoc Networks (VANETs) in Intelligent Transport Systems (ITS). Vast potential exists for increasing the effectiveness and safety of transport through the integration of VANETs into ITS. But there are a number of significant issues that must be resolved. These include difficulties with networking and communication, security and privacy issues, problems with data management, resource allocation optimisation, and complexities with system integration. Interdisciplinary research and the application of artificial intelligence, machine learning, and data analytics techniques are required to address these issues.

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